1 Standard setting in markets: the browser war

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Abstract

We study de facto standard setting in markets with network effects. We closely examine the "browser war," in which Netscape Navigator at first appeared likely to be a de facto standard, but Microsoft Internet Explorer eventually became the standard. This reversal is a puzzle we seek to explain. We draw on the theory of standard setting, especially on the positive economics predictions about market outcomes, such as a tendency to tip and a tendency toward inertia. The basic insights of standard setting theory are borne out in the browser war. In addition, linking standard setting logic to an analysis of market conditions, such as the rate of growth of demand and the distribution system, leads to a complete positive theory of standard setting. This complete theory explains the otherwise surprising reversal.

1 Introduction

1.1 De facto standard setting

We study de facto standard setting in markets with network effects. In markets for system goods – e.g., a computer and the software that runs on it, a CD player and music, a computer connecting to Internet websites – interface standards are particularly important. Like the other chapters in this book, we define interface standards as technical specifications that determine the compatibility or interoperability of different technologies. In such markets, standard setting is linked to the exploitation of network effects. Which standard is ultimately adopted is a key determinant of the variety of systems available to users, market competition, and

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technological progress. This has brought a great deal of attention to standard setting from technologists, economists, and policymakers.

Many standards are embodied in particular products. For example, the standard kind of personal computer (PC) used today is defined by its use of Microsoft Windows and Intel-architecture microprocessors. An entire body of theory has grown up to understand de facto standard setting when standards are embodied in products.[1] In these circumstances, the commercial importance of standards and the market success of products are closely linked. The most popular product will also be the de facto standard, and setting a standard can offer a product a dominant market position. Thus de facto standard setting in these cases is of enormous concern to firms in systems industries and will often be central to their business strategies.[2]

1.2 The standards supporting electronic commerce

To examine the positive economics of standard setting in markets, we undertake a case study: setting standards for mass market online commercial applications such as electronic commerce, online content, blogs and many more.

The standards that connect PCs to large "servers" with web pages, electronic commerce sites, and corporate databases were one of the most valuable technological advances of the late twentieth century.[3]

[1] For example, see Farrell and Saloner (1985), Besen and Saloner (1989), Church and Gandal (1992), and Dranove and Gandal (2004). Overviews of the broad standards literature can be found in David and Greenstein (1990), Greenstein (1992), Weiss and Cargill (1992), Besen and Farrell (1994), Katz and Shapiro (1994), David and Shurmer (1996), and Stango (2004).

[2] For treatment of strategic issues, see Cusumano et al. (1992), Besen and Farrell (1994), Shapiro and Varian (1999), Gallagher and Park (2002), Ehrhardt (2004), and Yamada and Kurokawa (2005).

[3] A number of distinct standards were set in order to connect PCs to the Internet. Many of these standards, especially those associated with the "plumbing" of the Internet, were set in standards committees or by other de jure methods. By "plumbing" we mean standards in the lower levels of the network's engineering reference model. The most important such standard for the Internet is TCP/IP, known as the Internet protocol suite. It contains a number of standardized communications protocols, including the transmission control protocol (TCP) and Internet protocol (IP). How standards are set in such contexts is an important topic, but not one we take up.

De jure standard setting is an important topic with a rich and interesting literature (Farrell and Saloner 1988; Weiss and Sirbu 1990; Weiss and Cargill 1992; Anton

Commercialization of the browser ended years of failed attempts to set standards for mass market online commercial applications, enabling an explosion of investment in PCs, servers, telecommunications, networking, and software. Browsers embody standards that define the end-user experience for using the World Wide Web (WWW) and enable online commercial applications.[4] This growth has fostered new markets, such as all the auction, resale and retail markets that have emerged on eBay, and has permitted substantial changes in old ones, such as in the distribution of airline tickets. The WWW enabled both large, complex online applications and simpler ones developed by individual "webmasters" (website developers) to reach the mass market.

As a result, society had a large stake in how the browser standard was set. Standard setting for the browser was a race between two firms, Netscape and Microsoft. Each had a powerful incentive to promote its own browser as the winning standard, since the technical features of its browser would define web page design and the exact way in which users interacted with online applications. This standards race also affected competition in the personal computer industry and on the Internet, leading to intense interest from public policy circles as well.[5]

Our second reason for studying the race to set browser standards is theoretical. This case study will teach us much about the theory of de facto standard setting.

The main agents in the browser standards race closely resemble those in the economic theory of indirect network effects. Webmasters and users gained indirect network effects from using particular standards and the associated products. Developers could program websites to be accessible via Netscape or Microsoft's Internet Explorer (IE) or both

and Yao 1995; Axelrod et al. 1995; Hawkins et al. 1995; von Burg 2001; Simcoe 2003; Augereau et al., in press; Gandal et al., in press; and Lerner and Tirole, in press). While often thought of in purely technical terms, sometimes de jure standard setting can be strategic. For example, see MacKie-Mason and Netz (in press).

[4] Our use of the language here follows the theory. Network effects may be realized through a proprietary standard (e.g., when each brand of word processing software stores files in its own way so that users sharing files must buy the same brand) or an open standard (e.g., when any word processing program can read the files of any other). In the browser case, both brands respected open standards such as basic HTML but provided proprietary technologies for more complex applications and web pages.

The commercially important standards included such areas as security, which was critical to use of credit cards for online purchases.

[5] Evans et al. (2001), Fisher and Rubinfeld (2001), and Gilbert and Katz (2001).

(at some cost). Users would run Netscape or IE or both (at some cost). All else equal, website developers preferred to write for the browser that had the most usage by their customers, and users preferred the browser which gave them access to the most and best websites. These are the classic payoffs of indirect network effects.

Standard setting agents of the browser race corresponded closely to those described in the theory. Netscape and Microsoft each had a proprietary browser which embodied a particular set of interface standards between files and applications on the WWW and the user's PC. The race to establish browser standards was an effort to attain a position where positive feedback between mass market browser usage and web pages seeking a mass audience would reinforce one standard over another.

The final reason to study this race is feasibility. The race is well documented in the internal communications of both firms (much of which has been made public) and in quantitative data.

1.3 Our contributions

In the next section, we lay out the positive economics implications of standard setting theory. A number of these are critical both to the logic of the theory and for understanding the race to establish browser standards. The implications we emphasize that apply to the behavior of users and developers include positive feedback in the decision rules of individual actors; indeterminacy of equilibrium; and inertia around particular standards (installed base effects). The implications we emphasize that apply to standard setting firms include first-mover advantages (barriers to entry) and strategic competition that is intense in the period of establishing a standard, then largely absent after standards are set. We thus emphasize competition for the market rather than competition in the market in standards industries.

We depart from received theory, however, by emphasizing the impact of market conditions on de facto standard setting. This apparently simple change takes us through a series of points which at first seem very closely connected to our application but which ultimately lead us to a conceptual departure from received theory.

To begin, we emphasize demand dynamics and distribution as essential background conditions for standard setting. In the browser wars, we are studying a mass market with a growing number of users, and standard setting theory emphasizes the importance of having a large installed base. Mass market use of a technology involves mass distribution of that technology.

The key role of demand dynamics and distribution permit us to understand the most puzzling event of our case study. After Netscape took an early lead in browser standard setting, Microsoft entered with a series of imitative products. The standards race ultimately tipped to Microsoft despite that firm's failure to leapfrog Netscape in the attractiveness of its browser to users.[6]

Growing demand undercut Netscape's initial standard setting advantage but enhanced the strategic importance of Microsoft's control over distribution channels for new browsers. Market conditions devalued Netscape's first-mover advantage and enhanced Microsoft's advantage as a strong second.

These specific results about the browser war are related to a set of general conclusions.

Complementary markets and pre-existing standards play an important role in understanding standard setting in systems industries with dominant multiproduct firms, such as IBM in mainframes in one era of computing or Microsoft in PC software in another. New technologies in computing are frequently invented by outsiders (as they were in the case of the browser). An existing dominant firm typically has control of existing standards and products complementary to the new technology. The firm's position in complements gives it an asymmetric advantage in influencing the channels of distribution. This asymmetry can influence the identity of the standards winner.

Market conditions do not overturn standard setting logic. On the contrary, our broader conclusion is that there is a fundamental interaction between market conditions and the logic of standards theory. The relative strengths of distribution and first-mover advantages vary over time, leaving at most a finite window of time when a second mover can act strategically to interrupt the network effects that build around a first mover. Second, supply-side factors such as taking control of distribution are not sufficient to win a standards race. They matter far

[6] This assertion has been highly controversial in economics but not, as we shall see in this paper, controversial among suppliers of commercial browsers. In Bresnahan and Yin (in press), we provide a complete econometric analysis of the importance of browser product quality. More on the controversy can be found in Davis and Murphy (2000), Schmalensee (2000), Evans et al. (2000, 2001), Fisher and Rubinfeld (2001), and Gilbert and Katz (2001).

more if they coincide with rapid and mass adoption of a technology on the demand side. Interaction effects like this are a general feature of a complete positive theory of de facto standard setting in markets.

Our story of the importance of timing and distribution is novel in its connection to the theory of standards, but it is familiar to the most analytical industry practitioners.[7] It is a cliché of the standards literature that a firm's control of standards can result in a dominant market position. It is far less well understood how market demand and supply conditions and suppliers' pre-existing market positions influence standard setting. This chapter contributes to the standard setting literature by analyzing the *market* conditions behind standard setting.

Our positive-economics emphasis on market conditions finally leads us to a sharp conceptual departure from the theoretical standards literature. To resolve the uncertainty in standard setting, many analysts emphasize agents' *expectations* about the de facto standards outcome and/or coordinating *contracts* among agents. This has led to two competing completions of the theory. One emphasizes efficiency while the other emphasizes inertia.[8] We argue that both the efficiency and inefficiency theories have failed to provide a complete positive-economics theory of standard setting. Our market approach provides just that key element.

The missing element in both efficiency and inefficiency theories lies in their treatment of inertia. Neither treats standards inertia quantitatively. Inefficiency theories write as if inertia were infinitely large, or at least so large as to make inefficient standards persist for generations. Efficiency theories write as if inertia were zero, or at least so small that it can always be overcome by contracts. As a result, neither theory can provide a positive explanation of the occasions on which existing inertial standards are overturned.

2 Standards theory 1: demand side/small actors

The positive implications of the theory are important, if incomplete, for understanding standard setting in markets. We divide the key positive implications into two groups. The first group is related to the behavior of

[7] In his first book, Bill Gates summarized the strategic implications of the "positive feedback cycle" in a "growing market" by saying that "Both timing and marketing are key to acceptance with technology markets." (Gates et al. 1995, 135)

[8] For examples of efficiency arguments, see Liebowitz and Margolis (1990, 1994). For examples of inertia, see David (1985) and Arthur (1989).

the small or "non-strategic" individual actors, such as individual users of a system or developers of particular applications for the system.

2.1 Positive feedback

The literature on standards and network effects begins with the utility (or profit) of users and developers who are modeled as non-strategic actors.[9] "Indirect network effects" arise when users' utility depends on the number or variety of developers and developers' profits depend on the number or variety of users.

These assumptions about utility and profit have implications for individual behavior. Individual users will tend to choose systems with the most or best applications provided by developers. Users who have sunk costs of obtaining a system will tend to choose systems based at least in part on their expectations of future applications availability.[10] Of course, any particular user will trade off the number and variety of developer applications on a system against other considerations, such as the price of that system or the difficulty of connecting to it.

Similarly, developers will tend to provide for systems that have the most users (or the most profitable users for their particular application). If developers sink costs into a system (for example, by learning how it works), then they will base their choice at least in part on expectations about demand. If the incremental costs of developing for a second system are positive ("porting costs" in the language of developers), then there will be an incentive to supply first or only to the system with the most or most profitable users. Developers will trade off the number and variety of users against other system features, such as technical quality as a development environment, and will sometimes need to act based on expectations.

2.2 Social scale economies

An alternative normative language for network effects and standards uses the language "social scale economies."[11] This normative language emphasizes the benefits of sharing ("social") the network effects

9 See Farrell and Klemperer (in press).

10 Although individual user and developer sunk costs are distinct from inertia around an existing standard, sunk costs make expectations more important, which increases the tendency toward tipping and inertia.

11 See Arthur (1994).

associated with standards, and suggests the value of having only one or a few standards ("scale economies"). This articulation is employed to explain standardization as a solution to the inefficiencies of a market of highly complementary goods that is fragmented into multiple systems.

Some scholars, however, use the normative analysis as a positive theory, assuming that there must be a strong equilibrium tendency toward the socially correct degree of standardization and efficient standards choice. This is an elementary error.[12] Like any other scale economies, social scale economies tend to lead to equilibrium with concentration. In this case, it is concentration of standards. However, the social scale economies in and of themselves guarantee only concentration; they do not guarantee either the optimum degree of standardization or the efficient choice of standards.

2.3 *Indeterminacy*

There is a fundamental indeterminacy at this static level of analysis. The network effects tell us there will be few standards, but not which ones. If we look only at the (static) Nash game among users, or users and developers, it is indeterminate. Indeed, one equilibrium can be the inferior of the two standards, as parts of the literature have emphasized.[13]

One way the literature has resolved the indeterminacy is to model users and developers as choosing systems sequentially, assuming that choices are irreversible, so that the choices of the early ones condition the choices of the later ones.[14] A strong version leads to determinacy in favor of the standard that first gains market share. More generally, the literature examines sequential models with uncertainty (about the system or about future adopters' preferences) in the early going. Then early choices will tend to persist, even if later information arrives that might suggest reversals. The system tends to converge to a single standard: not necessarily the ex post Pareto-superior one, but rather the one preferred by early choosers.

Another way to resolve the indeterminacy is to assume the existence of a contractual, institutional or entrepreneurial mechanism that arises

12 Normative analysis as positive theory is a familiar error in the economics of regulation. See Joskow and Noll (1981) and Peltzman (1989).
13 See David (1985) and Arthur (1989).
14 See Farrell and Klemperer (in press) for an overview.

to coordinate choices. The motivation for this resolution arises from the possibility that uncoordinated choices might lead to a Pareto-inferior outcome.[15] In the case of costless contracting or an effective institution, these theories lead to an efficient, coordinated technology choice. Obviously, costless contracting among users and developers (or a perfect coordinating institution) is a strong assumption. In the case of technology choice played out over time, this implies that late adopters and early adopters contract to change the behavior of early adopters.[16]

A final mechanism to resolve the uncertainty is expectations. If early choosers anticipate that later events will lead to a particular standard, they may choose that standard just as if they were late adopters and a large installed base already existed. As a mechanism for resolving the uncertainty, however, rational expectation is an unsatisfactory approach. When more than one option presents a viable standard, then the absence of unique equilibrium in the static game can also lead to expectation indeterminacy in the dynamic game. If the expectation mechanism tends to track efficiency, then the market outcome is likely to be efficient. If the expectation mechanism has an element of persistence forecasting, however, the market outcome is likely to be inertial.[17]

3 Standards theory 2: supply side/strategic actors

The second set of positive implications concerns the incentives and behavior of strategic actors, such as sellers of products that embody interface standards. The theory models these actors as having a strategic motive to influence standards choice.[18] The literature has studied how firms' preferences over standards outcomes vary with their existing product position.[19] The literature has also brought to the foreground a

[15] In this case, we are dealing with the choice of a standard, but the same argument would arise in connection with standardization in general. There are strong theoretical reasons to believe individual action will lead to too little standardization and too much fragmentation in many contexts.

[16] See David and Greenstein (1990).

[17] This argument is made carefully in the *Handbook* chapter by Farrell and Klemperer (in press).

[18] See Farrell and Klemperer (in press) for an overview.

[19] Firms' existing products may be based on technologies which would make them prefer one technical standard over another. Alternatively, firms whose products embody a popular standard may oppose an open or industry-wide standard (or a

powerful incentive for firms whose products embody standards to win a standards race.[20] Once a standard that is embodied in a particular firm's product is set, that firm enjoys a strong market position as users and developers will have limited ability to substitute away from it.

The theory also has brought forward positive implications that inform firm strategy. When users and developers sink system-specific investments, the network effects are dynamic, offering a role for expectations, for strategy, and for inertia. When strategic actors sponsor system-defining technologies, this situation leads to a very rich set of strategic issues, especially when multiple strategic actors contend for the same leading position. As we shall see, these implications are well known not only to economists and strategy scholars, but also to practical business people.[21] This encourages us in further investigation into their value as a positive analysis.

Sellers of systems that might be the beneficiaries of positive feedback should have high willingness to pay to have their standard adopted. In the early phase of market development, sellers will engage in a momentum race to recruit complementors, to gain market share with users, and to seek to improve the features of their systems products relative to competing offerings in order to gain that momentum.[22] The theory has emphasized the value of strategies such as "penetration pricing," i.e., setting a low price – during the period of standard setting – for products embodying standards. It has also emphasized the value of volume-building strategies, such as price discrimination in favor of marginal users and developers.[23]

converter technology), while firms whose existing products embody an unpopular standard will tend to favor it. See Farrell and Saloner (1988, 1992).

[20] See Farrell and Klemperer (in press) for an overview.

[21] See, for example, the email exchange between the CEO of Microsoft and the Chief Technology Officer (Gates and Myhrvold 1994, DX 386) in which Myhrvold writes, "The strength of the Internet is that it is the beneficiary of the positive feedback cycle – more people get on, which attracts more content (and causes more BBS postings) which makes it more attractive for others to get on," and later, "Connectivity tends to make the market share leader become even stronger at the expense of everything else, because of increased sharing."

The email exchange was documented in the antitrust trial *United States* v. *Microsoft Corporation*, Civil Action No. 98-1232 as Defense Exhibit 386 (DX 386). Henceforth, the notation "GX" will refer to government exhibits (accessible at http://www.usdoj.gov/atr/cases/ms_exhibits.htm) and "DX" will refer to defense exhibits.

[22] See Besen and Farrell (1994) or Shapiro and Varian (1999) for efforts to draw these and related implications about supply formally and as advice to managers.

[23] See Farrell and Klemperer (in press) for an overview.

While the literature has emphasized this pattern in connection with price competition, the same points apply to quality competition. On the user side, systems products can offer better quality features that they deliver directly, such as a better user interface. To encourage developer supply based on a particular standard, systems providers may offer a higher quality development environment.[24] More generally, sellers of a systems product embodying a particular standard have a powerful motive to gain both users and developers during a standards race, and thus an incentive to act in a number of ways to attract them.

A particular point in the literature about developer supply has a great deal of strategic importance. A modular technology encourages development of complementary inputs.[25] Developers will tend toward popular technologies because of network effects and toward modular ones because it lowers their costs and increases their opportunities. Developers who rely on the provider of a systems product, however, will be concerned with ex post opportunism after a standard is set. Finding a mechanism to mitigate these concerns and commit to continued openness and modularity is strategic.[26] The strategy literature has also emphasized the importance of a number of different problems for the firm that arise when outside complementors such as developers are important.[27]

This strategic discussion brings forward two different views of the role of strategy by the sellers of goods that embody a standard. In the first view, the positive feedback loop arises because developers choose a standard not only for its native technological qualities as a development environment, but also for the extent to which it is used, while users choose products that embody the standard not only for their

[24] See Bresnahan and Yin (in press) for work on estimating quality competition and Besen and Farrell (1994) for complementary supply analysis and references.

[25] "Modular" technologies are complex systems comprising smaller components that can be independently designed but are able to connect to other components to function as a system (Baldwin and Clark 2000).

[26] See Henderson and Clark (1990), Baldwin and Clark (1997), Gawer and Cusumano (2002), and Miller (2005).

[27] The management literature discusses the trade-off between complements and system integration, in-house vs. out-of-house production of complements, developing and supporting a select few complements or allowing complements to compete against each other. See Cusumano and Gawer (2002). See Yoffie et al. (2004) for examination of these issues by Palmsource, Inc., and Gawer and Henderson (2005) for complement management at Intel.

stand-alone qualities but also for the degree to which developers enhance it. Firms may not have much of a strategic role in this case to influence coordination around their standard if standards are set by expectations or quality differences. Eventually, the race is won, and positive feedback surrounding a systems product is established. The network effects strengthen around the winner and create barriers to entry for alternative standards. In this later phase of market evolution, momentum and comparison to competitors should be far less important as the winner of the "standards race" enjoys a period of monopoly with entry barriers.

A second view is that competition for the market among suppliers of systems products is the mechanism that resolves the indeterminacy about standard setting. The indeterminacy is removed by a refinement, in this case penetration pricing by a particular seller or technological innovation to obtain industry leadership.

4 Resolutions to the indeterminacy of standards theory

Many network effects theorists, especially those thinking about policy issues, at this stage take a normative stance in order to resolve the indeterminacy of standards theory. The first theoretical line exaggerates inertia and suggests that the indeterminacy of equilibrium is resolved by early, irreversible choices. The second theoretical line assumes that the indeterminacy of equilibrium is resolved by an efficient mechanism, typically implemented by the seller of a network good.

Those extreme views might appear to be caricatures, but they are not. Many economists believe that network theory tells us either that there is an efficient mechanism for choosing equilibrium standards or that standards are characterized in the first instance by extreme inertia.

One view sees the inertial costs of moving to a new standard as near zero; the other sees them as so large as to prevent movement to very valuable new standards. What both views miss is the simple economic point that inertia could be an intermediate cost. In that case, an old standard will prevail if inertia is larger than the forces for change to a new standard. Positive economics has a great deal to say in the case of intermediate levels of inertia.

Network effects inertia is the collective cost for users and developers to move to a new standard. Like any cost, when a larger force comes along, it is overcome. In the case of network effects, the larger force needs to affect a large number of users and developers, because only a collective switch to a new standard will succeed. What market conditions will tend to make inertial costs large? What market conditions will tend to foster large forces for movement to a new standard? When will a second mover be able to tip the market in its favor when network effects inertia should create barriers to entry around the first mover?

4.1 Three forces

The logic of network effects theory suggests a number of forces that shift the relative strengths of inertia and of forces for change. The most obvious of these is the invention of new and superior technologies. That gives users and developers a motive to move to a new standard. As the theory emphasizes, however, there is no necessary relationship between that collective motive and individual incentives to move.

A second force is demand dynamics. Rapid growth in the market can devalue the network effects associated with a technology that has an early lead.[28] Each new user can choose, along with other new users, to gain network effects; if other new users outnumber established users, the inertial forces will be swamped by the forces for change. This rapid growth in the market can lead to changes in market leadership, depending on which standard is able to capture the newest adopters of the technology.

This argument is more than a narrow theoretical point. The diffusion of new technologies is very often described by an S-curve. If a standard is established in the early phase of diffusion, it may have considerable inertia among early adopters of the technology. Once adoption of the technology begins to climb the steep part of the S-curve, however, the group of early adopters will be swamped, in absolute numbers, by the mass market of new adopters. That opens a window for a standards switch whose timing is related to the diffusion of technology.

As a result of these changes in market conditions over time, timing matters for participants in a standards race: although inertia will favor the first mover, there is a finite window of time when a second mover can act to take advantage of rapid growth among a large number of mass market adopters. Inertial costs will make it difficult to cause the installed base of adopters to switch to an alternative standard, but the rapid

[28] Farrell and Saloner (1986) model new users, but they do not study the rate of growth of the new users.

growth in demand presents an opportunity for an alternative standard to capture the newest adopters in numbers that swamp the size of the installed base. Once market growth has slowed and the number of new users will no longer swamp the number in the installed base, the positive feedback effects and inertia around the leading standard will begin to strengthen, limiting choices by users and developers.

Another way in which markets for new technologies change over time is in the composition of demand. The early adopters of a technology tend to be different from the mass market adopters. They often have a higher willingness to pay for any given level of technical capability, and they are more informed about standards and technologies that are available in the market. Later adopters tend to have much higher adoption costs and worse information. As a result, later adopters can be more responsive to convenience of adoption than they are to the technical capability of the technology. Early adopters may be comparatively insensitive to the number or quality of products developers have brought to market that work with a particular standard, while later adopters are waiting for complete, ready-to-go systems.

The heterogeneity between early and late adopters affects inertia and the forces for change in a number of ways. Early adopters' superior technical knowledge could make their choice influential on later adopters, for example, which would strengthen inertia. Or heterogeneity could mean that mass market users are distant in interests and tastes from early adopters, outside the communications of early adopters, and so on, which would tend to weaken network effects between early and mass market adopters and thus weaken inertia.

In indirect network effects industries, the emergence of important applications will drive the growth rate of users, and thus determine the strength of inertia and the forces for change. Late-emerging applications that users value highly and that choose to work with a particular standard can swing the networks effect momentum to that standard. Unfortunately, there is far less empirical work about the dynamics of supply of applications compatible with a new standard than about the dynamics of diffusion. The management literature on computing, however, emphasizes the importance of the single very influential application, or "killer app," that moves many users to adopt a new standard and creates momentum for a tip to that standard.[29]

[29] Downes and Mui (1998) and Negroponte (1995).

The final point about demand and developer-supply relates to their influence on the supply of products embodying a standard. If the size of the market is large, then there are greater financial incentives for winning a standards race. If market conditions change over time, then the applicable theory on standard setting is likely to be different at different times.

4.2 Market is part of an industry comprising complementary markets

For analytical clarity, the theory of indirect network effects has been written with only users, developers, and suppliers of products embodying standards. While many systems-good industries have all three elements of that vertical structure, the simple three-layer structure is often an abstraction away from a complex environment of complementary markets. Firms' positions in other complementary markets may affect their *incentives* to participate in a standards race and their preferences over which standard is set or whether a standard is set.

Firms' positions in complementary markets may also give them *strategic opportunities* to influence the outcome of a standards race. Network effects imply a strategic goal of gaining a large market share early. The literature focuses on one particular strategic tool for the firm, penetration pricing, to increase the volume of adopters to a particular standard. A firm which has a strong position in complementary markets may, for example, also have control of distribution channels. If the firms engaged in a standard setting race have asymmetric control over distribution channels, the firm with better control may be able to slow the distribution of a competitor's standard and hasten the distribution of their own standard. These strategies can be used to lengthen the window of opportunity for a second mover to upset an incumbent standard by slowing the adoption and therefore positive feedback for the first mover and accelerating the build-up of positive feedback for itself.

Similar considerations relate to strategic opportunities to influence developers. A firm participating in a standards race with control over other, established, complementary standards may be able to influence the technological choices of developers. One strategy is breaking modularity. Making an existing complementary standard incompatible with one of the competing standards makes the technological system less modular. It will also influence developers' choices. A standard setting firm that has an advantage in existing technologies may thereby take advantage of it to steer developers in a new standards race.

A final point is about uncertainty. If expectations do not form around a standard, tipping to that standard may be delayed. This gives a second mover an incentive to create uncertainty if it can. Uncertainty helps the second mover by slowing the build-up of network effects and tipping to the current market leader.[30]

Clearly there are interactions between these strategic opportunities for the firm and the equilibrium logic of network effects. Control over distribution, like creation of uncertainty or penetration pricing, will be more helpful to a second mover if timing of the strategic move pre-dates a potential tip and if there is rapid and substantial growth in demand.

5 Effort to set standards by Netscape

We now turn to the actual events of the browser war to examine how standards theory applied to this incident and to explore the interaction between standards theory and market analysis.

We begin by examining the browser war through the lens of business managers' decisions about strategy. This is helpful because computer industry managers are actively using a framework for thinking remarkably close to the theory of network effects equilibrium. Managers will be helpful, too, in showing how that theory works in a market context. In a later section we will turn to empirical evidence on market outcomes as well as on managers' ideas in order to nail down the importance of distribution in a market context for standard setting.

Before Netscape was founded, there was an "Internet mania" around the browser in 1993 and 1994. These events were well described by the "small actors" part of network theory. The browser was invented inside the academic Internet by students and staffers at a university. The browser let less-technical users access the Internet. A number of open WWW standards let pre-existing data become "content," and also opened up opportunities for new, easily supplied websites. There was a positive feedback loop between users, whose demand for browsers was fed by freeware products such as Mosaic, and webmasters, who had a

30 See Rysman (2004) for a model of delayed adoption that leads to inefficiency.

larger audience for their content. The early positive feedback loop was powerful, but limited in scope to noncommercial uses.

The Internet mania also drove an explosion in demand for PCs. Access to the Internet made the PC more valuable. Web browsing, email, and instant messaging were among the new and important applications that raised the value of PCs. The overall effect was an increased demand for personal computers, speeding the growth of that market.[31] This growth in demand only increased with the commercialization of the World Wide Web via the introduction of the Netscape browser in 1994.

The entrepreneurial firm Netscape was founded to commercialize the browser. The firm took on aspects both of the open standards of the Internet and of proprietary software companies. Netscape's idea for the browser was to set a commercial standard for online applications, and to have a single interface between all users of online applications and all content and applications. To that end, Netscape's browser was a modular component of an open system rather than integrated into a closed system.[32] Prior use of closed systems had meant that the user could access content and data only from sources sponsored by the system provider. The browser's open systems approach meant the user could access content from any provider who used Internet standards. This was a dramatic improvement in the ease of accessing online materials and of providing them.[33]

Coordination on a single standard would allow many applications to create economies of scale in adoption: once adoption costs are incurred, the adopter then has access to all current and future applications. The fixed cost of adoption now can be spread over all browser applications. Applications developers could benefit from being able to access all customers on any type of PC or browser via this open standard. However, the communication protocol between the Netscape browser and the server where the website was being hosted was still proprietary Netscape technology.

31 Goolsbee and Klenow (2002) examine the impact of Internet use on computer demand, especially the externalities across households in adopting.
32 See Cusumano and Yoffie (1998) for a discussion of Netscape's "open, but not open" platform strategy.
33 See Gates et al. (1995) for a contrast between the open systems and earlier, inferior, Microsoft approaches.

The essence of the Netscape strategy was, as founder Marc Andreessen put it, "ubiquity" to set a standard that would then be partially proprietary. He characterized this in an interview as "basically a Microsoft lesson, right? If you get ubiquity ... you can get paid by the product you are ubiquitous on, but you can also get paid on products that benefit as a result."[34]

Netscape practiced the types of penetration pricing that standards theory suggested would be effective for strategic actors on the supply side. The Netscape browser was "free but not free." The browser was free to the end user to encourage adoption of the Netscape browser and thus create a large installed base that would attract webmasters. After a period of time, Netscape also sought to gain some browser revenue from corporations and PC manufacturers; they continued, however, to price discriminate in favor of marginal users with some form of free browser. Also, Netscape charged money for the server-side software that would host the websites. (These are "products that benefit as a result.") Thus, those who would directly profit from the commercial application of the browser would be the ones to fund Netscape's efforts.

Netscape also understood the importance of distributing their product to make adoption as easy as possible for new users. Netscape signed contracts to distribute its browser through Internet Service Providers (ISPs) and along with new PCs. This service and hardware was a strong complement to the browser: a user had to have both in order to access Internet content, along with the browser. Netscape employed these distribution channels to overcome the adoption costs for their browser.

Netscape had substantial early success with these strategies. That is not surprising. The possibility of online applications meant there was a large commercial opportunity. The possibility of setting a standard meant that a firm could earn a large return. By this stage in the history of computing, the basic logic of standards theory was familiar from experience and guided efforts to create a new mass market standard.

6 Entry by Microsoft

At first, Microsoft left the browser market to others. The firm limited its Internet connectivity work to low-level "plumbing."

[34] See Cusumano and Yoffie (1998, 22) for this interview.

Microsoft did have a plan in place in 1994 and early 1995 for mass market electronic commerce and online applications. That plan did not rely on the widespread use of the Internet, but instead had a closed, proprietary architecture. After Netscape released its commercial browser in December 1994, Microsoft undertook an internal debate between proponents of a browser and proponents of the closed architecture. By spring, the pro-Internet side won that debate. Microsoft entered the browser standards race in the summer of that year with IE version 1.

For Microsoft, the commercial benefits of the browser in isolation were not the main reason for entry into the browser standards race. Instead, an independent browser posed a threat of entry and competition in the operating systems (OS) market. The OS was a valuable monopoly to Microsoft, with high entry barriers. An independent browser might ultimately lead to "commodification" of the OS, just as an independent OS had earlier led to commodification of the personal computer. Alternatively, an independent browser, combined with new technologies from Sun Microsystems called "Java" might lower entry barriers into the OS business. Microsoft was concerned that something "far cheaper than a PC," such as a network computer, might compete with Windows machines (Gates 1995, GX 20).[35]

Microsoft did not so much object to proprietary control of the browser by Netscape as to outside control in general. Much of the early alarm about the browser was that the WWW was open and outside anyone's control. For example, Paul Maritz, number three in the Microsoft leadership at the time, posed a rhetorical question about important developer standards, "What is worse, an open object model or an alternative non-MS one?" (Maritz 1995, GX 498).

This discussion of Microsoft's decision to enter reveals two important and general connections to standards theory. First, the aspects of the browser which made it a potential threat to Microsoft are closely related to browser standard setting: its mass market appeal to users and its appeal to developers seeking to make new applications. Second, Microsoft's defensive decision to enter the browser race illustrates the

[35] The historical analogy, the analysis, the remark about commodification, and the quotation all come from a memo by Gates (1995, GX 20) entitled "The Internet Tidal Wave." This memo was documented in the antitrust trial *United States* v. *Microsoft Corporation*, Civil Action No. 98-1232.

important general principle that an established firm may have incentives to control standards in a new, complementary technology.

6.1 Implementation

Implementation of a Microsoft strategy to deal with the possibility of a Netscape browser standard applied the theory of network effects to the specific industry context, as can be seen in a Microsoft browser marketing plan presentation from summer, 1996 (Maritz 1996a, GX 488).[36] This is approximately a year after Microsoft entered the browser standards race. Microsoft had, by this time, made rapid progress in improving its browser and was beginning to catch up to Netscape in product quality. The browser marketing plan laid out the problem facing Microsoft; market share leader Netscape was becoming a "de facto standard."

In Figure 1.1, we reproduce the slide that addresses the problem of reversing Netscape's leadership under the heading of "turning this around." The slide lays out the positive feedback loop of indirect network effects, closely following the core logic of standards theory. The loop passes through end user demand for IE and through websites where developers might use Microsoft technologies (IE/ActiveX sites/ ActiveX controls).[37] This is the positive feedback loop Microsoft would like to get going to "turn around" the situation in which Netscape technologies, plus Java, were becoming an indirect network effects standard.

The slide alludes to many of the key business strategy implications of network effects theory. First, the goal is "winning the platform API [applications programming interface] battle." To win in the WWW-browser context, "Internet Explorer share is key." To get that share, one needs "critical mass and momentum" with end users on the developer/website side. Getting "critical mass and momentum" leads to the positive feedback cycle graphically shown.

[36] Other slides from this presentation show a number of quantitative measures used to buttress the argument.

[37] At this time, "ActiveX controls" were small computer programs that ran inside other larger programs in a browser. They permitted website developers to add such features as displaying complex multimedia and database documents in the user's browser. More generally, ActiveX is a Microsoft brand name variously applied to technologies developers use for media, web, etc.

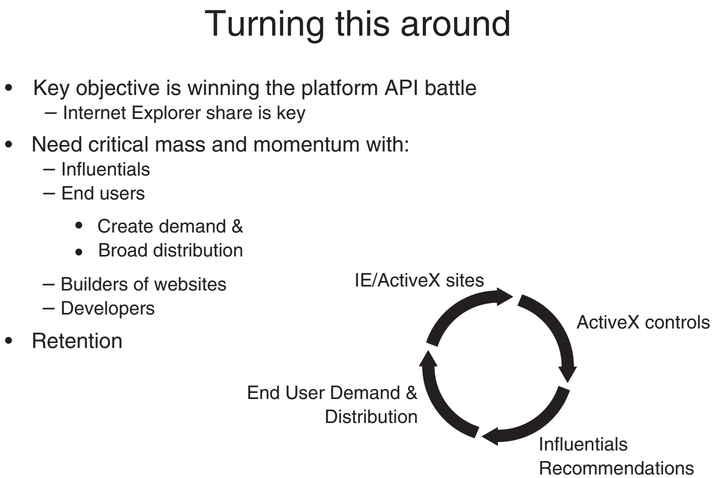

Figure 1.1. Slide from Microsoft marketing presentation (Maritz 1996a, GX 488).

In addition to those familiar theoretical ideas, the slide indicates the importance of distribution as part of building end user demand. This is an example of Microsoft adapting network effects logic to a real world market situation.

The rest of the plan brings forward quantitative evidence for the tip to Netscape and directs a number of employees to induce use of Microsoft technologies by outsiders: users, website builders, developers, and "influentials." The "influentials" (pundits, the trade press, etc.) do not play any role in the theoretical literature, but it is simple to understand their importance in light of the theory. "Influentials" could diminish expectations of end users and developers of a tip to a Netscape standard, leaving time for Microsoft's entry.

The use of network effects theory at Microsoft, as at Netscape, is not limited to a few instances. In other strategic documents not cited here, many analyses leading to management decisions are based on the theory. Managing for de facto standard setting in markets is one of the most important capabilities at Microsoft.

6.2 *Individual user switching costs*

Individual user switching costs can substantially enhance network effects inertia by increasing the commitment of existing users to the established standard. Microsoft's browser marketing organization set out to measure the importance of individual user switching costs in order to devise strategies for overcoming those costs. We examine reports based on user surveys and on focus groups.

Kumar Mehta (1997, GX 204), responding to the question about whether IE should be tied to Windows 98, summarized "all the IE research we have done" (primarily consumer market research by survey). He wrote, "80% of those who do not use IE say that they have no plans to switch to it, which means that if we take away IE from the o/s most nav [Navigator] users will never switch to us." Mehta's analysis reflects an individual user switching cost model, although some of the reason not to switch may be network effects.[38]

Christian Wildfeuer (1997, GX 202), writing about the results of focus groups of early adopters of Windows 95 (Microsoft's most inframarginal end user customers), summarized the same issue in this way:

> Most of our IEUs [individual end users] were Navigator users. They said they would not switch, would not want to download IE 4 to replace their Navigator browser ... To make them switch away from Netscape, we need to make them to upgrade to Memphis [Windows 98] ... <u>We need to strengthen our key asset and our key brand which is Windows to win the internet war on the desktop side</u> ... convert the Navigator installed base and eclipse Netscape's browser market share leadership. But if we rely on IE 4 alone to achieve this, we will fail. (Emphasis in original.)

Microsoft took the advice of these marketing people, avoiding individual end user switching costs by distributing IE to new users and those upgrading to new computers. For these users, the relative cost of switching or adopting IE would be subsumed into the cost they were already incurring to adopt the PC or ISP. Brad Chase (1996a, GX 465) operationalized this by giving higher market share targets to marketing teams in different countries, based on the degree to which Netscape was entrenched.[39]

[38] Jonathan Roberts (1997, GX 205) uses the same theoretical frame: "the only real chance IE has of getting them to switch is thru a new pc, an OS upgrade, or a new ISP kit."

[39] This remark led to a standing effort to "out-localize" Navigator and some frustration on Microsoft's part when Netscape effectively produced non-English versions.

However, the only way that capturing new users would help Microsoft gain enough market share to attract webmasters was if the number of new users was substantial relative to the number of users already part of the installed base. As a result, Microsoft had a finite window of time to capture these new users before the Netscape browser diffused throughout the entire population of potential adopters and market growth slowed. Afterward, Microsoft would face the much harder task of overturning switching costs, which would reinforce inertia. Microsoft executives recognized the urgency of their task.

The implementation of Microsoft's strategy, like its strategic plan, draws heavily on standards theory.[40]

6.3 Timing

Microsoft understood the timing challenges it faced against first mover Netscape in a market with network effects. Mr. Maritz (1996b, GX 42) emphasized the importance of timing with his focus on "Near-term browser share." Using the release cycle of browsers as his timing metric, he wrote, "We have to stop the Nav [Navigator]-Web site reinforcement cycle with IE3 and shift it in direction of ActiveX. We thus have to get significant shift BEFORE Nav 4 ships, and in so doing prevent web sites from automatically shifting to exclusively exploit it as they did on Nav 2."

Mr. Maritz was concerned about developers' technical progress in making online applications. As websites became more complex, they would have more features that would involve sinking costs to a particular standard; supplying multiple standards would become too costly. Because of the high share in browser usage enjoyed by Navigator, he forecast that website developers would be tied more and more into Netscape standards (Maritz 1996b, GX 42).

There is an important link to theory here. At the early stage, the second mover's priority is not to gain a leading share but to prevent a tip to the first mover's standard. Microsoft, which controlled the distribution channel, was able to slow down the progress of Netscape. Their early goal, however, was merely to achieve 30 percent market share in twelve months (Chase 1996b, GX 684), not to become the

[40] See "How to Get 30% [Browser] Share in 12 Months: Summary Recommendations" (Chase 1996b, GX 684).

market leader. While their market share of the installed base of browser users might be small, it was large enough to be a viable alternative standard in the minds of webmasters. Microsoft referred to this as gaining "mindshare." As long as there was uncertainty about the expected browser standard and high costs to supporting multiple standards, webmasters would delay their decisions about supporting only Netscape. By this strategy, Microsoft delayed the emergence of insurmountable network effects inertia around the Netscape standard and thereby lengthened their window of opportunity to catch up in both installed base and quality.

6.4 Product improvement

Although Microsoft entered the market hastily with an unimpressive clone of Navigator, the firm was one of the best in the world at improving software. It put tremendous resources into rapidly improving the IE browser. Brad Chase (1996b, GX 684) laid out a clear goal of effective imitation: "We must have a plan to clone all the features they [Netscape] have today, plus new ones they will add between now and our next releases."[41] Imitator Microsoft succeeded at closing the gap with innovator Netscape in quality and features.

Given that Microsoft was behind in the standard setting race, a strategy based purely on quality was unlikely to work. Microsoft managers linked this to the theory of indirect network effects. Mr. Chase (1996a, GX 465), in his memo, "Winning the Internet Platform Battle," writes that Microsoft needs a "significant user installed base" to attract developers to either IE or Windows. Without that, "the industry would simply ignore our standards. Few would write Windows apps without the Windows user base."

If both Netscape and IE were being offered via all the same distribution channels, then IE would be at a disadvantage from a network effects perspective, regardless of quality differences. James Allchin (1997, GX 48) wrote:

> Pitting browser against browser is hard since Netscape has 80% marketshare and we have <20%. I am especially worried that we don't have a long term winning strategy … Even if we get IE to be totally competitive with

[41] Ibid.

Nav/Communicator, why would [it] be chosen? They have 80% marketshare. I am convinced we have to use Windows – this is the one thing they don't have.

Because of network effects, simply offering a comparable browser would not be enough to take users from Netscape.

6.5 *Distribution*

Taking advantage of "Windows ... the one thing they don't have" meant, in practice, using Windows to achieve advantaged distribution for IE.

Why did distribution matter? Microsoft marketing managers identified time and effort to download software over the Internet and the complexity of installing a new piece of software on a computer as costs of adoption.[42] Less sophisticated users could avoid installation hassles by using software that came pre-installed on their computers. Less sophisticated users also tended to be uninformed about new products. They were more likely to adopt whatever came with their PC or ISP.

Distribution through corporate PC purchases ensured distribution of IE to the installed base of Internet users as well, lowering the cost of switching from Netscape. Since information technology managers bought computers en masse, the distribution of IE would be even more rapid.

Given the importance of distribution to capturing these new users, Microsoft contractually obligated computer manufacturers (OEMs) to distribute IE. Starting with the release of Windows 95 in August 1995, OEMs were required to distribute first IE1 and then IE2 with all new Windows 95 computers as a condition to keep their Windows licenses. Consumers who bought Windows 95 without buying a computer, however, would at first find that it had no browser included, and later that it would have IE1 or IE2 included but on a separate disk. Throughout 1995, Microsoft compelled distribution of IE with Windows 95; beginning in early 1996, Microsoft enforced restrictions which compelled display of IE as well, including putting an IE icon on the Windows desktop, under the "Windows Experience" marketing label. Starting with IE3, Microsoft went beyond limitations on OEMs.

[42] Over the time period studied, modem speeds grew faster while browsers also grew larger, so the time cost of a download remained roughly constant for the average user.

It was harder for the end user to remove IE from their computer. With IE4, this was even more difficult for consumers. Similarly, Microsoft tightened restrictions on OEMs incrementally over time.

Rapid growth in PC and ISP sales themselves would not necessarily limit distribution of Netscape relative to IE. Indeed, widespread distribution of IE alone would not overcome Netscape's lead. Consumers overwhelmingly preferred Netscape. OEMs protested that there were substantial costs (confusion, support calls, etc.) of distributing the product consumers didn't want next to the product they did.[43]

Microsoft saw that it could create a strong asymmetry between IE and Netscape by contractually blocking distribution of Netscape on PCs and ISPs and enforcing distribution of IE alone. Microsoft blocked OEMs from distribution and display of Netscape Navigator.[44] When technical progress by OEMs tended to make it easier for consumers to choose Netscape over IE, Microsoft banned it.[45] This raised the relative cost of adoption of Netscape dramatically compared to IE. Microsoft could slow down the build-up of network effects around Netscape, thus extending the window of time within which Microsoft could act to gain enough market share to prevent a tip to Netscape.

Why did OEMs agree to these contracts? Microsoft controlled the de facto OS standard for PCs, Windows. The OEMs could not afford *not* to distribute Microsoft Windows and survive commercially. Microsoft's ability to actually control distribution and applications development via the PC and ISPs was a consequence of the existing broader market structure. It was able to use its control of this complement to the browser in order to create an asymmetric advantage in capturing new adopters of browsers. This advantage, combined with a period of rapid growth in new adopters, was able to outweigh the inertial forces and positive feedback that surrounded Netscape.

43 OEMs had designed programs to make it easier for consumers to set up their computer for good "OOB (out-of-box) Experience." When Microsoft banned the practice, a Hewlett-Packard executive wrote, "From a consumer perspective ... [you] are hurting our industry and our customers." (Romano 1997, GX 309)

44 Compaq executives, for example, had compiled a list of twelve ways in which Microsoft could carry out its threats to punish cooperating with an entrant in a document entitled "Judgment: How Retaliatory Would They Get?" (Thibodeau 1999).

45 The bans were possible only because Microsoft had a monopoly: "if we had another supplier, I guarantee [that] you would not be our supplier of choice." (Romano 1997, GX 309)

6.6 *Likelihood of contracting alternatives*

Why couldn't developers coordinate and contract between themselves to determine the market outcome or force compatibility between Netscape and IE?

Nathan Myhrvold and Bill Gates of Microsoft considered this question: would users, including content developers, prefer a tip to the IE standard, and if not, could they contract or organize to get the outcome they want? From an email exchange (Gates and Myhrvold 1994, DX 386):

> Content developers will try to remain platform neutral, tool neutral and format neutral, and for the most part they will fail. Once people start to compete they will increasingly become platform and tool specific if there is any advantage in doing so. This includes both the computing platform (i.e. Windows) and also the online service environment . . . This will create a new inertia in changing standards.

Mr. Myhrvold thought that only a "large player who can create something significantly new and evangelize it successfully" can lead to a new standard. Efforts of the smaller players to have technologies develop the way they like "for the most part . . . will fail." Microsoft executives examined the potential "Coasian" or "price theoretic" limitations of standard standards theory and rejected them. Users would have to act together to defeat the strategy, and that would be prohibitively expensive to coordinate, especially as the more technically aware followers, the developers, are in competition with one another.

7 Evidence from market outcomes

In this section we graphically examine browser usage over time to highlight the role of distribution. We gathered data from a website that has kept logs of browser usage since very early in the browser standard setting race. We tracked the usage shares of five major versions of Netscape Navigator and Microsoft IE over time.[46] The core idea of the graphical analysis is to contrast the browser usage of

[46] Our sample is all users using either Netscape or IE to browse a website at the University of Illinois–Urbana Champagne between April 1996 and December 2000. More details on the data can be found in Bresnahan and Yin (in press). Although the sample is likely to overweight users who are tech-savvy and

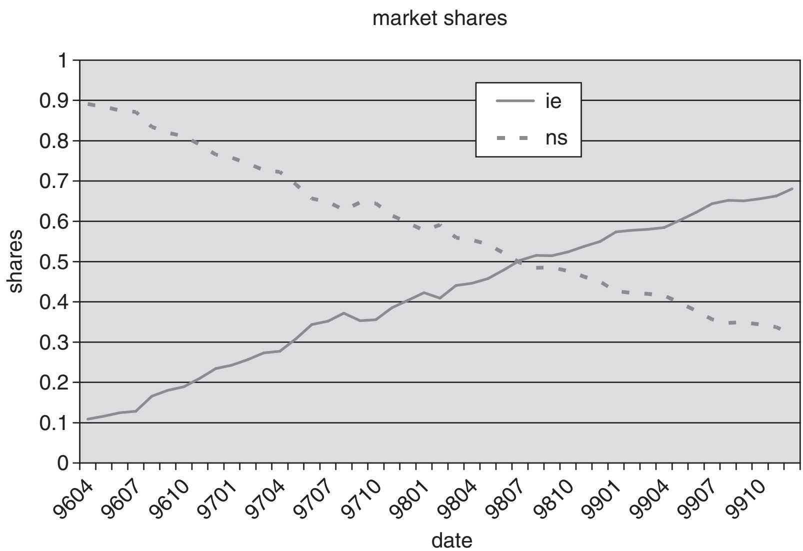

Figure 1.2. Aggregate shares of IE and Netscape browser usage.

observable groups of users. We focus on the gap between groups who are likely to be new users, comparing them to older users, and on groups likely to be particularly influenced by Microsoft's distribution restrictions.

We begin with the aggregate figures. Figure 1.2 shows usage of all versions of IE and Netscape by users of all OSs. Here we see the tipping of the browser market from Netscape to IE.[47]

In addition to knowing what browser they used, we also know what OS users were running on their computer. This lets us distinguish, to some degree, users who had acquired their computer more recently (at the time of usage). Users of Microsoft Windows 98 and Windows 95 obtained their computers during the browser standard setting race, while users of Windows 3.1 (and older versions) did not.

prefer Netscape, both of these biases should tend to minimize the impact of distribution.

47 This graph shows the same pattern as shown in other analyses of the IE versus Netscape shares (including Henderson 2000), with the crossing-point occurring at about the same date.

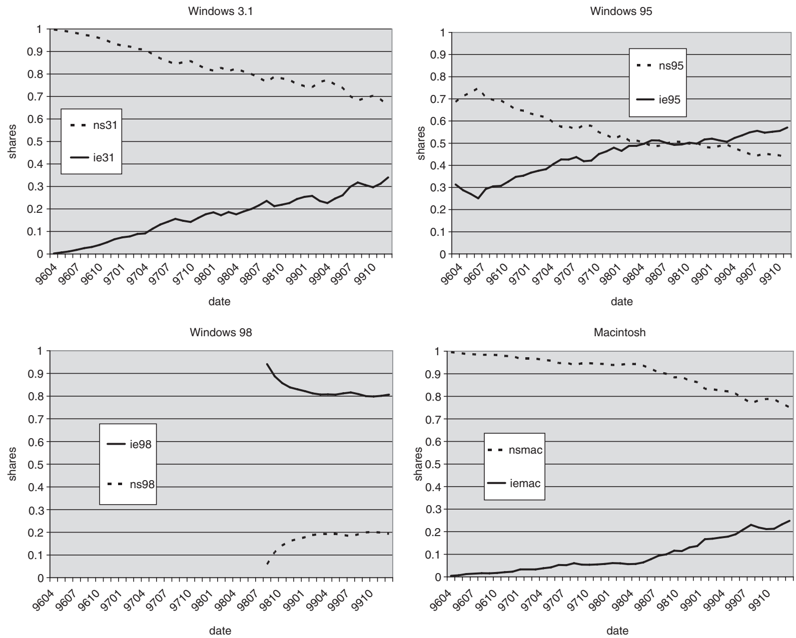

Figure 1.3. Browser brand shares on different operating systems.

Also, users of the more recent Windows versions bought their computers under a more restrictive distribution regime. We also know browser usage by Macintosh computer users; restrictions on the distribution of browsers with new Macs were put in place only part way through our sample.

Figure 1.3 disaggregates by OS, showing the share of each brand of browser on each OS. The tip seen in the previous figure did not occur among the users of each OS; there is a switch from majority usage of NS to majority usage of IE only on Windows 95. There are two patterns on the other OSs. Windows 3.1 users, like Macintosh users, were majority-Netscape throughout the period. Windows 98 users began with a very high share of IE usage, which declines somewhat over time. Much of the change in aggregate shares in which IE came to dominate Netscape in Figure 1.2 merely reflects the higher share of IE on Windows 95 and Windows 98.

The differences across the OSs reflect a number of forces, including differences in the tastes of the users and differences in the availability of browsers. The quality of IE was catching up to NS over time, explaining part of the general tendency toward IE use.[48]

The disaggregated figure immediately casts doubt on a theory in which it was only the increases in IE quality over Netscape quality that explained market tipping to IE. To begin with, the two OSs that finish majority-IE, Windows 98 and Windows 95, are the two on which the distribution advantages for IE were the largest. We can see that the pre-existing users of Windows 3.1 and the largely stable population of Macintosh users were not tipping to IE.[49]

The lack of tipping on Windows 3.1 might be explained by the growing obsolescence of this platform. However, this would not explain the lack of tipping to IE on the Macintosh (Mac). Sales of Macs remained steady during this time. The new users entering the market were not so numerous that they swamped the installed base of Mac users. The figure clearly shows that Netscape users on the Mac were not switching to IE as new and better versions come out.

Similarly, the movement over time toward Netscape browser usage on Windows 98 cannot be explained by IE's growing quality. Every Windows 98 user had a copy of IE distributed with their computer, while almost no Windows 98 users had a copy of Netscape distributed with their computer. Some of the Windows 98 users who preferred Netscape switched to it, taking some time to download and install it (particularly difficult because it was difficult to remove IE).

The importance of distribution and market growth can be seen in Figure 1.4, displaying three kinds of information. In the first pane, we show Windows 98 sales (flow), and in the second pane, the installed base of the four OSs we studied (stock). Both are based on worldwide OS sales over the time period we observed.[50] As can be seen, Windows

48 In Bresnahan and Yin (in press), we provide a fuller econometric analysis of these data, which controls for quality. We also investigate the role of distribution in accelerating the diffusion of new versions of browsers. Our econometric results show a more important role quantitatively for distribution than for quality, both in brand choice and in the diffusion of new versions of the same brand.

49 Windows 3.1 is unaffected by the distribution restrictions because almost all copies of it were sold before IE was released. It was not until more than halfway through our sample that Macintosh computers came with IE exclusively.

50 Data derived from Microsoft and IDC resources. IDC, a leading IT market research firm, does not separately report monthly shipments by OS. It reports monthly shipments of all PCs and annual totals by OS (IDC 2000a, 2000b, 2000c, 2000d, 2000e, 2000f, 2000g, and 2000h [additional data from 1996–8

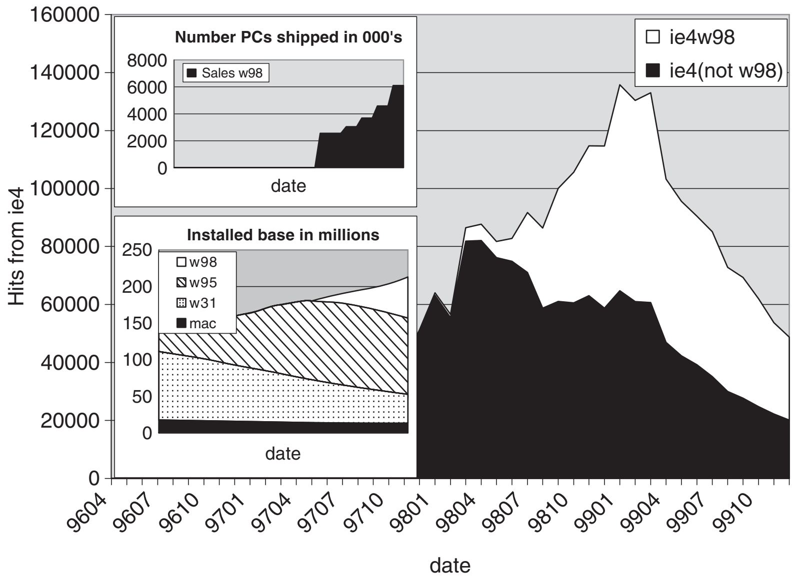

Figure 1.4. Windows 98, OS installed base, and IE4 usage.

98 was a very successful product, but not one that replaced a substantial fraction of the installed base of computers.

In the third pane of Figure 1.4, we show the total usage of IE4 in our data, broken down into two parts. One part is usage of IE4 by Windows 98 users. Overwhelmingly, these are users who got IE but not Netscape with their new computer. The other part is usage of IE4 by all other OS users. While many of the other OS users had obtained IE4 (and not Netscape) with a new computer, some of them were existing computer users who would have to download (or otherwise seek out) IE4 in order to use it.[51] As can be seen from the figure, by the time the usage of IE4

were used]). Fortunately, Microsoft internal documents detail the rate at which new versions of its OS replace old ones in the marketplace. For example, the Microsoft "OEM Sales FY '96 Midyear Review" gives the early history of Windows 95 vs. Windows 3.1 sales (Kempin 1998, GX 421). This forms the basis for our allocation. We follow IDC by assuming 25 percent annual depreciation; lacking the retirements data they keep internally, we use a constant proportional depreciation assumption.

51 The number of other OS users who had IE4 bundled is substantial. In the average month in the period after IE4 was made available for Windows 95, just over 40% of users had obtained their computer with IE4 bundled to it. The corresponding figure for Macintosh is just under 20%.

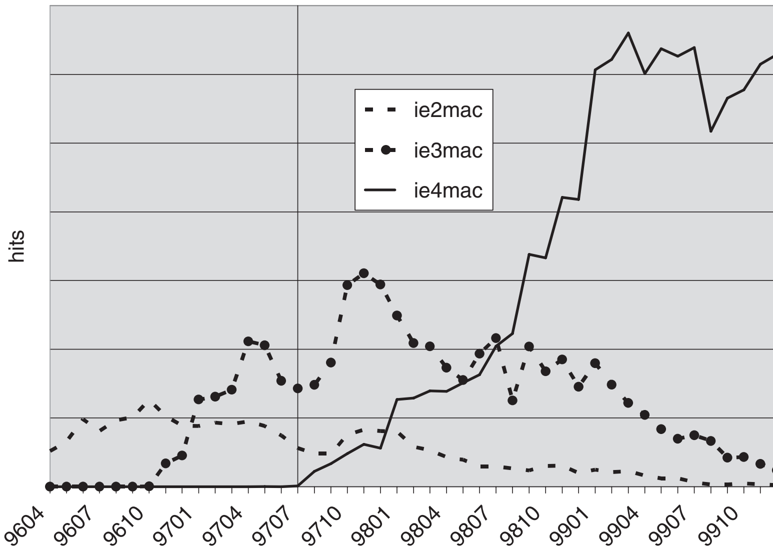

Figure 1.5. Usage of IE browsers by Macintosh users.

peaked, the majority of users were those who obtained it with Windows 98. Thus, the fraction of IE4 users who were using the browser that was distributed with their computer must be even larger.

In Figure 1.5, we highlight the effect of distribution requirements for IE on the Macintosh. Sales of new Macintosh computers were approximately constant over the period, as was the Macintosh installed base. The figure shows usage of three IE browsers on the Macintosh. Two of them, IE2 and IE3, were introduced before the contract between Apple and Microsoft that required distribution of IE with Macs and forbade distribution of NS browsers with them. By contrast, IE4 was released just after that contract took effect. Note that the earlier versions of IE did not exhibit the dramatic growth and high level of usage by Mac users we see for IE4, which was helped by distribution requirements.[52]

[52] The figure does not preclude the possibility that this change was caused by a large improvement in IE quality embodied in IE4. Determining whether technical progress or distribution was the larger force in the rapid upswing in IE4 share growth requires regression analysis as conducted in Bresnahan and Yin (in press).

While it is difficult to show graphically, our econometric results show similar impacts for distribution among Windows 95 users (Bresnahan and Yin, in press). New versions of IE were taken up very rapidly by users who obtained them bundled with new computers; other populations did not take up the new versions nearly so rapidly.

The impact of rapid market growth and of control over the distribution of products is dramatic. For a mass market product, tipping involves a large volume of usage. Obtaining that usage is, in a realistic market context, a matter of distribution and marketing as much as of product quality or pricing.

The conditions under which Microsoft was able to overturn Netscape's early lead in the standard setting race can now be seen clearly. Microsoft was able to quickly narrow the gap in quality between IE and Netscape. To create a "strong second" in a short time requires significant financial and intellectual resources, which Microsoft possessed. Microsoft entered not all that long after Netscape, before the market had tipped. Their effort was consistent with the basic timing conclusion of network effects, i.e., that there is more volatility before a tip and more inertia afterwards. They also entered when the market was growing rapidly. Microsoft exercised control over the most important channels of distribution for new PC software to create asymmetric distribution between IE and Netscape. By gaining advantaged distribution for its browser while blocking efficient distribution of Netscape's browser, Microsoft took advantage of the rapid growth in the market to garner a quantitatively large share of browser usage.

There are two important analytical messages here. First, it took an alignment of powerful forces to overcome Netscape's first-mover advantage, including a timely and effective entrant, rapid demand growth, and distribution advantages for the second mover. Second, distribution is key to achieving tipping volume. In a mass market, mass distribution matters. Both of these points arise from connecting the logic of network theory to the market context.

8 Standards theory in markets

Standard setting theory is central to understanding the browser war between Netscape and Microsoft. Many have thought that the second-mover success of IE is a contradiction of the theory in which inertia is infinite and leaped to the conclusion that the zero-inertia version must be correct.

As our empirical examination of the browser war shows, however, the correct completion of the theory arises from linking to market analysis. This section draws from our case study to construct a more complete positive theory of de facto standard setting.

8.1 Inertia can be overcome by new users

The tip to second-mover IE shows that inertia around the first proposed standard need not determine the outcome. Why did developers and users not tip to a Netscape standard?

The first part of the answer lies in the early entry by IE before a standard was set. Netscape Navigator had remarkable success in adoption by users in 1995, and at that stage many websites were developed for Netscape browsers. Nonetheless, two developments remained for the future. The first was the creation of Internet-based markets in online content and e-commerce. As those markets were created, developers would build websites based on advanced, commercial browser features.

The second future development was a large growth in the market for browsers. There were two main sources of growth. Existing PC users adopted the Internet over time. Far more important, however, the demand for PCs expanded rapidly because of the Internet, bringing many new browser customers to the market. As with many technologies, many new browser users were less technically savvy than the early adopters. New users without technical sophistication were particularly influenced by distribution.

At the time of Microsoft's entry only a small portion of the ultimate body of browser users had already chosen the Netscape standard. Advantaged distribution of Microsoft's browser entrant targeted new users. This strategy was effective in the standards war only because it happened early, while demand was still growing rapidly.

Here we have a basic piece of logic of market standard setting. A second mover must arrive "early" in the sense of preceding many decisions. The second mover must be adopted by many users; in the case of IE, this was because of improved distribution. This same logic would also apply to a second mover with a superior product. If it arrives at the market early enough to precede most user and developer decisions, and if it is attractive enough, it may be adopted. Otherwise, positive feedback will lead to inertia around the first mover in setting the standard.

8.2 Complementary markets as source of asymmetry

Analyzing standard setting races without consideration of existing standards in complementary markets can miss important forces. The existence of the de facto standard Windows OS was central to standard setting in browsers. Ignoring complements would lead to a poor model of the incentives for standard setting and of the mechanisms of standard setting.

Pre-existing standards in complements change the incentives of firms that sponsor those standards. In the case of Microsoft, the incentive was to have the browser standard inside its control to avoid competition in the complementary OS market.

Another role of pre-existing standards is to make standard setting strategically asymmetric. In the browser case, the key asymmetry arose in control of distribution channels.

Pre-existing complementary standards can also affect firms' abilities to influence expectations and thereby influence standard setting, as many analysts have noted. More generally, any kind of market power or cost advantage that allows one firm to have differential adoption costs, distribution costs, or means of overcoming inertia than another firm will drive its ability to set the standard.

These strategic asymmetries, however, do not automatically lead to adoption of the advantaged firm's standard. Instead, firm strategy can take advantage of the strategic asymmetries only in a way congruent to industry conditions. The strategic mechanisms of firm influence on standards will, therefore, be highly industry specific. The elements susceptible to general analysis are those linked to large volume and to timing.

There may be a general analysis of "strong seconds" in information technology markets. The second mover will have a greater effect if it implements its strategy before the first inflection point in the S-shaped adoption curve. Similarly, a strong second strategy will have a greater effect before developers have undertaken complex applications. A delay in the arrival of the most important and complex applications and an S-shaped diffusion curve are both characteristic of information technology markets.

Another general point is that prices and contracts are not the only, or even the most important, strategic choice variable in standard setting. Distribution channels and other marketing strategies are equally important. The importance of distribution is a simple and direct extension of the existing positive feedback implications of standards theory. Mass distribution, rapidly achieved, is a step toward positive feedback.

A complete theory of standard setting that links to market analysis implies that there exists a narrow window for strategic action during which a "strong second" can tip the market away from a first mover. The mechanism for doing so will be linked to the volume and timing of demand in the market. New users present an opportunity for a "strong second" to create network effects that can compete with those already established within the installed base of the first mover. Distribution becomes a very important mechanism under this framework for analysis. Complementary markets and pre-existing standards will drive the asymmetries in distribution and incentives that determine the identity of the winner of a standards race. Inertia and network effects around the first mover can be overcome, but only during a finite window of opportunity.

9 Conclusions

By connecting theory to market conditions, we are able to characterize the mechanisms for de facto standard setting in markets. A number of phenomena can be seen both in the logic of standards theory and in the browser market. Positive feedback builds up around a standard, giving markets a tendency toward tipping and toward inertia. This gives standard setting firms an incentive to compete for the market. That incentive is stronger before inertia sets in, and weaker thereafter.

Tipping induces a fundamental indeterminacy in standard setting. Standard setting theory has a variety of normative analyses suggesting mechanisms to resolve the indeterminacy. These range from efficient contracting (which entirely solves the problem of network externalities) to extreme inertia (in which indeterminacy isn't solved at all) or to expectations (which are themselves in general indeterminate).

Our case study of the browser market points to another class of mechanisms, based in markets. It was certainly not the case that efficient contracting among those with an interest in the standard determined the outcome. Instead, the distribution advantages of a large existing firm created a mass of demand which led the tip to a particular browser. It is also certainly not the case that extreme inertia meant that the first mover had an impossible advantage. Instead, a second mover with large distribution advantages, entering while demand was still growing rapidly, was able to reverse the direction of the tip. The positive economic theory of standard setting can be completed by linking it to market analysis.

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