Back from the brink: Microsoft and the strategic use of standards in the Browser Wars

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Abstract

The browser wars are probably the best-chronicled standards competition in recent history. Yet the standard lock-in model does not readily account for the dramatic change in fortunes of Microsoft. At one time it seemed that Microsoft would be go the way of IBM before it and fail to catch the next technological wave in the computer industry. However Microsoft managed to capture the browser market, overturning Netscape's initial domination of the market. In seeking to understand this dramatic return of events, the paper begins by outlining the key elements of the Arthur model. This is followed by a historical narrative of the browser wars that highlights three aspects of this technological competition; firms' strategic use of standards, users' considerations of initial set-up costs, and the degree of interconnectivity between product markets. The paper finally considers how the standard lock-in model may be extended in order to encompass these dimensions.

Keywords: technological lock-in, web browsers, Microsoft, Netscape, internet.

1. The Arthur lock-in model

In 1995 Netscape appeared to be running away with the Internet. With a 90% installed user base for its browser, Netscape was one of the fastest-growing software companies in history and the darling of Wall Street. Microsoft, by contrast, had virtually zero market share and many commentators were suggesting it would go the way of IBM before it - a Goliath that was unable to negotiate the new technological wave. Today the picture is reversed. By the end of 1997, Microsoft had managed claim a 39% market share (DataQuest, 1997). Microsoft continued to eat into Netscape's market share, causing the latter to lose money at an alarming rate. Netscape, with no other revenue stream, became the subject of a successful take-over bid by AOL. In August 1999 Microsoft's share of the browser market stood at 76 %, the total share of the Netscape browser having slumped to just 23% (Statmarket, 1999). How did this change in fortunes occur? And to what extent can lock-in theory help explain these events? These are the principal questions addressed in this paper. In this section of the paper we outline the Arthur model of technological lock-in. This sets the scene for a discussion of the Browser Wars in section 2.

Grindley (1992) identifies different types of 'standards' discussed in the literature. First, there are minimum attribute standards that cover basic product requirements for measurement and minimum quality such as grades, health/safety and trades descriptions. Second, there are compatibility standards that define the interface requirements which ensure interoperability between products when connected together. Third, there are standard product characteristics; the bundles of features that define a group of similar products (e.g. the WinTel personal computer). To this list we should also add design standards; those aspects of aesthetic design which determine the appearance of a product, its access conditions, and its ease (or difficulty) of use. Grindley observes that, for a number of products and services, one aspect of standards may be pertinent and so it is legitimate to restrict the discussion accordingly. However, this is almost impossible for ICT, where the various different aspects of standards seem, if anything, to be increasingly interwoven. One direct consequence of this, Grindley has argued, is a tendency towards 'open' standards in ICT.

Arthur's model of technological lock-in focuses on the third type of 'standard' defined by Grindley: standard product characteristics. While authors are apt to refer to 'a' formal model when discussing Arthur's work on technological lock-in, this is, strictly speaking, incorrect. One can find three different models in Arthur's work. Historically, the earliest model is a random walk model with two absorbing barriers (Arthur, 1983). The second model, developed in association with Ermoliev and Kaniovski, is a Polya Urn model (Arthur, Ermoliev and Kaniovski, 1984; 1987) while the third model is a 45° random walk model (Arthur, 1986). The majority of authors, when discussing 'the' Arthur model, implicitly refer to the Polya Urn model. Arthur, however, appears quite happy to switch from one model to another. Indeed in his 1989 Economic Journal paper he employs all three models in order to highlight different aspects of his lock-in account of technological competition. There are good reasons, it should be said, why attention has focussed on the Polya Urn model. Firstly, Arthur claims that the results generated by the other two models are generalisable to a Polya Urn, thereby giving greatest weight to the Urn model. Secondly, and in no small thanks to the work of Ermoliev and Kaniovski, the Polya

Urn model is the most rigorously developed of the three models. Thirdly, and perhaps most importantly, the AEK Strong Law (see below) is derived from the Urn model.

Following Arthur (1989), the gist of the lock-in model is captured by a formal adoption equation in which an individual selects between two rival variants of a new technology (A and B). This (s)he does by evaluating the payoff (Π) associated with each variant. The payoff at time *t* is

$$\Pi = X_{ij} + r\,(n_j^t) \qquad (1)$$

where X_{ij} is individual *i*'s personal preference for technology *j* and *r* is a term that captures the increasing returns to adoption. The value of *r* is higher the greater the number of previous adopters of the technology (n_j) at time *t*. By contrast, X_{ij} is an independent term indicating the hedonistic value an individual attaches to a technology, regardless of the number of other adopters.

The probability of adopting variant A at time *t* is

$$\Pr\{\, X_A + r\,(n_A^t) \geq X_B + r\,(n_B^t) \,\}$$

Following Bassanini and Dosi (1998), this can be rewritten as

$$\Pr\{\, X_B - X_A \geq r\,(n_A^t) - r\,(n_B^t) \,\}$$

$$= F\phi\,[r\,(n_A^t) - r\,(n_B^t)]$$

where $F\phi\,()$ is the distribution function $\phi^t = X_B - X_A$.

Arthur's main theorem can be derived from equation (2);

> *Theorem:* If the improvement function r increases at least at rate $\varepsilon > 0$ as n_j increases, the adoption process converges to the dominance of a single technology, with probability one (Arthur, 1989).

This theorem is the basic result which each of Arthur's models seeks to reveal. The system will lock in either variant A or B, producing a market monopoly. However, and this is the point that Arthur wishes to stress, when selection is frequency-dependent it is impossible to predict *ex ante* which variant of a new technology will be the winner. If the relative fitness of a variant depends on population shares (including that variant's own share) then the strategic choices of individual buyers are interdependent. Bandwagon effects can quickly spread as a result of changes in the

behaviour of other adopters. As a consequence, selection in the models is non-ergodic and highly sensitive to initial starting conditions, the final outcome depending on the way in which adoptions are built up. Kirman (1997) notes that this path dependency depends on two features of these models. First, it can arise when there is an increasing size of population - the Polya Urn model, for example, assumes an indefinitely increasing population in order to establish asymptotic results. A second factor is the strictly sequential nature of decision-making. Bassanini and Dosi (1998) add that the AEK theorem only strictly holds when returns are linearly increasing and there is homogeneity of consumer preferences (or at least the degree of heterogeneity is small).

The combination of increasing returns to adoption and path dependency has a number of consequences for market-driven *de facto* standards. Arthur emphasises the extent to which small historical events, (i.e. random and unpredictable) that occur in the early stages of a technology's history can fundamentally affect its development and diffusion. Such chance events can, Arthur stresses, easily lead to the selection of a sub-optimal technology. This analytical result seriously undermines the claim that the market mechanism will automatically select the variant that is optimal for a particular set of preferences and production constraints[1].

2. A lock-in account of the Browser Wars

Following David's seminal study of the QWERTY keyboard (David, 1985), the lock-in account has been applied to a number of product standards battles. Arthur (1988) has discussed the impact of small chance events (i.e. random and unpredictable) on the development of the car industry. At the turn of the century there existed three alternative technology options; petrol, steam and electric battery engine cars. Arthur provocatively argues that a key point event which turned the competition in favour of the petrol engine was an outbreak of foot and mouth disease in the US in 1914. This shut down the horse troughs from which steam cars drew their water, giving an important stimulus to petrol-driven designs. Two other standards battles cited by Arthur are the Sony Betamax vs. JVC VHS video recorder battle, and the IBM PC vs. Apple Macintosh battle. As with the QWERTY keyboard, there was a lock-in to a technology variant which, even at the time, was widely recognised to be the sub-optimal alternative. The lock-in model has been applied to a number of other standards battles. Lock-in theory has also become popular in the strategic management literature. Of particular note here are the collections of case studies by Grindley (1992) and Schnaars (1994). The empirical literature now covers a diversity of product and process technologies, ranging from magnetic resonance imaging (MRI), automated teller machines (ATMs) and CAT scanners to high definition television (HDTV), cordless telephones and light beer. As well as deepening our understanding of technological lock-in, this body of empirical work has brought the theory to a wide audience. At first sight the Netscape-Microsoft Browser War seems obvious candidate for a lock-in study. As well as being the most chronicled standards battle in recent history, it has attracted the attention of the US authorities, which have pursued a long and drawn-out antitrust lawsuit against Microsoft. Indeed US and

[1] See Windrum (1999a) for a discussion of how this result undermined the proposition that there is an economic equivalent to R.A. Fisher's Fundamental Theorem of Natural Selection.

European media frequently refer to lock-in theory when interpreting the issues of this case for their readership. It therefore seems an opportune moment to test appropriateness of the lock-in account.

A typical lock-in account proceeds in the following manner. It begins by defining the product under study, in this case the web browser. It then sets up a 'standards battle'. A particular date is given as marking t_0. At t_0 there are *n* rival firms, each offering a rival variant of the product. There is usually little or no attempt to contextualise the battle beyond the leading protagonists (i.e. to discuss the broader commercial, social or political factors that shape events) or to consider how history prior to this date t_0 influences the strategies of the protagonists or in some other way affects the outcome. Rather, attention is squarely focussed on the competitive strategy that each firm pursues in order to win the standards battle. There then follows a detailed account of how the dynamics of increasing returns to adoption explain why one firm's strategy was more effective than its rivals and, thus, how the particular variant offered by that firm comes to dominate the market.

Let us consider what a lock-in account of the Browser Wars would look like. The browser battle is all but over due to two factors. The first is the take-over of Netscape by AOL. This followed the serious financial difficulties faced by Netscape once Microsoft started to make inroads into its market. The second, and related, factor, is the shift in focus from browsers to portal sites as the key strategic battleground for commercial control of the Internet. It is therefore possible to construct a historical narrative that sheds light on the factors leading to a victory for one of the competing technology variants. Furthermore, the web browser is a well-defined technological artefact. It is used to communicate over the Internet with Web servers using HTTP (HyperText Transfer Protocol). HTTP enables the user's browser to pull up information or else to 'surf' the Web. The basics of the browser are quite simple. When a user first opens his/her browser, the browser follows a link that reads a document written in the HTML language and displays this in a window. For example, let us say that you wish to read the electronic version of this document held on the MERIT website at <http://meritbbs.unimaas.nl/staff/windrum/.html>. To access this document your browser will use the HTTP protocol to send a network request for this file to the web server where the document resides. The Web server will then respond to your browser's request and, by following the HTTP protocol, send this document to your browser. Your browser can interpret the HTML in the document and is able to display it on your screen.

While an important part of the underpinning technology of the Web was developed in Europe, the US quickly came to dominate and shape its commercial development. Two US corporations in particular, Netscape Communications and Microsoft, have shaped the commercial development of the Web through their control of the browser platform. Neither company was the first to develop a commercial Web browser. That honour goes to the National Center for Supercomputing Applications (NCSA), who released its Mosaic browser in 1993. Mosaic was superseded by Netscape's rival browser. The beta version of Netscape Navigator 1.0 was released on 14th October 1994, with the final commercial version following on 15th December. Netscape Navigator 1.0 represented a significant achievement, both as a technology and for Netscape as a company. Founded on 4th April 1994 by Jim Clark and Marc Andreesen, the

company's design team was able to develop and launch its browser within just six months[2]. Netscape 1.0 was by far the best graphical interface platform around at the time, both in terms of its ease of use and its technical design. As well as being able to load graphic images faster than Mosaic (thanks to its innovative 'continuous document streaming' code), Netscape offered the user improved features such as easy-to-use navigation and new text formatting options. In subsequent versions of Navigator the company would add Frames, coloured backgrounds and many other features that are now considered a normal part of Web page design. In addition to having a superior product, Netscape effectively gave away Navigator 1.0 for free. As well as the beta test version being freely available, Netscape allowed companies and individuals to download the finished commercial version of Navigator 1.0 from the Internet free of charge[3]. By giving away a superior product, Netscape quickly captured the Web browser market.

The decision to give the browser away was a clever piece of marketing. Clark and Andreesen were more interested in the profits generated by Netscape server software packages - for which it charged up to $50,000 - than by royalties on the browser itself (Newman, 1997). They were well aware of, and drew lessons from, the example provided by the Microsoft's Windows operating system. They knew that getting designers to pay for server software would require building up a large installed user base, thereby locking the market into their particular Web browser. This they quickly succeeded in doing. By the time Netscape Communications Corp. became a publicly quoted company in August 1995, its browser was one of the fastest-growing software companies in history with a 90% share of the Web browser market. Amid investor frenzy, its share price rocketed from an initial price of $14 to $86 on the first day of trading, turning Clark and Andreesen into paper millionaires.

Equation (1) assists our conceptual understanding of the Mosaic-Navigator battle. While the Mosaic browser had an initial advantage in terms of its installed user base (r), Netscape was able to turn the market in its favour by satisfying personal preferences (Xi) for a superior browser technology. Indeed Netscape seems to provide a good example of a company that sought to exploit the key principles of lock-in theory. In addition to strategically planning to establish a large installed user base, it has pursued a strategy of incremental innovation in order to extend its browser's functionality while at the same time enabling users to retain their core skills and knowledges. Surely Netscape, with an installed user base of 90%, had an unassailable position and this would be the end of the story? The answer, as we know today, was 'no'. Bill Gates' famous 'Pearl Harbour Speech' signalled the commencement of a second Browser War on 7th December 1995. It was one thing for Gates to proclaim that Microsoft would become a leading Internet player, it was quite another to realise this ambition. Microsoft was a late market entrant whose Internet Explorer (IE) browser was not on the market at time t_0[4]. What is more, Microsoft had showed little or no any interest in the Internet prior to Gates' speech. By the time it did act, Netscape had been left plenty of time to build up a large installed user base. Let us consider

[2] Originally called Mosaic Communications Corp., the company changed its name to Netscape Communications Corp. in November 1994 following a legal wrangling with NCSA over rights to the Mosaic name.

[3] A charge was only made on those users wishing to receive a 90 day warranty and customer support.

[4] Netscape Navigator 1.0 was released in December 1994, version 1.1 in April 1995, version 1.2 in July 1995, version 2.0 in December 1995, version 3.0 in August 1996 and version 4.0 in June 1997. Microsoft did not release version 1.0 of Internet Explorer (IE) until August 1995, with version 2.0 following in November 1995, and version 3.0 in August 1996.

some of the key factors, or 'stylised facts', relevant to the Netscape-Microsoft battle. Thereafter we shall consider whether the lock-in model helps us understand this second series of events.

Two aspects of consumer demand greatly assisted Microsoft. First, users are loath to switch from the first browser they come into contact with. Once a particular browser is installed on a user's computer there needs to be a very good reason for him/her to download an alternative browser. Of the 7,000 respondents contacted by the 8th GVU World Wide Web Survey in Autumn 1997, 72% stated they had never switched browsers. 81% of new users (defined as users with 12 months or less experience of the Internet) stuck with the first browser they came into contact with. The report suggests this rigidity is not due to difficulties in learning how to use a rival browser or to differences between the product features offered of rival browsers. Instead users are, in general, simply unwilling to invest time in searching for, and testing, alternative browser software. Moreover, new users' inexperience of the Internet appears to make them uneasy with even the idea of downloading software (including rival browsers) over the Internet. The second factor working in Microsoft's favour was the spectacular growth rate of the Internet, which continues to double in size year upon year[5]. This provided ample scope for a late entrant, such as Microsoft, to drive a wedge between the existing generation of users (who had overwhelmingly chosen the Netscape browser) and the next generation of users. Potentially, at least, Microsoft could achieve parity in market share with Netscape within two to three years *provided* it could capture the majority of new users.

There were essentially three planks to the Microsoft strategy. First, effort was put into improving the quality of its IE browser so that it would at least approach the quality of the Netscape browser. Second, Microsoft made IE 3.0 freely available to both individuals and companies. This contrasted with Netscape who, by this time, was exploiting its market position and charging end-users $5 for its browser software[6]. The commitment of Microsoft to establishing itself as a major Internet player was such that it was willingness to sustain large losses in the short-run in order to gain market share. The sheer earning power of Microsoft meant it had no problem cross-subsidising these activities. This action alone may not have invoked the wrath of the US Department of Justice (DoJ), indeed Microsoft could justifiably claim that it was merely following Netscape's earlier example. However Microsoft's strategy did not end here. The third plank of its strategy was to control the key distribution channels through which new users acquire their first web browser. Evidence brought against Microsoft in the US antitrust lawsuit indicates it was well aware of the stickiness of user demand. It was also aware that most users were either acquiring their browser in a hardware or software bundle, or else through their Internet Service Provider (ISP) (Foley, 1998). Microsoft therefore sought to use its power within the computer industry[7] to ensure its Internet Explorer was the first browser new users would come into contact with.

It was this third plank of Microsoft's strategy that brought it into direct conflict with the US authorities. Pressuring the leading OEMs (original equipment manufacturers) to automatically

[5] See Windrum and Swann (1999) for a detailed discussion of this phenomenon.
[6] Netscape subsequently reacted to Microsoft's move by similarly making its browser freely available.
[7] 90% of all PCs sold work under one or other version of Microsoft Windows

bundle IE 3.0 as a standard part of their PC packages invoked the first legal proceedings for anti-competitive practices in 1996. The release of IE 4.0 prompted a second antitrust lawsuit, this time brought by the US DoJ, in December 1997. Here Microsoft's attempt to integrate its browser into its Windows95 operating system was upheld as unfair competition. In addition to hardware and software bundling, Microsoft had acted to ensure IE would be the automatic default browser for subscribers to the major retail ISPs. The distribution of subscribers is highly skewed to four ISPs - America Online (AOL), Internet MCI, Microsoft Network and CompuServe - giving them a very powerful position within the market. Of these, AOL is easily the largest retail ISP with 14 million subscribers. Microsoft's strategy to control this particular distribution channel comprised two parts. The first part involved its heavily investing in Microsoft Network in order to establishing itself as a major ISP in its own right. The second part involved striking a series of exclusivity and cross-advertising deals with the other major ISPs. In exchange for Microsoft listing their services on its Windows95 Internet Connection wizard, the other ISPs agreed to offer IE as their standard default browser. A Senate Commerce Committee found Microsoft guilty of putting pressure on the large retail ISPs in promoting its IE browser. Yet, despite the Committee forcing Microsoft to abandon its ISP agreements in March 1998, IE remains the sole default browser offered by the top four ISPs (Newman, 1998).

This string of lawsuits were just a foretaste for the sweeping legal action brought against Microsoft by the US DoJ and 20 states on 18th May 1998. The central issue is again the extent to which Microsoft has exploited its powerful position within the computer industry in order to control the distribution channels through which users acquire their browser software. For example, DoJ Exhibit No. 233 - an internal Microsoft document titled "IE 5 OEM Marketing Plan" - discusses how exclusivity deals were to be struck with the top 10 PC hardware manufacturers in order to ensure the success of IE 5.0. The same document refers to a plan that would not only integrate IE with Microsoft's Windows98 operating system, but virtually every piece of Microsoft application software. This, the DoJ argues, threatens to eliminate any competition in the browser market because consumers will be unable to use many functions of Windows with anything other than IE. IBM, one of the few large ISPs still offering Netscape as its preferred browser, announced in September 1998 that it would henceforth only distribute IE. After examining Windows98, IBM strategy manager Adam Wong announced that "Windows Explorer and Internet Explorer are meshed... If you're in Windows Explorer [file manager] and you want to launch [a Web page in] Netscape, that ain't gonna happen" (quoted by Newman, 1998).

The DoJ lawsuit was billed by the media as one of the most important anti-trust actions in history. But they have proved too little too late for Netscape. By the beginning of 1998 the 'smart money' was already riding on Microsoft to win the Browser War. IE's share of the market stood at 39% in January 1998, up from 21% in January 1997. While the number of computers installed with Netscape grew by only 33% during 1997, the number installed with IE had nearly tripled, indicating that Microsoft was indeed succeeding in capturing the vast majority of new users. Netscape's problems were confirmed when it announced a fourth quarter loss of $88.3 million for 1997, bringing its total loss over the year to $115.5 million. Unlike Microsoft, Netscape could not subsidise these losses with profits from elsewhere. The announcement of a decision to axe 400 jobs in January 1998 sharpened questions about Netscape's survival. In November 1998 the company was the subject of a successful take-over bid by America Online

(AOL). The take-over is likely to mark the final chapter in the second Browser War. AOL is not interested in selling browser software. Moreover the lack of a standard browser platform, and the market uncertainty which this creates, is detrimental to AOL's main business interest, which is the development of e-commerce. The key attraction of Netscape for AOL was its Netcenter portal website. Netcenter's 9 million registered users are mainly business subscribers. This compliments AOL's 14 million subscription base, who are largely consumers. AOL-Netscape is easily the biggest portal on the Web - the site through which most people pass as they look for information or buy/sell goods. It has 50% more visitors than its closest rival Yahoo. It is here that the strategic battle for commercial control of the Internet is now focussed. Again, competition is between differentiated rival products. Such differentiation is designed to ensure the adoption of one particular technology variant by all end-users. This raises a large question mark against Grindley's suggestion that there is a 'natural tendency' towards open standards in ICT. It is interesting to note comments made by Jim Clark, Netscape CEO, on this question;

> "At some level, (open) standards certainly play a role, but the real issue is whether there is a set of people, a set of very powerful companies, out there who don't play the standards game. For the standards game to work, everyone has to play it, everyone has to acknowledge it's a game. Companies such as Microsoft aren't going to sit around and wait for some standards body to tell them 'You can do this'. If your philosophy is to adhere to the standards, the guy who just does the de facto thing that serves the market need instantly has got an advantage." (Jim Clark, quoted by Newman, 1997).

This suggests that firms will seek to capture an underpinning standard whenever this confers a competitive advantage. In the case of HTML this involved the privatisation of a previously open and common standard. This is not only true for Microsoft but for all firms competing for control of the Internet. It was Netscape, not Microsoft, who first used this tactic - adding its own proprietary extensions to HTML – in order to win a standards battle. Under what conditions will firms choose to develop open standards? Previous research based on interviews with practitioners (Windrum, 1999b) suggest that two conditions have been important in Internet competitions; a high degree of market uncertainty, and that no company (or coalition of companies) has previously developed a core technology capable of becoming a *de facto* standard. In the browser case the latter did not hold, with market competition focusing on the choice between rival, proprietary alternatives.

3. Empirical criticisms and extensions

Turning to the Arthur model of product standardisation, this model does assist our understanding of the Mosaic-Netscape browser war. However, it sheds very little light on the Netscape-Microsoft war. Microsoft did not stage a comeback via the development of a superior browser technology. Versions 1.0 and 2.0 of its IE browser were essentially licensed versions of the old NCSA Mosaic technology and, as such, were inferior in quality to Netscape's Navigator 1.0 and 2.0. As well as being slower in its page display and image rendering, IE 2.0 did not provide support for three key features of Navigator 2.0 - frames, plug-ins and Java. Not surprisingly, IE failed to make an impact on the market. The release of IE 3.0, in the wake of Gates' Pearl Harbour speech, marked a significant improvement over earlier versions of IE. However this was achieved by cloning numerous Netscape features rather than the introduction of its own novel features. The general consensus is that Microsoft actually took a step backwards with IE 4.0, which was poorly designed and overly complicated to use. Matters have improved somewhat with IE 5.0, although there are few that would suggest that IE 5.0 is a superior product to Netscape's rival offering.

In itself the inability to explain the outcome of the Navigator-IE standards battle through the *Xi* term of equation (1) does not undermine the theory. Indeed, as section 2 noted, a major claim made by the theory's proponents is its discussion of how inferior technology variants can (and do) win standards battles through the externality *r* term of equation (1). Unfortunately, in the Navigator-IE case, Navigator started out with 90% of the installed user base. With this size of bandwagon already in place, Arthur's model does not assist in explaining how Microsoft managed to return from the brink of defeat. Is it perhaps that we are simply are pushing the model too far and applying it to a situation for which it was not designed?[8] The model, it should be remembered, was originally intended to describe technological competitions between contemporaneous and unsponsored standards that begin with roughly equal market shares. It was *not* designed to explain how late entrants use their control over distribution channels or some other factor to overcome the first-mover advantages of an earlier entrant. How can we respond to this problem? There seem to be two possibilities. One is to jettison the Arthur model and look for an alternative conceptual framework. However this may involve throwing the baby out with the bath water. An alternative response is to try and extend the standard model in order to accommodate the particular facets of the case. Here we consider the second response.

Understanding the Netscape-Microsoft battle requires an examination of the particular demand conditions that existed in the browser market between 1996 and 1998. First, there is an important distinction between the current installed user base and the rate of growth of the user base. If the user base is expanding rapidly, as it was in the browser market at that time, then an initially large share of the installed user base - even a 90% share - is *no longer* a sufficient condition to ensure a technology lock-in through *r*. Second, section 2 highlighted the extent to which the influence of previous adopters n_i^t can be outweighed by other considerations. We suggest that two changes need to be made to the standard Arthur model in order to discuss the Netscape-Microsoft browser

[8] I am indebted to Robin Cowan for raising this point.

war. To begin with, equation (1) omits the costs associated with acquiring and using each of the competing variants. It is therefore a utility function rather than a calculation of net payoff. It. There is a second issue regarding the definition of a 'market'. By integrating its browser and operating system software, Microsoft purposely linked together what had been, up to that point, two separate product markets. This changed the dynamics of the competition dramatically.

Reducing the estimated payoff function (Π) to a utility function is a useful simplification if one is considering standards battles in which price differentials are not significant and other initial set up costs (e.g. investment of time and effort) are approximately the same. This was not the case in the Netscape-Microsoft standards battle, however. Expanding Arthur's model (1) to incorporate pecuniary and non- pecuniary costs;

$$\Pi = X_{ij} + r\,(n_j^t) - [I_j + P_j] \qquad (2)$$

where I_j is the initial investment in time and effort required to acquire and set up technology j while P_j is the pecuniary price initially paid for that technology.

Price (P_j) was a relevant factor at the outset of the Netscape-Microsoft battle. While Netscape was at this time charging users, Microsoft made its browser software free to the end user. As Microsoft began to eat into Netscape's market share, the latter responded by also giving away its browser for free. Given that this action did not prevent the continued erosion of Netscape's market share, the events of the browser war cannot be solely explained through P_j. Turning to the initial set up costs (I_j) associated with each technology, we observe that the ability of Microsoft to make its IE software freely available on all new PCs effectively meant the initial set-up cost of acquiring IE became zero. By contrast, users wanting to use the Netscape browser needed to download its software over the Internet, incurring positive set-up costs. The evidence seems to suggest that users were quite happy to use whatever browser they happened to first came into contact with. Consequently I_j appears to have been an important factor in the competition between Netscape and Microsoft. At the same time this user indifference between the two browsers - itself perhaps a consequence of their similarity in function and design - suggests that X_{ij} was not a key determining factor. Moreover, the extent to which end-users were quite happy to use whatever browser happened to come free with their PC (or else provided by their ISP) also suggests that adoption decisions were was not so much effected by the installed user base $r(n_j^t)$ as by Microsoft's ability to ensure its browser was the one that automatically appeared on their new computers. This enabled Microsoft to drive a wedge between the old and the new generation of adopters[9].

[9] A number of the case studies conducted by Schnaars (1994) similarly highlight the importance of market power to control distribution channels. Schnaars identifies three key strategies (that may be used independently or in combination) by which late entrants can overcome the first-mover advantages of a pioneer; (1) offer lower prices than the pioneer, (2) develop a superior product, or (3) use their market power to overwhelm a weaker pioneer. It is this third strategic dimension that similarly distinguishes Schnaars' analysis from Arthur's model.

Turning to the second issue regarding the linking of markets, Microsoft sought to fuse its IE browser with its Windows operating system software in order to link what had, until this point, been separate markets. Microsoft users are able to exploit an integrated browser that allows them to browse the Internet in just the same way as they browse their hard disk, the distinction between hyperlinks and files disappearing. This approach once again reflects the familiar Microsoft strategy of facilitating change by breaking a technological transition into a number of incremental steps, allowing users to (re)build their existing knowledge and skills bases through a series of software upgrades. Clearly, the Microsoft's objective was to exploit its market power in the PC market to gain competitive leverage in the web browser market. In order to accommodate this observation, one can extend the Arthur model by expanding *r* such that it also includes the installed user base of Microsoft's PC operating system (n_k^t). The payoff associated with each technology variant at time *t* then becomes

$$\Pi = X_{ij} + r\,(n_j^t + n_k^t) - [I_j + P_j] \qquad (3)$$

The result of introducing n_k^t is rather dramatic. In effect we derive a new model in which there are two, coupled Polya Urns[10]. It is very likely that this new Urn model will have completely different roots. Most probably it will have just one solution - a monopoly for Microsoft. This recognises the sheer market power and financial clout of Microsoft in relation to Netscape, the absolute size of n_j^t being dwarfed by n_i^t. Regardless of the total share of n_i^t commanded by Netscape in 1995, it could not compete in the long-run given Microsoft's 90% share of n_j^t.

4. Conclusions: The strategic use of standards in the browser wars

Microsoft's strategy in the browser wars not only succeeded in bringing the company back from the brink of defeat, it ensured that its IE browser became the *de facto* standard. A key part of this strategy involved the minor differentiation of its browser software from that of Netscape, sufficient to ensure that pages designed using IE cannot be viewed correctly by users with Netscape software. Such differentiation is designed to ensure the adoption of one particular browser by all end-users. This was the same strategy used by Netscape in its earlier battle with NCSA. The net effect has been the privatisation of HTML, previously an open and common standard. This calls into doubt Grindley's suggestion of a 'natural tendency' towards open standards in ICT. Rather, the browser wars case suggests that firms will seek to capture an underpinning standard whenever this confers a competitive advantage. This is not only true for Microsoft but for all firms competing for control of the Internet.

The other aspect of standards competition highlighted by the browser wars is the ability of a late

[10] We note that Dosi and Kaniovski (1994) have previously considered the possibility of linked technology markets, and hence coupled Polya Urns. However they did not pursue a formal investigation of the properties of such a model, or how it would differ from the standard Urn model.

entrant to use its market power in one area - in Microsoft's case, its control of the Windows operating system - to gain leverage in another. Indeed Microsoft has sought to merge what had previously been considered to be two separate markets, in order to manage its own corporate transition from personal computing to networked computing. This coupling has proven attractive to end-users. As well as linking the two installed user bases, the bundling of browser and windows software reduces the time and effort required to get connected to the Internet. At the same time, integrating Internet and standard PC software adds functionality. The Internet is a very effective distribution mechanism. Giving away one's software for free can be a successful way of rapidly gaining market share, as first Netscape and then Microsoft proved in the browser wars. However the problem is to keep this installed user base. In the browser wars, Microsoft has sought to achieve this by developing an integrated browser that enables the end-user to move seamlessly between the files held on the Internet and those held on the user's hard disk drive, adding increased functionality to both in the process.

We observed that the Arthur model – at least in its standard form - sheds very little light on the Netscape-Microsoft browser war. Microsoft did not stage a comeback via the development of a superior browser technology. Moreover, given the size of bandwagon effect enjoyed by Navigator at the outset, the Arthur model would predict victory for Netscape rather than Microsoft. The paper discussed two steps by which the basic structure of the model may be extended in order to accommodate the stylised facts of the browser competition. The first step involved an explicit formulation of the pecuniary and non-pecuniary costs associated with acquiring and using each of the competing variants. In the browser case it was the initial investment in time and effort required to acquire and set up rival variant technologies which counted, not price differentials. Both pieces of software were offered free to the end-user. However, by bundling its IE on all new PCs, Microsoft effectively reduced users' initial set-up costs to zero. By contrast, users wanting to use the Netscape browser needed to download its software over the Internet, incurring positive set-up costs. The second step involved a consideration of the extent to which cross-market effects, due to complimentary goods or the merging of technologies, effect the competitive outcome. It quickly becomes clear that, in the presence of strong cross-market linkages, the impact can be dramatic. A model based on coupled Polya Urns will have different roots to a single Urn model and, consequently, will yield a different solution. Moreover, one would expect such a model to yield a solution in which there is a market monopoly for Microsoft.

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