Reconsidering the Assumptions for "Tipping" in Network Markets

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Abstract

The work of Katz & Shapiro and others developed the concept of positive network externalities and switching costs as the key dynamics of standards competition. These researchers conclude that a positive feedback loop irrevocably "tips" a standards battle in favor of the standard with the largest share of users and complementary assets.

Such theories have driven standards strategies by producers and users throughout information technology industries for the past decade. Using standards contests of the past 20 years, this paper examines the implicit assumptions of such theories and suggests examples where such assumptions do not appear to be valid.

The most influential theories regarding *de facto* standards competition — those of positive network externalities and increasing returns to scale — rest upon a series of rarely examined assumptions. Here I argue the importance of re-examining those assumptions and thus the widely accepted predictions made by theory.

I. LITERATURE REVIEW

A. Theories of "Tipping" in Standards Contests

The concept of positive network externalities in product adoption was introduced by Katz & Shapiro [15], who wrote "There are many products for which the utility that a user derives from consumption of the good increases with the number of other agents consuming the good." While this theory of positive network externalities have been used to explain the adoption of specific innovations (e.g., [24]), its greatest impact has come from its prediction that greater market share in a standards battle increases product utility

As extended and developed by the original authors and others, they describe a model of competition between rival standards that is resolved by a positive feedback loop involving and adopters and producers of complementary assets. They focus on a class of complementary assets generically referred to as "software", which includes computer programs, pre-recorded entertainment and other assets co-specialized to the standard.

In this model, the most popular standard attracts the largest supply of software, which, in turn, further increases the standard's popularity with adopters and thus its attractiveness to software producers. The leading standard enjoys demand-side economies of scale, where every new adopter increases its advantage over rivals. Eventually producers shift to making products compatible with the dominant standard rather than sticking with an incompatible losing standard [5, 11, 12, 15, 16, 17, 28].

A second stream of standards research examines the effect of asymmetric switching costs upon adopter decisions [3, 9, 18]. If intra-standard adoption of successive generations of products is less expensive than inter-standard adoptions, customers tend to "lock in" to one standard, as Greenstein [13] demonstrated with U.S. mainframe computer purchases.

New adopters can calculate the net present value of a prospective switching cost, decreasing the attractiveness of a flagging standard that might eventually disappear. This is one reason researchers have concluded that the combination of network externalities and switching costs lead to the "tipping" of the standards contest [1, 2, 12, 17, 26]). Specifically, the theories make a strong and unambiguous prediction that, *ceteris paribus*, a virtuous cycle will inevitably "tip" a standard contest in favor of the leader, consigning the trailing standard(s) to market pressures that irrevocably force its share to zero. Or, to quote Katz and Shapiro: "In dynamic models, tipping is reflected in equilibria where new placements of the losing standard simply dry up once a rival system is introduced or accepted in the marketplace" [17: 106].

The most often cited example of such a tippy standards battle is that of VHS vs. Betamax [8]. This "Betamax" phenomenon has long been recognized in the popular press (e.g., [6]). And whether directly through the VCR wars or indirectly through academic theories of positive network externalities, there is little doubt that this winner-take-all, positive feedback model has driven standards-related decisions by adopters, producers and regulators. For more than a decade, producers developed aggressive strategies to improve the actual supply of software, by courting software developers and using a penetration pricing strategy to quickly establish a market share lead that would attract developers.

Producers have also sought to influence the perception of software availability and market share (truthfully or otherwise) to attract both users and producers of complementary assets. Adopters have sought to reduce their likelihood of adopting a losing standard (and paying the concomitant switching costs) by handicapping standards battles based on the availability of software and perceived market share.

Meanwhile, the role of proprietary standards upon competition policy has not gone unnoticed. Because technology such as software is easily reverse-engineered, intellectual property protection such as trade secret, copyright or patent is sought by standards producers to protect themselves from competition. At the same time, the tendency of standards battles to tip to a single victor has prompted policy concerns about the anti-competitive nature of such standards monopolies. In response, various governments throughout the world have reduced intellectual property protection, instituted compulsory licensing, or filed anti-trust lawsuits to rein in the power of the standards-holders [27, 28, 29].

B. Reservations

Despite the pervasive impact of the "tippy", positive-feedback model upon theory, practice and policy, a few reservations have been expressed. Berg [4: 365] concluded that "although the network externality formulation sheds light on market performance, the predictive capabilities of these models are limited."

The most pointed criticism has come from Liebowitz and Margolis [20, 21, 22], who term such models an overgeneralization of the VCR and typewriter standards cases and contend there is limited empirical support for such theories. Not surprisingly, Shapiro & Varian [26] endorse theories of network externalities and positive feedback, but admit "not every market tips," arguing that the likelihood of tipping depends on the combination of economies of scale and homogeneous customer tastes.

C. Reconciling Opposing Perspectives

It is possible that one or the other perspective is exactly right — either that positive network externalities (mediated by a supply of complementary assets) explain tipping results, or that the outcomes of standards battles are completely explained by other factors. However, a more likely explanation for the conflicting interpretations is that their are contingencies that explain when markets are tippy and when they are not. Shapiro & Varian notwithstanding, little effort has been made to reconcile these perspectives by identifying the potential moderators of the hypothesized positive feedback loop in standards battles.

In a re-examination of these network theories, a logical place to start is with the assumptions that undergird them. Therefore, the goal of this paper is to revisit the explicit and implicit assumptions of theories of positive network externalities. First, it shows the importance of these assumptions to outcomes predicted by the theories; second, through a (non-systematic) examination of recent standard battle, it shows that such assumptions are frequently violated. Finally, the paper will consider the possible outcome of standards contests in cases where some or all of the assumptions are not valid.

II. REVISITING NETWORK ASSUMPTIONS

A. Articulating the Assumptions

A number of assumptions are implicit in theories of network externalities. Some of these can be directly tied back to the specifics of the VHS vs. Betamax standards competition among U.S. and Japanese VCR buyers during the 1980s. Here we will focus on four of these assumptions.

First is the *ceteris paribus* assumption implicit in any predictive theory. This is particularly difficult to verify in standards contests: the small number of such contests, of standards within a contest and typically firms within a given standard makes it nearly impossible to eliminate possible confounding explanations. Certainly we must agree with Liebowitz & Margolis [22] that if there is a fundamental difference between standards that more parsimoniously explains the outcome, then such an outcome does not offer unequivocal evidence supporting theories of network externalities.

Three other key assumptions underlie what Katz & Shapiro [15: 424] term "indirect effects that give rise to consumption externalities," specifically the role of "software" (or other complementary assets) that increase the utility of one standard over another. They are:

- *Software maximizing vs. satisficing.* The VCR wars — driven as they were by the consumption of an ongoing supply of new video entertainment — have prompted the view that the standard with a greater variety of software has greater utility for the adopter (e.g., see [15, 16]). But is this applicable to all classes of standardized products? Are there some categories where a certain minimal variety of software is satisfactory for most users, and any additional variety produces little or no marginal utility?

- *Observability.* Perhaps an increasing supply of the specialized complementary asset (software) does increase consumer utility. But are the consumers always able to evaluate which standard has the

greater supply? It was particularly easy for VCR or PC owners visiting their local videotape or PC software store to see the difference between standards, but is this applicable to all classes of goods? Does it even apply today in the case of online vendors which, lacking inventory, blur the distinctions between high-volume and low-volume products [19]?

- *Only indirectly actionable.* The models of positive feedback generally assume that the complementary assets are provided by independent third parties, as happened with movie studios for VCRs or software publishers for personal computers. In these cases, the variety of software is determined by these independent producers — make their own profit-maximizing decisions based on perceived market share — and thus is only indirectly actionable by the standards-owner. But in many cases, the provisioning of the software can be internalized within the firm so that it is directly actionable [28]; such vertical integration has become increasing common.

Computers & Operating Systems
PC operating systems: Windows vs. OS/2 vs. Mac
PC architectures (Japan): PC-98 vs. DOS/V
Unix variations: OSF vs. Unix International
Java
Multimedia: MPEG
CD-ROM

Application Software
Word processors: Word vs. WordPerfect
Spreadsheets: Excel vs. Lotus 1-2-3
Databases: Oracle vs. Access vs. Sybase
Object frameworks: ActiveX vs. Corba

Networking and Communications
Web browsers: Netscape vs. Internet Explorer
Streaming Media: RealMedia vs. NetShow
Networking protocols: TCP/IP vs. OSI
LAN: 100Base-T vs. 100VG
Wireless LAN: IEEE 802.11 vs. OpenAir
56K Modems: x2 vs. 56flex
Teleconferencing: H.320 vs. ProShare
Digital cellular telephones (U.S.): GSM vs. CDMA

Consumer Electronics
Video cassette recorders: VHS vs. Beta
Camcorders: VHS-C vs. Hi-8
MD disk
DVD: DVD vs. DVD-ROM vs. DVD-RAM
HDTV: Japan vs. Europe vs. U.S.
Video games: (multiple generations)
DAT
CD
Uncontested standards shown in italics

Table 1: Major recent de facto standards battles

Finally, in operationalizing the theory's predictions, it is difficult to define which are similar vs. successive generations (Shapiro & Varian again being a notable exception).

B. How Often Are Assumptions Valid

Table 1 offers a list of many recent standards battles, taken from 902 articles from the ABI/Inform database published during the 1990s related to computing and communications standards. These were supplemented by books [14, 25] and various articles on standards competition.

In examining the assumptions, first start with possible confounds. For many attributes, it is difficult to measure the magnitude and importance of confounding differences. Was the VHS format of comparable quality and superior utility to Beta, as Liebowitz and Margolis [22] argue? Did the DOS/V cost advantage in Japan explain how it overcame the PC-98's head start [30]? Will the advantages of "Open Source" in Linux be sufficient to overcome the tremendous market share and software library lead of Windows [10]?

A more objectively measurable confound is market power. For computers during the 1960s and 1970s, there was no more powerful firm than IBM, which is why the IBM's late entry into the PC industry was immediately expected to be successful [7]. Similarly, the recent success of Microsoft in web browser, ActiveX and streaming media Internet standards has been attributed (by U.S. prosecutors) to Microsoft's market power, which arguably also played a role in its earlier successes in word processors, spreadsheets and databases.

Such a market power argument has to be weighed against a first-mover advantage [20], as IBM and Microsoft in these cases started later with no share and few complementary assets. More evenly matched cases where the leading standard started earlier and never trailed included MS-DOS vs. Macintosh PCs, TCP/IP vs. OSI networking and GSM vs. CDMA cellular phones.

Considering the role of complementary assets, theory assumes that the larger "software" library is readily observable. This may be true for most categories, but what about the case of rival cellular telephone systems — where consumers won't know of any disadvantages (poor coverage) at the time of initial purchase, and where it's difficult to compare to rival standards unless (s)he owns products from each?

Similarly, the telephone user who keeps a cell phone for use between home and work won't be trying to maximize utility — there will be a minimal acceptable utility and then anything beyond that is of little value. Similarly, a PC owner may not be interested in maximizing the software variety — if a few basic packages are available, like E-mail, word processing and web browsing. When picking a modem, as long as the current Internet provider supports the modem standard, does it matter how many other firms support it as well?

The last software-related item is the explicit premise in the model that the standards promoter can only indirectly induce software (by delivering market share). Again, telecommunications networks require a minimum level of investment, and vendors normally make such investment themselves if they seriously intend to attract customers. Similarly, after the VCR wars, Sony purchased Columbia Pictures and Records, while Matsushita bought Paramount — giving each internal control of software for future standards, such as MD recordable disks and DVD. Today, Microsoft develops applications to emphasize its latest operating system, while Intel acquires or funds companies to develop software that shows off its current processor.

Finally, how do we know when a later standard is not directly competing with the incumbent standard, but instead creating a new market? The successive generations of video game consoles — where standards leadership changed hands between the 16-bit, 32-bit and 64-bit consoles — offer one example where the technological change is clearly large enough to render existing share and libraries irrelevant. But does it always require a 10x performance change, as Shapiro and Varian [26] argue? Is this either necessary or sufficient?

III. CONCLUSIONS

This paper has re-examined the assumptions behind theories of network externalities, and shown examples where they are not valid. Obviously the results are suggestive, not conclusive.

Instead, it is hoped that this paper will stimulate a systematic re-examination of the evidence provided by various standards battles of the past two decades. This examination could provide empirical evidence once and for all that confirms — or rejects — the theories we have assumed to be true for the past 15 years.

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