Standards, Complexity and Transitional Technology Markets

By Shane Greenstein, January 28, 2006

For Bolin/Cargill, The Standard's Edge

Abstract

In this essay, I address two common and seemingly unconnected beliefs about the market role for standards: The first belief is that despite increasing knowledge and study, standardization strategy has become more complex over the last two decades. The second is that the introduction of standards can make a market either more or less differentiated – yet, because of the market's increased complexity, one cannot make predictions about the direction of change.

I argue that analysts must first analyze different types of *transitional technology markets*. In such markets, vendors sell users goods and services that move the user from one level of technology to another. Analysts should ask two sets of questions. First, they should ask whether a standard makes a market more *autonomous* or *interconnected*. Autonomous markets display behavior disconnected from events in other markets. Second, analysts must ask whether standards in the installed base define a comparatively *uniform* installed base or a *varied* one. That is, are potential adopters of the new technology improving on a similar (uniform) situation or on a different (varied) one. The framework is illustrated on many examples from a variety of electronics markets.

Complexity and Standardization

The specification for a standard serves as a reference for designers, either for those employed at a firm who embed the design in a product, or for others whose products must work with a design. The standard may be a focal point that stays fixed over time, or it may be widely acknowledged as temporary, ready for change when new technological possibilities and commercial opportunities warrant it.

In this essay, I address two common and seemingly unconnected beliefs about the market role for standards: The first belief is that despite increasing knowledge and study, standardization strategy has become more complex over the last two decades. The second is that the introduction of standards can make a market either more or less differentiated – yet, because of the market's increased complexity, one cannot make predictions about the direction of change.

Although there may be a grain of truth to these beliefs, they are incomplete. Actually, the reasons behind (or the explanations for) the presence of these perceptions are what will lead us to a greater understanding of standards market and why it has become so complex. In fact, I believe there are interconnected and interrelated reasons for the increased complexity in standardization strategy and the inability of being able to forecast the direction of a market before standards are introduced.

For the most part, many do not recognize why the complexity in the market has occurred. Some believe that increasingly complex technologies breed increasingly complex standards markets. Yet, I do not think the increased presence of complex technologies is solely responsible. Even with relatively simple technology standards models, the market has become increasingly complex. To understand the standards market's complexity, one must first analyze different types of *transitional technology markets*.

In transitional technology markets, vendors sell users goods and services that move the user from one level of technology to another. Such markets emerge because the installed base of pre-existing sub-par older equipment operates at a level far from the potential of a frontier prototype. These markets arise in many guises in almost any market where new technology diffuses (e.g., electronics, video cassette recorders [VCRs], digital cameras, personal computers [PCs], notebooks, Wi-Fi.).

All transitional technology markets are not alike, however, so the impact from introducing a standard differs according to the market setting. Concretely, standards play a role on both sides of a transitional market. Standards shape the design for the products that vendors sell, but they also shape the conditions at the already-installed base, which buyers, by purchasing products based on these standards, are trying to improve.

Hence, to understand transitional technology markets, analysts should ask two sets of questions. First, they should ask whether a standard makes a market more *autonomous* or *interconnected*. Autonomous markets display behavior disconnected from events in other markets. The first VCR and the early DVD (digital video disc) upgrade were close to autonomous markets. Conversely, in interconnected markets, standards shape events in multiple market segments. The pending format war among Blu-Ray and HD-DVD (high-definition–DVD) is one of many such examples, since its outcome will affect (and be affected by) events in gaming, television broadcasting, music players, and PCs.

Second, analysts must ask whether standards in the installed base define a comparatively *uniform* installed base or a *varied* one. That is, are potential adopters of the new technology improving on a similar (uniform) situation or on a different (varied) one, and by extension, whether or not different market participants will react in similar ways to the introduction of a new specification for a standard. This is not as straightforward as it sounds. As I explain subsequently, the VCR's installed base used to be uniform, but it is not so any longer. Indeed, a comparatively simple technology like the dial-up modem market was never uniform.

But why do analysts need to think about strategies for standards in new ways? Simply put, the two most common conventional approaches are incomplete. First, the conventional approach to analyzing new markets starts from the "s-curve" of diffusion, best known through the presentations in the Chasm approach or the Bass model.[i] Nevertheless, most firms in high technology today do not experience such s-curves directly, unless they happen to monopolize an entire technological category. Instead, most firms experience fleeting steps along the way up different s-curves in competition with other firms. In other words, there are different types of competitive environments

underneath the s-curves. This type of competition is an environment that is prone to change fundamentally before any firm gets settled into one strategy.

Second, the conventional approach for understanding standardization highlights its governance, whether the standard is mandated by a government agency or designed by a committee, for example. While this can be useful for understanding what designers intend, it is not the whole story. It often overlooks differences in the market environment in which the new product diffuses.

In an era where the fundamentals change rapidly, so too should the conceptual underpinning for strategic analysis. Standards alter competitive behavior and the strategies that inform this behavior. Their impact is where the locus of attention should be, and that is the focus of this essay.

Standards and Autonomy

Let's begin with analyzing the simplest situation: In an autonomous transitional technology market, the movement from old to new has little consequences for other markets. In practice, the market looks similar to a features-oriented upgrade, where the upgrade has no relationship with any other market. In the beginning, the market for DVD players was an autonomous transitional technology market: The primary motive for most home purchases was to upgrade from the VHS to the DVD, and for the first few years that was all it was. This market had its own internal momentum. Getting enough titles on DVD was the central concern of all parties.

Nevertheless, vendors did not, or could not, let this market remain autonomous, and they tried to establish and exploit links across markets. For example, there have been several attempts to induce HD television (TV) buyers to buy better DVD players, as well as attempts to link copyright protection (on the DiVX, or Digital video express, format) with deals with movie distributors. [ii]

Those marketing ploys were only successful with niche buyers, which caused comparatively small blips on aggregate sales volumes. The one big exception occurred in the gaming market, when Sony embedded a DVD player in the Play Station 2, first released in Japan in 2000. The X-Box followed with a similar choice. Both of these

decisions helped sell games, and both gave an additional kick to the DVD market in return.

In other words, vendors could not resist turning an otherwise autonomous market into an interconnected market. As a result, this dispute spilled into market events in a variety of hardware and software markets, not just the first one in which the new technology diffused. In fact, The Consumer Electronics Association has tracked DVD sales since their launch in the spring of 1997. Sales grew steadily until 2003—reaching over 65 million units sold over the prior seven years, not counting game players that read DVD disks. In June of that same year, DVD movie rentals exceeded those for VHS. And by 2004, the market had exhausted virtually all possibilities for growing sales through new users in the United States. Today, most sales are replacement purchases.

In light of all the prior recording format failures, it is amazing this competitive ploy worked at all. Yet, it also illustrates the main point: Standards are just one facet of competitive rivalry between differentiated firms. In an autonomous market, the popularity of a standard is determined by the accumulation of a number of competitive actions affiliated with the continuous cycle of prototyping, launching, and marketing—the usual behavior of continual competition. In such a setting, it is not surprising to see firms bring all available assets to bear on competitive outcomes.

Examining the Predecessor

Another autonomous and uniform market preceded the DVD: The VCR market. This market was different from the DVD market, however, in that it became interconnected unexpectedly, whereas with the DVD, many anticipated the market's growing interconnectedness.

To begin, the fight between JVC's VHS and Sony's Betamax is regarded as the classic format war. Nevertheless, as with canonical events, popular retelling diminishes how events appeared to contemporaries. It is time to dust off this old story and revisit the lessons from it. [iii]

To most of the participants in the mid-1970s, the VCRs looked like any other nascent market with competitive rivalry among differentiated firms. Ampex, RCA, Sony,

JVC and many other firms had been trying to develop a consumer VCR for more than a decade, with little commercial success except among hobbyists and experimentalists. [iv]

Everyone lost money for a long time. Ampex, the technical leader for over a decade, gave up trying to pioneer the product after launching a failed design in the early 1970s. RCA, the electronics behemoth and largest television manufacturer at the time, also gave up. Things took off in the mid- and late 1970s, but only after Sony and JVC persisted. Both firms deserve credit for that persistence in the face of years of discouraging events.

As in any competitive situation, a large number of factors shaped outcomes. For example, while Sony's Betamax had a great picture, the first models could only record for one hour. Then VHS came out a year later and recorded for two hours, and it rewound more quickly. In addition, JVC's VHS system had better distribution in the United States. Following its typical practices, Sony preferred a slightly higher margin on its products than did JVC, thereby sacrificing a few sales. Then competition did the rest. Some users chose Betamax, more choose VHS. Both firms made a good profit in the late 1970s.

It is hard to appreciate now the atmosphere at the time. A layer of bitterness informed everything, a consequence of the fallout between Sony and JVC during a prior attempt to launch a VCR in the early 1970s. In spite of that, for strategic reasons that must have made sense to the executive at the time, Sony preferred to strictly license technologies for royalty (even to JVC). In contrast, JVC was viewed as a friendlier partner, gaining many more firms in its alliance. In other words, the format standard was just one of many things that differed between two firms that had competed and cooperated (in limited ways) for a number of years. As in most pioneering markets, good technology helped, but it did not determine outcomes. A dozen different factors mattered.

Then, unexpectedly, in the early 1980s, the video rental market emerged. The key word here is *unexpected*. Until then, all firms and users employed the VCR to record television programs. Indeed, that use so dominated thinking that it generated a major copyright lawsuit from broadcasters (which was eventually decided in Sony's favor at the U.S. Supreme Court).

Video rentals exacerbated JVC's lead in market share. More VHS titles motivated users to buy VHS hardware, which motivated video rental stores to carry fewer Betamax

titles. Somewhat inexorably, and painfully for Betamax owners with libraries of recordings, Betamax died a commercial death. Most of the world moved on, except some Betamax owners, who—even to this day—complain about their fate. More to the point, that competitive experience left its mark, a mark still felt today on contemporary strategic doctrine.

The truly decisive factor, video rental stores, was not something any vendor had planned for—arriving as it did after more than two decades of investment. Sony and JVC would have acted differently if the firms had known that the emergence of rental stores would tip the format wars toward one side. Henceforth, both firms, as well as plenty of others, learned a key lesson, i.e., about diminishing the role of luck (or unexpected interconnectedness) with every strategic action. Some said that Sony even went so far as to buy a Hollywood movie studio so it could effectively guarantee titles for the next format war.

Thus, here I do *not* highlight the many debates over prior standard wars, such as whether the VHS or the Betamax was technologically better, whether markets sometimes choose an inferior technology, or whether sub-optimality never rises. Rather, what this canonical standards war illustrates is that these events had a tactical role in shaping modern strategic doctrine for standardization. Namely, firms learned that if one is to start a format war, it should be conducted in as thorough a manner as possible, which leads to a partial explanation for the previously mentioned common perception about the market role for standards—that standardization strategy has become increasingly complex.

For now, let's also walk away with a general lesson about the role of standards in competitive settings: This story highlights how standards act as a point of differentiation between firms competing for the same users. Competition between standards in autonomous transitional markets arises as an outgrowth of competition over features, where the standard is just one of many features that firms embed in their products. These features and standards change in an almost continuous cycle of prototyping, launching, and marketing, followed by the same cycle again for the next upgrade. De facto standards can arise from this continual competition.[v]

The Role of the Installed Base

I have just discussed two examples of autonomous transitional technology markets becoming interconnected. But it is important to analyze the role of the installed base in the standards market, as well. Doing so is complicated, because the accumulation of products with embedded legacy standards shapes a market's potential. That is, new products rarely diffuse into greenfield environments where there is no precedent for the product, as the VCR did in the 1970s and 1980s. Instead, there is usually an installed base of equipment that the new product seeks to replace, as the DVD faced in the mid- to late 1990s.

Thus, the role of the installed base affects the strategic role of standards in transitional technology markets. The effect, however, is different depending on what kind of market it is, because standards can determine whether many or few potential adopters of the new technology will improve on their existing technology. In this sense, standards define whether a transitional technology market is large, small, or potentially lucrative for the firms involved in the market. And the type of installed base can determine whether the standard's effect on the competitive landscape is easy to forecast.

The simplest situation is one in which the installed base has nearly a singular uniform legacy standard in use and the transitional technology market is nearly autonomous (Note that calling this the *simplest* situation is not the same as calling it *simple*.) As was previously noted, the first upgrade from VHS to DVD had this feature.

Now consider a setting with more complexity, the upgrade from 28k modems to 56k modems, a market fight that began in mid-1997. This scenario illustrates why complexity is more often the norm, arising from seemingly small features of a market's installed base.[vi]

For all intent and purposes, the installed base for modems was in different camps. There were two market segments interested in the upgrade: Users and ISPs (Internet Service Providers). Among users, there were two sub-segments—those new to the Web and those who already owned a 28k modem and wanted it to work with the new equipment. Among ISPs there were two large sub-segments and one extremely small one. There were those using equipment from US Robotics (USR) and those using it from

Rockwell or Lucent. Then there was the small segment that had equipment from both firms already.

Each side had assets that appeared valuable for the upcoming standards war. Both companies had many allies and friends in the industry. USR had excellent brand recognition and an established distribution network with consumers, as well as entrepreneurial spunk and energy. Rockwell and Lucent had a large network as well, but primarily with ISPs; and they had the additional advantage of having designed the standard chipset for the previous generation of modems.

Both sides were confident at the outset, but as is well known, the fight between the two camps was mutually disastrous. The largest ISPs committed verbally to different standards but actually did not invest at first, because they waited to see how events would develop. In many markets, users and ISPs split between the two standards, if anyone adopted at all. The situation generated so much confusion that the whole market stalled in its first year, yielding sales much smaller than had been forecast, especially given the increasing demand for higher bandwidth to take advantage of commercial applications of the World –Wide Web, which were growing quickly at the time.

Once the ITU (International Telecommunication Union) intervened with a new design, both camps accepted it and users bought 56k modems. The market grew so fast after the introduction of the new standard there was no doubt that the lack of a uniform new standard contributed to lack of growth in the first year. Consequently, the conventional view blames the two sides for the initial fight, putting the onus on the failure of USR and Rockwell and Lucent to come to an agreement at the outset.

This conventional view is somewhat unfair to both sides. One might just as easily blame the situation on the non-uniformity of the installed base, a factor that permitted each management team to forecast very different futures about the outcome of the standards war. In other words, the war over the 56k modem design had many of the features of a fight between two differentiated firms, to be sure; but the instinct for differentiation was magnified by the features of the installed base that led each side to over-value its own competitive strengths and under-value its rival's. The installed base was comparatively large and varied, which fostered the false perception among the two

camps of equipment suppliers that each had a unique asset to employ in the war, each knew something the other did not, and each could win a war of differentiated standards.

From Interconnected to Autonomous

The previously described examples illustrate how standards can cause an autonomous market to become interconnected; however, standards can also make a market flow in the opposite direction, from interconnected to more autonomous. In this exceptional and special situation, the introduction of the standard simultaneously reduces firms' degree of differentiation along one dimension while enhancing it along others. This occurs when a standard's introduction raises demand for a community of firms concurrently.

The first example I discuss depicts a market with a relatively uniform base. In the early to mid-1970s, the FCC (Federal Communications Commission) mandated standards for all telephone equipment in the United States. These mandates, along with some administrative rules, known colloquially as *Computers I, II and III*, established a bright line between equipment owned by AT&T (and its equipment subsidiary, Western Electric) and every other potential equipment supplier.

Prior to these changes, AT&T owned the equipment that users had at their home, and users "rented" it from the company. Such an arrangement was part of a broad set of policies at AT&T to increase the book value of assets AT&T claimed in rate-of-return hearings. More to the point, every time other firms attempted to introduce telephone equipment into the customer premise market and make choices available to users, AT&T sued them. Consequently, *Computers I, II, and III* evolved from a long list of regulatory and court-mediated challenges to AT&T's near monopoly over the design of telephone equipment.[vii] Implementing the rules fragmented AT&T's control over the design, which then allowed for more competition. Similarly, the establishment of the standard was successful, because it limited the market power of AT&T to alter interfaces between equipment and the rest of the network, which then separated events in customer equipment markets from events everywhere else in the telephone system.

The standard increased the market's complexity by transforming an interconnected market struggling under a monopoly into an autonomous one that

encouraged competitive behavior in other aspects of the customer premise equipment market. Specifically, after several decades it is clear that changes to the rule fostered a large community of suppliers from a variety of backgrounds. For example, today land-line telephone handset markets have their own market-based momentum. A customer can buy a phone at Wal-Mart, Radio Shack, Office Max, as well as a host of places on-line. Firms attempt to sell whatever they think will appeal to users and are only constrained by a few rules about spectrum and electrical interference with other equipment. As a result, new designs and minor innovations – reflecting myriad views about the most lucrative points of differentiation and about what appeals to consumer tastes – find their way into the market, pushing it forward faster than it would have evolved had a single firm remained the dominant designer.

The previous example involved a government agency, a unique historical experiment, and a uniform base. A similar but slightly more subtle process occurs when an industry-sponsored standards committee designs the specification that turns an interconnected market into an autonomous one for a varied installed base. On an abstract level, the similarity is straightforward, but, practically speaking, the differences are no less important. For example, the process can arise even where there is no single firm with market power.

How? This happens when differentiated competition involves a large community of suppliers whose interests align enough so that coordinating their design improves the demand for all their products simultaneously. That is a mouthful so I take that one piece at a time.

Let's start with the similarity. Buyers in transitional technology markets enjoy buying from a large potential pool of suppliers, so buyers enjoy the emergence of a design that fosters a community of firms who build "complements." These equipment firms treat the design as a fixed feature of each of their products, but they all have plenty of opportunity to design a variety of different products, reflecting differences in assets and visions about the best market opportunities. In other words, while the standard eliminates points of differentiation, its presence can help grow a market if it leaves sufficient flexibility for firms to find other points.

In a well known case, the first designs for USB (Universal Serial Bus) did just that.[viii] Inside the Wintel world – where the Firewire standard did not prevail as it did with Apple equipment – there was no such specification for peripheral vendors. Users eventually liked USB for its hot-link properties, which opened many opportunities for peripheral vendors who foresaw a variety of applications for it. While there are many on-line descriptions about who designed USB and why, those details are less salient than the simple observation that once the USB specification was set and published, it was up to peripheral vendors for the Wintel PC world to decide how they wanted to differentiate their products by designing them any way they could. Presently, USB 2.0 is the most common in new equipment, and clearly most PC vendors who can use it do so.[ix]

As another illustration, consider the design for the Ethernet that eventually became dominant.[x] In 1980, it was initially backed by only a few upstart firms (i.e., DEC [Digital Equipment Corp.], Intel and 3Com) that thought making Bob Metcalfe's nonproprietary design would help them compete with other proprietary versions of Ethernet or IBM's proprietary Token Ring.

That gamble turned out to be correct. Scores of firms eventually entered into production of compatible equipment. To be sure, it did not happen overnight. IBM's poor marketing of Token Ring and a decade of development and use also helped propel Metcalfe's Ethernet deisgn into success. Indeed, the standard became so important in so many applications that the IEEE had to generate many committees to write upgrades to it.

Both examples also illustrate an important practical difference between a government agency's mandate and a standard coming from a committee. Aside from lacking the force of law, industry-sponsored design need not reflect any public interest. Standards committees are themselves comprised of technologists and representatives from firms making products, and these committees reflect the commercial interests of those firms and participants. That does not necessarily result in better or worse outcomes, nor does it mean the designers get what they intended; it is just means that a vendor with a thorough strategic approach to standardization will get involved in efforts related to their core product markets.

For example, because it helped grow the Wintel platform, USB served the interest of some of the largest firms in the computing and telecom equipment industry (e.g., Intel,

Microsoft, Philips, NEC, HP and Lucent), and they backed its design for that reason. Similarly, when it was first proposed, some dominant firms were ambivalent about USB, because it eliminated points of differentiation between Wintel vendors.

More broadly, before a new market takes off it is often difficult to forecast where the primary value for the new technology will lie. It might lie in implementing a simple low-cost version of a technology, in which case there will be few opportunities to differentiate. Or, it might lie in the design, production, and distribution of a massive variety of peripheral components from a variety of firms. In the latter case the introduction of a standard creates value even as it eliminates differences between firms, even when it makes events in the market less interconnected.

Scenarios for Interconnected Markets

Autonomous transitional markets seem increasingly rare. Why? It is partly because innovations in communications technologies increasingly permit different devices to coordinate with one another, which makes different markets more complex and more interconnected as a technical matter. It is also, I believe, due to changes in the norms for business strategy, which favor more thorough and more complex strategies. As illustration, consider a best-case scenario for an interconnected market: Even in a situation that went well, as the one I am about to describe did, a large firm could not resist using standards as an element in its broad strategies to further its own interest. Its intervention made the market more complex, regardless of whether its involvement was a positive or negative influence.

Specifically, embedding wireless capabilities in PCs could have happened in a number of different ways, but the key and deciding event occurred in 1999. The IEEE subcommittee for Committee 802.11—which concerns itself with wireless traffic for local area networks using Ethernet protocol—published Standard 802.11b, which altered some features on an earlier attempt at a standard for local Ethernet protocol (increasing the speed, among other things). Because many vendors had experimented with earlier variations of this standard, the publication of 802.11b generated a large vendor response from those who were already making equipment.

Perhaps more interesting, with Ethernet, Committee 802.11 did not initially intend to design a wireless standard for generating Internet access in coffee shops. It has morphed into that for reasons I will describe subsequently, but that was not part of the original charter.

The publication spurred more commercial experiments. The earliest entrants gambled a bit. It was not clear that many customers outside of traditional big users (e.g., FedEx, UPS [United Parcel Service], Wal-Mart, Sears, and Boeing) would like short-range Ethernet, but, as it turned out, it was a popular mode for wireless Internet access in a variety of different geographic spaces. To meet the market demand, firms sold antennae, compatible cards, and adapters for laptops and desktops.

At about the same time, pioneers of the standard—including 3Com, Aironet (now a division of Cisco), Harris Semiconductor (now Intersil), Lucent (now Agere), Nokia, and Symbol Technologies—formed the Wireless Ethernet Compatibility Alliance (WECA). As a marketing ploy, WECA branded the new technology *Wi-Fi*. The group also performed testing, certified interoperability of products, and promoted the technology. Additionally, in 2003, WECA renamed itself the Wi-Fi Alliance. Today, most equipment producers are members.

Not everything went smoothly, to be sure. I recall the earliest days as exciting but full of hardware and software glitches. There was always an outside chance that the something could go wrong in a specific laptop. Even if something worked at one place with one antenna, there was a good chance it would not work at other locations. Despite the initial technical hiccups, the early experience demonstrated the presence of market value. That demonstration motivated more sophisticated firms to introduce ever-more reliable products. Public access to the Internet in many quasi-private spaces – such as coffee shops and airports – generated experiments with increased security, both at the standards-writing committees and at the private firms. Near-Darwinian competition drove quality up and prices down. More recently, the recent upgrade in Wi-Fi's capabilities involved moving all equipment from IEEE Standard 802.11b to 802.11g. Because g, published in 2003, was backward compatible with b, this went smoothly in the market, for the most part.

More to the point, in the midst of all this, Intel decided to install wireless capability in its notebooks, branding it *Centrino*. They anticipated that their endorsement would help increase demand for wireless capabilities within notebooks. Non-trivially, they also anticipated that the branding would help sell notebooks using Intel chips and designs, much as the *Intel Inside* campaign had.

To be fair, Intel's strategic success *was not* inevitable. They ran into several snafus at first, such as insufficient parts and a trademark dispute over the use of the butterfly. Also, and non-trivially, motherboard suppliers, card makers and OEMs (original equipment manufacturers) did not like Intel's action. Yet, by embedding the standards in its products, Intel made Wi-Fi, or rather Centrino, easy to use. Only Dell was able to put up any substantial resistance, insisting on selling its own branded Wi-Fi products right next to Intel's, supporting some of the card makers. Despite this resistance, the cooperation from antenna makers and (importantly) users helped Intel reach its strategic goals.

Now Intel has invested more money and employee time in related actions, such as supporting Wi-Max (i.e., IEEE Standard 802.16) and the Wi-Max Forum.[xi] Intel managers claim that they intend to embed Wi-Max into the system processors and board architectures for laptop, PDAs, (personal digital assistants), and other devices. The ability to embed the standard into consumer and Information Technology products should make the transition to Wi-Max, if it occurs, more likely, though it would be naïve not to expect a few glitches along the way too.

More broadly, this interconnected market was complex and the installed base was varied, but strategic thinking by a large firm did not hurt the market, and, arguably, even helped it progress. It also angered a number of other suppliers, but that is par for the course in competitive matters such as these. In spite of disputes among firms within the platform about what was to be done, things went reasonably smoothly for users.

Finally, consider a different interconnected market: The next generation of storage formatting, a transitional technology market with potential as big as its predecessors, to be sure. This last example illustrates why large firms rarely let events in an autonomous market stay independent of others.

Sometime soon Sony intends to embed Blu-Ray into the Play Station 3 and its home video players. They have gone to great lengths to generate a coalition of firms to support this action. Opposing Blu-Ray is the HD DVD, which is sponsored and supported by many firms, including Toshiba, NEC, Sanyo and Microsoft and Intel.

This fight is difficult to handicap, as the details are complex and often changing. Yet, in spite of the risk of being outdated shortly after this essay is published, the recent past supports three broad points that should remain valid no matter how the standards battle turns out.

The first observation concerns the increasing sophistication of standardization strategies. The firms involved in this fight have thorough and detailed plans for achieving their commercial goals. For example, they are not letting this situation become an autonomous market, even from the outset. If one looks deeper, this dispute also intersects with distinct approaches over managing rights for digital applications.

Second, this sophistication is not unusual. Indeed, it is almost required because a complex strategy for standardization is the norm today. It is the lesson that CEOs, consultants and the marketing departments take from the past. The strategy directs firms to employ assets from many settings, leveraging as many cross-market advantages as possible. Hence, the processes in multiple markets inevitably become interlinked and complex. The strategies do not always work, but recognizing that does not make the process any simpler.

Third, any large firm reflexively avoids treating a standardization decision as if were occurring in an autonomous setting—an attitude that reflects learning acquired over the last four decades about competition between platforms. And, even if a firm did treat the standardization decision as such, the firm would be likely to fail if it faced a smart competitor that could outmaneuver it through use of one of these more sophisticated strategies.

So, for the most part, autonomous strategies do not survive, pushed out of the market by the interconnected ones. The same can be said of simple strategies. Complexity prevails and thrives. In other words, Sony and Toshiba are following the latest upgrade in the standards strategy playbook, thereby making events complex and difficult to forecast in the pending battle of Blu-Ray and HD DVD.

Big or Small Impact

Why have some standards had a large impact while others have not? Why has there been a secular trend towards increasingly complex events? I have tried to argue that both puzzles can be addressed within one framework, focused on understanding the role of standards within transitional technology markets.

Analysis needs to account for differences in the market environment in which standards diffuse, distinguishing between autonomous and interconnected markets, and between those with uniform and varied installed bases. Executives need to consider questions about whether the standard makes the market more autonomous or not and whether its appeal to a situation is uniform or not.

Autonomous transitional markets seem increasingly rare because strategic behavior at big firms makes it that way. Large firms take actions to turn autonomous settings into interconnected ones, if they can, as standards can be part of a large strategy to link behavior across markets. That makes the effects of standardization more complex to follow and predict.

Endnotes

[i] This refers, respectively, to Moore (2002), *Crossing the Chasm.* New York*:* Collins, and Bass (1969), "A New Product Growth Model for Consumer Durables," *Management Science*, 13 (5) 215–27, and the voluminous literature built on these analyses. See also Rogers (1995), *Diffusion of Innovations.* New York: Free Press.

[ii] See e.g., Dranove and Gandal (2003), "The DVD vs. DIVX Standard War: Empirical Evidence of Network Effects and Preannouncement Effects," *Journal of Economics and Management Science* 12 (3): 363–86.

[iii] The topic of this standards war usually gets sidetracked into disputes about prior wars. Many orphaned users have kept these arguments alive in textual food fights within blog discussion groups. The passion of the arguments is an extension of a much broader debate about the optimality of design standards, such as QWERTY, the typewriter standard. Some researchers are committed to the proposition that markets may chose an inferior technology and others are deeply committed to the proposition that sub-optimality never arises. Just try having a sober conversation with the faithful. For a related debate, see research about the development of QWERTY. See the reaction of Liebowitz and Margolis (1990) "The Fable of the Keys," *Journal of Law and Economics* 33. to David (1985), "CLIO and the Economics of QWERTY," *American Economic Review* 75: 332–37, and then David's (2001) response in "Path Dependence, Its Critics and the Quest for 'Historical Economics.'" In *Evolution and Path Dependence in Economic Ideas: Past and Present*, P. Garrouste and S. Ionnides, eds. Cheltenham, England: Edward Elgar Publishing. Gould (1991), Chapter 4, *Bully for Brontosaurus*, *Reflections in Natural History*. Norton: New York.offers a quite distinct perspective.

[iv] For an account of this early era, see e.g., Cusumano and Rosenblum (1987), "Technological Pioneering and Competitive Advantage: The Birth of the VCR Industry," *California Management Review*, 29 (Summer): 4.

[v] For more extensive discussion about the determinants of de facto standards, see David and Greenstein (1990), "The Economics of Compatibility Standards: An Introduction to Recent Research," *Economics of Innovation and New Technology*, 1: 3-41, and Shapiro, C. and H. Varian (1999), *Information Rules: A Strategic Guide to the Network Economy*. Cambridge, MA: Harvard Business School Press.

[vi] To read more detail about the events surrounding the 56K modem war, see, e.g., Augereau, Greenstein, and Rysman (2006), "Coordination versus Differentiation in a Standards War: 56K modems," *Rand Journal of Economics*, and Greenstein and Rysman (2006), "Coordination Costs and Standard Setting: Lessons from 56K." In *Standards and Public Policy*, Shane Greenstein and Victor Stango, eds. Cambridge: Cambridge Press.

[vii] Of course, this is but one of many examples of the FCC mandating technical specifications as national standards. For a broad discussion in the context of broadcasting, see Besen and Johnson (1986) *Compatibility Standards, Competition and Innovation in the Broadcasting Industry*. Santa Monica, CA: Rand Corporation or Farrell and Shapiro (1992), Standard Setting in High-Definition Television, *Brookings Papers on Economic Activity. MicroEconomics*, 1-77.

[viii] That statement is still true even if one accounts for all the slightly different flavors of USB, including 1.0, 1.1 and 2.0, albeit multiple versions make it more difficult to identify the precise date at which the community of users and vendors enjoyed their benefits.

[ix] For analysis of USB 2.0, which differs in many respects from the original USB, see Mackie-Mason and Netz (2006), "Manipulating Interface Strategy as Anti-Competitive Strategy," In *Standards and Public Policy*, Shane Greenstein and Victor Stango, eds. Cambridge: Cambridge Press.

[x] Once again, this is a long story with many complex details. For the full details, see Von Burg (2001), *The Triumph of Ethernet, Technological Communities and the Battle for the LAN*. Stanford, CA: Stanford University Press.

[xi] The Wi-Max Forum exists to, in its own words, "certify compatibility and interoperability of broadband wireless products" (see http://www.wimaxforum.org/home/), though, because actual implementations are scarce, now it seems to do mostly marketing and promotion.