Paper to be presented at the

DRUID Society Conference 2014, CBS, Copenhagen, June 16-18

Limits to increasing returns. Niche standards? role in limiting power imbalances in standards markets

Kristina Birgitta Dahlin
HEC Paris
Strategy
dahlin@hec.fr

Ranjita Singh
University of Amsterdam
School of Business
R.M.Singh@uva.nl

Annika Rickne
University of Goteborg
Business School
Annika.Rickne@handels.gu.se

Abstract

We propose that many dominant standards experience limits to increasing returns due to the existence of alternative standards. We propose factors that facilitate the emergence, gaining of a market foothold and finally, a stable market position for alternatives to dominant standards, that we label niche standards. While technical heterogeneity is a necessary condition for emergence, it is the relationship the dominant standards owner has with its adopters that create opportunities for niche standards to diffuse and gain a stable market position. We use the concept of power balance from resource dependence theory and focus on the relationships between owners and adopters in our predictions. In addition, we discuss two adopter industry structures: platform industries and modular industries. In the former adopters are independent decision makers that adopt sequentially, in the latter case firms adopt simultaneously as a cluster with one or a few decision makers, creating two different situations for niche standards.

Jelcodes:O33,-

Limits to increasing returns. Niche standards' role in limiting power imbalances in standards markets

Abstract

We propose that many dominant standards experience limits to increasing returns due to the existence of alternative standards. We propose factors that facilitate the emergence, gaining of a market foothold and finally, a stable market position for alternatives to dominant standards, that we label niche standards. While technical heterogeneity is a necessary condition for emergence, it is the relationship the dominant standards owner has with its adopters that create opportunities for niche standards to diffuse and gain a stable market position. We use the concept of power balance from resource dependence theory and focus on the relationships between owners and adopters in our predictions. In addition, we discuss two adopter industry structures: platform industries and modular industries. In the former adopters are independent decision makers that adopt sequentially, in the latter case firms adopt simultaneously as a cluster with one or a few decision makers, creating two different situations for niche standards.

1 Introduction

With increasing modularization of technology firms are becoming more specialized and interdependent (Schilling, 2000; Pil & Cohen, 2006) and as a consequence, coordination within and between firms depends on technical standards. Technical standards as a coordination mechanism contributes to cost reduction, not just by reducing duplicate R&D efforts and homogenizing technologies for firms, but also on a macro level: standards-based coordination is estimated to contribute 6% of Canada's GNP (Haimowitz & Warren, 2007) and to benefit the German economy by 18 billion euros a year (DIN, 2011). Standardization's impact on the economy motivates public investments and the OECD countries spend more than US$ 1 billion of public funds on standardization every year formulating thousands of standards[1].

Firms have become progressively sophisticated in dealing with standards, as the need has increased to navigate standards markets in addition to product markets for commercial success. As IP rights have changed, allowing for patent pools for instance, an intensifying focus on standards' revenue generating properties has lead to business strategies where some firms' primary income is based on licensing intellectual property rights in standards (e.g. Qualcomm); other firms with large R&D investments supplement their sales of products with licensing incomes (e.g. Philips, Sony and Microsoft), while still others chose to license their IP rights in standards for free, attracting more buyers to their products (e.g. Intel).

Academics have also increased their interest in standards (for some recent reviews see Narayanan & Chen, 2012; Quelin, et al., 2005). A literature focusing on competing standards has provided insights on how monopoly standards are created (Bekkers, Teagarden et al, 1999, Arthur, 1989, Schilling, 2002) and there are ample examples of standards wars with the focus on winner-takes-all situations (Shapiro & Varian, 1999). However, we argue that

[1]In 2008 IEEE, ISO and IEC, three of the largest international standards organizations have annual budgets of US$300 million, $125 million and $22 million; the European Committee for Standardization, CEN, has a budget of $30 million (each organization's website); the UK reportedly spends £6 million of public funds on national standards organizations on top of membership fees in international organizations (Swan, 2000); British Telecom spent £10 million; Intel, Microsoft and other large firms report membership in over 100 standards organizations, involving personnel costs when traveling and participating in standards meetings and legal and dissemination costs within the home organization, etc (various presentations, SIIT, 2007)

relatively few standards battles end up with a monopoly standard since the three necessary conditions for a winner-takes-all outcome -- that it is costly for users to adopt more than one technology; that there are network effects; and that there is no preference for special features (Narayanan and Chen, 2012; Eisenmann, Parker & Alsyne, 2006), are only met in a portion of all standards setting cases. In fact, we instead see a number of market structures not expected by increasing returns models.

In this paper we outline a series of propositions explaining (1) why multiple standards are likely to emerge, (2) what factors impact the likelihood of them gaining a market foothold and (3) what factors makes for stable co-existence of niche and dominant standards. We maintain that many standards that lose standards battles do not disappear but often retain a market share and survive as niche standards (West, 2007). In fact, we will argue that there are factors that limit the homogenization processes, resulting in other standards market structures besides monopoly: duopoly (2G cellular telephony signals), fragmented markets (screw head designs) and, maybe most common, markets with one dominant and at least one niche standard (computer operating systems). As the exploration of niche standards reveals a more complex standard setting process than the one discussed in winner-takes-all situations we bridge across technology- and firm-level factors and acknowledge the many constrains on firm actions, our model aims to help managers navigate the landscape and outline firms' strategic options.

2 Dimensions of standards

Technical standard definitions varies across studies (Tassey, 2000; Narayanan & Chen, 2012) but are all variations on ISO's definition that a standard is "a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose." (ISO, 2013).[2] As technical fields mature standards setting moves from establishing definitions and

[2] A common more far-reaching definition is "a standard can be defined broadly as the consensus of different agents to do certain key activities according to agreed-upon rules" (Farrell and Saloner, 1992; Nickerson and

measurements to developing a shared understanding, then deciding on reasonable operating conditions, and finally establishing interfaces to specify how parts of a system fit together (e.g. electrical outlets and power cord plugs) since even moderately complex technical systems tend to become modularized (David, 1987: 214; Krechmer, 2000, Pil & Cohen, 2006). It is the third standards type - interface standards or compatibility standards - that has evoked both the greatest interest from scholars and competitive tension among firms (cf. David & Steinmueller, 1994; Kahin & Abbate, 1995; Tassey, 2000). Only as long as interface parameters are kept constant, or change in predictable ways, can firms experiment with module design independently of what happens to other components (Ulrich, 1995).[3] In contrast, when interface parameters change there is a ripple effect, forcing module makers to adjust to the altered interface. Given their importance for coordination and firm competition we focus most of this paper on compatibility standards.

2.1 Standards market structures.

When there are competing ways to design an interface and there are clear advantages to minimizing the number of different standards versions, tensions often arise as to what will become the dominant standard (Arthur, 1990: 92). From a firm's perspective the stakes in standards setting are high since a firm can charge licensing fees if it owns intellectual property rights in the standard[4]. And, as it takes many years of R&D investment to develop a standard it is both costly and time-consuming in terms of e.g. revising product designs if a firm bets on a losing technology ().[5]

An common assumption is that there might be initial competition between standards

---

Muehlen, 2006). We prefer ISOs more specific one that, for instance, points out that a standard is explicit and described in a written document.

[3]The Internet is a highly modularized system with well specified and publicized public interface standards enabling it to accept new modules from thousands of different sources on a daily basis (IETF, 2008; W3C, 2008).

[4] Sony and Phillips co-owned patents in the CD-Rom standard and charged $.03 to $.045 in licensing fees per manufactured CD (Philips, 2008). From 1983 (when the standard was launched) and till 2008 over 200 billion CDs were sold worldwide (Jurrien, 2007). Assuming that half of all fees were paid, the two firms received between 3 and 4.5 billion US dollars in licensing income.

[5] A concept sometimes seen as parallel with technical standards is the idea of dominant designs. A dominant design is the technical configuration (aka a similarity standard, Kretchmer, 2001) that ends up with 50% market share in a technical market (Abernathy & Utterback, 1967). A dominant design sometimes coincides with a dominant technical standard but usually encompasses a larger combination of elements, such as the automobile dominant design of a car chassis with four wheels (Gallagher, 2007; Narayan & Chen, 2012).

formulations but that over time the competition will be resolved, ending with a single winning standard that prevails (Arthur, 1990; Quelin et al. 2005). The greatest attention in academic work on standards has been given to increasing returns and network effects causing "winner-takes-it-all" situations (David, 1985; Schilling, 2002), and some literature even presumes a final monopoly status of the standard, a single version of a technology in a geographical market (cf. Hill, 1997; Schilling, 2002). However, there is strong empirical support that it is mainly government mandated, *de jure*, standards that are likely to result in true monopoly standards (see Table 1), and even in the famous QWERTY case (David, 1985) there are plenty of alternatives holding majority positions in different geographical markets (such as AZERTY for France, and йцукен for Russia).

We observe coexisting standards in a large number of settings (Scott, 2008) and there are at least four discernable market structures related to standards: a) a monopoly standard (Arthur, 1986); b) a dominant standard with a large market share and one or more niche standards, c) a duopoly with two similarly strong standards (cf. Casadesus-Masanell & Ghemawat, 2006; Hemphill, 2006) and d) multiple coexisting standards with equally large market shares (see Table 1 for examples). The existence of different market configurations for standards has implications for both standards users and owners: it means that users have more than one technical solution to chose from, and even if a standards owner does not succeed in making their standard the dominant one, there is more than one attractive market position for the standard.[6]

Insert Table 1 about here

---

[6] While we generally assume that all standards owners want their version of a standard to be the generic market version, some manufacturers might aim for higher-margin niche markets, as evidenced by the existence of so called vendor-specific standards (cf. Updegrove, 2007).

2.2 Niche standards: adopter industry structures, relationships owners-adopters and the process of standards emergence

Standards battles are side effects of the increased specialization and technical complexity that require more coordination making standardization critical. Any time there is more than one standard that can solve the coordination problem, we expect competition for market share. Not all technologies are dependent on multiple parties conforming to a standard but in multicomponent systems such as platform technologies and modular products standards are highly critical. At the same time as both platform and modular product ecologies depend heavily on standardization, we will argue that differences between these two settings lead to different conditions for niche standards.

Compatibility standards define linkages between modules and products, and when we consider standards we also need to consider the relationships between the firms that are linked together by the standards, or the relationship between on the one side, standards owners and, on the other side, adopters. As in most business relationships parties have partly conflicting interests and we will use the tension between owners and adopters to explain why there are limits to increasing returns and other effects creating opportunities for the co-existence of multiple standards.

Investigating the relationships between owners and adopters allows us to connect levels of analysis: Quelin et al (2006) pointed out that models of standard competition either focus on the user (adopter) or the seller (owner). Narayanan & Chen (2012) call for studies that bridge levels of analysis from firm to population-levels and across different degrees of determinism on the other. We will examine different levels of analysis as we discuss technological heterogeneity as a necessary condition for multiple standards to arise; consider different standards setting modes; look at the role of the relationship owners and adopters and allowing for firm agency on both the owner and the adopter side.

The two main characteristics of owner-adopter relationships are mutual dependency and, more importantly, asymmetries in this dependency that leads to power imbalance between the parties (Pfeffer & Salancik, 1978; Casciaro & Piskorski, 2005). We will argue

that especially the power advantages dominant standard owners have over adopters limit the attractiveness of a dominant standard and opens up opportunities for alternatives. We use power advantage as well as other factors to predict the emergence, gaining of a market foothold and stability of niche standards.

3 Emergence, foothold and stability of niche standards

Standards, especially those connecting components in complex systems, act as technical infrastructure and have because of this a "considerable public good content" (Tassey, 2000). The public good aspect creates expectations from some stakeholders that the standard should be free, in particular if investments in the standard were originally publicly funded or based on collective action[7] (cf. Malamud, 1992; The Economist, 2005). However, private firms might make further R&D investments that results in them owning IP rights in a standard, with the expectation of earning rents from these investments. Standards owner rent-seeking comes into conflict with cost and access motives by standards adopters, who would prefer to use the standard for free. To manage conflicting interests between owners, adopters and the public, governments have been involved in some standards setting either as a standards arbitrator or through policies to manage conflicts of interests (Greenstein & Stango, 2007). However, government policies are mainly reactive and conflicting interests in the day-to-day work on standards is mostly managed by self-organized collective action mechanisms (standards committees) overseen by the WTO as well as self-organizing local communities often activated by limited access to a particular standard (Ostrom, 1990), or by using open market mechanisms.

It is in this context of conflicting interests that multiple standards can emerge and gain a foothold. We will discuss niche standard applying a three-stage process: emergence, initial diffusion and a stable market position. We will outline two factors that contribute to niche standards emergence, five factors that lead to a standard gaining a market foothold, and eight factors that help a niche standard maintain a stable market position. Given that many parties

[7] The internet being a case in point.

are involved in the standards process we will shift between technology, firm and industry levels of analysis in our discussion as suggested by Narayanan & Chen (2012).

3.1 Why multiple standards emerge

The starting point for standardization is the need to manage many actors joining forces in producing a product or service: "in a broads sense standards are simple agreements on a common usage and they have existed from the beginnings of orgnized society" (Thompson, 1954:2). The agreements specify how to link technologies and technical standards are necessary for a multi-component system to operate. The resources fought over in standards wars are licensing fees gained from a firm owning IP rights that allows it to charge others for using the linking technology. While the *ex ante* assumption is that having only one such technology is the best option from a systemic efficiency perspective (Greenstein & Stango, 2007), this is rarely the case. We will make two arguments about the emergence of multiple standards that focus on characteristics of the technology: First, a necessary condition for multiple standards to emerge is that the underlying technology is complex, which we translate into it having multiple performance dimensions, and secondly, that there is a trade-off between these dimensions, at least in the short term.

Technological complexity as a necessary condition for niche standards

When evaluating a technology (such as a signal frequency or an automobile engine) there are multiple performance dimensions to consider (signal strength vs range; gas mileage versus acceleration). This technical heterogeneity is a precondition for the appearance of multiple standards since it means that users may prioritize different dimensions (Foster, 1986). Engineers designing technical solutions face greater uncertainty about the optimal solution (assuming one exists) both (a) as a function of the number of performance dimensions and (b) the perception of relative importance of the different performance dimensions[8]. When it is cost-less to design and adopt a standard with high performance on all,

[8]It is often unclear what the most important performance dimension is and what the lowest acceptable performance level is.

or most, performance dimensions, we expect a single standard to emerge, but there is usually a trade-off between performance dimensions (achieving a long signal range lowers the signal power for wireless signals; good gas mileage means slower acceleration for automobiles) why multiple standards are likely to emerge, displaying different performance profiles. *When the videotape standards VHS and Betamax were competing over market share in the early 1970s they provided different performance along two performance dimensions, recording time versus image quality: While VHS offered longer recording time (originally 1 hr versus Betamax's 15 min), Betamax provided higher image quality. Despite being substitutes for one another, each standard ended up dominating one part of the market -- recording time was critical for home videos where the ability to record a film onto one cassette for rental favored VHS, while image quality dominated in importance for production houses making TV programs and films (Cusumano, Mylonadis & Rosenbloom, 1992).* We argue that technologies with a larger number of performance dimensions are more likely to see multiple standards options emerge.

3.2 How niche standards gain a foothold

Anecdotal evidence suggests that most technical standards have no adopters, which is also illustrated by national standards libraries that can contain over 100,000 documents, of which many are never read.[9] This means that formulating a standard is just the start of a diffusion process, where the next step is to gain a minimum market acceptance, a foothold. In this section we discuss the problem of getting someone to actually adopt a standard, especially if there is a pre-existing standard in the market. Assuming that technical performance differences between standards are small enough for a challenger standard to substitute for a dominant standard, the focus on breaking into a market will be on challenging the relationship between a dominant standard's owner(s) and its adopters.

There are three modes by which technical standards are established: government mandated standards regulated by law (*de jure* standards); collective action processes taking

[9] The American National Standards Institute has 180,000 standards from 80 SDOs in their library. An anonymous source at the German Standards Institute claims that 90% of standards documents in their library are never accessed by anyone.

place in standards developing organizations, SDOs (committee standards); and by market competition establishing de facto standards (Krechmer, 2000; Farrell & Saloner, 1988).

D*e jure* standards involve technologies important from a public good and policy perspective (harmonization of electrical current to improve efficiency or safety standards such as pollution levels) and at times act as policy instruments protecting national industrial interests, usually by raising entry barriers for foreign firms (Yan, 2007; Gao, 2013)[10]. *De jure* standards are also a way to control predatory behavior by standards owners. *De jure* standards change when rendered obsolete due to technological evolution and/or new regulations[11].

The largest Standards Development Organizations follow guidelines issued by the World Trade Organization (WTO, 2008) and adhere to the three principles of consensus, universal applicability and openness[12] [13] (ISO, 2008) irrespective of technology (Schmidt & Werle, 1998). SDOs play a dominant role in standardization, as can be seen from the number of active committees: the four largest trans-national SDOs[14] currently run over 5000 standards initiatives (as of January 2014). SDOs are as a form of collective action: engineers that carry out the standardization work are employed by member organizations not the SDO. The SDO itself has a skeleton staff that supports the formation and running of the committees, but the committees are really a meeting point for self-designated interested parties to self-regulate.

While the benefit for standards owners participating in SDOs is collaboration and easier acceptance once a standard is agreed upon (Leiponen, 2008, ;Simcoe, 2007), one of the limitations of SDO standards is that the output, the standard, has to be licensed following FRAND conditions, that is, licensing fees should be fair, reasonable and non-discriminatory: all adopters should have the same access at the same cost (Economist, 2005). FRAND

[10] Chinese government's 3G cellular standard differs from standards established in other markets (Yan, 2007); French SECAM TV signals are incompatible with NTSC or PAL signals used in most of the world

[11] An example is the on-going EU "harmonization" which replaces national standards with a single EU standard and increasingly stringent car safety and environmental standards.

[12] "all interests are taken into account", "solutions to satisfy industries and customers worldwide" and "based on voluntary involvement of all interests in the market-place." (ISO, 2008).

[13] Any SDO member can organize a committee to set a standard (IEEE, 2008). Committees invite all SDO members to get involved with the standard and, finally, a standard is only approved after a general vote by SDO members. After approval, a standard is published and disseminated by the SDO, often via on-line standards libraries.

[14] "The International Organization for Standardization", ISO; "The International Electrotechnical Commission", IEC; and "The International Telecommunication Union", ITU (all based in Geneva); and IEEE (based in New York).

conditions limit potential revenues from a standard since the pricing is controlled by the SDO.

Market standards, also known as *de facto* standards, are the topic of most increasing returns and winner-takes-all models in management (Farrell & Saloner, 1988; Arthur, 1989; Schilling, 2002; Hill, 1990). A market standard is defined as the standard among a set of competing alternatives that are chosen by the largest number of adopters. Market standards are different from government and SDO standards in that they don't use an intermediary between a standards owner and adopters[15].

Market standard IP owners can set licensing and access conditions more freely than IP right owners with SDO-set standards can (Kipnis, 2000). In extreme cases of proprietary market standards, a single firm has dominating control of the standard (*Qualcomm for the 2G CDMA standard in cellular communications*) but more commonly a group of firms join forces in a consortium and charge participants (*Sony and Philips for the CD-Rom standard; the USB standard*). There is a natural time limit for how long a firm can earn rents from their IP rights, the patent life span (max 20 years from filing) and in order to maintain a revenue stream from a standard it has to contain patentable new technology, which both motivates the current owner to keep developing the standard but also offers an opportunity for adopting firms to vertically integrate into owning some right in the standard, offsetting dependency vis-à-vis the original owners.

Besides proprietary market standards there are open market standards. These are freely available to everyone without charge (examples are most safety standards and the operating system Linux). There is some mixed evidence that firms on the one hand seem to migrate towards open standards in complex systems but on the other hand, managerial cost often matters more than financial in adoption of complex standards, why proprietary standards sometimes are preferable (Zhu, Kraemer, Gurbaxani & Xu, 2006). In addition, when standards owners are able to charge licensing fees they have an incentive to update the standard and generate new patents that extend the period of time for which they can charge

[15] Many market standards actually use SDOs to coordinate producers and then the market setting to gain adopters.

the fees[16] and this greater promise to maintain a standard makes some users prefer proprietary standards rather than open ones (Singh, 2008).

The relationship between standards owners and adopters: mutual dependency

Adopting a standard that is critical to a firm's product or process technology has far-reaching consequences, since it impacts cost and quality of its production. When there is more than one standard fulfilling a technical function, potential adopters have a choice of what (rather than just whether or when) to adopt.

The adoption of an evolving standard establishes mutual dependency between owners and adopters -- owners need adopters to first select and then test, help improve and keep utilizing the standard (paying licensing fees and/or undermining the market power of alternatives); while adopters need owners for access to a high quality standard. When adopters choose between multiple standards for a function, in order to assess future cost and access to a standard, adopting firms care not just about the current technical and economic value of a critical standard but also about three aspects of their relationship with the standards owners[17]: the *power balance* between themselves (the adopter) and the standards owner; how *heterogeneously adopters are treated* by the owner; and *behavioral uncertainty* associated with the owner (the risk for hold up and moral hazard after adoption). All three factors impact the absolute as well as the relative (compared to that of adopting competitors) cost of adoption and, in summary, our propositions are that even under conditions of increasing returns, the opportunity for a niche standard to gain a foothold is greater when the dominant standard has an owner that treats adopters heterogeneously and when uncertainty about the dominant standard owners behavior leads to uncertainty about future costs of the standard, and that both these factors depend on the power balance owner-adopter (see Figure 1).

Power balance

[16]The CD-Rom optical storage standard was jointly owned by Sony and Philips. When patent protection for the CD-Rom expired, the same firms introduced a DVD standard to replace it. The Sony/Philips DVD was challenged by a consortium lead by Toshiba, and the conclusion of this challenge was product sharing features from both versions and split royalties. A third round in the fight over optical storage standards, the BluRay (Sony/Philips) – HDDVD (Toshiba) war was fought to initiate new fee requirements and a revenue stream from intellectual property rights in the standard.

[17] For simiplicity we will use owner in singular even thought there might be more than one party holding IP rights, and, hence, own a standard.

Exchange theory (Evans, 1952) and resource dependence theory (Pfeffer & Salancik, 1978) state that firms prefer situations with low dependency. However, more important than the degree to which a firm depends upon another is whether this dependence is asymmetrical, conferring a power advantage to one of the parties (Pfeffer & Salancik, 1978; Casicaro & Piskorski, 2006; Singh, 2008). As an adopter selects a standard and becomes dependent on it in order to deliver its own products or services, the standards owner is, in turn, dependent on adopter revenue to maintain and develop the standard[18]. We have power balance when both parties depend equally on each other (for instance when there is a so called vendor standard between one owner and its single customer (Updegrove, 2007) and an imbalance when one is more important than the other (*for instance the adopter when Qualcomm needed a first adopter of its 2G cellular standard in the US, while the potential adopters had at least one other tested standard to choose from*).

An owner has a power advantage when there are many prior adopters of its standard, making the new adopter's revenue contribution relatively small; or there are no viable standards alternatives, giving it a monopoly position. In either of these cases, an adopter is more motivated to look for alternatives since there are two unattractive features of power imbalance for the adopter: it might introduce heterogeneous treatment of adopters and it increases behavioral uncertainty, that is, the risk that access to and cost of the standard is altered by the owner.

Heterogeneous treatment of adopters stems from a combination of: (1) adopter discretion over their adoption decision, and (2) adopters' market power vis-à-vis the standards owners. These two factors are determined by both the importance of the standard to the adopter (does the adopter have to adopt?), the standards supply situation (is there more than one alternative?) and the size and/or status of the adopter in the market place. A large adopter will represent more of the overall market, and therefore have greater market power than a smaller adopter, but the first adopter of a standard will represent 100% of the owners'

[18] This revenue can be direct from licensing fees or indirect throught the sale of product the adopter is helping make more valuable on the market.

revenue, and be important even if small.

Adopter discretion and heterogeneous treatment

Adopter discretion describes how much influence potential adopters have over their adoption decisions and in Lawrence, Winn & Jennings' (2001) classification, adopters are either *objects* if they are forced to adopt or *subjects* if they can make the choice whether to adopt or not. We find a third role in standards setting: that of *active subjects.* These are firms that influence what is being adopted, that is, firms that participate in setting the standard (for instance by joining an SDO or a market-based alliance or consortium). Without adopter discretion, niche standards are unlikely to diffuse and gain a foothold.

When adopters do have discretion and there are multiple standards to choose from, owners have come to employ a variety of persuasion tactics to win over adopters. The two dimensions owners control are price and access to influence the standard. A broader portfolio of persuasion tactics is a sign of heterogeneous treatment of adopters: while some are granted special status and seen as key decision makers (that is, treated as subjects or active subjects), less attractive adopters are treated as objects, assumed to go along with the "winning" standard once one has emerged.[19] Differential treatment of adopters provides some adopters with better conditions by the standards owner, while other adopters are underserviced. And while not all adopters are interested in being active subjects, few like being discriminated against compared to their competitors who might get better access and/or lower licensing fees. In fact, a relative disadvantage compared to competitors raises the focal firm's relative cost and, thus reduces the (perceived) advantage of the dominant standard has over the niche standard. That some adopters have influence over a standard at the same time as less attractive adopters' needs are ignored, makes some adopters select a niche standard that will serve them better and whose owner will pay them more attention.

Behavioral uncertainty

[19]Sony used all these tactics when establishing BluRay as a storage media standard: Making the performance argument against the strongest competing standard, Toshiba's HD-DVD; inviting key firms into a consortia; striking a special deal with WalMart, the world's largest seller of storage media (presumably offering lower licensing costs to the retailer), and vertical integration into film studios, thus impacting their decision as to which standard to adopt.

Behavioral uncertainty refers to the risk that a standards owner changes access, cost (absolute or relative) or stops maintaining a standard after a firm has adopted it and is locked in with switching cost (Williamson, 1990). Again, we expect the power balance between adopting and owning firm to matter here: more powerful adopters are at less risk for unilateral licensing fee increases, for instance, and, if these are attempted, they are also better at withstanding them (they might simply refuse to pay or sue over royalty increases (Singh, 2008; Fosspatents, 2013). Still, behavioral uncertainty is not only about the power balance between an adopter and an owner, but also about an owners' behavioral pattern. Some standards owners have a history of raising fees or abandoning standards and we expect such owners' behavior to make adoption less attractive, and that risk averse or adopter who find this behavior morally questionable will be willing to accept possible disadvantage of adopting a smaller standard in an increasing returns market, or of incurring the higher cost of adopting two standards simultaneously, in order to lower their dependency on the dominant standard.

When adopters cluster together – module markets

Adopter industry structure is another dimension that impacts niche standard acceptance. Most models of standards adoption assume that adopters make independent decisions and make these sequentially, when instead many adoption decisions are made by clusters of firms at one point in time (Thompson, 1954). In contrast to platform settings where complementary products can be developed in parallel to one another, developing modules for a single product involves recursive interactions requiring intense coordination between firms (Teece, 1987; Thompson, 1967). Complex products produced by a group of firms each specializing in making one module of the product is highly demanding in terms of coordination and interface standards are critical in ensuring interoperability of all modules. When there are a large number of modules, the ensuing structure is a highly complex system of interlinked firms (Pil & Cohen 2006). As a consequence, modules in a product eco system need to adopt the same standard(s) to work well and joint decision-making results in a coarse-grained market consisting of clusters of firms rather than of independent targets.

In a modular cluster (the ecology around auto, airplane and computer makers are all

examples), all firms are not equal: dependencies between firms are asymmetrical and some firms are more influential than others. A firm holds more power the fewer alternative producers there are and the harder the firm is to replace (Pfeffer & Salancik, 1978; Porter, 1980; Casciaro & Piskorski, 2006). As a consequence, modularized industry structures can be described as a few central firms surrounded by satellite firms (Carlsson & Jacobsson, 1991; Afuah, 2000)[20] that make modules that are more easily substituted for. Decisions made by central firms affect the way in which an industry or technology develops and have a profound impact on satellite firms (Carlsson & Jacobsson, 1991). Standards adoption decisions are decisions made by a central firm and then 'imposed' on its satellites in its power of being the central node in that particular cluster or network. Or, the cluster of firms has one (or a few) subject(s) – the central firm(s) while most other firms are objects. Satellite firms that do not follow a central firm's adoption decision might need to switch cluster or exit the industry.[21]

When standards are adopted by clusters of firms and not by individual firms making independent choices, the impact of installed base and complementary assets are diminished inasmuch as satellite firms mainly care about the installed base of the cluster they interact with. When industries are structured into central and satellite firms, adopters have heterogeneous discretion over standards adoption. However, this heterogeneity is not caused by standards owner behaviors, so when a central firm makes a system-wide decision, most satellite firms find the situation acceptable – firms in modular systems are used to high coordination needs and centralized decisions (Carlsson & Jacobsson, 1991).

---

[20] The computer industry illustrates this heterogeneity in firm influence: most microchips are made by one of four firms (Intel, AMC, Motorola, or IBM); the video card is made by one set of firms; monitors, housings, and keyboards are made by still another set; etc. While all parts are necessary for the end product, some modules are less costly to redesign and adapt (the plastic shell), and the brand-name-owning computer firm that assembles the final product has full control over these subcontractor and is able to specify the design of such modules according to its wishes. In contrast, brand-name-owning computer firms are not in control when dealing with microchip firms, since a microchip supplier has greater control over the other modules that interface with its chip: massive fixed costs in R&D and economies of scale in manufacturing means that few firms can compete in making this module and there are also few potential entrants due to high entry barriers.

[21] Moreover, frequently the decision about a standard is *not* to adopt but to stay with an old, established standard. If a central firm decides not to adopt a new standard, it means that its satellite firms will abstain or at least delay their adoption. This pattern of a central firm sticking to an old inferior technology and not wanting to cannibalize the rents from previous investments (Reinganum, 1987) can be seen in the example of the operation of Knowles Electronics, a hearing aid component maker. Knowles holds such a volume- and cost-leadership position that its unwillingness to include new miniaturization technology forces its customers, satellite firms in the system (e.g. Siemens, who assembles and sells the end product) to delay introducing new technology in their products.

Having fewer decision-makers results in a more coarse-grained decision environment and since each adopting cluster of firms, constitutes a larger share of the market, the power balance between standards owner and adopting clusters is more in favor of the cluster.

While the more even power balance adopter-owner improves a cluster's power position with the dominant standard and this could make a cluster less interested in a niche standard; however,we instead expect a modularized industry to be more conducive to niche standards. The reason is that a cluster's sensitivity to installed base should be lower since when adopters are in a cluster it's the interdependences *within* business systems that are more important than those *across* such systems, allowing performance-based criteria to play a greater role.

Moreover, clusters of firms are often differentiated vis-à-vis each other (*BMW vs Mercedes*). This can have two positive effects on the likelihood of adopting a niche standard: When the standards choice contributes to the differentiation dimension, the adopter might prefer a niche rather than a dominant standard since it highlights the difference across clusters. And, at the same time the adopter's power balance will be more favorable with a smaller niche standard than a larger dominant standard.

What standards setting mode generates most niche standards?

Comparing heterogeneity in adopter treatment and behavioral uncertainty across standards setting modes, it is clear that *de jure* standards exhibit both the lowest heterogeneity in adopter treatment and the lowest behavioral uncertainty. *De jure* standards treat all adopters as objects and coercive pressures are high with financial penalties and, at times, jail sentences as consequences for non-compliance, and, thus, niche standards are unlikely to gain a foothold. Since the standards owner is different from the enforcer, behavioral uncertainty is less of a factor but presumably the enforcer will monitor behavioral uncertainty.

A key objective of committee standards, besides coordination, is to control owner behaviors by declaring that (F)RAND conditions should be met for any standard endorsed by the SDO. For standards owners there is a trade-off using SDOs for standards setting: SDO standards enjoy great legitimacy because of these F(RAND) principles, but also for the way they handle competing standards: parallel committees can formulate specifications for

different standards concerning the same technology; in exchange for the legitimacy gained, there is less room to negotiate licensing fees and control access. In essence, SDO standards attract adopters since an SDO endorsement exert a normative pressure on adopters to accept the SDO standard, at the same time as the open invitation to participate allows adopters to influence the standard. The open invitation makes resistance less legitimate and adoption more acceptable for non-participants given that they get to chose their level of discretion (subject or active subject) and heterogeneous treatment of adopters is forbidden.

Even though SDO processes are perceived as fair and involve parties with competing interests not everyone gets heard. Standards owners (firms doing R&D related to the standards and therefore holding IP rights in the standard) attempt to influence the process, at times trying to persuade committees by sending many representatives in hope that strength in numbers will help their version of a standard gain ground (Garud & Kumaraswamy, 1995; Garfinkel, 1998).[22] Difference in participation affects the decision-making power among target members, and non-participating users are less likely to adopt SDO enforced standards compared to the de jure standards.

The advantage for standards owners in participating and getting your standard SDO approved is that the mode is persuasive in itself and helps with diffusion of the standard. Adopters searching for suitable standards also search relevant SDO libraries, further helping with exposure and diffusion. The disadvantage in participating and getting your standard SDO-approved is that no special deals are permitted that could draw the most attractive adopters to the standard. This matters most for powerful owners, while small and medium sized firms have weaker power positions vis-à-vis powerful owners and therefore usually benefit more than they lose from participating in SDOs (Leiponen, 2008).

Since the upside to getting SDOs to approve your standard is so high, there are sanctions in place if owners abuse the SDO statutes (cf. Stern, 2007). Hence, coercion from SDOs is normative while at the same time the process leaves room for alternative standard formulations (sometimes developed within the SDO), emphasizing the weaker pressure to

[22] A sign of SDO power is the attempts some firms make to block or delay such standards.

adopt an SDO-set standard compared to a de jure standard.

Finally, market standard is the mode most likely to offer a foothold for a niche standard. It's the mode with the highest level of heterogeneous treatment of adopters and the highest behavioral uncertainty. As a consequence of there being no intermediary between owners and adopters, owners rely on a portfolio of persuasion tactics. The necessity for standards owners to engage in several ways to impact adopters and differentiate between them leads to further heterogeneity in adopter treatment.

3.3 Propositions: Why niche standards emerge and how they can gain a foothold

Based on our reasoning we make two propositions regarding emergence of a niche standard, and five propositions with three corollaries regarding the likelihood of niche standards gaining a market foothold:

Predicting emergence:

P1E: The more performance dimensions a technology has, the greater likelihood that multiple standards emerge.

P2E: Multiple standards are more likely to emerge in a technology that has multiple performance dimensions and trade-offs in optimization across these dimensions.

Predicting market foothold (see Figure 1 for a graphic summary):

P1F: The more heterogeneously adopters are treated by a dominant standards owner, the greater the likelihood that a niche standard can gain a market foothold.

P2F: The greater the differences in market power between adopters, the greater the likelihood that a niche standard can gain a market foothold.

P3F: The greater the behavioral uncertainty regarding a dominant standards owner, the greater the likelihood that a niche standard can gain a market foothold.

P4E: The greater the heterogeneity in adopter discretion, the greater the likelihood that a niche standard can gain a market foothold.

> ***Corollary 1***: Niche standards are most likely to gain a foothold when the dominant standard is set by the market than when the dominant standard is set by a SDO or is a de jure standard.
> ***Corollary 2***: Niche standards are the least likely to gain a foothold in the presence of a de jure standard.

P5E: Industry structure matters: When adopters make joint standards decision, the likelihood is greater that a niche standard can gain a market foothold.

Corollary 3. Niche standard are more likely to gain a foothold in a modular than a platform industry.

4 How niche standards gain stability

Standards diffusion is a dynamic process where the technology evolves as does the power balance between owners and adopters, impacting both attractiveness and switching costs of standards. Technological evolution, especially in quickly developing technologies, usually lead to cost decreases that grows the market for the technology and attracts new adopters. More adopters impact the power relationships in standards setting which standards owners need to consider if they wish to gain and maintain stability for their niche standard.

A niche standard will enjoy stable market position if it can maintain its user base. Maintaining the user base means doing at least one of two things: (1) conserving the switching cost for its own users vis-à-vis the dominant standard or (2) lower the switching cost for dominant standards users vis-à-vis itself. In contrast, a dominant standard that enjoys increasing returns at a higher rate than the niche standard poses a threat since the switching costs for the niche standards users converting to the dominant standard is lowered. In the next sections we will discuss how standards characteristics, differences in platform and modular product markets, dominant standards behaviors and the creation of adapters can all impact niche standard stability.

4.1 Technical quality and differentiation

The necessary conditions for niche standard emergence -- optimizing on a different technical performance dimension than the dominant standard-- means that a niche standard can be characterized as a differentiated product. As with traditional differentiated products, to enjoy a stable market position a niche standard needs to outperform the dominant standard at some (or several) performance dimension(s) at the same time as there exists a distinctive

market niche that values that performance advantage (Tirole, 2001)[23]. *Returning to the magnetic videotape case, the two market niches (consumers and video makers) were stable until optical and digital storage methods outperformed and replaced both VHS and Betamax collapsing both market niches into one*.

Differentiated products attract users since they have some specialized features that serve a section of the market better than a generic product does. To retain stability, and keep offering a higher value compared to a dominant standard, as in the product differentiation case, a niche standard needs to at least maintain the differentiation advantage towards a dominant standard.

To maintain its differentiation advantage a niche standard has to be flexible, that is change over time, by responding both to technology push from competing standards and adopters and market pull from current and potential adopters (Meek, 1996; Singh, 2008). Technology push can originate from the technology evolving or from firms that want to refresh and evergreen IP rights, and requires flexibility to maintain a standard's relative performance (Bekkers, 2001). Similarly, evolving market needs can change original standard formulations substantially (Barke, 1993) as increasing market expectations need to be met or the standard risks being abandoned by its current adherents. Furthermore, a flexible dominant standard is likely to over time incorporate the differentiating features of the niche standard (*Betamax increased recording time on tapes, VHS increased the image quality*), undermining the original differentiation difference, why a niche standard has an incentive to be equally or more flexible than the dominant standard, to maintain its differentiation distance and preserve market attractiveness. This means that the rate of change of key niche standard performance dimensions (fuel consumption, network range) needs to be at least the same as the dominant standard's rate of change on the performance metrics.

[23] If one extreme case is a monopoly standard with 100% market share, the other extreme is standards that are unique to each user (Braunstein & White, 1985). This signals that demand is so heterogeneous that customers' technical needs exceed any value to homogeneity.

4.2 Industry structure and its impact on stability

Compatibility standards play an integral role in two quite different settings: when coordinating platform products and when coordinating modular products. Platform and modular industry structures differ both in adopter discretion, coordination and timing of decisions: The "classic" standards battle backdrop in the academic literature is the two-sided platform with atomistic decision makers in competition with each other on each side, all with full discretion over their decisions and, importantly, adoption decisions are sequential; the modular product situation sports tightly linked non-competing firms with heterogeneous decision power, firms coordinated both with respect to what is adopted and when it is adopted. As a consequence, platform markets are fine grained with many decision points allowing for path dependence in installed base, while modular markets are coarse grained with few, or a single, decision point where competitors' adoption choices matter much less.

Platform technologies

The first point we want to make is that there is often more than one increasing returns community in a technology (*using the Win/Dos vs Apple/Unix example*) with lock-ins of users and some complementary product producers in each community (Arthur,1987).

Notwithstanding a dominant standard's larger installed base, a niche standard maintaining a *sufficiently* large installed base can attract complementary product producers and end users and be able to maintain a stable market share (Arthur, ibid). In fact, in line with our previous reasoning about the effects of power imbalance, a dominant standard with a large power advantage vis-à-vis adopters can unintentionally help in strengthening a niche standard: as increasing returns changes the power balance between owners and targets over time, this is likely to introduce heterogeneity in target treatment between early and late adopters (Mackie-Mason & Netz, 2007): Since early adopter's decisions are critical to the standards owners' attempt to get an early lead in a standards race, early

adopters are likely to get more favorable adoption conditions (lower licensing fees and more influence over the standard formulation, for instance) compared to later adopters. As more adopters join the dominant standard, owners' power advantage increases over time, with later adopters facing less attractive conditions. In other words, heterogeneous treatment of adopters is built into the market-based increasing returns cycle. This means that it might be less advantageous for later adopters to choose the dominant standard, and a niche standard with a foothold in the market, can attract adopters from the dominant standard, either by offering more equal treatment across adopters (signaling fairness and lower behavioral uncertainty) or by offering better adoption conditions to some of the adopters that would be worse treated by the dominant standard.

Adopting more than one platform standard

Further strengthening the niche standard and cementing a market structure with more than one standards option, is adopters' increasing willingness to adopt more than one standard. Three factors increase complementary product producers and users' willingness to participate in multiple standards communities: the absolute cost of adoption is likely to decrease as a technology evolves; the cost of adopting a second standard is offset by a growing niche standard market; and the dependence on the dominant standard decreases yielding a more favorable power balance.

Decreasing cost of adoption in combination with a larger market jointly improves the financial incentives to adopt a second standard. Decreasing adoption costs undermines one of the necessary conditions for winner-takes-all situations: that it is costly to adopt more than one technology (Naraynan & Chen, 2012). As niche standards markets either grow or, in a stagnant technology, end up as the remaining market niche to conquer, over time the interest for adopters (either end user or complementary product producers) increases in accessing to the full user base (if being a complementary product producer) or the full set of complementary products (if being an end user). While both cost decreases and market attractiveness of niche standards adoption has a side effect of lowering the power advantage of a dominant standard over its adopters, reducing the power advantage is often

an objective in itself, and an additional motivation for adopters joining a second standards community.

Video game consoles are a good example of users and complementary product producers adopting multiple platforms: while in the early stages of this technology most users had only one of the competing platforms with its associated, and usually proprietary games; today a majority of users own multiple platforms and key game designers adapt their games to at least two platforms.

Modular technologies and niche standards stability

Interface standards for modular products are selected for all members of a modular cluster at once since the objective of the standards adoption is to make components function together. Once a central decision has been made as to which standard the cluster should use, we expect this decision to be harder to change than when decision are made independently by each firm.

A cluster adoption is more stable because of the coordination cost required to change a central decision. The advantage of a modular system over an integrated on is that a higher efficiency in subsystems outstrips the coordination costs to manage the system. Still coordination costs makes it harder to revert coordinated decisions: the total switching cost for the cluster involves the switching cost for each module plus the coordination cost across modules. The coordination cost comprises the time it takes to implement the decision, even if there is a central decision maker the satellite firms need to be informed and have a say and there is always the risk that some module makers prefer to leave the cluster rather than face the switching cost.

However, all clusters are not equal, in some clusters module makers supply multiple clusters and if standards are varying across clusters, some module makers have already adopted more than one. The higher the share of module manufacturers that have adopted more than the niche standard, the less stable is the standards choice for the cluster since only those module makers that exclusively use on standard will incur a switching cost. The coordination cost is still there but the total switching cost for the cluster is lower.

In summary, we expect a niche standard foothold to be more stable in course grained markets – after all, an entire cluster of firms would need to abandon a standard before

adopting a new one. We also expect clusters with module makers that service multiple standards to have lower stability, which is the opposite of what we expect for the platform setting: there adopters adopting multiple standards enhances niche standard stability.

4.3 Connectors -- Bridging competing standards

Creation of *connector modules* is a technical solution that also changes standards competition. Connectors allow products designed for one standard to work with complementary products designed for other standards. Connector modules make the existence of competing standards less invisible to users who no longer need to choose between them.

Connectors do not only provide access to a larger market for adopters by reducing or even removing users' switching costs, it can also make complementary product producers' switching costs irrelevant: rather than abandoning the niche standard and adopting a dominant standard, connectors allows producers to keep their core technology (Eisenman, Parker & Van Alstyne, 2007).

Fundamentally, a connector lowers the cost of accessing multiple technologies, one of the key criteria for winner-takes-all situations. Niche standards should benefit when winner-takes-all conditions are undermined.

For example, a connector in the form of an added electronic circuit makes cellular telephones able to switch between competing networks, independent of what standard the network uses. For the period 2000-2005 about 66% of all cellular patents involved inventions that bridged the two competing cellular standards in the North American market (Singh, 2008). In computer operating systems, the niche producer Apple sells machines that can run both the dominant Windows and its Unix-based Mac operating systems. Connectors allowing seamless switching between standards can also be observed for de jure standards such as electrical current (110 versus 220 volts). Even if adding a connector leads to higher costs, expensive products that travel across geographical areas, such as laptop computers, warrant this cost.

A central question is, of course, who creates the connector? When it is the creation of

one of the standards owners, it can be a sign of weakness or of aggression: either a way to access the full market or to make oneself more attractive to adaptors by allowing them seamless access to the competing market sphere. We will therefore contend, that for a niche standards owner developing connectors can be one way to improve stability.

In the platform setting a connector undermines the dominant standard's increasing returns advantage as it lowers switching costs and offer complementary product producers and users access to multiple increasing returns ecologies, with added advantage of lowering of the dominant standard's power advantage – there is now a credible alternative.

In the modular product setting where each module maker exclusively supplies one cluster and have no interest in extending its market, there is little advantage for niche standards owners to develop adapters. However, when clusters are more interlinked, a connector offers module makers the option of supplying competing clusters that use different standards, and here we expect advantages for niche standards when introducing connectors – the entire cluster is not likely to switch from a dominant to a niche standard (or the other way around) while allowing module makers to service more than one standard will make the niche standard more attractive and also undermine the power position of the dominant standard.

In cases where a niche standard has a lower market penetration due to late market entry and have a strong differentiation advantage, using connectors would be a way to get over entry barriers. The risk with connectors is, of course, that adopters migrate away from the niche to the dominant standard, but overall we think it is a way to preserve stability for all parties.

4.4 How niche standards retain stability

Based on our discussion, we make eight propositions, with one corollary (see Figure 2 for an illustration).

P1S: A niche standard is more likely to enjoy a stable market position when the technology is complex and there are market niches with different technical performance needs.

P2S: A niche standard is more likely to enjoy a stable market position when it maintains its differentiation distance to the dominant standard.

Corollary: A niche standard is more likely to enjoy a stable market position when it is at least as flexible as the dominant standard.

P3S: A niche standard is more likely to enjoy a stable market position when the cost of adoption is decreasing.

P4S: A niche standard is more likely to enjoy a stable market position when the dominant standards owner treats adopters heterogeneously.

P5S: A niche standard is more likely to enjoy a stable market position in a platform setting when adopters adopt more than one standard.

P6S: A niche standard is more likely to enjoy a stable market position in a cluster setting when more module makers only adopt the niche and not the dominant standard.

P7S: A niche standard is more likely to enjoy a stable market position in a platform setting when the niche standards owner develops connectors.

P8S: A niche standard is more likely to enjoy a stable market position in a cluster setting when the niche standards owner develops connectors AND module makers service multiple standards.

Insert Figure 2 here

---

5 Summary

We discuss under what circumstances multiple standards emerge, diffuse and achieve a stable market position, and our arguments state that there are limits to increasing returns to dominant standard. Using resource dependence theory we look at the relationship between standards owners and adopters and argue that adopters dislike assymmetrical relationships, which opens up possibilities for niche standards to attract underserviced adopters. Furthermore, over time as the cost of a technology decreases and the income from in increases, the NPV of adopting a niche standard is enhanced, why many adopters chose to

adopt more than one standard – both to access the entire market and to diffuse the power a dominant standards owner has over the adopter. In fact, the necessary conditions underlying for a winner-takes-all situation are undermined when the cost of adoption plummets.

REFERENCES

Afuah, A. 2000. How much do your competitors' capabilities matter in the face of technological change? *Strategic Management Journal,* **21**: 387-404.

Arthur, W.B. 1989. Competing technologies, increasing returns, and lock-in by historical events, *The Economic Journal*, **99**: 106-131

Arthur, W.B. 1990. Positive feedbacks in the economy. *Scientific American*, Feb: 92-99.

Augeray, A., Greenstein, S. and M. Rysman. 2004. *Coordination Vs. differentiation in a standards war: 56K modems.* National Bureau of Economic Research, Working Paper 10334.

Axelrod, R., Mitchell, W., Thomas, R.E., Bennett, D.S., & Bruderer, E. 1995. Coalition formation in standard-setting alliances *Management Science*, 41: 1493-1508.

Barke, R. P. 1993. Managing technological change in Federal Communications Policy: The role of industry advisory groups. In Sabatier, P.A. & Jenkins-Smith, H.C. (eds.) *Policy Change and Learning: An Advocacy Coalition Approach*. Boulder: Westview Press

Bekkers, R. 2001. *Mobile Telecommunications Standards: GSM, UMTS, TETRA and ERMES.* Artech House, Inc. London, UK.

Besen S.M. & Farrell, J. 1994. Choosing how to compete: Strategies and tactics in standardization. *Journal of Economic Perspectives,* 8: 2.

Braunstein, Y.M., & White, L.J. 1985. Setting technical compatibility standards: an economic analysis. *The Antitrust Bulletin*, 31:3.

Carlsson, B. & Jacobsson, S. 1991. What makes the automation industry strategic? *Economics of Innovation and New Technology*, 1: 4.

Cusumano, M.A., Mylonadis, Y., & Rosenbloom, R.S. 1992. Strategic maneuvering and mass market dynamics: VHS over Beta. *Business History Review*, Spring.

David, P. A. 1985. Clio and the Economics of QWERTY**.** *American Economic Review*, 75: 2.

David, P.A. 1987. New standards for the economics of standardization in the information age. In Dasgupta, P.D. & Stoneman, P. (eds.) *Economic Theory and Technology Policy*. Cambridge University.

David, P.A., & Greenstein, S. 1990. The economics of compatibility standards: An introduction to recent research. *Economics of Innovation and New Technology*, 1: 1.

David, P. A. & Steinmueller, E. 1994. Economics of compatibility standards and competition in telecommunication networks. *Information Economics and Policy*, 6: 3-4.

Eisenmann, T., Parker, P. & M. Van Alstyne. *Platform envelopment*. Working Paper 07-104, Harvard Business School.

Farrell, J. & Gallini, N. 1988. Second sourcing as a commitment. *Quarterly Journal of Economics*, 103: 4,

Farrell, J., & Saloner, G. 1988. Coordination through markets and committees. *Rand Journal of Economics*, 19: 2.

Farrell, J. & Simcoe, T. 2007. Choosing the rules for formal standardization. *Advances in Economic Analysis and Policy*. Berkeley Electronic Press.

Foster, R.1986. *Innovation: The attacker's advantage*. Summit Books, Simon & Schuster New York.

Gallagher, S. 2007. The complementary role of dominant designs and standards. IEEE Transactions on Engineering Management. 54(2): 371-379.

Garfinkel, S.L. 1998. The Web's unelected government. *Technology Review*, November/December: 38-46.

Garud, R. & Kumaraswamy, A. 1995. Technological and organizational designs to achieve economies of substitution. *Strategic Management Journal*, 16: 1.

Granovetter, M. 1985. Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91: 481-510.

Gunther, M. 2001. Sony's Boogie Knight Sir Howard Stringer is on a quest. To battle the media giants, he must connect Sony's content to its magical electronics devices. Fortune Magazine, March 19.

Haimowitz, J. and J. Warren. 2007. *Economic value of standardization*. Standards Council of Canada, Ottawa.

Hemphill, T.A., 2009. Technology standards-setting in the US wireless telecommuni-cations industry: a study of three generations of digital standards development. Telematics and Informatics 26, 103–124.

Hill, C.W.L. 1997. Establishing a standard: Competitive strategy and technological standards in winner-take-all industries. *Academy of Management Executive*, 11: 2.

IEEE. 2008. Annual Report 2007. IEEE, New York.

ISO. 2008. Annual Report 2007. ISO, Geneva.

Jurrien, R. 2007. Philips CD anniversary. Let's go digital. Your online magazine for Digital Imaging. http://www.letsgodigital.org/en/16191/philips-cd/ *Last accessed June 26, 2008.*

Kahin, B. & Abbate, J. Eds, 1995. Standards Policy for Information Infrastructure, Cambridge: MIT Press.

Kipnis, J. 2000. Beating the system: Abuses of the standards adoption process. *IEEE Communications*. 38:7.

Krechmer, K. 2000. The fundamental nature of standards: Technical perspective. *IEEE Communications Magazine*, 38: 6.

Lawrence, T. B., Winn, M., & Jennings, P. D. 2001. The temporal dynamics of institutionalization. Academy of Management Review, 26:4.

Leiponen, A. 2008. Competing Through Cooperation: The Organization of Standard Setting in Wireless Telecommunications. Forthcoming. *Management Science*.

Maggi,G. & Morelli, M. 2006. Self-Enforcing voting in International Organizations. *American Economic Review*. 96:4.

Meek, B. 1996. Too soon, too late, too narrow, too wide, too shallow, too deep. *Standard View,* 4:2.

Net Applications, 2006. Market shares for operating systems. http://www.netapplications.com. Web pages accessed September 15, 2007.

Pfeffer, J. & Salancik, G.R. 1978. *The External Control of Organizations: A Resource Dependence Perspective*. New York, NY, Harper and Row.

Pil, K.F. & Cohen, S.K. 2006. Modularity: Implications for innovation and sustained advantage. *Academy of Management Review*, 31: 995-1011.

Philips. 2008. http://www.ip.philips.com/ Last accessed June 27, 2008.

Reinganum, J. 1987. The timing of innovation. In R. Schmalensee & R. Willig (eds.), *Book of Industrial Organization, vol 1*. 850-908. Elsevier. Amsterdam:North Holland.

Porter, M. 1980. *Competitive Strategy*, Free Press, New York.

Saloner, G. 1989. Economic issues in computer interface standardization. *Economics of Innovation and New Technology,* 1: 135-156.

Schilling, M.A. 2002. Technology success and failure in winner-take-all markets: Testing a model of technological lock out. *Academy of Management Journal*, 45: 2.

Schmidt, S.K., & Werle, R. 1998. *Co-ordinating Technology: Studies on the International Standardization of Telecommunications*. Cambridge Mass: MIT Press.

Scott, W. 2008. *Institutions and organizations: ideas and interests*. *3rd ed.* L Angeles : Sage Publications

Shapiro, C. & Varian H. 1999. The art of standards wars. *California Management Review*, 41: 2.

Simcoe, T. 2006. Delay and de jure standardization: Exploring the slowdown in internet standards development. Greenstein, S. & Stango, V. (eds.) *Standards and Public Policy.* Cambridge Press; Cambridge, UK.

Singh, R.M. 2008. *Why Do Firms Adopt a New Technical Standard in the US Cellular Communications Industry?* Unpublished dissertation, University of Toronto.

Richard Stern, "Antitrust Division Gives IEEE Standard Setters the Okay to Ask Patentees How RAND They Are," IEEE Micro, vol. 27, no. 3, pp. 106-109, May/June 2007, doi:10.1109/MM.2007.47

Swann, G.M.P. 2000. The economics of standardization: Final report for standards and technical regulation directorate of the department of trade and industry. http:www.dti.gov.uk/strd/economic%20benefits%20of%standardisation%20-%20EN.doc

Tassey, G. 2000. Standardization in technology-based markets. *Research Policy*, 29:4.

Teece, D.J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15: 285-305.

Thompson, J. D. 1967. *Organizations in Action*. McGraw-Hill, New York.

Tolbert, P.S. & Zucker, L.G. 1983. Institutional sources of change in the formal structure of organizations: The diffusion of civil service reform, 1880-1935. *Administrative Science Quarterly*, 28:1.

Ulrich, K. 1995. The role of product architecture in the manufacturing firm. *Research Policy*, 24: 419-440.

Updegrove, A. 2007. Consortium Standards Bulletin, http://www.consortiuminfo.org/bulletins/.

Webster. 2005. http://www.m-w.com/dictionary/standard. Accessed on October 10, 2007.

Weiss, B. H. & R. T. Toyokuku. 1996. Free-ridership in the standards-setting process: the case of 10BaseT. Standard View, 4(4).

Joel West, J. 2005. The fall of a Silicon Valley icon: Was Apple really Betamax redux?" in Richard A. Bettis, ed., Strategy in Transition, Oxford: Blackwell, 2005, pp. 274-301.

White, H. C. 1981. Where Do Markets Come From? The American Journal of Sociology, 87 (3): 517-547.

Yan, Hui. 2007. The 3G standard setting strategy and indigenous innovation policy in China: Is TD-SCDMA a flagship? Proceedings, 2007 DRUID conference in Copenhagen. http://www2.druid.dk/conferences/viewabstract.php?id=1454&cf=9

Table 1. Different standards market structures.

Market structure	Industry/technology	Standards	Comment
True monopoly	Electrical utility	110 V or 220V	Monopoly within each geographical market, Duopoly across geographical markets
Duopoly	2G wireless telephony	CDMA and TDMA	Duopoly across the world and in North America. GSM dominates in Europe.
Dominant standard with niches	Operating systems	Win/Dos, Mac, Linux	Dominant standard has 90%+ market share, niches currently (2008) increasing their market shares.
Dominant standard with niches	Railways	Standard gauge (1435mm), narrow (<1435mm) and broad (>1435) gauge	Standard gauge is close to monopoly in the UK, Western Europe, Australia, US, and Canada, is a niche (10%) in Spain and Portugal (who use Iberian gauge). Russia, Finland, Mongolia use broad gauge (1524mm).
Multiple niches	Screwdrivers	Slot, Philips, Roberts, Allen, star 5, star 6	All patents have expired at this time, stable co-existence.
Multiple niches	Ports for electronic devices	USB1, USB2, fire wire, Ethernet, Bluetooth, telephone	Also called “standards swarms” by Updegrove (2007). Were once seen as competing but today often considered complementary.

Figure 1. Factors impacting if a niche standard gains a foothold.

NS=niche standard, DS=dominant standard

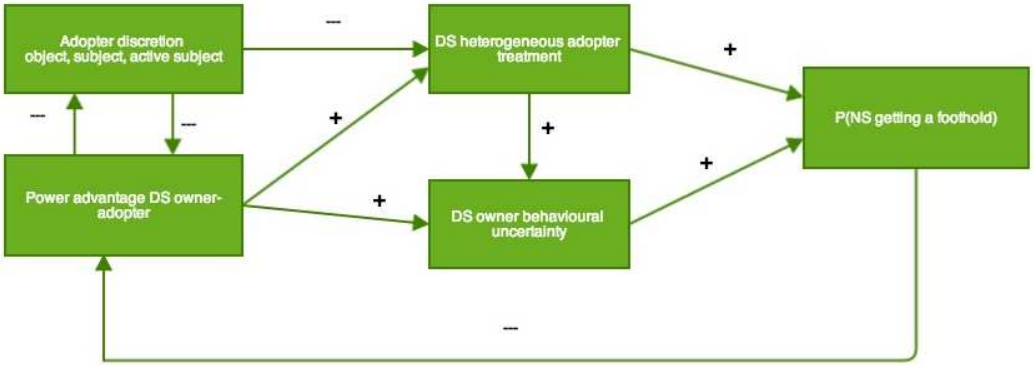

Figure 2. Niche standard stability (in a platform market).

NS=niche standard, DS=dominant standard, NPV=net present value

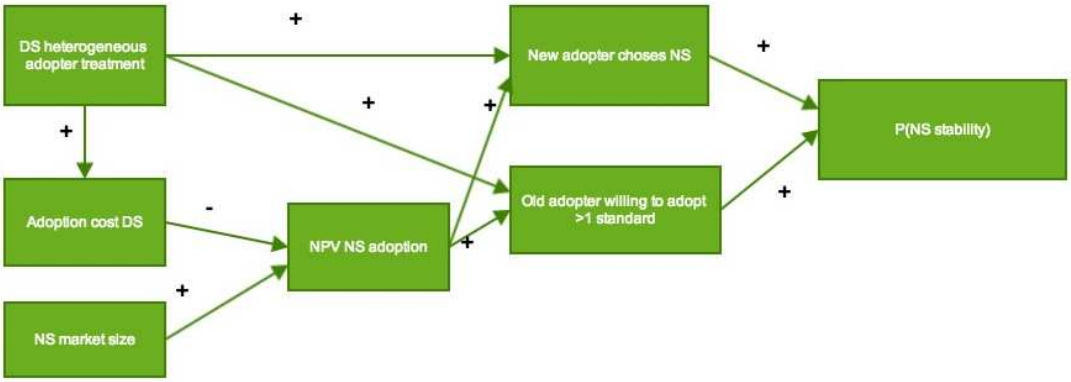

Table 1. Different standards market configurations.

,