"Standardization: Understanding the Process"


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ABSTRACT

Critics of the CCITT, ISO, ANSI, X3, IEEE and other Standards Development Organizations ("SDOs") complain that the formal approach to standard-setting followed by these institutions is too bureaucratic and time consuming. In this paper, I briefly describe the key features which distinguish SDO standard-setting and analyze these features in light of recent work in political economy. I argue that many of the features which lead to a slower process may be interpreted as an efficient institutional response to the problems posed by industry standardization. A better understanding of the motivation behind the design of formal SDOs is essential if we are to improve existing processes.

Introduction

Economists have been interested in the issue of voluntary industry compatibility standards for some time¹; however, most of their research has focused on the role of externalities and the

¹ David and Greenstein (1990) provide an excellent review of the economics of standardization literature.
potential for socially undesirable, inefficient outcomes when the industry relies on private, market-mediated mechanisms to set standards. They have produced surprisingly little formal analysis of the Standards Development Organizations ("SDOs") which help manage standardization processes even though there appears to be a growing perception that these are in need of reform².

Before we can address these concerns intelligently, we need to better understand the rationale which motivated the design of today's SDOs. This essay will first describe the institutional structure and procedures employed in the setting of Information Technology ("IT") standards. Following this brief description, I will interpret the salient design features in light of recent work by political economists.

A brief introduction to SDO processes

Although there are important differences, most of the SDOs active in national and international standardization in the United States and abroad are remarkably similar³. Most rely on voluntary, open participation and committee-based consensus decision-making. For expository convenience, I will focus on the procedures employed by the ANSI Accredited Standards Committee X3 for Information Processing Systems ("X3")⁴.

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³ See Cargill (1989) or Spring (1991) for a more extensive introduction to the many SDOs active in domestic and international standardization.

⁴ The American National Standards Institute ("ANSI") is the umbrella organization which oversees voluntary standardization efforts in the United States. ANSI certifies the procedural rules used by member organizations to manage the standards process (thus partially accounting for the similarity in approach). ANSI's membership includes both Accredited Committees ("ASCs") and Accredited Organizations ("AOs"). ASCs such as X3 and T1 (for telecommunications) exist solely
X3 is organized (roughly) into a three-tiered management hierarchy. At the bottom are Technical Groups ("TGs") where the real work of preparing draft standards takes place. At any one time, each TG focuses on at most a few closely related standards. In theory at least, TGs are created to develop specific standards and should cease to exist once that task is completed. In practice, TGs often prolong their lives by undertaking a succession of related tasks (e.g., developing extensions and/or successors to earlier standards).

Technical Committees ("TCs"), at the middle of the SDO hierarchy, supervise the activities of several TGs. Each TC has jurisdiction over standards which fall within a well-defined technical domain. In 1990, X3 had over 30 TCs supervising hundreds of different standards. At the top of the SDO hierarchy are a small number of standing committees which coordinate and oversee the activities of the TCs (including liaison between TCs and other SDOs). In X3, the Standards Planning and Requirement Committee ("SPARC") is responsible for supervising the activities of the TCs.

With the exception of a small administrative staff, all of the participants in X3 are unpaid to develop and promulgate standards within their area of jurisdiction; whereas AOs such as the Institute for Electrical and Electronics Engineers ("IEEE") and the Electronics Industry Association ("EIA") are professional organizations which happen to be active in standardization.

5 This brief introduction glosses over many important details of X3's formal structure. These are described more fully in a collection of ten standing documents maintained by X3's Secretariat, the Computer Business Equipment Manufacturers Association ("CBEMA"), which is located in Washington, DC. See Lehr (1992) for a more extensive analysis of X3's formal structure.

6 One of the problems confronting SDOs is that the technical boundaries separating different technologies have are increasingly blurred (e.g., are new wide-area data communication standards computer or telecommunications standards?).

7 For example, X3J12 is responsible for COBOL standards; while X3T9 is responsible for Input/Output Interface standards. The X3T9 TC sponsors the work of the X3T9.2 Task Group which is developing the Small Computer Systems Interface ("SCSI"); the X3T9.3 Task Group which is developing the Intelligent Peripheral Interface ("IPI"); and the X3T9.5 Task Group which is developing the Fiber Distributed Data Interface ("FDDI").
volunteers. These volunteers include representatives from government, academia, customer and vendor firms. Membership in X3 is open to anyone willing to pay the nominal dues. Since effective participation requires significant technical and business expertise, the opportunity cost of participation is quite high. Most of the "volunteers" are sponsored by vendors, who historically have dominated standards committees.

The formal development process begins when a coalition of sponsors, usually consisting of one or more vendor firms, submit a proposal to SPARC requesting authorization to develop a new standard. After SPARC's review, the entire X3 membership votes whether to approve the authorization request. Before approving a new development effort, X3 will consider the technical feasibility and market need for the proposed standard. In addition, X3 will examine whether the proposal is within X3's scope and does not duplicate standardization efforts being undertaken elsewhere.

Once approved, X3 assigns the standard to the appropriate TC (which in many cases is the source of the original proposal) and publishes a press release describing the new project\(^8\). The TC assigns the standard to a TG, which is formed from all interested parties wishing to participate in the preparation of a draft specification document. Initially, the TG may consist solely of participants from the original sponsors; however, the membership may grow as interest in the evolving standard develops.

In the TGs, engineers and scientists with specialized and often company-specific expertise

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\(^8\) X3 will establish liaison requirements when the proposal overlaps multiple TCs. If the proposal does not fit within an existing TC, X3 may create a Study Group (SG) to review the proposal, which may lead to the creation of a new TC.
share detailed technical information. Under the guidance of a chairperson who is elected by the TG, the TG prepares a draft version of what will eventually become the published standard. This usually requires reconciling numerous disagreements over technical details. The TG reviews proposals from the competing factions and attempts to reach a consensus. The TG's secretary keeps meeting minutes which document the committee's progress and record important votes (e.g., which of several competing proposals should be included in the draft standard).

Having reconciled its internal conflicts and prepared a complete draft, the TG membership votes to submit the draft standard to the TC for further processing and to obtain comments from a wider audience. This begins the comment and review cycles which characterize consensus-based decision-making. Although ANSI does not require unanimity to approve a proposal, it does require that an attempt be made to reconcile all negative votes and that a significant majority approve the standard.

In X3, important decisions such as the decision to initiate a new development project or to approve a draft standard for further processing require a 2/3rds majority. Each firm is allowed one voting member (although firms can and do send numerous non-voting participants to TG and TC meetings). There are formal rules which specify the timing and processing of ballots (e.g., time between successive ballots, time to respond to a ballot, contents of allowable responses, etcetera).

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9 X3 requires a majority of the membership and 2/3rds of the voting, non-abstaining membership approve.

10 SDOs differ in how voting rights are allocated. For example, in the IEEE, members participate as individuals and so multiple participants from a single firm may vote on the same standard. In the International Consultive Committee for Telephone and Telegraph (CCITT), each member nation has one vote. For example, Besen (1990) discusses why the European Telecommunications Standards Institute ("ETSI") adopted different procedures than the European Committee for Standardization ("CEN") and the European Committee for Electrotechnical Standardization ("CENELEC") with which ETSI competes. See Lehr (1992) for a comparison of X3 and the IEEE.
The standard cannot progress to the next level of the SDO hierarchy until it attracts 2/3rds majority support and a documented attempt has been made to respond to all negative votes and comments. Any unresolved negative comments must accompany the draft proposal as it progresses up the SDO hierarchy. Once the TC approves the standard, it is submitted to ANSI for a 4-month public review and to a letter ballot of the entire X3 membership. The TC must respond to comments from the public and X3 membership. Each time the standard is substantively changed (either to respond to X3 or public comments and/or negative ballots), another 2-month public review followed by a letter ballot of X3 is required. After addressing all comments and obtaining a 2/3rds majority from the X3 membership, the standard is forwarded to ANSI's Bureau of Standards Review ("BSR") for approval as an American National Standard ("ANS"). The BSR reviews the documentation of the process and affirms that the standard's sponsors followed approved-ANSI development procedures. This process is long and cumbersome, often taking from 3 to 7 years (see Cargill, 1989).

**Economic Analyses of the Process**

To many participants, the pace of the SDO process is too slow for an age of rapid technical progress where open systems are increasingly important\(^\text{11}\). Open participation rules, supplemented with public notice requirements, enhance the likelihood that all relevant information will be included in the cost/benefit analyses of competing standards proposals. The TGs provide an environment wherein industry participants may share information relatively inexpensively, thereby reducing collective uncertainty and lowering investment costs. Facilitating this communication is an

\[^{11}\text{See McQuillan (1991), Moad (1991), Vasquez (1990), or Verity et al (1991) for examples of industry unhappiness with SDO processes.}\]
important function for the SDOs; however, open participation also slows standardization. The public reviews and ballot processing for large voting groups is very time consuming, especially under the consensus decision-making rules. The "red tape" of formal, bureaucratic procedures introduces additional delays. These features would slow down SDO decision-making even if all of the participants were only interested in adopting technologies which would maximize total surplus. Unfortunately, this is not always the case.

Rational firms sponsor standards which they believe will be privately profitable. Although standards often produce significant benefits for the entire industry\textsuperscript{12}, there are many feasible standards which would not. Since firms technical skills differ, the choice of which technologies are adopted as industry standards affects them asymmetrically. A firm may find it profitable to promote a standard which promises to increase its market share even if total surplus declines. Those who benefit from standards do not always bear the full costs of adoption. For example, new component manufacturers who may benefit from lower entry costs may fail to share the switching costs faced by incumbent firms and their customers\textsuperscript{13}. Some participants may prefer if the industry delays standardization, perhaps indefinitely. A firm which dominates a market with a proprietary technology may fear increased competition if public standards are defined. The mechanism we use to select standards becomes more important when we recognize the importance of reconciling

\textsuperscript{12} Industry standards may increase overall market demand by increasing the supply of complementary products or by reducing switching costs; or, may decrease industry costs via experience gained from cumulative production. See Greenstein's discussion in Chapter ## of this journal.

\textsuperscript{13} These costs may be reduced if the new technology is backwardly compatible; however, this imposes restrictions on the choice of standards. Whether backward compatibility improves total surplus depends on the specific situation. For example, the desirability of maintaining backward compatibility has been a contentious issue in FCC debates regarding the allocation of bandwidth for High Definition Television (HDTV) services.
conflicting preferences.

In the absence of SDOs, industries rely on competition between firms to determine which technologies are adopted as standards. Since there are often increasing returns to cumulative adoptions, large firms with large installed bases are more likely to prevail in these de facto standards competitions. If there is no clear market leader then the outcome from de facto standard-setting will be uncertain, leading firms to sink investments in technologies which are subsequently abandoned. These deadweight losses can be avoided if firms coordinate their technology choices before committing to specialized investments.

Farrell and Saloner (1988) modeled de facto and SDO committee-based standardization as a "Battle of the Sexes" Game and found that the committee approach outperforms the de facto process, even though it is typically slower\(^\text{14}\). They also briefly consider the two other mechanisms which are used to actively generate coordination: tradition and authority. Rapid technical progress precludes relying on tradition; and authority requires an entity with sufficient power to enforce its decisions. As long as firms have private, asymmetric information, authoritarian approaches confront an agency problem. When monitoring and enforcement is difficult, it is expensive to force firms to comply with standards which are not individually rational. The IT industries no longer have firms which are powerful enough to unilaterally compel competitors to comply with their wishes; and the government, which is the other logical candidate for the authoritarian role, lacks sufficient

\(^{14}\) The "Battle of the Sexes" is a coordination game wherein each player prefers a different outcome, but both players prefer to compromise rather than each pursue conflicting strategies. De facto standardization is interpreted as a "grab the dollar" game. Whichever firm grabs the dollar first wins; but if both grab at the same time, they both lose. The SDO process is interpreted as a "game of attrition". In each stage, firms can either compromise or insist. In both cases, delay and coordination failures are costly. Farrell and Saloner explore the performance of the two models under a variety of scenarios.
information to be assured of choosing good technologies\textsuperscript{15}.

The SDOs reliance on "voluntary" compliance is consistent with a lack of cost-effective alternatives. Thus, it is encouraging that Farrell and Saloner find that a hybrid mechanism, which allows firms to choose between the committee and de facto processes, is superior to either of the pure mechanisms. In order for industry-wide cooperation to be ex ante rational for both incumbents and entrants, the SDOs formal structure needs to protect both groups' interests. The SDOs open participation, consensus decision-making and formal, bureaucratic rules respond to these concerns.

The TGs provide an environment wherein industry participants can share information relatively inexpensively, however, when competing firms get together to share detailed product design information, there is a real danger of collusive, anti-competitive behavior. Following Riker (1962), we have reason to fear that a winning coalition of firms might promote adoption of a technology which exploits minority interests. Third-party monitoring to detect such behavior would be quite costly given the technical sophistication required to follow most TG discussions. Open participation and consensus decision-making make the process self-monitoring. These institutional features provide potential victims with the tools to block the emergence of exploitative standards. Although both entrants and incumbents are potential victims, it is unclear who benefits more from voting procedures which protect minority interests.

Furthermore, unless we are willing to make unreasonably restrictive assumptions regarding preferences over the multi-dimensional space of potential standards, we cannot guarantee the

\textsuperscript{15} See David (1987) for a discussion of the problem of direct government intervention in standard setting.
existence of a Condorcet-winner under simple majority rule\textsuperscript{16}. McKelvey's (1979) "Chaos Theorem" showed that in the absence of a Condorcet-winner, open amendment procedures can lead to any outcome in the space of feasible alternatives. Voting institutions are vulnerable to strategic agenda manipulation\textsuperscript{17}. If a minority of firms could capture control of the agenda for standard-setting, they may be able to misuse this control to exploit the majority.

Those features which make SDOs slow, reduce the likelihood that a strategic minority will be able to successfully capture the standardization process. When incumbent firms with market power agree to cooperate in SDO standard-setting, they risk exploitation both from each other and the fringe of newly-enfranchised competitors. They face the former in both SDO and market fora; however, the latter become a greater threat under SDO standard-setting. The SDOs' allocation of decision-making authority is more egalitarian than the de facto process, which is based on firms' relative market power. Firms which are too small to have a significant influence on the outcome of de facto debates have the same rights as their larger competitors under the SDOs' open participation and voting rules.

Consensus decision-making, by empowering minority blocking coalitions, allows incumbent firms to enforce the status quo. Incumbent firms which are likely to fare reasonably well under de facto competition can exploit SDO minority-protection rules to delay the emergence of privately less-favorable outcomes. Granting large firms this sort of veto power protects the interests of firms

\textsuperscript{16} A Condorcet winner is an outcome which attracts a majority of votes and against which no other alternative can prevail. See Plott (1967) for a discussion of sufficient conditions for the existence of a Condorcet winner when preferences are multi-dimensional.

\textsuperscript{17} The Gibbard-Satterthwaite Theorem (1973, 1975) demonstrates that this vulnerability is a general property of all non-dictatorial social choice mechanisms. See Ordeshook (1986), pages 82-89, for a more accessible discussion of this result.
and consumers with a vested interest in installed technologies, and may be necessary if large firms are to find SDO cooperation individually rational.

Shepsle and Weingast (1984) argue against presuming that political solutions necessarily produce Pareto superior outcomes. A slow SDO process defaults to de facto standard-setting, which establishes a lower limit on the inefficiency of potential SDO outcomes. The social cost of slow SDO procedures is closely related to the magnitude of the inefficiencies associated with de facto standardization.

Even if cooperation in the SDO process is a dominant strategy for all firms, vulnerability to strategic manipulation of the process remains a problem. Imagine representing the SDO process as a Prisoner's Dilemma Game between two firms. Each firm can choose between one of two strategies: cooperate sincerely or attempt to capture the process. If the two firms cooperate sincerely, they split the benefits, B, from selecting the efficient technology. Each earns a payoff of B/2. If one is sincere while the other behaves strategically, then the opportunistic player captures all of the benefits. The payoff to the sincere player is 0 and the payoff to the opportunistic player is (B-C), where C is the cost of strategic behavior. If both firm's behave strategically, they end up with the identical allocation of net benefits but incur the costs of their strategic behavior. Each firm's payoff is (B/2 - C). If B>2C>0, each firm's dominant strategy will be to behave opportunistically, resulting in a net loss in total surplus of 2C due to deadweight bargaining costs. The SDO's formal structure helps reduce the likelihood that participants will find it profitable to manipulate the process in order to define exploitative standards.

Since many of the firms participate in multiple TGs both simultaneously and across time,
they have incentives to invest in reputations for cooperation (see Axelrod, 1984). A firm which behaves opportunistically in one TG may be punished in other TGs or face the higher bargaining costs associated with a breakdown in mutual trust. For these forces to be compelling, the industry needs an institutional memory which coordinates standards debates intertemporally and across market niches. A single industry SDO or tight liaison relationships across multiple SDOs improves the chances that reputational effects will be important.

Reputations may be less effective in constraining the behavior of firms which are only active in niche markets. Firms which do not expect to be involved in repeated interactions or who value the outcome from a single standardization debate highly enough, will not be deterred from behaving strategically. Entrepreneurs may have a stronger incentive to manipulate the standards process in order to promote an outcome which will enhance the value of a proprietary niche technology.

The SDOs also deter opportunistic behavior by changing the payoffs from such behavior. It the cost of mounting an effective capture strategy is increased such that \( C^* > B/2 \) then the game is no longer a Prisoner's Dilemma. Sincere cooperation becomes the dominant strategy. McCubbins, Noll and Weingast (1987) discuss how open participation and bureaucratic "red tape" create institutional early-warning systems. The slowness of the process precludes strategies which rely on rapid capture. Threatened firms have time to organize their opposition. When increasing returns from adoption are large, preventing early capture becomes more important. Large firms which are less able to respond flexibly to sudden changes may value such protection more than their smaller competition.

It is expensive for firms to monitor the activities of every TG. Incumbents need to monitor their established rivals as part of everyday strategic competition; however, incumbents would prefer
not to have to monitor every potential entrant seeking to exploit SDO procedures. When open participation rules allow a firm's installed customer base to participate in SDO debates, the incumbent firm's monitoring costs are reduced. The process becomes self-monitoring. This is attractive to government policy-makers who are anxious to prevent anti-competitive behavior.

The preceding discussion has focused on the benefits of a slow process in avoiding the costs of adopting privately-profitable, but socially-undesirable, technologies. If these costs are small (i.e., participants agree regarding the optimal selection of standards), then a more stream-lined, less bureaucratic approach would be unambiguously preferred. Unfortunately, such a coincidence of preferences appears unlikely in the face of rapid technical progress, which is itself an artifact of aggressive technology-based competition. Firms are likely to disagree both on which is the best alternative and regarding the optimal timing for standardization.

A firm with sunk investments associated with an existing standard or whose research program into future technologies is lagging rivals may prefer to postpone adoption of a new standard. Entrepreneurs in niche markets who may be more likely to try to manipulate SDO outcomes may also be more vulnerable to delays. For example, if the entrepreneur's product is only valuable as part of a more complex system utilizing components produced by others, then the firm's survival may depend on the existence of public interface standards. Since many high-technology entrepreneurs face cash flow constraints, delays which slow market growth can lead to bankruptcy.

The irony of industry standardization is that the rapid pace of technical change simultaneously increases the social costs both from delay and from adopting the wrong standards. The costs of delay are mitigated somewhat when systems-level competition is viable; however, the
fastest growing IT markets involve systems comprised of components from a diverse selection of vendors (e.g., enterprise-wide information communication networks). Today, IT standardization is both more contentious and more important than it was a decade ago. When we observe more brush fires, it may be because the fire department's performance is unsatisfactory, or it may be because the woods are more prone to fires.

Industry participants have responded to the perceived problem of SDO slowness in a variety of ways. First, a number of the SDOs are in the process of reassessing their roles and structure. For example, X3's Strategic Planning Committee was established in 1988 in order to help X3 improve its effectiveness in light of rapid changes in the IT industries. The European Telecommunications Standards Institute (ETSI) adopted less restrictive voting rules which make it more difficult to form blocking coalitions (see Besen, 1990). Industry consortia tend to be more restrictive in their membership requirements, which makes it possible to exclude participants who would delay the process.

Although relaxing the consensus decision-making rules and limiting participation may increase the speed with which committees approve standards, they reduce the protection SDO's have afforded minority interests. Furthermore, as alternative standard-setting fora proliferate they reduce the enforcement benefits from reputations and may risk the very effectiveness of public standard setting. Having too many standards is not very different from having too few. When interface specifications proliferate, interoperability testing and the specification of conformance test suites becomes more important. If the institutions which set standards affect market outcomes, then we need to guard against self-interested agents who seek to manipulate the institutional choice. By
showing how institutional delays can contribute to the efficiency of standard-setting, this essay highlights the difficulties and trade-offs faced by would-be reformers.

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