Computer Standards & Interfaces (http://www.elsevier.nl/locate/csi) vol. 16, 1994 321-329 

# Standards and the market acceptance of information technology: An exploration of relationships[1]

Jonathan A. Morell
*Industrial Technology Institute, Center for Electronic Commerce, PO Box 1485, Ann Arbor, MI 48105, USA*
jmorell@erim.org

## Abstract

This article proposes a model for understanding the relationship between standards and the market success of new information technology. Its purpose is to spur research on these relationships, and to increase the attention standards developers pay to the business implications of their work. We begin with an overall model, and then suggest important factors operating in five domains: technology acceptance, standards acceptance, the standard setting process, market structure and vendor strategies, and characteristics of the technology being standardized.

## 1. Standards as a factor in technology deployment

Standards for information technology have profound consequences for the viability of new technology markets, and through those markets, on the competitiveness of industries and nations. This criticality emerges because without standards, developers are loath to commit to development, production and marketing. From the user's perspective, standards affect the business, technological and organizational risks involved in the acquisition of new technology. In addition, standards often define interfaces among technologies. Thus a lack of standards may not only hinder individual technologies, but may also inhibit the deployment of associated technologies.

For two reasons, those concerned with information technology (IT) must pay particular attention to the relationship between standards and technology deployment. First, IT is exquisitely sensitive to the standards environment. As examples of this sensitivity, consider the relative market size for technologies based on TCP/IP and the Manufacturing Automation Protocol, or the impact of SUN's open system strategy on the workstation industry. Second, emerging elements of industrial and national competitiveness are intimately related to IT. To illustrate, consider product data exchange, intelligent vehicle and highway systems, and information superhighways. Each presents opportunity for the development of new products and services, new industrial sectors, and new opportunities to create wealth.

Moreover, existing industries and industrial sectors will be profoundly altered by these technologies. Whether promise becomes reality, however, may well depend on the successful development and adoption of IT standards.

In recognition of the importance of standards, the United States Office of Technology Assessment has concluded that:

> The government, as the sole representative of the Nation, has a considerable interest in the effectiveness of the U.S. standards setting process. Standards help determine the efficiency and effectiveness of the economy, the cost, quality, and availability of products and services, and the state of the Nation's health,

*Key words:* Standard setting process; Technology acceptance; Market development

[1] This document is replete with suggestions and ideas advanced by many people. Contributors include: Anthony M. Bratkovich, Mitchell Fleischer, Theresa Gidley, Bob Matthews, Andy McMillan, Lee Reid, Lou Tornatzky, Jack White and Ted Williams.

> safety, and quality of life. The government's stake in standard setting will loom even larger in the future, given a number of developments.[l, page 7].

Standards are also exceedingly expensive, as illustrated by the following time and travel estimates [2]:

- Electronic Data Interchange (ANSI X12) $10OM/year.
- X3T9.5 (FDDI) - $80,000/day for each day the committee met.
- All 300 OSI standards - $4B to date.

Given the costs and consequences, it is surprising how little we know about two vital questions:

- How do standards affect the acceptance of technology?
- How can a standards setting process be guided successfully from conception to completion?

## 2. Purpose of this document

This document is designed to serve as a foundation for one or more research studies concerning the interactions among standards, standard setting processes, and technology acceptance. Such research is important because very little of the existing literature on standards is based on empirical data. As Cargill puts it:

> To begin, there is no hard evidence that I have been able to find that proves that standards are worth anything. Most proof is negative proof, usually phrased along the lines of- "If we didn't have the standard, we'd have a million bazillion products." [2, page 2.]

The literature that does exist falls into three general categories. The vast majority of existing writings are descriptions of the standard setting process, or instructions for carrying out such a process. This literature is useful in providing a sense of how the formal standard setting process works, and what processes have to occur for acceptable standards to be developed, (examples include: [3-61).

The second body of literature emerges from analyses of the economic consequences of standardization. This literature is extremely valuable because it points out many variables which may be relevant to understanding standard setting, and presents simulations to show the impact of those variables under a variety of conditions. An important limitation of this literature, however, is that it presents simulations only, and does not contain empirical studies of actual standard setting or technology adoption (examples include [7-11]). A variant of this literature focuses on the costs and benefits of setting internal company standards. (Toth [12] provides an excellent overview of this literature, as well as a rich set of references to that literature.)

The third type of literature touches on standards through discussions of the impact of government investment in standards and standard setting bodies, in particular the National Institute of Standards and Technology (NIST, formerly the National Bureau of Standards). This research concentrates on the importance of infratechnology-standardized methods of measurement which would not be developed by any single industry, but which play a part in a wide range of scientific and technological endeavors. In this literature we obtain a sense of the return on government's investment in standardization. Empirical data is found in this research, but that data tends to deal with return on investment, rather than on rate or extent of technology adoption. (As examples, see [13-16].)

> We believe that empirical data can help improve both social policy regarding standards, and the effectiveness of standard setting. To help provide that information, we present a conceptual model of

how standards affect technology, and then speculate upon the relevant variables which populate that model.

## 3. A conceptual model for the impact of standards

The challenge is to develop standards in a way that leads to the marketing and use of products. Research to accomplish this goal must be based on a model of standard setting that:

- illustrates how standard making affects technology acceptance, and
- specifies activity at the intermediate stages between the process of making a standard and the acceptance of technology that is based on that standard.

To this end we propose a high level model in which standard setting efforts are determined by three general factors:

- the nature of the technology being standardized,
- the market for the technology, and
- technology vendors' marketing strategies.

The nature of a standards process, in turn, will affect whether a standard is accepted, which will then influence technology adoption. To complete the model, bi-directionality is introduced. Primarily, the acceptance (or perceived likely acceptance) of a standard will affect not only users' decisions about acquisition, but also producers' beliefs about the value of developing and marketing the technology. We caution that the proposed model is by no means a complete view of technology acceptance. Rather, it is a view which focuses on the impact of standards, leaving out many other critical considerations. (An overall model of technology acceptance, with an excellent analysis of relevant literature, can be found to Tornatzky and Fleischer [17]).

The entire model is depicted in Fig. 1. The following sections will provide some details on each aspect of this model. It will attempt to identify critical issues, and where possible, the direction of effects. We will begin with the end point of the model (impact of standards on technology acceptance) and move the discussion backward through each preceding step. The details presented in the following discussion emerged from the literature cited earlier, and from extensive conversations with a wide variety of people engaged in various aspects of standard setting efforts.

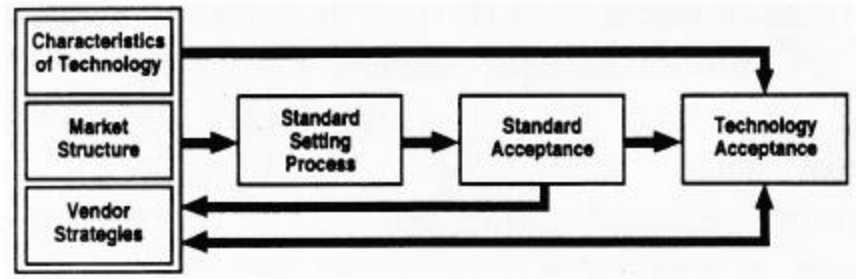

Fig. 1. Model of the standards process.

## 4. Impact of standards on the acceptance of technology

Standards affect technology in the following manner.

- *Assurance of performance.* If a technology is rated on accepted and standardized metrics, buyers are better able to choose among competing products, and to understand how a particular technology will actually

perform. Ratings however, must be backed by trustworthy assurances in the measures. Hence the importance of rigorous conformance testing and demonstrations of interoperability.

- *Communication between buyer and seller.* Related to assurance of performance is the ability of standards to allow buyers and sellers to communicate. One possibility is that standards will make it easier to conduct discussions about price versus performance, maintenance, functionality and many other issues, thus contributing to the likelihood of technology adoption. A second possibility is that standards may make communication between vendors and users more difficult. While not intuitively obvious, there is evidence that standards can result in such problems. Research on the acceptance of the Manufacturing Automation Protocol (MAP) has revealed that the MAP conformant technology was not marketed well because it was more complex than existing product lines, and hence it taxed the ability of marketing and sales personnel to represent the new product to users [181.

- *Compatibility with existing technology.* The value of a technology depends not only on its performance in isolation, but on its ability to work with other technology. Performance and interface standards can help assure successful integration, and thus to increase the appeal of a technology. In general, we believe that the greater the compatibility with existing technology, the greater the likelihood of successful technology acceptance. Exceptions to this rule may be cases where there is a widely accepted view that a fundamentally new solution is required to solve a particular problem or set of problems. While time will only tell, STEP may be an example of such a phenomenon, as the standard represents a quantum jump in our ability to describe and communicate product description data.

- *Compatibility with future technology.* The fear of being stuck with orphan technology is a legitimate and serious worry. It is hard to maintain and obtain user support for such technologies. Further, orphan technologies are not likely to be compatible with developments in other parts of a users' technological system, thus causing integration problems in the future. Again, standards can assure compatibility, which in turn increases the likelihood of technology acquisition.

- *Cost.* Standards often have the effect of lowering the range of choices available within a particular technology. The narrowed range limits the number of products that a producer has to build in order to market a full product line. The restricted range also introduces economies of scale into the production manufacturing process. Together, these factors operate to reduce costs and thus make technology acquisition more appealing to users. Depending on the nature of the market and the standard, however, cost may go up rather than down. This would be the case if a standard could only be met by a limited number of producers, who then chose to maximize unit profit rather than to increase sales volume.

- *Features.* The lower range of choices discussed above may have the effect of increasing related options for buyers. A classic case is the limited number of operating systems for microcomputers. Those limited choices have greatly increased the customer base for software, which has spurred considerable price and feature competition among software developers. The existence of that competition has contributed to the spread of microcomputer adoption. Also, compatibility allows buyers to mix and match from competing product lines, thus further increasing the choices available.

- *Development of ancillary technologies.* Any single effort at technological development is embedded in, and built upon, numerous other technological accomplishments. The decision to develop a technology may hinge on how much of that foundation is already in existence. As an example, designing a new computer chip may depend on the development of new or better chip materials. If the materials are already in existence, the cost of the design process drops. If the material itself first has to be developed, the overall design costs will increase. Thus the acceptance of a standard may in fact depend on the viability of complex set of related standards. (The seven layer OSI protocol comes to easily to mind.)

In addition to whether a technology will be accepted, a standard can have profound impact on *how a technology will be used.* As an example, the present standard for Electronic Data Interchange

(ANSI X12) uses transactions based on traditional non-automated business activities, and populates its transaction sets with complex data segments and a very large number of options. This situation makes it difficult for networks of trading partners to agree on unambiguous applications of the standard, thus limiting the value of EDI in numerous settings [19]. Thus when assessing the impact of standards, 'technology acceptance' must be seen not only in terms of the number of installations, but also in terms of how much benefit users obtain from the technology in question.

## 5. Acceptance of standards

The successful generation of a standard does not guarantee its acceptance. Rather, we believe that identifiable, measurable variables explain acceptance. Again drawing on the literature cited earlier, we propose the following as determining whether or not a standard, once developed, will be accepted:

- *Single vendor's ability to dominate a market.* Vendors whose products can dominate a market are in a position to establish de facto standards. Given such a controlling position, the acceptance of a standard will largely depend on how that vendor perceives its self interest. The SUN corporation represents a perfect example of one approach, that of assuring the value of one's technology by opening up one's architecture to make it easier for others to develop value added products [201. IBM's position on DOS may be a counter example, wherein an open architecture allowed direct competitors who provided a serious challenge to the originating company.

- *Impact of standards on vendor-customer relationships.* Standards may 'lock in' a vendor's existing customers, or may bring new customers to a vendor. Alternatively, the existence of a standard may increase customers' choices. Vendors' acceptance of a standard will depend largely on their view of how the standard affects this potential for business. Users acceptance will depend on their view of how increased choices will affect their technology base and ability to interact with their technology suppliers[2].

- *Impact of the standard on an installed base.* The existence of a large installed technology base, particularly one that is hard to replace, implies strong interests among users concerning that standard. If a powerful installed base exists, the fit between the standard and the existing. technology will play an important part in determining acceptance. Two contrasting examples illustrate this point. In its early days MAP was designed to run only on broadband, requirement that meant considerable trouble and expense in changing networking cables. This condition surely inhibited MAP's deployment. The present Fax 3 standard also required technology substitution, but it did so with a technology that was not highly integrated into other systems, and that was extremely inexpensive.

- *Ability of customers to drive standards.* Very large customers may be in a position to force standard adoption. The classic example of this is when the US Government sets standards for its suppliers. Given the market power of this customer, any standard insisted upon by the government is likely to be accepted by other sectors of the market as well. Even the US government however, (particularly in this era of shrinking procurement budgets) is not powerful enough to drive change all by itself. The real issue is how coherent demand is within groups of large customers, and whether customers can deliver on their promises to procure a particular standard conformant technology. The ability to deliver on promises is critical because it is often the case that the customer representatives who make the promises are corporate representatives who have only limited control over the behavior of those who commit funds. As an example, a member of a corporate IS standards group may not be able to require a plant manager to purchase a particular communications technology.

[2] This dynamic is more complex and uncertain than is indicated here, particularly when trying to predict the reactions of new buyers or new vendors [21].

- *Impact on compatibility.* A standard may increase or decrease the extent to which a particular technology is (and will continue to be) compatible with other parts of one's technological system. Thus users' views of the impact of a standard on compatibility will have much to do with their acceptance of that standard.

- *Competing standards.* Complicating standards acceptance is the existence of competing standards, each of which favors a different product line or technological direction. (The 'UNIX Wars' is a classic example of this problem.) As such conflicts arise, so too will the difficulties of a standard becoming accepted.

## 6. The standard setting process

Standards making has been on a trajectory of increasing complexity, and this trajectory is likely to continue. The reason for this situation is that with the growth of distributed computing, richer communication, and growing computing services, more and more functionality is being distributed across an ever greater number and variety of users. As the complexity of the computing environment grows, so too will the complexity of the standards needed to support that environment. Moreover, efforts to meet unfolding needs are likely to spur the growth of anticipatory standards, with their added complications of having to coordinate new standards with new product development.[3] Given these conditions, the efficiency of the standard setting process is likely to play an increasingly important role in affecting the ultimate acceptance of technology.

Our view of the standard setting process emerges from a workshop which drew together industry and government experts to explore best practices for the development of standards for information technology.[4] I The consensus that emerged from that workshop was that:

- Best practice should be seen in terms of a well-managed overall process flow for standards, permeated by appropriate metrics at critical points.

- Within the process, specific tools and methodologies are needed, i.e. an array of 'micro-level' best practices must be inserted to assure quality for specific activities.

- The fundamental purpose of a standard effort is to support the development of products that are economically viable for technology vendors, and whose use will support the business needs of users.

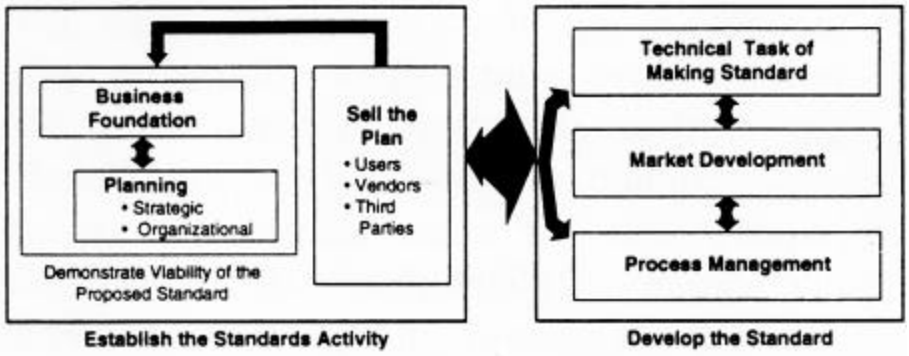


Fig. 2. High level view of standards making.

Given this perspective, critical aspects of the standard setting process can be depicted as in Fig. 2. Without getting into too much detail (which is contained in the Workshop Proceedings), two

[3] This analysis was inspired by Burrows' discussion of the changing role of users in standards for information technology [221.

[4] Standards Development for Information Technology, Gaithersburg, MD July 8-9, 1993, sponsored by the National Institute of Standards and Technology, and the Industrial Technology Institute.

critical issues are contained in the above diagram. First, each element of the standard setting process must be present, and carried out well. Second, success will hinge on coordination among the elements on the right - technical work of standard making, market development for standards conformant technologies, and overall process management.

## 7. Market structure and vendor strategies

Discerning the market for a new technology is a complex process that goes far beyond the realm of standards, and which requires immersion in the uncertain world of technology forecasting.[5] Adding to the stress of uncertainty is that control over architectures, and decisions about how open to make those architectures, is of growing importance in developing competitive strategies [24]. Within this context, certain elements of the market for a technology are likely to be particularly important with regard to vendor thinking about how standards will affect potential sales.

- *Other producers.* The number of one's competitors and their market shares will play a part in how companies relate to standards and standards development. In assessing this competition, vendors must consider not only individual companies, but strategic alliances as well witness how much of the personal computer industry has allied itself against IBM's bus architecture when it was announced, or the struggles over UNIX standards.

- *Dollar volume of the market.* Advocating for standards can be a tedious and expensive effort. Consequently, a company's view of the profitability of a market will have much to do with its willingness to engage in standards development efforts.

- *Structure of customer base.* Relevant elements here include a vendor's existing relationships with its customers, and the number of different customers who are available.

- *Impact of standard on vendor's other products.* Often, standards for one of a vendor's products will affect the desirability and cost of other elements of the customer's technological system which are provided by that same vendor. (One example was IBM's SAA architecture, which was designed to assure compatibility between all computers in IBM's product line.)

Given a particular market, vendors have to clarify their values as to how they should approach that market. Examples of factors they may consider include:

- *Open vs. closed architectures.* Will the company be better off under an open or a closed architecture? With few competitors, an established market, and an existing installed base, a company may choose the closed architecture. Such a choice constitutes a strategy to inhibit development of formal standards in the hope that a de facto standard will develop which favors the technology producer.

- *Willingness to compete on price and functionality.* A company with confidence in its ability to compete may favor standards, in the hope that it will gain from an increased user base.

- *Role of standards in market development. Re*lated to a willingness to compete are judgments about the role of standards in developing a market. Companies who believe that standards can play such a role will advocate for standards.

[5] Morell provides a review of critical issues in technology forecasting [23].

## 8. Characteristics of technology

The characteristics of a technology also affect whether standards are set, how that standard setting process develops, and whether the standards are accepted.

- *Network externalities.* One important question is whether the technology exhibits network externalities, i.e. whether the value of the technology for any given user increases with the number of other people who have the technology. A longer lasting drill bit, or a better parts inspection system do not exhibit such characteristics. In fact the fewer the companies who have such technology, the greater their competitive advantage. Contrast these examples with the case of the Next computer when it was marketed, which had a small installed base, and thus, a restricted range of available software. Developers' incentive to write software, an activity that would have benefited all users, was small because it was a function of the size of the installed base.

- *Stage of technological development.* Discussions with many people involved in standard setting have revealed the importance of developing standards at the proper time during a technology's development. If standards are attempted at too early a stage, there is a fear of limiting promising lines of development. There is also the worry that a rival technology will emerge unanticipated, and thus greatly complicate the standard setting process. Thus standards should not be attempted until there is reasonable confidence that the universe of feasible technological options can be explored.

- If standards are set too late, however, many of the complications discussed previously may emerge - competition among rival vendors, worries about compatibility from established users, and so on.

- *Consequences for compatibility and integration.* Although all technology can be said to work within a system, some technologies will have a far greater impact on their respective systems than others. The fax 3 standard, for example, will have fewer system wide consequences than would the change to a new operating system on a computer. Thus setting standards for more 'isolated' technologies can be expected to be easier than setting standards for more integrated technologies.

## 9. Conclusion and further action

In this article I tried to make the case that:

- Standards are critical for the deployment of technologies that will have profound impacts on industrial sectors and national economies. This is particularly the case for standards related to information technology.

- It is possible to identify critical variables which explain the relationship between standard setting and technology deployment.

- Those variables can be meaningfully grouped into four domains: acceptance of standards, the standard setting process, market structure and vendor strategies, and the characteristics of technology.

An important purpose of this effort was to stimulate thought about the true nature of the relationship between standards and technology deployment, as that relationship is surely different than the speculation presented above. My hope is to spur the formation of an 'invisible college' of interested people who will probe, test, and modify our collective understanding of these critical issues. I hope we can put the pages of this journal, the Internet, and other relevant publications to good use in carrying on the necessary exchange.

## References

Computer Standards & Interfaces (http://www.elsevier.nl/locate/csi) vol. 16, 1994 321-329 © Elsevier Science, reprinted with permission.

[1] U.S. Congress, Office of Technology Assessment, Global standards: Building blocks for the future, TC-F-512, Washington DC, U.S. Government Printing Office, March 1992.
[2] C. Cargill, in: *Conf. Proc. AIIM,* Chicago, IL (1993).
[3] S.M. Besen and G. Saloner, The economics of telecommunications standards, in: W. Crandall and K. Flamm, *Changing the Rules: Technological Change, International Competition, and Regulation in Communication* (Brookings Institution, Washington, D.C., 1989) 177-220.
[4] C.D. Sullivan, *Standards and Standardization: Basic Principles and Applications* (Marcel Dekker, N.Y., 1983).
[5] J.S. Quarterman and S. Wilhelm, *UNIX, POSIX, and Open Systems: 7he Open Standards Puzzle* (Addison-Wesley, Reading, MA, 1993).
[6] R.B. Toth, ed., *Standards Management: A Handbook for Profits* (American National Standards Institute, N.Y. 1990).
[7] J. Farrell, Standardization and intellectual property, *Jurimetrics J.* (1989) 35-50.
[8] J. Farrell and G. Saloner, Coordination through committees and markets, *RAND J. Economics* 9(2) (1988) 235252.
[9] M.L. Katz and C. Shapiro, Network externalities, competition and compatibility, *Amer. Economic Rev.* 75 (3) (1985) 424-440.
[10] M.L. Katz and C. Shapiro, Technology adoption in the presence of network externalities, *J. Political Economy* 94 (4) (1986) 822-841.
[11] C. Matutes and P. Regibeau, "Mix and match": product compatibility without network externalities *RAND J. Economics* 19 (2) (1988) 221-234.
[12] R.B. Toth, *The Economics of Standardization* Standards Engineering Society, Minneapolis, MN, 1984).
[13] H. Putnam and Bartlett, *The Impacts of Private Voluntary Standards on Industrial Innovation,* National Bureau of Standards, Gaithursburg, MD, (1982).
[14] G. Tassey, Infratechnologies and the role of government, *TechnoL Forecasting Social Change* 21, (1982) 163-180.
[15] G. Tassey, The role of government in supporting voluntary measurement standards for high technology industries, *Res. Policy 11* (1982) 311-320.
[16] G. Tassey, The role of the National Bureau of Standards in supporting industrial innovation, *IEEE Trans. Eng. Management* 33 (3) (1986) 162-171.
[17] L.G. Tornatzky and M. Fleischer, *The Process of Technological Innovation* (Lexington Books, Lexington, MA, 1990).
[18] J.A. Morell et al., Improving the deployment of Open Systems Technology: Lessons from the Manufacturing Automation Protocol Work performed for the U.S. Air Force @TECH Program, prime contract #F33615-89C5708 (Lawrence and Associates), subcontract #LAI-905708-88-2 (Industrial Technology Institute) task order #88 (1992).
[19] J.A. Morell et al., Promoting Electronic Data Interchange: Building a foundation for effective planning., Work performed for the U.S. Air Force MANTECH Manufacturing Technology Special Studies Program, prime contract #F33615-89-C-5708 (Lawrence and Associates) task order #126-3 (1993).
[20] M. Stahlman, Timeline: Ten years of success *Sun World* (Fall; 1992) 42-50.
[21] J. Farrell Standardization and intellectual property *Jurimetrics J.* (1989) 35-50.
[22] J.H. Burows, Information technology standards in a changing world: The role of users, *Computer Standard s& Interfaces 15,* (1) (1993) 49-56
[23] J.A. Morell, Integrating technological change into larger scale social change: An approach to planning Socio-economic Planning Sciences*: Int. J. Public Sector Decision Making* (in press).

[24] C.R. Morris and C.H. Ferguson, How architecture wins technology wars, *Harvard Business Rev.* (March-April 1993) 87-96.