THE ROLE OF STANDARDS IN THE CREATION AND USE OF INFORMATION SYSTEMS

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ABSTRACT

Technical interoperability standards play an important role in the creation and use of information systems. However, that role has been understudied in the MIS field, much as previous researchers have concluded that the role of technology has been understudied by the field.

This paper reviews various definitions of “standard”, but concentrates on the role of *de facto* product compatibility standards in the organizational adoption of information systems. It then considers the role of interorganizational standards upon the management of information systems. such as through the network effects and switching costs created by the supply of specialized complementary assets.. It concludes with suggestions for future research.

Keywords: standards, IS adoption, computer architecture, network effects, switching costs.

INTRODUCTION

A large portion of MIS research is directly or indirectly about standards. IT standards are front and center in research on product creation and competition in IT industries (e.g. Mendelson & Kraemer 1998; Dedrick & West 2000; Gallaugher & Wang 2002). But they are also a salient attribute of most information systems adoption decisions: sometimes the role of standards is explicitly considered (Kaufman et al 2000; Damsgaard & Truax 2000; Tam & Hui 2001), but usually the standards themselves are an implicit and unexamined aspect of the information systems artifact (e.g. Chau & Tam, 1997).

The disconnect between MIS and standards research has two deleterious consequences. First, in explaining MIS outcomes, researchers are largely overlooking a rich body of work about how such technologies are created and adopted. Information systems require compatibility standards to assure interoperability between disparate components, a major concern of those that must administer such systems on a daily basis. Researchers in economics, telecommunications and strategic management have studied the creation and selection of such standards, providing a theoretical framework for explaining the product choices faced by the MIS buyer.

The MIS community is also missing an opportunity for impact on other fields of social science research. The organizational adoption of information technologies is at the center of the field’s domain, and yet by ignoring the role of standards in IT production and use, the work of MIS researchers will tend to be overlooked by others considering such phenomena.

The gap between MIS and standards research is consonant with larger challenges facing the field. Orlikowski & Iacono (2001) have bemoaned the lack of technology in information technology research, while Benbasat & Zmud (2003) argue that to be relevant, MIS research must include either the IT artifact or its immediate precursors or consequences.

This article reviews the existing body of research related to IT standards, both inside and external to the MIS field. A review of peer-reviewed research on technology standards suggests that such research can be classified into four areas:

- **technical content:** details of specific new standards, which are well covered by professional journals such as *Communications of the ACM* and the various *IEEE Transactions*.
- **standards creation,** including standardization institutions, single- and multi-firm standardization initiatives and the process of standardization; such standardization in telecommunications is often found in *Telecommunications Policy.*
- **standards selection,** including standards adoption and competition between standards; such work has typically reported in economics and (rarely) MIS journals.
- **using standards,** measuring the economic value or impact of standards, which has rarely been measured if at all.

The first of these areas is well covered in engineering and computer science, while the remaining three areas correspond to the concerns of social science research. As such, the paper focuses on these latter areas and their potential applicability to MIS phenomena. The paper concludes with suggestions for future research.

DEFINING STANDARDS

In considering the impact of standards upon MIS, one first must agree upon a standard definition of the term. In one of the earliest typologies Hemenway (1975) subdivided standards along two dimensions: purpose (quality or uniformity) and degree of coercion (voluntary vs. mandatory). Antonelli (1994) terms these two dimensions as “reference” vs. “compatibility” and *de jure* vs. *de facto* standards. These dimensions are fully orthogonal, i.e. all four possible combinations can be found in practice (Table 1).

	Reference	Compatibility
De jure	Kilogram	NTSC, PAL
De facto	UL/CSA approval	Microsoft Windows

Table 1: Examples in the 2x2 typology of standards

These dimensions have been widely employed (either implicitly or explicitly) in the study of standards in I.T., and they will be considered in turn.

Reference vs. Compatibility Standards

Formal reference standards have an impact upon business practices, most notably through process quality standards such as ISO-9000. In systems analysis and design, the structured methodologies reported by Fichmann and Kemerer (1993) would fall into this category, even if they lack the formal ISO enforcement.

Reference standards have also been incorporated in *intraorganizational* standardization of MIS practices. For example, an MIS procurement policy might specify the approval process and decision authority, product compatibility standards (e.g. POSIX compliant), product reference standards (e.g. FCC Type B emissions certification), and policies for deployment and use. To the degree to which MIS research defines and improves “best practice”, it contributes to the *interorganizational* standardization of such practices. For example, Osmundson and colleagues (2003) developed quality metrics for the management of software development programs.

However, it is the technical role of compatibility standards makes such standards fundamental to IT products. Researchers and managers often use a simple unidimensional, bifurcated typology, terming any product as “compatible” or “incompatible” with a given standard. Beyond this, Gabel (1987) classifies compatibility as a multi-dimensional product attribute, with each attribute assuming one of several (discrete) levels. His dimensions (updated with contemporary examples) are:

- **multivendor compatibility,** such as the compatibility of PCs made by HP and Dell;
- **multivintage compatibility,** such as the compatibility of Dell 486-series PCs with subsequent Pentium-based models;
- **product-line compatibility,** as when desktop PCs (using Windows XP) from HP share a file format with its handheld (Windows CE) computers.

All three types of compatibility make it easier to reuse key complementary assets, and thus are germane to the study of MIS adoption decisions and producer strategies in information industries.

Nonetheless, in their study of EDI adoption Damsgaard and Truex (2000) concluded that the isotropic assumption of such *industrywide* standards was only one of three standardization patterns in EDI use. They listed two other approaches to standardization — standards negotiated by each pair of exchange partners, and hub-and-spoke rules imposed by a few large players on their smaller (usually supplier) partners. The latter concept could also be applied to multiple interpretations of Unix or HTML standards by proprietary vendors during the 1990s.

Systems of Related Compatibility Standards

A subset of compatibility standards can be classified as providing for interoperability between complementary components. Such interoperability standards are important because they allow for the design of modular systems, and, in particular, provide incentive for the development of cospecialized complementary assets (Teece 1986; Langlois & Robertson 1992).

Realistically, there are both economic and statutory limits as to the degree of vertical integration that is possible in promulgating a family of products that require such complementary assets. For example, while a computer company such as IBM, Apple or Sun may be capable of building a computer with an integrated operating system, it typically lacks the necessary resources to provide the additional software, hardware, training and documentation expected by customers. Even in cases where a firm has the ability to produce complementary assets, firms have an incentive to attract competitors to increase the supply of assets, as Sony did when it sought additional music companies to produce recorded music on compact disc (Grindley 1995: 101-124).[1]

By providing a series of interfaces for the required complementary products, the manufacturer can induce other firms to produce such products. This is particularly important if the complements must be “cospecialized”, as, for example, when software is provided for a Macintosh rather than an IBM-compatible PC. The developer of the standard then can choose to concentrate on those components of the system that provide the greatest barriers to entry and opportunities for profit, and use intellectual property protections in an attempt to realize those profits (Teece 1986).

A series of related standards often allow for the modular construction of complete systems, in which a group of products are combined using standardized interfaces. Among the best known examples are modular audio components and personal computers. This modularity allows for (and, in fact, encourages) producers to specialize in one particular component (such as

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[1] In 1987, Sony paid a 60% market premium to purchase CBS Records (Grindley 1995: 121). This was widely interpreted as a reaction by Sony to the failure of its Beta video tape format, a failure many attributed to a lack of pre-recorded movies.

speakers or software); the capability of the system is increased by multiple independent innovations by competing producers (Langlois & Robertson 1992). In a such a system of multiple standards, the control of the interface standard for the key complementary asset determines both the evolution of the system and which firms will profit from it (West and Dedrick, 2000).

A proprietary platform consists of an architecture of related standards, controlled by one or more sponsoring firms. For a computer system, the architectural standards typically encompass a processor, operating system (OS), and associated peripherals. Some have also extended the concept of a “platform” to include multiple layers of software, such as applications that rely on a “middle ware” tool such as Java or a database (Morris and Ferguson, 1993; Bresnahan and Greenstein, 1999; West and Dedrick, 2000).

A platform is but a specific example of the general class of technological innovations studied by Teece (1986), who links the ability of firms to profit from their technological innovations to the appropriability regime for intellectual property rights (IPR) — either through formal *de jure* protection (e.g. patents) or through *de facto* protection such as tacit knowledge or trade secrets. Absent such IPR protection, firms selling a given technology can be expected to adopt marginal cost pricing and drive profit margins to zero (Katz and Shapiro, 1986; Beggs and Klemperer, 1992). Without appropriability, Teece (1986) suggests that firms must use some combination of speed, timing and luck if they hope to appropriate returns generated by their innovation.

De Facto vs. De Jure Standardization

The classification dimensions for standards are often presented as dichotomous, assuming that each standard is, for example, either *de facto* or *de jure.* As with most typologies, in practice the classification of standards along a dimension is more a matter of degree than bifurcation.

Both Microsoft’s Windows and Apple’s MacOS are *de facto*, proprietary, partially restricted standards for personal computer operating systems. Both owned standards provide profits to their owners, and both allow (and encourage) the provisioning of a particular class of complementary assets, software applications. But the standards differ in their restrictions on PC hardware, with entry of new PC makers encouraged for Windows (like MS-DOS before it), while Apple forbade (except during a brief window) rival hardware makers for the Mac OS.

In the absence of a legal mandate, *de facto* standards creation tends to attract multiple competing implementations, thus forcing the IT adopter to choose from among the competing standards (or defer technology adoption until the outcome of the competition is more clear).

Some *de jure* standards are legally enforced by the government, as in the regulations of the U.S. Federal Communications Commission. In other cases, they are enforced by non-profit organizations with semi-official powers delegated by the government, such as the American National Standards Institute or the Japan Industrial Standards Committee (Hemenway 1975; McIntyre 1997). Damsgaard and Truex (2000) note the emergence of two major EDI standards, UN/EDIFACT and ANSI X.12, which were widely adopted by international shippers for the exchange of invoices.

In still other cases, private standards bodies have no official role, but non-compliance is so costly that adherence is nearly universal — as with the insistence of insurance companies on approval by Underwriters’ Laboratories or the Canadian Standards Association. Finally, multi-vendor standards consortia often attract such a critical mass of vendor support that any competing standard is suppressed and market (rather than political) institutions impose a single standard upon buyers and sellers.

The assumption of MIS adopters is that such *de jure* and quasi-*de jure* standards are exogenous to the firm, and immutable. But many of the *de jure* and consortia standards process identify a formal role for user-buyers in the standards creation. And the standardization process itself can make a large difference in the utility and adoption rate of the standardized technology, as Lyytinen and Fomin (2002) found for first-generation cellular telephone systems.

"Open" vs. "Proprietary"

The concept of an "open" standard has been juxtaposed against less desirable "proprietary" standards. Originally an "open" standard corresponded to "multivendor compatibility" of Gabel (1987) and the corresponding shift of negotiating power from I.T. providers to I.T. buyers. Meanwhile proprietary (or owned) standards provided sponsors with the economic returns and incentives to keep a technology up-to-date to attract buyers afraid of vendor lock-in (Morris & Ferguson, 1993).

As buyers expressed greater interest in "open" standards, the term's technical definition has been redefined by marketers eager to position their standards to prospective adopters. Various firms pursued a so-called "open systems" strategy (Garud & Kumaraswamy, 1993), which involved proprietary extensions to Unix-like operating systems to increase switching costs and relative advantage beyond a pure multivendor standard. Even an interest in standards conformance and interoperability does not accurately predict actual adoption of such "open systems" (Chau & Tam, 1997).

One of the problems of such dichotomies is that actual standards manifest different degrees of openness, ratable on an ordinal if not interval scale. West (2003) proposed a multi-attribute scale of operating systems standards openness, measuring factors such as multiple hardware vendors, multiple implementations and the availability of source code. He concluded that the most open standards were those which included unrestricted source code implementations, such as provided by a BSD-style or Apache-style open source license.

STANDARDS SELECTION AND ADOPTION

In some cases, I.T. standards are mandated by a national government agency or industry association. But more often, they are selected in the marketplace, through the adoption decisions of organizations or individuals.

Research on the economics of standards and organizational adoption of information systems both are concerned with adoption decisions for standardized I.T. products. The economics theories makes predictions about winning and losing standards, predictions that are tested in the aggregate across a national (or global) market; such theories have recently been used by MIS standards researchers (Table 2). MIS adoption theories such as TOE and TAM focus more specifically on organizations, and treat all technology as equivalent without regards to standards. The two literatures have rarely been joined, perhaps due to the different units of analysis.

De Facto Market Competition

Economics research on standards considers two ways in which standards affect the utility of a new technology: asymmetric switching costs and positive network effects. The two effects are mediated by the supply of co-specialized complementary products (such as software and peripherals) or other co-specialized complementary assets (such as IT worker skills).

Asymmetric Switching Costs

The presence of asymmetric switching costs mean that a buyer's previous adoption choices will change the relative attractiveness of future adoption choices, making some options more expensive than others. Among theoretical studies of switching costs, von Weizsäcker (1984) provides a model in which buyers discount future investments. In his economic model, Klemperer (1987) classified switching costs into three categories:

- transaction costs (e.g., the cost of uninstalling equipment from one supplier and installing equipment from a new supplier);
- learning costs (e.g. PC usage skills);
- contractual costs, or costs deliberately introduced by suppliers (e.g. frequent flyer programs).

Article	Phenomenon	Methodology	Theoretical Framework
Au & Kauffman 2001	Online billing	Theoretical model	Network effects
Brynjolfsson & Kemerer 1996	Spreadsheet product competition	Hedonic price regression	Network effects
Chau & Tam 1997	Open systems adoption	Logistic regression	Technology-organization-environment
Damsgaard & Truex 2000	EDI adoption	Multiple case studies	Linguistic grammars
Gallaugher & Wang 2002	Web server product competition	Hedonic price regression	Network effects, diffusion of innovations
Kauffman, McAndrews & Wang 2000	Bank ATM networks	Hazard model	Network effects
Tam & Hui 2001	Mainframe vendor competition	Regression	Network effects, Bass diffusion model
West & Dedrick 2000	PC standards competition	Case study	Network effects, product architectures

Sampling frame: Standards-related articles published in *MIS Quarterly, Information Systems Research, Journal of Management Information Systems, European Journal of Information Systems,* plus those in *Management Science* by MIS authors.
Search terms: standards, network externalities

Table 2: Standards-related research in MIS

"In all these markets, rational consumers display brand loyalty faced with a choice between functionally identical products. Products that are ex ante homogeneous become, after the purchase of one of them, ex post heterogeneous" (Klemperer 1987: 376).

Such product-specific switching costs give the incumbent vendor "some monopoly power" and weaken competition between firms (Farrell and Saloner 1988: 123). In a multi-period model of competition between two producers, Farrell & Saloner (1988) showed that an incumbent protected by switching costs has an incentive to exploit existing customers rather than aggressively seeking out new ones.

Other switching costs are specific to compatibility standards. Such standards provide a benefit that it is easy to mix and match products within the same standard (Langlois and Robertson 1992). Switching costs for computer owners typically fall into one of three categories:

- cospecialized complementary assets (e.g., software or peripherals), which becomes worthless with the new standard;
- user data, which requires conversion for use with new standard;
- user skills and training, often referred to as “psychic” switching costs.

Because of these switching costs, a standards-related re-adoption decision (such as for a computer) is fundamentally different than, say, a decision regarding an automobile or a copy machine.[2]

Perhaps the clearest empirical test of switching costs s Greenstein’s (1993) examination of U.S. federal government procurement of mainframe computers from 1971-1983. Using a multinomial logit model and controlling for likely confounds, he showed that government agencies did prefer compatibility in their subsequent computer purchases. Heide and Weiss (1995) found similar switching costs for commercial purchases of computer workstations, which they attribute to the uncertainty faced by organizational buyers in using a new technology.

Network Effects

Perhaps the most influential economic theory of standards adoption and competition is that of positive network effects, also referred to as positive network externalities.[3] The theory was originally developed for telecommunication technologies such as telephone or fax, where as Rohlfs (1974: 16) describes it, “the utility that a subscriber derives from a communications service increases as others join the system.” Such direct network effects also apply to the adoption of other bilateral communication technologies such as e-mail, videoconferencing or EDI (e.g., Riggins & Mukhopadhyay 1999).

But more broadly applicable are the category of indirect network effects identified by Katz & Shapiro (1985), in which the utility of a “hardware” innovation is mediated by the provision of specialized “software”:

> For example, an agent purchasing a personal computer will be concerned with the number of other agents purchasing similar hardware because the amount and variety of software that will be supplied for use with a given computer will be an increasing function of the number of hardware units that have been sold. This hardware-software paradigm also applies to video games, video players and recorders, and phonograph equipment (Katz & Shapiro, 1985: 424).

Such software is a specific category of what Teece (1986) categorizes as “cospecialized assets.” For some products (such as computers) most companies lack either the capital or the capabilities to produce all the complementary assets (“software”) necessary to make their products successful: instead, they must rely on third parties to provide this software. For standardized “hardware” such as personal computers and videocassette records, this software must be cospecialized by the software producer, and thus hardware producers must provide incentives to the software producer to make such investment (Teece 1986).

Because one of the most attractive incentives to a software producer is a large possible market, when there are competing hardware standards, the most widely adopt will theoretically attract

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2 Both the automobile and copy machine decisions may entail some psychic switching costs. However, these are probably less than for, say, switching word processors; also, there is little evidence to suggest that vendors of these products seek to provide multivintage or product-line compatibility of user skills, the way that a PC operating system or application standard inherently does.

3 There is some question as to whether the positive-feedback benefits of a network of adopters fit the economic definition of an “externality” (Liebowitz & Margolis 1994) . Subsequent economic researchers have used the term “network effects” to avoid making such claims (e.g. Shapiro & Varian 1999).

the largest supply of software, which in turn would make it even more attractive to potential adopters. This positive feedback loop results in “demand side economies of scale” (Katz & Shapiro 1986), or will contribute to “increasing returns to scale” (Arthur 1989), widening the lead of the dominant standard indefinitely.

Such theoretical models have been directly extended to the MIS field. In considering competition between electronic bill payments standards, Au & Kauffman (2001) showed the conditions under which the guarantee of upward compatibility would induce firms to wait for a later but “better” standard.

Among empirical studies of information systems, network effects have been used to explain the uncontested adoption of new technologies, such as automated teller machines (Saloner and Shepard, 1995; Kauffman, McAndrews and Wang, 2000).

Another possible test was presented by the many competing MS-DOS spreadsheet applications in the late 1980s. Hypothesizing that compatibility with the market leader (then Lotus 1-2-3) would allow a given applications to enjoy benefits from Lotus’ complementary assets, both Gandal (1994) and Brynjolfsson and Kemerer (1996) showed that such compatibility accounted for the gap between actual and hedonic price. However, the analyses did not distinguish between two possible benefits accruing to the Lotus “clones”: access to the network of Lotus-compatible assets, or reduced switching costs for existing Lotus users.

The empirical evidence on contested adoption of information systems (as predicted by Katz & Shapiro and others) is more equivocal. Tam & Hui (2001) studied U.S. sales of large computer systems from 1965-1993 and found that installed base did not predict market share for new sales of three product categories. In a study of Japanese PC standards, West & Dedrick (2000) concluded that the network effects of a large installed base and software library could be rendered obsolete through architectural reconfiguration.

The spreadsheet hedonic pricing test was extended to competing standards adoption by Gallaugher & Wang (2002), who also provided a more direct test of network effects model using the early phase of the web server market. Adjusted for relevant controls, they found that server market share (or the highly correlated browser market share) helped predict price, along with support for emerging standards and trialability.

Combining Networks and Switching Costs

In a real adoption decision, firms are likely to consider both network effects and switching costs. When one standard holds a majority share, then the combination of network advantages and installed base switching cost will tend enable the leading standard to get even further ahead (Arthur 1996). However, in a rapidly growing market, the effect of the installed base switching costs is dwarfed by the decisions of the larger population of new and potential adopters (Liebowitz & Margolis 1990; West & Dedrick 2000).

One way for a new MIS standard to become adopted in competition existing standards is through the provision of gateways or converters. Despite a promising theoretical literature (David & Bunn 1988; Farrell and Saloner 1992) and occasional use in industry practice (e.g. word processor import filters), this area has received little in the way of empirical study.

Adoption of IS Standards

The MIS field is, not surprisingly, interested in the adoption of information technologies by organizations. While such technologies often incorporate product compatibility standards, the study of such adoption has customarily been based on the diffusion of innovations framework.

Many researchers cite the sociological model of Rogers (1983, 2003) with its framework for the adoption and diffusion of technological innovations. MIS research has focused more on his enumeration of key innovation attributes (relative advantage, compatibility, complexity, trialability and observability) than his better known categorization of individual adopter personalities such as early adopters and laggards.

More specifically to MIS, the technology acceptance model (TAM) operationalizes an individual's adoption propensity in terms of two IS attributes: perceived usefulness and perceived ease of use (Davis 1989). The technology-organization-environment (TOE) model of Tornatzky and Fleischer (1990) has been use to explain intra- and inter-organizational factors that influence MIS adoption.

While these frameworks explain the adoption of an innovation, rarely do MIS researchers incorporate the salient characteristics of standards in their adoption studies. For example, in their study of open systems adoption, Chau & Tam (1997) treat the Unix-compatible operating systems standard (aka "open systems") as an innovation in the context of Rogers (1983) and Tornastky and Fleischer (1990). They do not, for example, measure network effects or switching costs as a predictor of switching propensity.[4]

In contrast, various MIS researchers have studied MIS adoption using standards theories but not TAM, TOE or similar MIS theories (e.g. Brynjolfsson & Kemerer 1996; Kauffman et al 2000; Gallaugher and Wang, 2002).

One of the few to integrate both perspectives is the early work of Fichmann & Kemerer (1993), who studied the adoption of three software process innovations using both the diffusion of innovations (of Rogers, Tornatzky and Fleischer) and network effects (of Katz, Shapiro and others) models. Although not studying standards *per se,* their use of the two competing theories provides an exemplar for how both MIS and economics theories could be employed to explain organizational adoption of standards.

It is anticipated that the recent call by *MIS Quarterly* for papers on standards in information systems will increase the supply of such work that crosses such boundaries.

CONCLUSIONS

The role of product compatibility standards has been under-studied in the MIS field. With key theories developed in economics and tested in management, economics and (rarely) in MIS, there is an accepted body of theory that could be used to explain the evolving technological environment facing MIS executives.

It is possible that the field might choose to turn away from such external standards theories in search of its own core discipline. The larger field of business research (MIS, finance, organizational studies, strategy, marketing) is rife with "paradigm envy" due to heavy borrowing from reference disciplines of economics, psychology and sociology. The concerns of Weber (2003) that borrowing external theories threatens the IS identify may represent an extreme position, but such concerns would tend to discourage extending on prior theories from other disciplines.

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[4] They also appear unaware of the earlier work of Gabel (1987) on open systems standards adoption, which is often cited among standards researchers.

Below are a few possible areas for future research on the adoption of information systems standards by organizations:

Integrating Standards and Innovation Research. As noted earlier, the MIS field has a rich and established body of research on innovation adoption, while economics offers theories of standards adoption. The two distinct constructs could be combined into a separate study, with each construct measured and tested separately. For example, the relational database of Fichmann & Kemerer (1993) is an organizational innovation (consistent with Tornatzky & Fleischer 1990), enjoying economic "bandwagon effects" (Rohlfs, 2001) as it achieved critical mass, while the competition among commercial database products (such as Oracle, Informix, Ingres, etc.) would be marked by network effects and switching costs (Katz & Shapiro, 1986; Greenstein, 1993).

Similarly, the perceived usefulness of a standardized technology (per Davis 1989) might include both attributes characteristics of standards adoption (availability of application software) and other attributes appropriate for any technology (price, reliability).

Impact of Standards. As Tornatzky & Fleischer (1990: 22) noted more than a decade ago, the adoption of an innovation is not the end of the story — there is also the question of whether it delivers the payoff expected by the adopter. The same question could (and should) be asked of standards. Do they in the abstract deliver the benefits of compatibility, modularity and interoperability as promised? Are MIS managers accurate in their ability *ex ante* to estimate the relative availability of complementary products for a prospective standards adoption, or the utility such products will provide?

Incorporating Technology. Standards research inside and outside MIS tend to conceptualize the actual technology in a nominal sense in the formulation of Orlikowski and Iacono (2001). But standards have an inherent technical role of allowing engineers to achieve interoperability between products and across organizations, and such motivations remain prominent in many formal standardization efforts such as those of the IEEE. So unanswered questions remain. Does the technical content matter, as when designers must trade off competing imperatives?[5] Is the quality of the standard (or the quality of the technology delivered by the standard) germane to an adoption decision? Is this an objective or subjective construct?

Changing Forms of Standards Competition. The importance of *de jure* standards seems to be declining as firms and multi-firm consortia ship products (such as 56K modems and 802.11g wireless network equipment) prior to formal standardization. How does this uncertainty affect adoption decisions? Absent a formal imprimatur, what guarantees of interoperability are important in standards adoption? Is the claim of "open"-ness of a standard have any impact, or is it only the reality of openness that increases adoption likelihood?

Effects of Open Source Software. Open source software has already had a major impact upon the development of information systems, particularly for applications that support Internet-related standards (Stewart & Gosain, 2001; West & Dedrick, 2001). How are MIS buyers' attitudes towards open source standards different from more customary "open" or "proprietary" standards? How can we measure the success of "free" software: for example, a hedonic pricing model of web server market share (Gallaugher & Wang, 2002) could not be used with current industry data, because the free open source server Apache has held a 60% market share since mid-2000.

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5 As an example, Liebowitz & Margolis (1994) noted that the initial design choices for videocassette formats provided two hours per VHS cassette, but limited smaller Beta cassettes to one hour each.

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