

# **Compatibility Standards, Competition, and Innovation in the Broadcasting Industry**

## **Executive Summary**

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**RAND**

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## PREFACE

If every television set cannot receive every broadcast signal, or every telephone subscriber reach every other subscriber, the costs to society may be great. At the same time, the costs of ensuring compatibility may also be great. How well compatibility is likely to be achieved through the operation of the marketplace, how innovation and competition among firms are affected, and what role should be played by public and private standard-setting bodies are thus of widespread concern.

This is an executive summary of a companion RAND report, *Compatibility Standards, Competition, and Innovation in the Broadcasting Industry*, R-3453-NSF, August 1986. That report analyzes the forces that determine whether compatibility standards develop in the broadcasting industry, the nature of standards that emerge, and the economic effects of these standards. The study focuses on broadcasting because (a) the industry is subject to rapid technological advances that continuously raise the question of whether new or modified standards are needed, (b) compatibility standards play a large role there, and (c) the Federal Communications Commission (FCC) is involved in standard setting in varying degrees, from relying solely on marketplace forces in some cases to adopting detailed mandatory standards in others. Analysis of FCC actions thus sheds light on the relationship between government and private activities in standard setting.

This study was funded under Grant PRA-8413108 from the Division of Policy Research and Analysis of the National Science Foundation. It should be of interest to participants in the telecommunications industry, regulatory bodies, the academic research community, and consumer groups.



## EXECUTIVE SUMMARY

The existence of product standards—or the lack of them—can greatly affect consumer welfare and the efficiency with which the economy operates. Standards relating to information, variety reduction, quality, and compatibility help to determine the availability and prices of goods and services, the ways in which the benefits and costs of innovation are distributed, and the speed with which innovation occurs. Given the obvious importance of standards, industry groups and other interested parties have a long history of involvement in the standard-setting process and in determining the precise nature of the resulting standards.

### PROCESSES FOR SETTING STANDARDS

Broadly speaking, there are three types of processes through which standards may be developed and adopted.

*Noncooperative behavior.* Through this process, commonly called the “marketplace approach,” firms adopt technologies independently and the industry may or may not coalesce around a single standard. Private action is noncooperative if private actors do not enter binding agreements to coordinate their behavior. These actors, however, may alter their behavior in response to the actions, or their expectations of the actions, of others.

*Cooperative behavior.* This approach is exemplified by the situation in which representatives of private firms and other interested parties, using formal procedures of committee participation and voting, meet to develop, recommend, and adopt industry standards. The resulting standards, generally referred to as “voluntary” private standards, may or may not be unanimously adopted. These coordinated actions usually take place under the auspices of trade associations and professional societies. Cooperation can also occur in less formal ways through negotiations involving a few firms or other parties and may involve side payments.

In telecommunications, for example, the Electronic Industries Association (EIA) sponsors the efforts of committees and working groups to evaluate alternative standards and to recommend particular ones for adoption. The International Radio Consultative Committee (CCIR), a permanent organ of the International Telecommunications Union (ITU), evaluates and recommends standards for worldwide adoption. Its activities parallel those of the International Telegraph and Tele-

phone Consultative Committee (CCITT), which is concerned with standards for nonradio services.<sup>1</sup>

*Government action.* Government agencies, at the federal, state, and local levels, sometimes mandate the adoption of particular standards. They do so by requiring the use of standards either recommended by outside organizations (such as the EIA) or developed or evaluated by their own staffs. These standards are distinguished from private standards by the fact that adherence to them is mandatory.

## SCOPE OF THE STUDY

How well each of these processes works in achieving socially beneficial outcomes is of concern to producers and consumers alike. Standards are important because they affect the nature and prices of the goods and services available to the public through their effects on competition and innovation. However, the role of standards is so large, and their effects so pervasive, that they can be best analyzed by focusing on a subset of standards, defined either by their form or by the nature of their effects.

One promising way to approach the subject is to concentrate on *compatibility* standards in one major industry. We focus on compatibility standards because they affect, and in some cases reduce the need for, other types of standards. For example, greater compatibility reduces the need for particular kinds of *information* (and standards for it) required to make intelligent consumer choices. The degree of compatibility also affects the *variety* of products available (and hence the need for variety reduction standards), and it clearly affects the *performance* of products (and thus the need for performance standards) measured, for example, by reliability and durability.

Moreover, compatibility standards have widespread effects—aside from their interaction with other forms of standards. Users clearly benefit if every television set can receive every broadcast signal or every telephone subscriber can reach every other subscriber, although there may be countervailing benefits from specialization, and, hence

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<sup>1</sup>These are only a few of the many organizations involved in standard setting. For example, the American National Standards Institute (ANSI) is a federation of the nation's leading professional and technical societies, trade organizations, consumer groups, retailers, and manufacturers. It acts as a clearinghouse, coordinating the approval of standards submitted to it by others. If ANSI's Board of Standards Review determines that a national consensus exists, a standard is published as a "national" voluntary standard. The International Standards Organization (ISO), to which ANSI is the U.S. representative, promotes standardization worldwide. ISO includes about 2,300 working bodies covering virtually all areas of technology, with some 5,600 standards having been published.

from incompatibility. How well compatibility is likely to be achieved through the operation of the private marketplace, how competition and innovation among firms is affected, and what role should be played by public and private standard-setting bodies are thus questions of great concern.

We focus on the *telecommunications industry* because (a) compatibility standards play a large role in this industry, (b) the industry is subject to rapid technological advances that continuously raise questions of whether new or modified standards are needed to serve suppliers and users, and (c) the federal government is involved in standard setting in widely varying degrees, ranging from relying on the marketplace in some instances to adoption of detailed mandatory standards in others.

However, the telecommunications industry, consisting of both wire-line and broadcast technologies that provide voice, data, and television services, is still very broad for analytical purposes. Consequently, this study focuses on that portion of the industry—broadcasting—in which the Federal Communications Commission (FCC) has played a major role in either influencing the nature of the private standard-setting process or itself establishing standards.

For our purposes, broadcasting includes both point-to-multipoint services (such as television) and point-to-point services (such as cellular radio). In both cases these services use the radio spectrum for over-the-air transmission—an area falling under FCC jurisdiction. By focusing on this facet of the telecommunications industry, we are able to shed light on the important differences between government and private standard setting. The cases we have selected for analysis are AM stereo, TV stereo, teletext, color television, direct broadcast satellites, and cellular radio. In addition, we include three other cases that are closely related to broadcasting but where the FCC was not involved. These are videotex, high definition television, and television program scrambling.

## **ORGANIZATION AND GOAL OF THE STUDY**

The study surveys the theoretical literature dealing with the economics of compatibility standard setting and, using that literature as an analytic framework, it examines the cases noted above. Because the cases span a long historical period and involve widely differing roles for government, they provide an excellent opportunity to examine many of the hypotheses from the literature.

Our goal is a better understanding of (a) the conditions under which compatibility standards are likely to be established through market

forces or cooperative action, (b) the role that government agencies should play in mandating standards or in encouraging standard setting, and (c) the conditions under which compatibility among technologies is economically efficient.

Among the specific questions that we address are:

1. What determines the extent to which product standardization emerges from the free play of market forces? If there is convergence on a standard, what factors determine which standard is adopted? How well does the degree of standardization, and the standard, if any, serve the interests of consumers and firms?
2. Under what conditions will firms be able to use standards to put their rivals at a disadvantage? How can such behavior be distinguished from the ordinary workings of competition?
3. Under what conditions will standards be adopted through private voluntary agreements, e.g., negotiations among firms and arrangements within trade associations? What determines which standards are chosen? How do such agreements affect the welfare of firms and consumers?
4. What role should government play in establishing standards, either in ratifying private agreements or in setting standards on its own? How do government actions affect producer profits and consumer welfare?
5. What normative rules should the government employ in setting standards? At what point in the lifetime of a technology should the government consider establishing standards? What form should these standards take? What are the symptoms of ineffective or premature action?

## CONCLUSIONS

The theoretical literature is useful in relating assumptions about the availability of information, user preferences, and other factors to whether standards will emerge and the types of standards they will be. For example, if all firms prefer the same technology and if each knows that all others have the same preference, the industry will adopt that technology as a standard. However, such circumstances rarely exist. Because of incomplete information about the preferences of other users, as well as differences in preferences, a wide range of outcomes is possible. Some of these outcomes, which involve both cooperative and noncooperative behavior among firms, are efficient; others are not.

With noncooperative behavior, several outcomes are identified in the theoretical literature.

*Excess inertia.* A standard may not be adopted even when its adoption would be in the interest of all users, because potential adopters are not confident that others will follow.

*Inefficient bandwagon.* A switch of technology by some users forces other users to switch, but the welfare of the followers and the combined welfare of both groups are lower than if neither had switched.

*Inadequate compatibility.* Some users do not switch to a new incompatible technology because they obtain no private gains from doing so, although users collectively would be better off if all switched.

*Inefficient adoption.* Some users switch and, although other users do not follow, total welfare is reduced.

*Inefficient and efficient promotional pricing.* A firm initially sets prices below its costs to increase its "installed base," thus encouraging consumers to choose its technology in later periods—a practice that may or may not lead to an efficient standard.

If firms or users can exchange information about their preferences among technologies, excess inertia may be prevented. Moreover, side payments (in the form of, say, free access to patents) may be required to facilitate adoption of standards.

Drawing from the assumptions and outcomes treated in the theoretical literature, this study examines the following cases of standard setting, illustrating a wide variety of experiences and outcomes.

*AM stereo.* The FCC evaluated competing AM stereo technologies and initially selected one as a mandatory standard. Industry response was immediately negative, however, leading the commission to abandon its decision, leaving the choice of a standard to the marketplace. Two incompatible technologies are presently being marketed as a result, and adoptions are occurring very slowly.

*TV stereo.* After an industry committee evaluated alternative technologies and recommended the Zenith/dbx system as the standard, the FCC decided not to make use of this system mandatory but rather to protect it from radio interference by other systems. Nonetheless, the Zenith/dbx system has become the de facto standard and the use of TV stereo is growing rapidly.

*Teletext and videotex.* These information search-and-retrieval systems, tailored for use by those with limited computer skills, are being marketed with incompatible technologies. However, each technology has advantages in meeting particular needs and, in light of the costs of achieving compatibility, the absence of an industry or government standard may be socially beneficial.

*Color television.* After intensive investigation starting in 1949, the FCC chose the CBS technology as a mandatory standard. The decision

was quickly seen as a mistake, and further industry deliberations led to the recommendation of the RCA technology as the standard. The FCC accepted this recommendation and the RCA standard remains in use today.

*Television program scrambling.* Driven by the desire to prevent unauthorized use of television programs by owners of satellite earth stations, the cable television industry quickly moved to a standard for program scrambling and an authorization system to permit access to programs on a pay basis. Neither government action nor cooperative standard setting was involved.

*Direct broadcast satellites.* Two industry committees were established to develop standards for satellite broadcasting. However, disagreements prevented the adoption of a video format standard, so both technologies will be strong contenders for use if direct broadcast satellite services are marketed in accordance with earlier plans.

*High definition television.* Attempts are being made to develop a worldwide standard for the production of high definition television programming. The United States backs a Japanese system; some European nations favor other approaches. No worldwide standard has been adopted, but the possibility exists that the Japanese system could become the de facto international standard.

*Cellular radio.* Because of extensive field testing, an industry committee quickly developed and recommended a standard to ensure compatibility among cellular mobile telephone units throughout the United States. The FCC adopted the recommendation and the industry is enjoying rapid growth.

For three reasons, the theoretical literature provides only limited, albeit important, explanations for the diverse outcomes among our case studies. First, although the theories identify many factors likely to be important in explaining whether a standard emerges and what that standard will be, they generally do not describe the conditions under which various outcomes occur with sufficient precision to permit definite predictions in particular cases. In other words, the empirical counterparts of the theoretical constructs are difficult, or impossible, to observe. Thus, the theories are more useful for classifying outcomes than they are for predicting them.

Second, the theories of standard setting generally do not emphasize the role of the vertical structure of the market in which the standard is to be set. The theories are essentially confined to analyzing the behavior of vertically integrated firms that offer complete systems to final consumers or firms. As a result, most theories do not address the question of how, if at all, firms involved at different stages of

production coordinate their behavior. Similarly, the theories do not identify the critical stage. Such identification would be helpful, for example, in the case of AM stereo where it is not obvious whether, in attempting to explain observed outcomes, one should focus on the behavior of receiver manufacturers, or radio stations, or both. Moreover, it is unclear whether the theory would have us focus on the nature of the product at each stage of manufacture or sale or on each stage's market structure.

Third, although the theories are helpful in identifying where non-cooperative behavior by firms is least likely to lead to standardization, they provide only limited guidance in explaining whether cooperative standard setting will occur as an alternative, which firms will cooperate, what form the cooperation will take, and which standard will emerge. Clearly, additional work is required to bring the theory of cooperative standard setting to the same level as that presently reached in the theory of noncooperative standard setting.

Despite the wide range of outcomes and the fact that existing theories are limited in their ability to explain behavior, a number of useful lessons emerge from the case studies.

1. *Formal standard setting, either by government or private bodies, may be especially important where users lack knowledge of the preferences of others and where no technology is clearly preferred.* A de facto standard is less likely to emerge where early adopters have incomplete information about the preferences of others and therefore cannot be certain that others will follow their lead. At the same time, coalescence around a formal standard is likely if users regard the various technologies as close substitutes. In this case, a government or private standard-setting body may have an important role, since failing to establish a standard may lead to excess inertia with no firm willing to go first. Conversely, where one technology is clearly preferred by most users, noncooperative behavior is likely to result in that technology becoming the de facto standard.

Table S.1 illustrates the interaction between the existence of a clear preference among technologies and the presence of a standard on the rate of diffusion of a technology.

If one technology is clearly better than alternatives for all users, and if that fact is known to all, any user can be confident that his choice will be emulated. However, if it is unclear whether a particular technology is preferred by all, early adopters will be less certain that they will be followed. In such cases, unless a standard is adopted, diffusion will be slow and the establishment of a de facto standard will be difficult.

Table S.1

## DETERMINANTS OF TECHNOLOGY DIFFUSION

	No Standard	Standard
No Clear Preference	Slow diffusion (AM stereo)	Rapid diffusion (TV stereo)
Clear Preference	Rapid diffusion	Rapid diffusion

AM and TV stereo are examples of cases in which no technology seems clearly superior. In the absence of a standard, substantial inertia exists in AM stereo, although that may be changed by the decision of a major industry participant—Delco—to adopt a particular technology. By contrast, inertia has not arisen in TV stereo, in part because of the FCC's decision to provide interference protection to one technology.

2. *Government or private action may be important in determining whether a standard is adopted, even if the action amounts only to establishing a "focal point."* Coordinating the actions of private agents may be difficult where information is incomplete, if each agent has serious doubts about the actions that others will take in response to his own actions. However, such doubts may be reduced if the government or a private body has expressed a preference for one technology. By distinguishing that technology, the likelihood is increased that the various agents will coalesce around it, even if the only distinctive feature of the technology is that it has been singled out. This phenomenon may partially explain the success of the Zenith/dbx system in the case of TV stereo.

3. *Formal standard setting, either by government or private parties, should be avoided during the time that the technologies in question are rapidly changing.* A salient example is color television where the FCC's decision in favor of the CBS technology as a mandatory standard was quickly seen as a mistake. A key difficulty was that even during the FCC's deliberations the competing technologies were being modified and perfected, making objective evaluations very difficult. It was only after early marketing tests showed the CBS approach to be seriously flawed—and further development of the RCA approach showed it to be better—that an industry committee was able to recommend the RCA approach as the standard. The FCC quickly accepted this recommendation as a substitute for its earlier decision.

4. *Weak demand for a service may prevent the widespread adoption of a technology even where it has been chosen as a formal standard, and failure to adopt a formal standard may not prevent widespread adoption of a technology where the demand for a service is strong.* Where no formal standard exists but demand is very strong, diffusion may be rapid and a de facto standard may emerge, as in the case of television program scrambling. At the same time, adoption of a formal standard may not guarantee rapid diffusion where demand is weak, as in the early days of color television after the RCA standard was adopted. In the middle ground, the existence of a standard is helpful in promoting adoption where demand is moderate, so that a technology that might not achieve widespread acceptance if it were not a formal standard might be adopted if it were the standard.

Table S.2 illustrates the interaction between the strength of demand for a service and the existence of a formal standard in affecting the speed of a technology's diffusion.

The ideal conditions for the diffusion of a technology exist where there is both a formal standard and a strong demand for the service. Cellular radio, combining a pentup demand for land mobile radio service and an FCC standard, illustrates this situation.<sup>2</sup>

However, rapid diffusion of a technology may still occur, even in the absence of a formal standard, if demand is strong. Television program scrambling, where the cable industry wished to adopt scrambling quickly and a de facto standard rapidly emerged, exemplifies this situation.<sup>3</sup>

Table S.2

DETERMINANTS OF TECHNOLOGY DIFFUSION

	Strong Demand	Weak Demand
No Formal Standard	Rapid diffusion and de facto standard (program scrambling)	Slow diffusion (AM stereo, direct broadcast satellites)
Formal Standard	Rapid diffusion (cellular radio)	Slow diffusion (early color TV)

<sup>2</sup>Of course, the fact that a standard can be adopted quickly may itself reflect the strong demand for the service.

<sup>3</sup>However, it is conceivable that, with strong demand, firms may make rapid choices without regard to the choices of others, resulting in the proliferation of incompatible technologies. This has not occurred in any of the cases we have considered. But strong

Even the presence of a formal standard may still not lead to rapid diffusion if demand for the service is weak. Slow diffusion of color television during its early years is a case in point, as noted above.

Finally, where there is no formal standard and weak demand, the prospect of rapid diffusion is bleakest, perhaps illustrated by the present situation in AM stereo.

5. *The justification for a standard is weakest in cases where a particular technology has widely varying uses.* Although standardization clearly confers benefits, it is not without costs, since the technology chosen as a standard may not serve the needs of all users equally. The costs of "variety reduction" are likely to be significant, as in the case of teletext, where users have widely varying needs. On the other hand, where various users have similar needs, as in the case of AM stereo, the advantages of standardization are likely to overwhelm those of variety.

6. *Where a standard is adopted noncooperatively, participants in the most concentrated stage of production are likely to have a disproportionate effect on the standard that is adopted.* Producers with small market shares who adopt a new technology may not be emulated by others, and they will experience the smallest gains from the adoption of a new technology if they do so alone. As a result, they are unlikely to start a "bandwagon." By contrast, producers with large market shares may experience the greatest gains from an innovation and may be more confident that their choice will be followed by their rivals. Therefore, we would expect that early adopters will be firms with large market shares and firms that operate at the stages of production that are relatively concentrated. Thus, it is no surprise that leadership in the adoption of an AM stereo standard appears to come not from broadcasting, which is quite unconcentrated, but from the automobile industry, and in particular from Delco, which has the largest market share in the most concentrated stage of production. Similarly, leadership in choosing a television program scrambling standard came from the largest cable program service, Home Box Office.

7. *Agreements on standards are easiest to reach when technologies are nonproprietary and there are no differences in preferences.* The ease with which a standard was set in cellular radio reflects, in part, the fact that the technologies in question were nonproprietary. In contrast, standard-setting bodies have greater difficulty when they attempt to

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demand may contribute to such outcomes as the simultaneous use of the Beta and VHS formats for video cassette recorders and the CP/M, MS-DOS, and Apple computer operating systems. One possible reason for the difference between these cases and our cases is that the network externalities are much stronger in the broadcasting industry than in other markets.

choose among proprietary technologies, where decisions may result in large transfers of wealth to successful producers. Thus, standard-setting procedures can be highly contentious, sorting out claims and counterclaims may be exceedingly difficult, and unsuccessful contenders may seek redress in the courts. The fact that technologies are nonproprietary does not guarantee agreement, however, since the benefits of using particular technologies may not be symmetric among users. Where users prefer different technologies because of, say, differences in their experiences with them, agreement on a standard may still be difficult. To avoid antitrust challenges to their actions, some private standard-setting bodies are reluctant to adopt standards—for example, note the decision by the National Association of Broadcasters not to adopt an AM stereo standard. If they do proceed, they are careful to adopt procedures designed to assure fairness in their deliberations.





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