Interoperability and Electronic Commerce: A New Policy Framework for Evaluating Strategic Options

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Abstract

This paper provides a new policy framework for the development of standards for interoperability in electronic commerce. It stresses the complexity of the notion of interoperability and provides a structure for reviewing interoperability between various players in the markets for electronic commerce. Furthermore, the paper highlights the need to structure the questions surrounding policy intervention in terms of market development. However, a key issue that needs to be resolved is the question of interoperability. Interoperability is defined as the set of protocols that ensure end-to-end provision of a given service in a consistent and predictable way. These protocols not only include a set of technical specifications but also include a set of contractual procedures to ensure fair, transparent and consistent interconnection as well as an institutional framework that ensures fair competition. Thus interoperability can be seen to take a variety of policy formats as the market evolves. This paper develops a new framework which offers the ability to shape policy in such a way as to accommodate the trade-offs between the incentives to innovate and the need to avoid anti-competitive behavior and ensure all firms can trade equally within given markets.

Introduction

Our purpose in this paper is to develop a strategic policy framework for interoperability and electronic commerce through the critical analysis of key areas of uncertainty. The standards debate has evolved over recent years and this evolution has had important institutional effects in addition to reshaping the process of setting standards. The evolution has seen the standards debate move from a concern over the detailed and precise specification of individual products, a detailed product 'rule book,' to a focus on functionality to a new concern for establishing a policy framework, such as openness and interoperability. In the wake of these changes the standards-making process has been changed. The primary concern is on building a consensus around the policy objectives as well as negotiating neutral interpretations of these policy objectives by firms and public policy makers. Thus in the case of electronic commerce the policy process has elevated interoperability to the status of key objective and the policy community is currently engaged in a consensus-building process in order to translate this objective into an operational model. There are dangers, however, that the policy objective of interoperability is subject to so many different
interpretations that its power as a heuristic for building a consensus-based set of standards is not being fully realized. Our objective in this paper is to help clarify the notion of interoperability and the ways in which policy actions can be defined. Thus the paper seeks to explore the ideas of interoperability and from this analysis propose a strategic framework for policy action rather than enumerate a specific set of policy actions. This approach is consistent with the notion of standards setting as consensus-building exercise.

In developing a policy for interoperability for electronic commerce there are a number of key policy dilemmas. What is known about electronic commerce can only be expressed in terms of its promise, technological uncertainties and the need for high rates of innovation. All of these suggest a policy regime that encourages the development of strong incentives for firms to invest in high-risk activities. There is also a need for public policy measures that ensure that the trust and confidence held by consumers in traditional markets is carried over into electronic commerce and its related electronic markets. Given these uncertainties there are perhaps four key policy dilemmas, namely:

- The inherent conflict between establishing an open standard for interoperability and maintaining a wide range of incentives for firms to undertake and reap the benefits of innovative activity.
- The tension between penetration pricing policy which for a product where there are high complementarities, such as hardware and software, may result in below-cost pricing and predatory pricing which distorts competitive behavior.
- The balance between encouraging activity when there are high network externalities and the locking-in of behavior in a path-dependent manner, which may result in a non-optimum outcome.
- The information asymmetries that necessarily exist between various players, in particular policy makers and market makers, and the inevitable exacerbation of information asymmetries through the innovative activity of firms.

The paper contains four main sections. The first section considers the existing array of policy initiatives that surround the emergence of electronic commerce, ranging from the clarion calls of the United States to an analysis of concepts central to electronic commerce. In the course of outlining electronic commerce and interoperability the second section illustrates not only the definitional imprecision of the concept 'electronic commerce,' but also how interoperability can occur on a variety of levels. The third section discusses some of the theoretical issues surrounding the setting of standards. The section charts the development of the theoretical debate from a set of concerns about the ability of markets to provide timely technological standards to questions about the ability of the market to select standards which are socially optimum. Such new questions are particularly pertinent under conditions of positive feedback, conditions that exist where there are strong complementarities between products or the products that clearly form part of a system,
as is the case for electronic commerce. The fourth section provides a synthesis of the analysis of electronic commerce and the theoretical debates and highlights a number of areas for discussion. Areas for further research are also raised in this section. These areas range from the incentives for innovation to the degree to which second movers are able to offer effective competition to the dominant firm and the extent to which public policy can play a role in seeding market developments. This section also provides a framework for policy analysts to both guide the allocation of resources into standards debates and a heuristic for establishing different kinds of policy action.

The main technological focus of this paper is the Internet. Although this restricts the definition of electronic commerce in that it excludes EDI networks it does concentrate the discussion around the medium that is believed will carry a dominant proportion of electronic commerce.

Openness and Interoperability: The Policy Debate

The promise of electronic commerce, its growth and global scope has stimulated a wide-ranging policy debate. This policy debate has begun to address not only the fiscal implications of the electronic commerce that will, for example, circumvent traditional market arrangements but also how to deliver the necessary components to and fulfill the promise of electronic commerce for all.

Some of the problematic issues raised by electronic commerce include interoperability, the role of the user and the relationship between national and international regulatory and industry structures (Global Standards Conference, 1997; Sacher Report, 1997; OECD, 1999). Public policy makers have stressed that solutions should be user and market led, that interoperability rather than harmonization should result and that the role of the regulator should be one of consensus-builder and facilitator. Or, as articulated by Stefano Micossi:

"The borders between technology and markets are blurring, and many old ideologies are failing. Early possession of standards, of course, provides a competitive advantage to companies. However, this does not mean that regulation can determine the process by making standards mandatory. Ultimately, it is the consumer who decides what technologies and services he is prepared to spend his money [sic]" (Global Standards Conference 1997, page 47).

At a 1997 OECD sponsored meeting, four basic policy issues were highlighted that form the foundations of a coherent policy framework for electronic commerce (OECD, 1997). These issues are:
ensuring access to the information infrastructure,
building user and consumer trust in information systems and electronic transactions,
minimizing regulatory uncertainty in the new electronic environment,
removing logistical problems for payment and delivery.

The latter three points are addressed further in the discussion below.

**User and Consumer Trust**

Trust and security are central to the development of electronic commerce. The common standpoint is that without trust neither consumers nor vendors will be willing participants in the development of electronic commerce. Security in electronic commerce is a three-dimensional concept: these dimensions are the network, the user and the vendor (i.e., the service provider).

At the network level there is widespread agreement that international standard-setting and co-operation is required to ensure that the lowest common denominator is able to withstand the most concerted efforts to commit fraud. Otherwise the weakest link would become the point of entry for fraudulent activity across all of the connected networks.

Both vendors and users need assurance as to the integrity of information, and payment mechanisms should be secure and communication/information free from interception and misrepresentation. To counter public concern strong encryption technologies have been proposed that would safeguard confidentiality, but these same technologies are open to abuse. Consequently, some have argued that encryption keys should be lodged with third parties, or that the most secure technologies should remain within government control. However, business leaders have proposed that the use of imposed government solutions in these areas should be avoided for fear of undermining consumer trust in electronic commerce (TABD, 1997).

Related to, but distinctive from, the above debate is the need to ensure privacy in electronic commerce. It is widely argued by advocates of civil liberty that Internet-generated and/or stored information should not be passed on to third parties without the prior consent of the individuals concerned. Events such as the dismissal of an American naval officer after AOL released information to an Naval investigation, and the sale of customer browsing information by companies such as Amazon.com, have dramatically highlighted an issue already under discussion by legislators and industry fora alike (Dunlop, 2000). However, the present state of Internet economics, where the bulk of revenues are generated by advertisements rather than direct sales, engenders an imperative on the part of advertising companies to obtain as much information as possible from users. This information is valuable not only to the advertisers themselves, but also through its sale to others as well.
Legislators and industry fora have sought to assure users through various efforts. It is now common for websites to both state their own privacy policies explicitly as well as make reference to their endorsement by third parties such as TRUSTe. In addition, the OECD has recently proposed that online shoppers should be afforded protection no less than that afforded offline (OECD, 1999).

Vendors need to protect electronic products through intellectual property rights. The common standpoint is that intellectual property rights are vital to the future development and vitality of electronic commerce:

... it is clear that continued success in innovation, R&D, and the introduction of new products to meet consumer needs is directly tied to global efforts to protect intellectual property. (Transatlantic Business Dialogue, 1997)

Moreover, a surprising degree of consensus can also be found as to the best way forward, namely through the incorporation of the 1996 World Intellectual Property Organisation treaties into both national law and international fora so that national distortions, that could enhance competitiveness, can be avoided. Without minimal levels of intellectual property rights companies will remain reluctant to innovate and partake in electronic commerce. However, intellectual property rights should not be used by companies to stifle competition in electronic commerce:

... it has also to be assured that international standards are accessible to everybody, and hence, standards will not be established knowingly in cases where an intellectual property right holder can discriminate potential standards users (Transatlantic Business Dialogue, 1997).

To this end a distinction should be made between copyright, patents and trademarks on the one hand, and standards and interfaces on the other. Although both relate to the protection of intellectual capital the former relate to content, and the latter to the interoperability of hardware and software configurations.

**Policy Fragmentation and Uncertainty**

It is often argued that electronic commerce should not be subject to either standards and/or fragmented regulation, as this would stifle innovation and the creation of the *global* market. Policy makers have argued for harmonization to ensure that transactions can freely flow across borders (Global Standards Conference, 1997). This view has resulted in a call that the determination of standards should be open and transparent, that all interested and affected parties should participate and national and international standards should conform. Figure 1 depicts the three participant groups within electronic commerce: business, governments and users (individuals).

Standards need to be determined by the interaction of these three
groups. The exclusion of one of more of these actors will be detrimental to the creation of optimal standards in electronic commerce.

Figure 1: Participant groups within electronic commerce. *Source:* Sacher Report, 1997.

Wherever possible the principal actors in the determination of standards should be industry and users. *Prima facie* evidence suggests that government- mandated standards have been unsuccessful in stimulating innovative industries. Moreover, governments along with international fora have been and are incapable of developing and then implementing standards as quickly and extensively as the rapidly evolving market for electronic, telecommunications and information technology goods and services. Thus, the role of governments in standard-setting ought to be restricted to the development and maintenance of a framework in which innovations may prosper.

The growth of electronic commerce, international in nature, raises complex issues relating to the validity of traditional taxation regimes. Electronic commerce offers the opportunity for traditional revenue mechanisms, such as sales taxes, corporate taxes, and value-added taxes to be circumvented to the detriment of the national revenue basis. In order to prevent revenue shortfalls it is possible that governments will decide to tax electronic commerce and in some cases they have already sought to identify where and on what basis taxes can be levied.

The United States has argued that electronic commerce should be tax-free whenever it is used to deliver products or services, and that no new taxes should be imposed on Internet commerce (The Whitehouse, 1997). However, if, as expected, electronic commerce reduces price differentials between countries, taxation revenue will be affected with the result that governments will act to impose some form of tax burden on electronic commerce. Similarly, if electronic commerce revenues grow as anticipated then a substantial portion of global trade would be placed outside of the taxation regime. It would be wholly uncharacteristic of governments to allow such a potentially lucrative source of revenue to completely escape
taxation. Thus, for a combination of reasons, which can be characterized as necessity and the lucrative nature of the opportunity that electronic commerce presents, the American position is ultimately untenable.

Interestingly, and in contradiction to the aforementioned stance several guidelines for Internet taxes have been detailed by the United States. These include that the imposed taxes should not distort commercial activities, are open and transparent and easily incorporated into existing regimes. The Sacher Report (1997), which brought together industrialists from across the OECD to discuss how the role of governments will be affected by electronic commerce, did not express concern about taxation per se, but instead about the level, scope and practicalities of any imposed regime: "... the main concern of the Group is not that electronic transactions will be subject to tax, but that the tax regime employed is workable and non-discriminatory. A further concern is the possibility that some firms could gain unfair advantages by operating from tax havens (p. 52)."

Several alternative taxation scenarios have been suggested, for instance taxation at the point of consumption, or on a per bit consumed basis. Problems abound in all the suggestions, not the least of which is how to impose a global taxation regime onto a framework both notorious for loopholes, and that is composed of bilateral rather than multilateral relationships. Witness the increasing fragmentation of American policy: states gaining from electronic commerce, such as California and Massachusetts, along with Federal bodies, have called for a tax-free Internet, whereas rural and rustbelt states, which are experiencing a reduction in their tax base, have argued that Internet-based commercial activities should be taxed.

Framework for Global Electronic Commerce

Though the United States is only one actor among many in the policy debate, its pivotal position within the development of electronic commerce, as well as its unique structural position within many international organizations, necessitates mention. Initially outlined in the Framework for Global Electronic Commerce (Whitehouse, 1997) and on subsequent occasions by Ira Magaziner among others, the United States has articulated five principles (Framework for Global Electronic Commerce, 1997):

1. The private sector must lead.
2. The market and not regulation must drive events.
3. Government actions must be specific, precise, and transparent.
4. Governments should provide the framework in which the decentralized Internet can operate.
5. The Internet is global.

The ability to articulate a coherent agenda across many platforms could enable the United States to impose a distinctly American feel
on electronic commerce, a feel that would advance its own national interests at the expense of others. For example, the Clinton Administration has proposed fundamental alterations to the way in which the Internet is governed, effectively ceding control to commercial users in particular. Advocates of the traditional Internet governance structure have objected, arguing that the changes will leave America in control of the crucial domain name system.

Electronic Commerce and Interoperability: Definitions

What is Electronic Commerce?

Defining electronic commerce is problematic; its versatility and intuitiveness ensure that often it is not defined, or that it is defined in an all-encompassing fashion where it is taken to refer to any transaction conducted over a network. Illustrative definitions include:

Electronic commerce is a general term for the conduct of business with the assistance of telecommunications, and telecommunications-based tools (Clarke, 1993).

Electronic commerce refers generally to all forms of transactions relating to commercial activities, involving both organizations and individuals, that are based upon the processing and transmission of digitized data, including text, sound and visual images (Sacher Report, 1997).

[Electronic commerce is] commerce conducted through the electronic exchange of digitally encoded information (Steinauer, Wakid & Rasberry, 1997).

Such definitions are broad, embodying in a single phrase a disparate range of activities which includes email as well as database access, trading support mechanisms for the online sale of goods and services, electronic data interchange and payment systems (Clarke, 1993). Consequently, it is possible to point to the large value of transactions conducted electronically, for instance, the level of business-to-business electronic commerce has been estimated at $114 billion for 1999 (Cohn, 2000).

Some, however, have been more parsimonious in their definition of electronic commerce. Definitions have been proposed which limit electronic commerce to business-to-business, or business-to-consumer-transactions. The ITU (1997) distinguishes between those services that are ordered, billed and consumed entirely online, and those that are billed and consumed off-line. The OECD (1997) makes an additional distinction between those companies using electronic commerce as another sales channel for their existing
activities, and those whose sole business is electronic commerce. The same report demonstrates that Internet-based electronic commerce, from business to consumer, is dominated by companies using the Internet as an additional sales channel and that these sales in comparison to the other forms of electronic commerce are relatively minor.

Figure 2 demonstrates the different focus of electronic commerce definitions. The broadest definitions are to be found at the base of the pyramid and include electronic funds transfer and credit card transactions. In the 'electronic commerce infrastructure' layer definitions make reference to the need for electronic commerce to occur over the underlying infrastructure, although 'business to consumer' oriented definitions include all electronic forms of business and customer interactions. The most restrictive definitions are located within the top layer of the pyramid, and are limited to only those instances where an electronic transaction occurs between a business and a customer.

![Figure 2: A typology of electronic commerce definitions. Source: OECD, 1997.](http://www.ascusc.org/jcmc/vol5/issue3/williams.htm)
payment system that transcended national borders. The Internet extends this beyond the transaction itself to everything that comes before and after, from marketing and product display to order-tracking and sometimes even delivery. And unlike the commercial online services, which reserve their service for their subscribers and selected merchants, the Internet is open to everyone (The Economist, 1997: p. 5).

**Interoperability: Openness and Interfaces**

The growth of electronic commerce depends critically on one issue: interoperability between different systems. Oftel defines interoperability as:

> ... the technical features of a group of interconnected systems ... which ensures [sic] end-to-end provision of a given service in a consistent and predictable way. (OFTEL, 1997)

Thus, interoperability links systems together. For example, it enables banks to link together their cash-point networks, extending the number of points at which service can be provided in a consistent and predictable fashion even though ownership remains split between the individual banks.

Central to interoperability are the two inter-related issues of *interfaces* and *openness*. Where two networks adjoin one another each must be able to understand the operation of the other if a service is to cross between the two. Interfaces, the technical and physical links between networks, are the mechanisms through which this understanding occurs. *Network interfaces* exist at the point where one network connects with another. However, as interoperability must also occur between the network and user, another set of interfaces, termed *user interfaces*, exists at the user's point of connection with the network. Both types of interfaces must co-operate with one another in the sending or receiving of a service.

Interfaces are intrinsic to interoperability, but if this is to occur the technical specifications of interfaces need to be open:

> ... an interface is open if its specifications are readily and non-discriminatorily available to all vendors, service providers, and users, and if such specifications are revised only with timely notice and public process. (Eurobit-ITIC-JEIDA Paper, January 1995, quoted in Band, 1997)

From this two characteristics of openness can be discerned; first, that interface specifications should be transparent, and secondly, that they should not be subject to unilateral alteration by one party to the detriment of others. Both of these are at odds with Microsoft's definition of openness, where voluntary licensing occurs, as this permits the possibility for unilateral alterations, as well as...
competitiveness enhancing hidden specifications. Moreover, the commercial imperative ensures that companies will be reluctant to license for fear of creating a competitor, as Band (1997) notes:

> *Microsoft ... has not agreed to license its interface specifications to firms seeking to develop operating systems that compete directly with Microsoft operating systems.* (Band, 1997)

Contrary to the notion of openness is the unilateral alteration of interface specifications by either a company, or a standards forum. Implicit within the notion of openness is the transparent and consensual determination of interface specifications, so that once set such specifications take on many of the characteristics of public goods. However, if one party is able, through whatever means, to alter interface specifications without the consent of others, it will be in a position to lock in customers, as well as extract higher returns from the market. Once undertaken the rest of the market must decide to either follow suit, or remain with existing specifications that would split the market into competing camps. Consequently, in a fragmenting market interoperability is dependent not only on interfaces within the same specifications group but also between different groups.

Fragmented but interoperable interface specifications are advantageous, as they provide a stimulus for technology-based innovation:

> *... developers of specifications for interfaces must be able to retain ownership of and benefit from the intellectual property that goes into the specifications, in order to maintain incentives to develop new technologies.* (Computer Software Policy Project, quoted in Band, 1997)

Intellectual property rights provide the innovator with the ability to recoup its research and development costs. Furthermore, the lucrative nature of captive markets engenders competition through the entry of other companies wishing to extract income from the market for themselves. Eventually it is possible to imagine a competitive market, both within and between interface specification groups, where competition is vigorous and innovative. Possible benefits under such a scenario include reduced prices, enhanced innovative tendencies by companies, and improved choice.

A single set of open interface specifications are also capable of acting as a platform for competition while maintaining interoperability, once a distinction is drawn between specifications and implementations:

> *... interfaces specifications are pieces of paper; implementations are actual products or services.* (Band, 1997)
Companies will be free to combine open specifications uniquely to create goods and services that are proprietary in nature. These then compete with one another:

... this combination of non-proprietary interface specifications and proprietary implementations meets the imperative of balancing the requirement of providing incentives to developers of new technology with the societal need for interoperability.... (Band, 1997)

At all times interoperability will be retained due to the open specifications on which products and services are based. Even so this may not encourage companies to enter the market. The market leader may be highly entrenched, and display sufficient market power so that companies are deterred from entering the market.

**A Multi-Level Approach to Interoperability**

Interoperability allows systems to be connected to one another, with services being delivered in a consistent and predictable fashion. As it has already been shown this may occur at either the network or user level, but these are not the only instances of interoperability in electronic commerce.

A multilevel approach to interoperability is depicted in Figure 3 below. In this multilevel approach interoperability will be influenced by two sets of factors. The decision as to whether a good or service should be *made or bought* influences interoperability. If a good or service is bought in from external sources interoperability becomes a more prominent issue. Furthermore, if the acquired good or service is to be incorporated into the existing activities of the firm interoperability is essential.

The *scale* of interoperability is shaped by whether or not the transaction is retail or wholesale in nature. In retail transactions interoperability is on a limited scale, whereas wholesale transactions require that interoperability is possible between a potentially much larger range of goods and services.
End user to end user
Interoperability allows one end user to communicate or transact with another in a consistent and predictable fashion. For all intents and purpose interoperability at this level occurs directly between the end users, even though communications and transactions pass from one to the other over one or more vendor networks. Moreover, interoperability occurs at the individual level, between each of the end users, and with a limited range of other goods and services. It is not the case that an infinite combination of goods and services is possible, as limited resources will be available at either end point.

Business supplier to end user
Two interpretations of business supplier to end user exchange relations are imaginable. The first interpretation involves a business supplier and individual user while the second is business-to-business in nature. In the first of these the interoperability imperative rests with the individual. It is frequently suggested that one consequence of dis-intermediation is that users willing to trade seek out suppliers. If users cannot interoperate with the supplier's systems the initial stimulus, desire, is left unfulfilled. It is clear that in this instance interoperability is influenced by trade and retail considerations.

In the second imaginable scenario the individual end user is replaced by another business. Through conforming to purchaser behavior the interoperability imperative remains with the initiator of the transaction. However, if the balance of this arrangement alters so that it becomes more equitable both parties will see the benefits from interoperability. In this second scenario the wholesale model is more appropriate.

An instance of the first scenario would be the online purchase of goods and services from, say, Amazon.com, and the second is
exemplified by financial institutions access to online services and databases.

- **Network to network**

The issue of interoperability on a network-to-network basis can be addressed through reference to interconnection. In the telecommunications industry interconnection is:

... *the means by which the providers of one set of infrastructures are able to establish "any to any" connectivity across networks whether these are alternative suppliers or incumbents.* (Scanlan, Williams & Whalley, 1998)

According to Louth (1997), the EU's interconnection directive is underpinned by three principles, similar to those for open interoperability interface standards, namely:

1. **Transparency.** The terms of interconnection are available to all as public documents.
2. **Non-discrimination.** Not only do the same rules apply in similar circumstances but the incumbent should not favor itself in any shape or form.
3. **Cost-orientation.** Charges must be cost-oriented as well as being sufficiently unbundled, but only if significant market power exists; otherwise, processes are determined by normal commercial considerations.

Without interconnection and interoperability where standards differ, international telephone calls would not be possible. For instance, with interoperability it is possible to originate a telephone call in London and terminate it in Chicago. In doing so operators are required to co-operate, as laid out in interconnection agreements, so that the call can be routed from one network to another so that termination is successful. Where the call moves from one network to the next points of interoperability will occur.

As it would be impractical for individuals to negotiate interconnection agreements whenever a network-to-network call is necessitated, arrangements are agreed on a company-to-company, or wholesale, basis.

Until now it has been assumed that interoperability is between two or more telecommunications networks, but it may be the case that interoperability is required between different types of networks. Though telecommunications networks are the principal way through which the Internet is accessed, other electronic commerce delivery media, such as broadcast, are also available. The distribution of a given service through a combination of broadcasting and telecommunications networks requires interoperability at the point where connection occurs.
• **Network service to network service**
Within both telecommunications and electronic commerce a plurality of service providers exist. This enables the market to be characterized by on the one hand universal service providers, and on the other specialist boutiques offering niche or a limited number of services. Motivated by quality, pricing or convenience considerations, consumers may eschew the universal service providers in favor of the more specialized operators.

In such circumstances interoperability is necessary so that various services can be combined. This would enable, for example, the integration of voice with video images at the point of origin. Interoperability occurs at the point where the two services are combined. Without interoperability the two complimentary service components would remain separate. The combination of two or more services is an illustration of horizontal interoperability.

The ability to combine service components facilitates proprietary combinations. Depending on the scale at which these are conducted the combinations may involve either, involve trade between provider and individual user, or wholesale arrangements where service components are bought and then combined by companies before being sold to third parties. A telecommunications parallel to this latter case would be unbundled network elements bought by new entrants from incumbents and then subsequently resold to customers.

• **Network to network application**
Interoperability at this level occurs at the point where the underlying network and the network application connect. Consequently, interoperability is vertical in nature. Generic examples of network applications include voice as well as fax and email, while sectorial instances include credit card/financial payment mechanisms in the financial sector, and reservation systems in the travel industry. Airline reservations systems exemplify specialized network applications.

A network application which is generic needs to be interoperable as more likely than not it will be incorporated with other applications and services. Within electronic commerce, payment systems will fit into this category. Interoperability will be necessary whether or not the network application is at the retail (individual) or wholesale (mass) scale. One possible distinction is that in the former case interoperability may be more limited when compared to the latter; a whole network application with limited interoperability would reduce the possible combinations, and thus commercial opportunities, of this with other applications.
New Business Models

The emergence of electronic commerce has provoked considerable debate with a number of spheres, such as public policy and business strategy. One of the key themes of these debates has been the concept of interoperability. It is clear, however, that the theoretical foundations of such a debate, especially with regard to standards have been less well articulated. In some case the debate over standards is little more than a claim for particular behaviors rather than a sustained argument. Such assertions can be seen for example in the consistent claim that the private sector should set standards largely through the operation of market forces, one of the Magaziner's five principles as outlined above.

Our purpose in this section is to set out some of the theoretical arguments that underpin the development of standards whether as a result of market-based behavior or the intervention of public policy. The initial description of the problem draws on the work of Katz and Shapiro (1985, 1987, 1994). In the last decade the focal point of the economic debate over standards has shifted from questions about the ability of markets to provide timely technological standards to questions about the ability of the market to select standards which are socially optimum. These new questions are particularly pertinent under conditions of positive feedback, conditions that exist where there are strong complementarities between products or where the products clearly form part of a system, as is the case for electronic commerce.

In developing a theoretical perspective about the manner of standard-setting in electronic commerce it is first necessary to provide a basic conceptual model for both the products in question and the nature of standards. Understanding electronic commerce as a system with considerable network externalities provides an initial point of departure. The argument is that, as with many products and services, their value lies in their use in combination with other products and services and as such strong complementarities exist. In such systems it is well recognized that the demand for the system is a function of both its price and the expected size of the network. As such a dynamic system can be characterized where adoption and diffusion effects can profoundly affect market behavior and performance. The well-rehearsed argument of what is the value of the first telephone, or fax machine, is a powerful illustration of these adoption and diffusion effects. These issues are discussed in some detail below.

Standard: What Is It and How Is It Formed?

It is possible to consider technical standards as a mechanism for encoding, storing, processing and communicating information. A standard can be seen as a set of technical specifications adhered to by a producer, either tacitly or as a result of formal agreement. Given this perspective several kinds of standards can be discerned: reference, minimum quality standards, and interfaces or
'compatibility' standards. Reference and minimum quality standards provide signals that a given product conforms to the content and level of pre-defined characteristics. As such generic reference standards reduce the transaction costs for users and producers in evaluating consumption and production activities. A product that conforms to an interface standard can serve as a subsystem within a larger system built from numerous components and subsystems.

The establishment of a standard can be seen as a result of a variety of processes, of which four distinct routes can be identified:

1. "Un-sponsored,"
2. "Sponsored" by those with a proprietorial interest in the outcome,
3. Standards agreements arrived at by consensus through voluntary standards-writing agencies,
4. Mandated standards promulgated by government or other agencies with statutory authority.

The first two processes result in *de-facto* standards as a result of market-mediated behavior, and the latter two processes rely on *de jure* procedures. A fuller discussion of these routes is presented below.

**Competition between Systems**

As observed by Katz and Shapiro (1994), market competition between systems as opposed to market competition between individual products is shaped by three key forces:

- Expectations,
- Co-ordination,
- Compatibility.

Of particular interest is the way in which the behavior and performance of both private firms and public institutions associated with system markets influence expectations, facilitate co-ordination and achieve compatibility.

Where the consumer is buying a system which will involve additional specific investment, for example in the case of a computer in human capital and software, then the consumer's expectations about future prices, availability and quality of components will have a material impact on current purchasing decisions. In such a situation where the belief is that one system is expected to be popular, and thus have for example widely available components of high quality and low prices, then that system is likely to be popular on the basis of such expectations. Such positive feedback loops are critical in shaping the adoption and widespread diffusion of systems technologies.

Co-ordination problems exist for firms as well as consumers. A firm's decision to invest in one element of a system is in part dependent on the availability, quality and price of other components, such as
the availability of software for a new architecture for microprocessors or music programming for new hardware. While co-ordination issues exist in all markets they are particularly problematic where there is systems competition. Moreover, the resolution of these co-ordination issues typically requires more explicit and extensive measures such as common ownership of various components, long term contracts and industrywide standard-setting bodies. For consumers co-ordination can be valuable where network externalities exist; for example, in the case of a communications network the value of the network to one user is positively affected when another user joins the network. A similar situation occurs for consumers when they purchase a consumer durable, the use and value of which is dependent on the supply of complementary products, e.g. compact discs for CD players. Where economies of scale exist in the production of 'software' then the availability of software will be dependent on the behavior of other consumers.

The third issue, of compatibility, essentially focuses on the degree to which a product or service designed to operate in one system can function within another system. At this stage it is important to stress that compatibility is more than a particular case of co-ordination failure. The obvious benefits that appear to flow from compatibility are derived from what can be seen as quite considerable sacrifices, for example, reduced product variety and restraints on innovation and the appropriation of benefits from risk in research and development.

The impacts of these three issues, expectations, co-ordination and compatibility, on systems where there are external adoption effects can be analyzed in the case of both a single system and where there is competition between incompatible systems.

**Single System Competition**

In the case of *single systems* one of the key issues concerns the way in which consumer expectations of the future development and value of the network intersect with the current prices levels and the adoption of the technology. Thus there is the potential for the social marginal benefits to exceed the private marginal benefits. That is, given there are network/adoptions externalities the equilibrium network size is smaller than the socially optimum network size and the perfectly competitive equilibrium is not efficient. Katz and Shapiro (1994) argue that in such circumstances even where the adoption externalities are small at the individual level the aggregate social welfare loss can be large. The variation between private and socially optimum size of a network is illustrated in the diagram below.

Moreover as observed by David (1989, 1990) the existence of positive externalities can have important impacts on the manner in which a market develops geographically: "the positive externalities at a local level can generate multiple-equilibria and non-ergodicity at
a global level". In a stochastic model where members of a finite population make recurrent technological decisions subject to the positive influence of the currently prevailing technology used by neighboring agents, it can be shown that the choices of agents become correlated. Therefore, standardization on one or another of the alternative technologies is a certainty. As a consequence the total population will be locked into a system although "each agent's decisions continue to involve a renewable commitment having only a comparative brief expected duration" (David, 1990). In an increasingly global economy the policy implications of this process of lock-in may be considerable. The process by which local externalities may manifest themselves in the adoption of a global system suggests that there can be considerable advantages to first mover markets where there is a high expectation of success. Thus in the context of the Internet, first mover behaviors in technologically dynamic markets, such as in California, could subsequently result in path-dependent decision being taken by users in other markets who are late adopters of the technology (for a variety of reasons including culture and language diversity).

![Costs and Utilities Diagram](http://www.ascusc.org/jcmc/vol5/issue3/williams.htm)

**Figure 4: Private vs. social optimum.** Source: Noam, E. (199-). Beyond liberalization III: Reforming universal service. *Telecommunications Policy*, 18 (9), 687-704.

Importantly the divergence between the private and social optimum begs the question as to what consumers and firms can do to influence the market outcome. Here two broad responses can be identified. The first concerns the way in which property rights that influence the ownership and integration of the network may be a source of innovative pricing strategies that solve the externality and
investment problems, that is, that of underutilization and inadequate investment in a expanding network. The second area of response concerns the policies that can be implemented to attract users to the network.

Where there is an owner of a single network the firm may be willing to make investments in the network that competitive suppliers would not. Such sponsorship of a network is well illustrated in the video games industry where Sega and Nintendo sell both the hardware and complementary software by adopting a pricing policy that encourages sales of the hardware platform. In these cases lower margins are accepted on the hardware, recognizing that hardware sales stimulate software sales. Similar pricing behavior can be seen in communications networks where, for example, the cost of mobile handsets is subsidized to ensure the rapid diffusion of a technology to provide a large consumer base from which to generate call revenues.

As observed by Katz and Shapiro (1994), network ownership is most effective in overcoming network externalities if the network sponsor captures some of the benefits derived from a larger network, for example through a stake in the software vendor. This inter-relationship between 'hardware and software' underpins a wide range of strategic alliances and the cross-holding of equity in ICT industries. Most recently we have seen a wide range of strategic alliances in the telecommunications and broadcasting sectors as new services and technologies undermine the historical and well established relationships between 'hardware and software' providers. Some instances of strategic alliances are illustrated below in Table 1. In the case of telecommunications, the replacement of the international accounting rate systems with a market-based system of interconnection prices radically reshapes the flow of revenues in international calls. Similarly the move to digital broadcasting is creating turmoil in the hitherto relatively stable broadcasting sector.

- Vivendi and Vodafone AirTouch have formed an alliance to provide Internet services to their customers. The alliance will create a portal that offers multiple access to services, through either television, mobile phones or PCs (Iskander, Owen, & Atkins, 2000).
- AOL and Time-Warner have agreed to a $150 billion merger. This merger will combine AOL's Internet businesses with Time-Warner's content businesses (The Economist, 2000).
- Ericsson and Microsoft have agreed to co-operate in the development of messaging and wireless products that provide fast access regardless of the device (Attwood, 2000)

Table 1: Illustrations of strategic alliances in information, communication and telecommunications industries.

The second area or response concerns the various strategies available to the network vendors to attract users. Here expectations about the availability, quality and cost of future services (software)
are critical but highly problematic, as no vendor is able or willing to make binding commitments. Inevitably, therefore, in the absence of binding commitments about future products and services, there is a credibility problem. This credibility problem can be overcome in several ways.

- First, the vendor can indirectly commit itself to a price-competitive path by opening up the 'second period' market to competitive suppliers. In practice this may mean establishing an "open" system so that third parties can provide products. IBM used a royalty-free version of this strategy to encourage software developers to support its initial foray into the PC market. Nintendo used a similar strategy to increase the diversity of the software available for its hardware but in this case charged the third party vendors a royalty.
- Another strategy is simply to rent the hardware to consumers. In so doing the vendor absorbs the risk of any subsequent capital loss.
- Vertical integration is yet another strategy which signals commitment to ensuring subsequent development of the network and its products and services.
- Where scale economies exist in the production of software, 'penetration' pricing (for example by initially selling the hardware below cost) can signal a commitment to second period activity.
- A firm can create valuable assets that signal its commitment to the market; most notably reputation is a key asset in this respect. Where the firm has a strong reputation, that is, it is used as a key market differentiator, then the firm will be reluctant to leave customers 'stranded' as a result of product developments. One of the best cases here is the commitment given by Xerox to service its machines regardless of whether or not the customer's machine is in production.

In summary, the above analysis suggests that the expected equilibrium arrived at in systems markets may well diverge from the social optimum and therefore give rise to welfare losses. The reasons for this divergence are twofold. First, the existence of economies of scale and product differentiation means that systems markets are typically characterized by oligopoly and monopolistic competition. Secondly, these markets are often characterized by temporary monopolies as a consequence of the importance of R&D and innovation coupled with an ability to appropriate the returns from such activity.

Importantly the result of this discussion is that market outcomes may be inefficient and therefore provide a prima facie case for intervention through public policy. In the context of this analysis, however, three issues need to be borne in mind when shaping a public policy initiative. First, although the existence of market inefficiencies is clear the actual extent of these inefficiencies and associated welfare loss is not at all obvious, especially as such inefficiencies could well give rise to private institutions designed to achieve co-ordination and internalize externalities. Thus the
inefficiencies themselves may give rise to initiatives which minimize
the welfare loss and in so doing remove a basis for public policy
intervention.

Second, even where the rationale for public policy intervention
remains strong there are considerable uncertainties about the
beneficiaries of such intervention. A reasonable case can be made
that public policy would be designed in such a way as to protect
existing producers and users and thereby have the unintended
consequence of blocking or imposing inefficiently high costs on
emerging technologies. There is *prima facie* evidence from the US
that the FCC policy on HDTV has resulted in this unintended
consequence because of its allocation to operators of the 6mHz
band.

Third, there remains the problem of both a lack of information and
information asymmetries. Such informational problems are
particularly difficult when setting standards with respect to emerging
technologies. In such case it is almost impossible ex-ante to know
which is the "correct" standard.

**Establishing Standards**

As discussed above there are several routes by which a standard
can be established. These routes can be analyzed in terms of four
basic categories, namely:

- Laissez-faire, or sponsored standards,
- Consensus, standards arrived at through voluntary action but
  with a quasi *de-jure* status once established,
- *De-jure* standards,
- Un-sponsored.

In the "un-sponsored" route, a set of a well-documented and public
domain standards exists but they have no identified originator
holding proprietary interests, nor subsequent sponsoring agency.
Such standards, for example the QWERTY keyboard, are often the
result of path-dependency, that is non-ergodic systems, where the
decisions in one period lock in behaviors in subsequent periods. In
such cases positive feedback is sustained through economies of
scale in production as well experience-based learning. It should be
noted however, that because a standard is "un-sponsored" it does
not necessarily mean that public policy measures are not necessary
or desirable. Such policy action may be required because although
the standard is "un-sponsored" it does not necessarily mean that
certain firms have acquired property rights that they seek to earn
rents from.

Sponsored standardization differs sharply from the un-sponsored
process. The key issue here is that influence in the standardization
process derives from the ownership of assets that are committed to,
and derive their value from, the standards being promulgated. A
number of strategic responses can be seen as firms sponsor a
particular standard. In many respects these strategic initiatives will

be designed to frustrate a de-jure process and through a variety of market-based actions, such as penetration pricing and creating a bandwagon effect, attempt to establish a de-facto standard.

Consensus based standards is predicated on collaborative advantages accruing in such way that the problems created by expectation, co-ordination and compatibility are more than offset by the development of the market. One of the problems with consensus-based standards, as well as de jure-based, is the information asymmetries that exist between different participants in the standards making process both in terms of the technology in question, the technology trajectory and the behavior of the market. In some cases these information asymmetries can be alleviated ex-ante, but others cases, such as consumer behavior they cannot.

Mandatory standards are a result of processes that are backed by statutory authority. Such standard setting processes may well involve a wide degree of consultation and consensus-building but the essential decision-making process and the enforcement of the standard is legitimated by statutory power.

**Interoperability and Electronic Commerce: Implications for Public Policy**

Our purpose in this section is to focus the preceding discussion in terms of a public policy debate over the development of standards for electronic commerce. Priority is placed on the issues of standardization as might be perceived from a user's perspective. The first subsection brings the analysis and debate set out above together in the form a simple matrix. The second subsection offers a heuristics for structuring a debate over standards. Both these subsections have been written to stimulate a debate rather than provide a definitive set of solutions.

**Matrix Analysis**

The above debate raises a number of issues about the standards process. In particular there is clearly a tension between the incentive structures that exist for stimulating research and development and innovative activity, and measures that ensure social welfare maximization. As observed there are dangers of the under-utilization of networks and a paucity of investment should the incentive structures be inadequate. However, there are real dangers associated with the creation and abuse of monopoly position, and other issues relating to the lock-in of inappropriate technologies, where the suppliers are able to internalize and appropriate all the benefits for R&D and innovation in a system where there are positive network effects.
Table 2. Consumer perception of the importance of standards in electronic commerce.

In Table 2 above we offer a framework for defining the locus of standard setting activities and the processes by which such standards could be derived. This table has been constructed from a consumer's viewpoint. A different perspective, such as an Internet service provider’s, could be expected to yield a different set of results. This framework is designed to facilitate a focused discussion. In the first instance the categories which define the table are themselves subject to debate. Thus for example the typology of electronic commerce relationships may need to be evaluated. We have set out our arguments for this typology but recognize other perspectives exist. We would argue, however, that there is broad agreement about the routes to standards setting and as such little debate should be provoked by the classification used in the table.

The assessment offered here of the relative importance of each cell in the table is subjective and clearly more work and discussion is required. The purpose of our assessment is to demonstrate that there are a wide variety of outcomes and that a single panacea would be inappropriate. Moreover, understanding this variety of outcomes can help in prioritization of the standard setting process.

Developing a New Policy Framework

This section begins to outline a policy framework that could be used to shape a detailed policy process. We have elevated two key issues in the standards debate, the first being the need to establish an effective framework for appropriation. The second and related concern is the need to inhibit anti-competitive behavior. Such behavior could be derived from either exclusive technological rights or market-based strategies, such as those that bundle technologies and services into a single offering that is encapsulated in restricted contracts. The tradeoff between standards and risks is illustrated below in Figure 5. This highly stylized graphic demonstrates that at the extremes there is an inherent conflict between standards and the risk associated with innovative activity. It is important to note that although innovative activity can manifest itself in terms of
products/services, processes and organizational design standards tend to have a more limited expression, typically in terms of products and services. Thus where open standards are developed and implemented the signal to innovators is to focus on those areas, such as processes and organizational designs where the benefits of innovation can be appropriated.

![Diagram](image)

Figure 5. Standards vs. appropriation trade-off.

For the policymaker the question remains as to when and how to structure a standards-setting initiative given the objective is to achieve a compromise between the incentives to innovate and the facilitation of the rapid diffusion of the system/technology. There appear to be four policy instruments available:

- Allow for the full exploitation of proprietary rights derived from intellectual and other property rights,
- Facilitate the development and use of adapters,
- Establish interface standards,
- Require *de-jure* open standards.

For the policymaker then the issue becomes one of shaping an appropriate policy response. Not only does this involve the identification of the appropriate policy vehicle but also the timing of such actions. The general thrust of our argument is captured in Figure 6 below. By using a product life cycle model it is possible to identify the ways in which different policy instruments may map onto market developments. We would argue that the question of timing is both a function of time and also one of market share. Thus we would argue that a particular market share, regardless of the period in which the product has been in the marketplace, could trigger a move from one policy stance to another. Conversely a stable but low market share would mean that the product/system in question would remain within a particular policy initiative.
This analysis again provides a focus for debate in that it requires estimates and forecast of diffusion rates and the definition of the trigger points that switch policy initiatives from one format to another. The significance of these questions is mapped out in Figure 7, where the basic model presented above has been elaborated. In this diagram three distinct states can be identified, each of which has its own policy objective, such as 'interfaces' and the policy objective or minimizing anti-competitive behavior. Importantly this model also identifies two key stages in the standards-setting debate that moves the industry from one stage to another. The two dynamic forces are labeled 'adapters' and 'openness'.

![Diagram](image)

**Figure 6. A framework for policy intervention (1).**

The use of adapters can be seen as a way by which collaboration with the innovative firm can result in the broader development of the market. The purpose of adapters can be seen to stimulate market uptake of new services and provide additional incentives to innovative activity. In contrast to 'openness', where the technical interfaces and the protocols can be seen to have the attributes of a public good, such features remain private property in the context of developing adapters.

In essence 'openness', or interfaces, is where the full technical specification of a system is available through a variety of collaborative arrangements to competing firms in order to ensure interoperability between their products. The outcome thus is competition in terms of prices and quality, including functionality. Interfaces, therefore, can be seen to play a critical role where a product/service is well established in terms of market penetration and where the underlying technological development is relatively stable. In contrast, adapters can be seen as a mechanism by which a firm with technological leadership seeks to bring other firms into partnerships in order to develop a strong market position. In such
circumstances the dominant firm maintains control of the underlying technology. Thus the outcome in terms of competition is distinctly different than in those cases where interfaces exist. The use of adapters can be seen to foster competition of ideas and therefore leads to product diversity, i.e. analogous to monopolistic competition. It should be noted that adapters could be used by a dominant firm to maintain its position in the market. Alternatively adapters could be used as a vehicle for building collaborative advantage whereby collective and cohesive action by competitors can challenge the dominant position of a firm. Perhaps the best illustration of the use of adapters to break the position of a dominant firm is that of Fujitsu in its promotion of open standards to break the 'monopoly' of IBM in the mainframe market.

![Diagram](http://www.ascusc.org/jcmc/vol5/issue3/williams.htm)

**Figure 7: A framework for policy intervention (2).**

**Future Research**

Beyond the issues raised above there are a number of questions that could form part of a broad policy debate. While not exhaustive the following issues need further clarification.

**Openness vs. Appropriation of the Benefits of Innovative Activity**

The issue here is the balance between the incentives to innovative and the extent to which all firms have access to new technologies. Given that innovative activity is designed to exploit some as yet unrealized economic opportunity a firm necessarily will seek to protect the result of its innovative activity. Where the system for appropriating the benefits of innovation is weak the level of
innovation will be low. Thus a firm will innovate where there are clear advantages of being a first mover and these advantages can be protected for a period sufficient to recover costs. However, where the regime for appropriation is strong a firm may well be able to exploit a series of technological advantages into other commercial advantages that can be sustained even where technological leadership has been surrendered. Thus, for example, short-term technological leadership might also manifest itself in the long-term control of distribution channels or more subtly in terms of the decision-making framework used by consumers (such as IBM with mainframes and perhaps currently with Microsoft and PC-based systems).

It is clear that where the regime of appropriation is weak innovative activity is low. In such circumstances any move to establish open standards will militate against innovative activity. Such a state of affairs can be detrimental, especially where consumer welfare would be enhanced by significant new technological, product and process developments. Thus the creation and imposition of standards at an early stage of market development may well be counterproductive.

A number of key questions need to be addressed, such as the rate of diffusion and the extent to which the product or service can be circumscribed in the subsequent choices of consumers. In cases where the diffusion rate is rapid and where subsequent choices may be severely curtailed then the case for public policy intervention is strong. The forms of this intervention, however, may be varied. Public policy intervention could include treating the product/service as an 'essential facility', the regulation of the supplier, or the funding of research and development of alternative technologies. In the case of electronic commerce these issues may well be very complex as rapid diffusion is relative commonplace, for example, Microsoft reportedly estimated that 60% of the existing Windows installed base would have adopted Windows 98 within 8 months of its launch in June, 1998 (Financial Times).

Second Mover Issues

Where a firm entering a market is clearly a second mover there are a range of concerns as to the extent to which such a firm can provide effective competition to the dominant firm. Clearly there are questions over the extent to which consumers will respond to the products/services provided by the late entrant, especially when a new generation of technology undermines previous generations. This undermining of a product is clearly evident in ICT industries where, for example, PC's based on 486 processors became obsolete with the introduction of the Pentium. This cycle continues to repeat itself as each new generation of processors is introduced. There are also concerns when the second mover only has a freedom to operate in particular and limited markets. As a consequence the second mover may well not realize any economies of scale nor achieve sufficient levels of income to fund subsequent developments and become an effective competitor to established...
firms. The European semiconductor industry is perhaps a good example of a situation where territorially defined markets ultimately undermined the ability to compete internationally.

**Seeding Market Developments**

Where network externalities can be said to exist then consumer behavior will, as discussed above, be dependent on expectations about the availability, quality and price of complementary systems components. Inevitably therefore there is a role for public policy that not only encourages a diversity of products and competitors but also encourages consumers to experiment with new services at minimum risk. Thus with the Internet there is a debate about providing access in schools and libraries as a way of providing a major stimulus to users to explore the value and utility of the Internet, and for suppliers to explore the cost and revenues of a relatively rapid rollout of service. However, such market priming policies must inevitably be short-term and designed to address a series of information asymmetries that may result in a form of market failure. In the case of electronic commerce it could be argued that there is a case for public policy initiatives to encourage firms to explore migration strategies to new forms of trading and for the resulting information to be freely available.

Further, by addressing information asymmetries public policy makers also begin to provide inputs into the design and implementation of policy initiatives. Clearly public policy makers do not have the appropriate information to be able to know the path of technological and market developments and thus 'pick winners' with any degree of confidence.

**Regulatory Certainty**

In the case of electronic commerce where an international viewpoint dominates thinking about the issues there exists the possibility of fragmented and conflicting policy interventions both within a jurisdiction and between jurisdictions. Such policy confusion will act as a major inhibitor of innovative activity and create a set of incentives that will ensure that investment and the adoption of new technologies occurs in those locations where the policy tensions are at their minimum. Here public policymakers have an important role to play in shaping and building a consensus around standard-setting behaviors.

**Summary**

In this paper, a new policy framework for the development of standards for interoperability in electronic commerce is developed. The framework stresses the complexity of the notion of interoperability and provides a structure for reviewing interoperability between various players in the markets for electronic commerce.
Furthermore the paper highlighted the need to structure the questions surrounding policy intervention in terms of market developments, and mapped out the dynamics of policy intervention.

The technological focus of electronic commerce in this paper is the Internet. This is because Internet-based electronic commerce represents an unprecedented opportunity: it is a rapidly growing and international market that promises to climb to more than $330 billion by 2002 (OECD, 1998, p. 12). Moreover, electronic commerce promises to revolutionize customer-supplier exchange relationships largely through processes of dis-intermediation.

In this paper, interoperability is seen as the set of protocols that ensures end-to-end provision of a given service in a consistent and predictable way. These protocols not only include a set of technical specifications but also include a set of contractual procedures to ensure fair, transparent and consistent interconnection as well as an institutional framework, which ensure fair competition. Thus interoperability is expected to take a variety of policy formats as the market evolves. This development is illustrated in Figure 7. This diagram offers the ability to shape policy in such a way as to accommodate the trade-offs between the incentives to innovate and the need to avoid anti-competitive behavior and ensure all firms can trade equally within given markets.

Footnotes

1. Sacher Report, 1997. Three main delivery media are noted in this report: telecommunications terminals (including fixed and mobile voice telephony, and fax), computer terminals (ranging from mainframes to PCs), and broadcast terminals (comprising terrestrial, cable and satellite transmission).

References


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