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DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
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OECD WORKSHOPS ON THE ECONOMICS OF THE INFORMATION SOCIETY

WORKSHOP No. 6

London, 19-20 March 1997

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FOREWORD

The OECD Workshops on the Economics of the Information Society are aimed at developing economic data, research and analysis in the area of "Global Information Infrastructure -- Global Information Society." They are conducted under the aegis and direction of the ICCP Committee as the precursor for policy discussions within the Committee. The workshops concentrate on providing leading edge research on the economics of the coming "information society", will have a quantitative and empirical focus and identify and refine the analytical and statistical tools needed for dealing with these issues.

The **sixth** in the series of Workshops was held in **London** on the **19 and 20 March 1997** on the theme of "Market Competition and Innovation in the Information Society." The Workshop was co-organised by the Science Policy Research Unit (SPRU) of the University of Sussex, UK, and the Institution of Electrical Engineers (IEE), together with the European Commission and the OECD. Overall co-ordination of the workshop was carried out by SPRU.

The London workshop focused on issues associated with market competition and innovation in an information economy because these are essential tenants for economic growth, and establishing an environment for attaining healthy competition and active innovation have, and continue to be, key public policy objectives. But the market behaviour of firms and the process of innovation is poorly understood in those sectors which are key to the Information Economy (e.g. software, network services, hardware). Here a premium is placed on intangible assets, establishing networks and protecting intellectual property. A shift in emphasis to these factors could have implications for the structure of the economy (small vs. large firms) and how firms interact in that economy.

On the occasion of this Workshop, leading experts from major economic research centres, academic bodies, consultancies, industry groups, think-tanks, as well as government officials, presented their views and ideas for discussion. It provided the opportunity for interaction and debate on the economic impacts and policy implications of electronic commerce from various aspects, provided a stimulus for further research and highlighted priorities for future investigation. This report outlines the highlights of the contributions and discussions at the Workshop, and provides a list of participants. The OECD acknowledges with thanks the support and enthusiasm of all those involved.

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POLICY IMPLICATIONS

The discussion of market competition and innovation in an information economy underscored a number of implications for public policy, extending from a basic need for policy makers to ensure that they are better educated and informed about this new economy to the fact that the basic data which are required to evaluate the efficacy of competition and innovation policy in information sectors was lacking. The policy implications fall into three broad areas that are each further developed in the Rapporteur's summary: 1) improving communication with the policy community, 2) the implications of network economies on competition policy and 3) challenges for SME policy.

1. Interacting with the policy community

Many participants agreed on the need for greater attention to broadening the public's and policy makers' understanding of developments beyond the relatively small community of those "in the know". The current policy agenda is strongly influenced by the need to accelerate job creation and economic growth, and there are many influential voices in the policy community that regard information society issues as peripheral to, and in some countries, counter to these central concerns. The following policy implications emerged:

- *Revive interest in the problems of technology transfer*. Both within nations in the improvement of higher education teaching the development of skills that are relevant to industrial needs and between nations in assuring that what is now being learned about business and other organisational transformation becomes available to developing nations.

- *Develop an understanding of how information and communication technologies can aid in the profound structural transformation* underway as we move toward the information society.

- *Do no harm*. Even with improved knowledge of the changing situation, policy interventions, particularly in the area of regulation, were increasingly hazardous due to the difficulty of providing timely and comprehensible information to public officials.

- *The market can not provide all the solutions*. The need for providing safeguards that ensure market competition is heightened by major changes in industrial structure and significant challenges to the competitive operation of markets. This raises concerns about the outcomes that may be achieved through processes that are entirely market-led.

2. The impact of network economies

The utility of many products in the information economy grows as more people join a network which in turn attracts new members to the network. This can create "lock in" on certain technologies, giving early leaders a competitive advantage and reducing the acceptance of innovations. Research is needed to analyse the impact of network economies on market competition and innovations more carefully. In particular, the workshop identified the following areas in need of attention:

- Is there a potential for such networks to erect substantial barriers to entry or create other barriers to competition?

  The general conclusion of the discussion was affirmative. The difficulty of commercialising new complex system "platforms" allows incumbents to exert market power over their suppliers. Similarly, when a network is established based on the control of intellectual property rights there are significant risks that the market power legitimately conferred by these rights may be extended more broadly, either to bind the network together more tightly than would otherwise be possible or to create market power in areas where it would not otherwise exist.

- Is there a boundary between the organisation of such networks for improving innovative performance and for achieving market dominance?

  Here the general opinion of the discussion was more qualified. There is likely to be both private and social value in transforming competitors into "complementors" when the result is the more rapid development of new markets or the avoidance of duplicative "zero sum" research and development efforts . In many cases, networks require a co-ordinating entity or a "trusted third party" to manage exchanges, particularly in areas where security considerations are present. And frequently, network co-operation means the creation of shared assets whose value may depend upon the persistence of the network relationship -- in some cases it can be durable and in other cases fleeting.

3. The challenge for SMEs

Information and knowledge are important sources of innovative opportunities and management challenges. Thus firms, such as SMEs, that lack the resources to develop, acquire and use information will be at a disadvantage. Policies could be developed that seek to mitigate this problem by:

- helping SMEs develop effective strategies for acquiring knowledge;

- expanding policies beyond diffusion oriented policies to include advice on how to use IT to enhance and ultimately transform business processes where potentially larger gains may be achieved;

- refocusing information technologies policies to encompass the human dimensions of the process (e.g. skills development, greater use of women) and focus on usability;

- shifting the focus of policies designed to help young information and communication technology firms from technology or production to areas such as finance and marketing.

Many information technology products are essentially global products from the day of their release. Consequently, a company that neglects the potential of the world market is creating an "arbitrage" opportunity for a company with established capabilities to serve global markets.

- The consequence of immediate global marketing is that young and small companies must have a strategy for extending their reach without engaging a full scale global distribution system. While a variety of co-marketing and agency relationships are partial solutions to this problem, this could also be an extension of the traditional role of government as a promoter of exports.

4. Improved Measurement of market competition and innovation

It was generally felt that the current state of our measurement techniques created a substantial risk in that we may either be missing or inappropriately responding to transformations currently underway. This concern was highlighted in the discussions of intellectual property and regulatory transformation. In the area of intellectual property the movement toward stronger intellectual property regimes is premised upon the belief that these will help accelerate innovative and competitive performance. Yet, it was clear from a number of the presentations that the speed of transformation itself is sufficiently rapid to create adjustment problems and that there are significant risks that a stronger intellectual property rights regime can be a route toward augmenting market power rather than competition. This raises the important question of whether the use of this regulatory structure is, in fact, achieving the aims which, in principal, it claims to support.

- Improved indicators are needed to better evaluate the impact policies have on market competition and innovation.

PROGRAMME

OECD WORKSHOPS ON THE ECONOMICS OF THE INFORMATION SOCIETY

Workshop No. 6, London, UK
Wednesday 19 March and Thursday 20 March, 1997

Organising Institutions:

Science Policy Research Unit (SPRU), University of Sussex
Institution of Electrical Engineers (IEE)
European Commission (EC)
Organisation for Economic Co-operation and Development (OECD)

Venue:

The Institution of Electrical Engineers (IEE),
Savoy Place, London, UK

Background

The OECD Workshops on the Economics of the Information Society are aimed at developing economic data, research and analysis under the aegis and direction of the Committee for Information, Computer and Communications Policy (ICCP) as the precursor to policy discussions within the Committee.

The workshops concentrate on providing leading edge research on the economics of the coming "information society", have a quantitative and empirical emphasis and identify and refine the analytical and statistical tools for dealing with these issues.

The sixth in the series of Workshops, the London Workshop, contributes to the OECD activities on "Global Information Infrastructure - Global Information Society". The Workshop is jointly organised by the OECD, the Science Policy Research Unit (SPRU), University of Sussex, the Institution of Electrical Engineers (IEE), and the European Commission and hosted by SPRU.

Objective of the London Workshop

The overall theme for the workshop is "Market Competition and Innovation in the Information Society". Competition and innovation are major forces driving economic growth. Establishing an environment for attaining healthy competition and active innovation are key public policy objectives.

The market behaviour of firms in key sectors of the Information Economy is increasingly varied and not yet well understood. Intangible assets are central to competition and innovative performance and new growth potential is expected to emerge as a result of the activities of innovative entrepreneurs. At the London Workshop, key aspects of market behaviour in the Global Information Society and their implications for policies were discussed.

First, the discussion focused on a characteristic of many sectors of the ICT industry, such as software, network services and even hardware, that users or consumers are connected by networks -- such as communications networks or networks of compatible technologies. The implications of such networking for competition and innovation will be considered. In these industries, unlike in the traditional goods industry, economic returns can increase with the scale of production due to very small or minimal increments in the costs of production (although initial development costs may be very high). In many cases, the market share of the installed base matters more than current sales share. This has led firms in some ICT sectors to adopt strategies which would be considered unusual in traditional industries -- for example, aggressive marketing to develop new customer bases and to secure the existing customer base are commonly seen in both the software and mobile communications markets. Various forms of standard-setting strategy and strong competition are taking place in nearly every segment of the ICT industry. The formation of consortia, joint ventures and other types of industrial co-operation involving competitors is more common than in other industries. The nature of the inter-firm competition and associated business conduct which exist in "network" industries are considered as key elements of the competitive environment of the Information Economy.

Second, the role of Intellectual Property Rights (IPRs) and related regimes is considered from a global perspective. The ownership and control of intangible assets play a crucial role in the Information Economy, but it is questionable as to whether the existing regimes are well adapted to economic activity in the Global Information Economy. Existing institutional regimes for IPRs, e.g. patent, copyright and trade secret protection, may not be providing adequate incentive to invest in innovative activities, at least not to the degree originally intended. The extension and consolidation of protection for intangible assets on a global basis may create uncertainties with regard to enforcement and may also complicate the process of market entry and competition. In addition, the technological environment is changing rapidly. For example, digital network technology enables copyrighted works to be reproduced, adapted and distributed easily across borders. There are increasing calls for steps to ensure the application of copyright protection to products and services developed by the content industry. More frequent access to and use of patents and other IPRs are expected more generally across industrial sectors. Technological solutions are also worthy of consideration. These developments suggest the need to examine whether existing regimes for handling IPRs are efficient and workable for protecting rights and responding to increasing demand for protection, and to consider the impact on innovation and the competitive environment.

Third, the opportunities and potential for innovative small firms are discussed. While larger firms often continue to be innovative, smaller firms tend to be in both risky and specialised market positions. Smaller firms have a growing range of opportunities to create and commercially exploit new ideas and knowledge and many are taking advantage of them -- in the software industry, for example. Expectations for their contribution to job creation in the Information Economy are high. The increasing adoption of electronic commerce may enable these firms to participate in global markets. However, electronic commerce may also promote the emergence of a new intermediary business and there is a risk that these firms will dominate the electronic market. Although there remains great uncertainty with regard to the role of small firms in electronic commerce and it is not clear how many of these firms will remain viable or contribute to job creation as the market matures, there is growing interest in their creation, growth and entrepreneurial role in the Information Economy.

Fourth, the principles for promoting competition and innovation in the Global Information Economy are discussed. There are areas where dominance may persist or may be created in new ways, or market competition may be harmed. For example, the technical convergence of telecommunication, computing, audio-visual and software technologies has been accompanied by the emergence of new business strategies that may affect the contestability of markets. Many products and services are being disaggregated or bundled in new and complex ways that interact with the changing patterns of vertical and horizontal integration of firms. The impact of new forms of integration could be significant for competition policy regimes and there may be a need to harmonise the underlying principles of these regimes internationally. This session addresses the implications of these developments for the implementation of competition policy and for the promotion of innovation.

Thus, following the workshops in Toronto, Istanbul, Tokyo, Helsinki and Seoul, this sixth workshop (the London Workshop) will look at the competitive and innovative environment of the market. The implications of this environment for public policies are drawn.

Overall structure of the Workshop

Session 1: What are the key features of the changing nature of the market? Is the market becoming more pro-competitive in the Information Economy? Is there a trend toward greater competition in the Information Economy?

Session 2: Are the methods of protecting intangible assets through the creation of intellectual property rights providing the proper balance between incentives for innovation and competition? Is the enforcement of IPR protection efficient and effective in the Global Information Society? What are the implications for the competitive environment?

Session 3: What factors are making smaller firms more innovative and competitive? Are the conditions for entry and growth of innovative entrepreneurial firms changing? How are markets responding to innovative entrepreneurs and smaller firms?

Session 4: What are the principles for promoting competition and innovation in the Global Information Society?

Session 5: What conclusions can be drawn from the Workshop? What is the future research agenda for governments and for international organisations?

Proceedings of each Session

Each session will start with presentations by speakers (each approx. 20 minutes) followed by comments and questions from discussants (each approx. 15 minutes) after which the sessions will be open to questions from the floor.

WEDNESDAY, 19 MARCH 1997

08.30 Registration

09:15 Welcome Address

-- Lord Renwick, Chairman EURIM
-- John Williams, Secretary and Chief Executive, IEE
-- Detlef Eckert, European Commission, DGXIII
-- Michael Oborne, Deputy Director, DSTI, OECD

10:00 Introduction

-- Christopher Freeman, SPRU
-- Robin Mansell, SPRU
-- Mission of the London Workshop
-- Administrative Matters

10:15-13:15 Session 1: Changing nature of the market in the Information Economy ... "Network" nature and its impact on industry conduct

In this session the "Network" characteristics of the key industries in the Information Economy and its implications were discussed. As a result of the discussion, the underlying economic mechanisms of the Network industry, and the industry conduct deriving from such mechanisms were identified.

Issues discussed:

- *The economic mechanisms of the Network industry*. How are firms motivated to compete or to cooperate? What are the key forms of industry conduct that characterise the Network industry?

- The competitive nature of the market. Is there a move toward a more pro-competitive market? Or are the markets tending toward monopoly where stable patterns of large scale vertical and horizontal integration emerge?

- *The innovation environment of the market.* How does the "network" nature of the industry affect innovations? Are there any risks that the new forms of business conduct will limit innovation? To what extent does continuing innovation in new technologies lead to "breakthroughs" or "leaps" that limit such risk?

- *Social welfare aspects of the market*. How are consumers benefiting from the market mechanism? Is the market mechanism allocating resources appropriately? What are the risks for continuing use of the current tools of competition policy?

(Chairman)

-- Gary Hewitt, Division of Competition and Consumer Policy, Directorate for Financial and Fiscal Affairs, OECD

(Speakers)

-- Jiro Kokuryo, Keio University, Japan
-- Brian Kahin, Harvard University, USA
-- Yasunori Baba, Tokyo University, Japan
-- Richard Cawley, EC, DGXIII, Belgium
-- Shane Greenstein, University of Illinois in Urbana/Champaign, USA

(Discussants)

-- Staffan Hulten, Stockholm School of Economics, Sweden
-- Rowan Douglas, Wire Ltd, UK

(Session Rapporteur)

-- Natasha Constantelou, SPRU Doctoral Student

13:15-14:30 LUNCH

14:30-17:30 Session 2: Intellectual Property Rights ... innovation and market dynamics ... Are the IPR protection regimes driving innovations in a healthy manner?

Are the incentives created by the protection of Intellectual Property Rights (IPRs) adequate to support innovation in the Global Information Economy? The session focused on the characteristics of regimes for handling IPRs and on the issues of enforcement, promotion of compliance and technological fixes.

In this session, the regimes for handling IPRs were reviewed. Discussion focused upon the nature of current regimes and its implications for the Global Information Economy. For example, can existing methods of licensing and royalty payments be made more efficient as a result of institutional or legal changes?

Issues discussed:

- *The role of IPR protection in the market and the importance of intangible assets.* What is its expected role? Are existing regimes providing incentives for innovation and competition?

- *Issues in establishing "rights".* How should specific intangibles be treated? What are the differences between "data", "information", and "knowledge"? What are the differences in establishing a right of "ideas" and "expressions"? How can various intangible assets in the Information Economy be treated?

- *Issues in enforcing the "rights".* What are the specific problems of handling copyrights, patents, trade marks, and standards, etc., in the Global Information Economy? How is the complexity of handling different IPRs in different markets being managed? And what are the prospects for improved methods of managing IPRs in different markets?

- Possibility of technological solutions for better handling of IPRs. For example, can existing methods of licensing and royalty payment be made more efficient as a result of institutional or legal changes?

- *The role of IPR protection in the market.* What is the expected role? Are existing regimes providing incentives for innovation and competition?

(Chairman)

-- Paul A David, Stanford University US/All Souls College Oxford UK

(Speakers)

-- Robert Anderson, Rank Xerox Ltd, UK
-- Jens Gaster, EC DGXV, Belgium
-- Brian Collins, University of Glamorgan, UK
-- John Barton, Stanford Law School, USA

(Discussants)

-- Cristiano Antonelli, Turin University
-- Sam Paltridge, OECD
-- Franco Malerba, Bocconi University, Italy

(Session Rapporteur)

-- Richard Hawkins, SPRU Research Fellow

19:00 Buffet Dinner: Paintings Gallery, the Theatre Museum, Covent Garden

THURSDAY, 20 MARCH 1997

9:30-12:00 Session 3: Opportunities and potential for innovative small firms ... How can the market respond to innovative entrepreneurs?

This session considered the characteristics of the market for smaller innovative firms and the ways in which entrepreneurial behaviour can be promoted in the Global Information Society. What roles are entrepreneurial firms playing in the growth of the Information Economy? What conditions make small firms innovative and competitive? Will such conditions to support the growth of small firms persist as the market matures and becomes more complex? Are policies supporting small firms needed and what policies would be most effective?

Issues discussed:

- *The accessibility and openness of the market.* What conditions will affect market entry for smaller firms in the Information Economy? What are some of the key factors affecting the contestability of the market?

- *The growth potential of small entrepreneurial firms.* How and to what degree are smaller enterprises contributing to innovation and competition in the Global Information Economy?

- *The environment which permits innovative firms and entrepreneurship to flourish.* What factors, including human resources, availability of capital, labour mobility, institution characteristics, regulation and regional policies, contribute to innovative behaviour and new market entry?

(Chairman)

-- Dick Butler, Hampshire Technology Centre, UK

(Speakers)

-- Anne Leeming, City University London, UK
-- Ken Guy, Technopolis, UK
-- Charles Steinfield, Michigan State University, USA
-- Brian Hoyle, Geosoft Ltd, UK

(Discussants)

-- Inuk Chung, KISDI, South Korea
-- Horace Mitchell, European Telework Development Initiative, UK
-- David Audretsch, WZB, Germany (currently visiting Georgia State University)

(Session Rapporteur)

-- Qing Wang, SPRU Lecturer

12:00-13:30 LUNCH

13:30-16:30 Session 4: Roles of competition and innovation policies in the Information Economy. What are the principles for promoting competition and innovation?

This session took into account the issues of the previous sessions to examine the role of competition policy and innovation in the Information Economy. What role can competition play in the Information Economy? What are the areas of concern about business conduct in the face of the rapid pace of innovation? What principles might be developed internationally to encourage competition and innovation?

Issues discussed:

- The role of industry regulation in a dynamic economy. How are innovative developments such as "convergence" and the transformation of the industry to be treated from a regulatory perspective? What aspects of the "Network" industry need to be regulated?

- Ways to implement competition policy ... In a dynamic and innovative industry environment, what are the key principles which should underpin the implementation of competition policy? What approaches are possible for addressing the concerns that the "Network" industry raises regarding competition policy?

- Principles for keeping the market innovative ... How are risks in the market which limit innovation minimised? And how are innovations in the market promoted? What new policy directions are needed to ensure continuing innovation in the Global Information Society?

- Harmonisation of market policies and regimes ... What is the impact of regional differences in competition policy, intellectual property rights and innovation policy regimes? What actions need to be taken and what are the implications for the globalization of business activity in the Information Society?

(Chairman)

-- Detlef Eckert, EC DGXIII

(Speakers)

-- Christian Micas, Consultant, Belgium
-- Martin Cave, Brunel University, UK
-- Tsuruhiko Nambu, Gakushuin University, Japan
-- Peter Walker, OFTEL, UK
-- Clark Wadlow, Sidley & Austin, USA

(Discussants)

-- Timothy Bresnahan, Stanford University, USA
-- Gérard Pogorel, Ecole Nationale Supérieure des Telecom, France

(Session Rapporteur)

-- Aldo Geuna, Post-doctoral Fellow, BETA Université Louis Pasteur, Strasbourg, France

16:45-18:00 Session 5: Wrap Up

This session took stock of the two days of discussion and highlights the conclusions to be drawn from the Workshop.

The Rapporteur summarised the key issues and conclusions of previous sessions. Discussion was introduced by a panel.

The discussion addressed:

- What are the economic and policy implications of the Workshop sessions for governments and for international organisations ?
- What are the priority issues that governments should tackle (based upon the discussions)?
- What are the priority areas for further research, data collection and analysis?
- What should be the role of international organisations?

(Chairman)

-- John Dryden, OECD

(Workshop Rapporteur)

-- W. Edward Steinmueller, SPRU

(Panellists)

-- Detlef Eckert, EC DGXIII
-- Paul A David, Stanford/All Souls, USA
-- Dick Butler, Hampshire Technology Centre, UK
-- Ambassador Pasi Rutanen, Permanent Representative of Finland to the OECD
-- Brian Kahin, Harvard University, USA

18:00 Farewell Cocktail : Strand Palace Hotel

RAPPORTEUR'S SUMMARY[1]

The 6th OECD Workshop on the Economics of the Information Society was held at the Institution of Electrical Engineers (IEE), Savoy Place, London and was attended by just over 100 individuals from business, government and academia from Europe, North America, Japan and Korea.

The themes of the workshop were "market competition and innovation in the information society" and presentations were made in four main sessions as well as a fifth "wrap-up" discussion. The sessions were:

- Session 1: The Changing Nature of the Market in the Information Economy: "Networked" Enterprises and the Impacts of Networks on Industry Conduct;
- Session 2: Intellectual Property Rights: Innovation and Market Dynamics;
- Session 3: Opportunities and Potential for Innovative Small Firms;
- Session 4: Roles of Competition and Innovation Policies in the Information Economy.

The themes and sessions of the workshop highlight the sustained commitment to market liberalisation throughout the OECD countries as well as the rapid pace of innovation contributing to the emergence of the information society. The challenge of this workshop was to examine two of the most controversial policy issues associated with the development of the information society, intellectual property and competition policy, and two of the transformations whose full impacts are most difficult to comprehend, the growth of "networks" of enterprises and the role of small and medium sized enterprises. As in the five earlier workshops, these issues were explored by industrial, government and academic speakers and discussants, a format which creates a complex mosaic of viewpoint and dialogue. This summary provides an overview of the workshop and is accompanied by an annex that summarises the individual sessions.

A unifying theme of the entire workshop was the extent to which the transformations that are now occurring challenge the received wisdom on the behaviour of companies and the role of public policy. Many of the issues considered by this workshop as well as earlier workshops appear to be distant from public awareness although it is clear that their impacts are widespread (Mansell). The technical sophistication of developments as well as the new ways in which actors are interacting with each other present a major challenge to "increase the bandwidth" of transmission of knowledge to the policy community (Kahin). These concerns suggest that carrying forward understanding of developments to the policy making process is problematic.

Several of the speakers were convinced that policy interventions, particularly in the area of regulation, were increasingly hazardous due to the difficulty of providing timely and comprehensible information to public officials (Renwick, Kahin, Collins, Anderson).

At the same time, however, major changes in industrial structure (Micas, Wadlow, Nambu) and significant challenges to the competitive operation of markets (Greenstein, Barton, Cave) raise concerns about the outcomes that may be achieved through processes that are entirely market-led.

Uncertainties about which interventions are likely to be effective suggest:

- incremental approaches building on accepted models (Gaster);
- specific rules for enforcing the openness of markets to entry and innovation (Walker);
- close attention to areas where imbalances are possible such as the relative weight of competition and intellectual property protection (Barton);
- improvements in the knowledge base for monitoring developments (Freeman);
- facilitating progress through standards and development of common institutions (Cawley, Collins).

Structural transformation was a second theme that pervaded much of the workshop. A remarkable feature of the proceedings was the infrequency with which the traditional approach of "convergence" between industries due to digitisation and the assumed desirability of constructing vertical value chains (Cawley was a notable exception) was identified and discussed. While major transformation in industrial structure is occurring in both the US and Europe (Wadlow, Micas) and the need for such transformation is of growing concern in Japan (Nambu), this process is largely occurring "within" information industry sectors rather than across them. Strictly speaking, these combinations are not purely "horizontal" since many of the companies participate in two or more vertical market segments in varying proportions. As a result, the merged entity often has the potential for stronger vertical links than its individual predecessors. What is not happening, however, are major vertical consolidations or conglomerate formations similar to those of Sony or Time Warner during the 1980s.

Two interpretations for the dominance of horizontal over vertical combination were offered; market liberalisation is increasing the need for scale to achieve global reach within segments (Micas) and the relative difficulty of commercialising new "platforms" which contributes to the stability of existing industrial boundaries (Greenstein). Neither of these explanations suggest the need for major policy intervention to influence market outcomes. Many of the transformations discussed during the workshop were not directly linked to traditional issues of market definition or structure and are best addressed by highlighting specific topics considered by the speakers, discussants, and participants.

The workshop presentations and discussion highlighted many topical issues that cannot easily be captured in a third "theme". A common feature of these topics was that existing patterns of economic and social interaction are being altered in the development of the information society. In most cases, the alteration is not the replacement of an entirely new pattern for traditional patterns. Instead, a new interpretation of relationships and exchanges is the principal source of change. While subtle, this effect suggests a developing *zeitgeist* of the information economy which may have widespread effects on social and economic relationships.

Perhaps the clearest and most easily isolated example from the workshop was a discussion of customer to customer interactions in the promotion and support of software products (Kokuryo). Many of these interactions occur over electronic networks in which users with a common interest in identifying the value of software products or in resolving problems in the use of particular software share information

with one another. A point raised in discussion was whether these interactions were substantively different than those that occur within social networks (without electronic intermediation) among existing and/or prospective owners of a particular automobile. While there are some identifiable differences between mediated and non-mediated interactions it is not clear which are the most significant or when one is better than the other for a particular purpose. The robustness of these new interpretations needs to be tested by a comparative approach.

Additional topics addressed during the Workshop

To Compete or co-operate?: The pro- and anti-competitive impacts of enterprise networks

Entry Barrier Issues

The Balance Between Improving Innovative Performance and Increasing Market Power

Management challenges for Small and Medium Sized Enterprises and other organisations

Within Organisations

Between Organisations

The process of entry and innovation

Traditional Challenges

Distinctive Challenges in the Information and Communication Technology Industries

Regulatory dimensions

Regulation of the Convergence of Telephony and Cable Television

Regulation of Interoperability

Content Regulation

Achieving Confidence and Trust in the Use of Shared Information

To Compete or cooperate?: The pro- and anti-competitive impacts of enterprise networks

The traditional dominance of large vertically integrated companies in the design of complex systems is undergoing a transformation in which "networks" of the component and subsystem suppliers are mobilised to design and manufacture such systems. The implications of this new form of organisation for traditional questions of industrial structure are profound.

Is there a potential for such networks to erect substantial barriers to entry or create other barriers to competition?

- A mechanism for achieving this outcome is the creation of a new structure for "patent pooling" based upon a complex and dense network of cross-licensing arrangements and tacit agreements among incumbent companies with established patent portfolios to avoid litigation with one another (Barton).

- The difficulty of commercialising new complex system "platforms" suggests that incumbents are likely to be able to exert market power over their suppliers (Greenstein).

- When a network is established based on the control of intellectual property rights there are significant risks that the market power legitimately conferred by these rights may be extended more broadly, either to bind the network together more tightly than would otherwise be possible or to create market power in areas where it would not otherwise exist (Barton).

Is there a boundary between the organisation of such networks for improving innovative performance and for achieving market dominance?

- There is likely to be both private and social value in transforming competitors into "complementors" when the result is the more rapid development of new markets or the avoidance of duplicative "zero sum" research and development efforts (Anderson).

- A number of networks require a co-ordinating entity or a "trusted third party" to manage exchanges, particularly in areas where security considerations are present (Collins).

- A consequence of network co-operation is the creation of shared assets whose value may depend upon the persistence of the network relationship as illustrated by the recent co-operation between Japanese firms and Boeing in the development of the 777 (Baba).

Management challenges for Small and Medium-Sized Enterprises and other organisations

In an information rich environment, boundaries defining the limits of the organisation are often indistinct. The problems of transforming the raw material of information into useful knowledge may constitute a common challenge to a number of organisations (Freeman). The result is likely to be the establishment of norms and processes for information sharing within organisations in which it cannot be assumed that access to information and knowledge within an organisation is universal (Collins). The process of defining a network, establishes both an inside and outside. The result can be significant barriers to the flow of information and knowledge within organisations as well as the intended and unintended barriers to the flow of information to other organisations or individuals. These features of the information and knowledge are an important source of innovative opportunities and management challenges.

Within the organisation

- SMEs' capabilities for generating knowledge are limited by their specialisation and must therefore develop effective strategies for acquiring knowledge (Guy).

- The use of information technology (IT) involves distinct stages in capability in which substitution of IT provides the first tangible gains and which is often the exclusive focus of policy (diffusion oriented policies in which IT is treated similarly to other "best practice" technology). Using IT to enhance and ultimately transform business processes are steps where larger gains may be possible and which are often neglected in policy and delayed in implementation within organisations (Guy).

- The enhancement and transformation stages in the use of information technologies require a much more profound concern for the human dimensions of the process. We are long past the time in which computability was the central problem in the application of information and communication technologies. Usability must be the central focus of development efforts (Leeming).

- The central challenge for all organisations is the development of skills and the extension of skills development opportunities throughout the population. The current record of performance of many industrialised countries, including the UK, is dismal with regard to the inclusion of women in the ranks of professional technologists (Leeming).

- In larger enterprises, capabilities are necessarily more complex, knowledge may be generated as an adjunct to other activities, and skills may be difficult to mobilise outside of the frameworks in which they were first created. There may therefore be major management challenges in larger organisations in achieving the flexibility to redistribute knowledge in ways that improve the organisation's performance (Baba, Anderson).

- The fact that many of these opportunities and challenges are being first encountered within the enterprise suggest considerable potential remains for both positive and disruptive impacts in the further development of the information economy (Freeman).

Between organisations

- Within a complex network, there are growing opportunities for entrepreneurs to add value by serving as agents for the transfer of information and skill (Douglas).

- Smaller enterprises often have advantages in constructing these linkages if they can create a valuable knowledge asset as well as devise an appropriate strategy for commercialising this asset (Hoyle).

- Organisational use of computer networks involves a learning process in which internal use plays a major role in determining the extent and efficacy of inter-organisational use of networking capabilities. In both cases, however, it is clear that much of the value of computer network use is in the augmentation of inter-personal interaction (Steinfield).

- Learning is also progressive in terms of functional descriptions of network use -- telecooperation precedes teletrade and teletrade is likely to be well developed before the full potentials of telework area exploited (Mitchell).

- Mobilising knowledge and applying it to the innovative process is neither an obvious nor straightforward process since it necessarily involves extensive bargaining among interested parties, each of which is likely to have different stocks of information and knowledge. One

approach to resolving these problems is to tighten links among customers so that they are viewed as clients for the knowledge generation and application capabilities of the supplier organisation (Anderson).

The process of entry and innovation

The processes of transformation brought about by the growing use of information and communication technologies involve a collection of "entry" processes. In established organisations, "entry" involves extending and adapting the organisation to meet new markets and develop new capabilities. Market opportunities also stimulate the creation of new enterprises which face the traditional problems of financing, management and marketing as well as new challenges that are either unique or unusually pronounced in information and communication technology-related industries.

Traditional challenges

The traditional challenges facing young information and communication technology firms are more likely to occur in the area of finance and marketing than in technology or production.

A significant financial problem for firms in the information and communication technology industries, and software firms in particular, is the fact that the most significant assets of young firms are likely to be intangible (Hoyle).

Even after overcoming the problem of financing, young technology-based enterprises face a major set of problems in marketing their product. These problems often involve the creation of a business model for commercialising an innovation. Most software and information technology products are not mass market products and cannot effectively be sold in significant volume either through traditional mass market outlets (which, in any case, require massive investment) or through simple advertising-based strategies. Overcoming this challenge is a major source of failure to commercialise new knowledge and innovation is significantly constrained by the marketing problem (Hoyle).

Distinctive challenges in the information and communication technology industries

Some of the distinctive features of the information and communication technology industries, and related industries including software, are the tendencies to develop standardised "platforms" that shape the development of markets, the role of users in sharing information about the viability and quality of particular products and the global nature of markets for these technologies.

"System platforms", are so named because they provide a foundation for the commercialisation of a wide range of complementary products and services as well as substantial user co-investment in skills and knowledge (including software) (Greenstein). "Platforms" have several implications for the dynamics of the entry process.

- The co-investment process creates a strong impetus to the consolidation of the market around the most successful platform of a particular technological generation which is sometimes referred to as a "lock-in" effect (Greenstein).

- Although "lock-in" effects can be and are defeated through the entry of new firms or innovations from existing firms, such challenges are relatively rare and seldom occur directly (Greenstein).

- A possible strategy for the entrant is the creation of a product that services a particular class of users with specialised needs. Even here, however, it is essential that the entrant be able to rapidly consolidate their market position before effective competitive responses from incumbent firms can be mobilised (Greenstein).

- This suggests that a substantial problem to be resolved is the "right sizing" of enterprises with the possibility that larger enterprises bear responsibility for the management of system products with the opportunity for smaller enterprises to participate in producing complementary products (Chung).

The complexity of information technology and software markets as well as the widespread access of users of these technologies to electronic networks means that there is an unprecedented degree of communication about the features and drawbacks of particular products.

- A problematic feature of user communications for the producer is that they have very little control of this information. If users communicate positively about their product there are potentially large savings in advertising and marketing expenses as well as in product support costs while negative communication (even if unjustified) may create insurmountable barriers (Kokuryo).

- An empirical study in Japan indicates that users are highly resistant to direct involvement of producers in their communications with one another (Kokuryo).

Many information technology products are essentially global products on the day of their release. This is because a company that neglects the potential of the world market is creating an "abitrage" opportunity for a company with established capabilities to serve global markets.

- The consequence of immediate global marketing is that a young company must have a strategy for extending its reach without engaging in full scale global distribution system (Hoyle). A variety of co-marketing and agency relationships are partial solutions to this problem.

Regulatory dimensions

Market liberalisation has been accompanied by significant changes in the tasks of regulatory authorities. There is considerably less attention to issues of pricing on the presumption that markets are becoming contestable. Major new roles for regulatory authority are, nonetheless, emerging. These areas include the question of whether to expand the scope of regulatory authority across industries in which convergence is occurring, the creation of rules governing the interconnection and interoperability of new telecommunication services, the control of access to content that is regarded as harmful and the creation of mechanisms for enhancing security and authentication of information exchanges. The first two of these areas address the role of the regulator in the context of market liberalisation while the latter two are areas where the role of the regulator is to address problems that arise from freeing the market.

Regulation of the convergence of telephony and cable television

The technological capability to jointly offer telephony and cable television services over the same telecommunication infrastructure challenges the regulatory structure of those countries in which the two services are separately regulated and where cable television has not yet developed a significant penetration.

The requirement for separate cable and telephony services is most commonly achieved asymmetrically, by prohibiting the supply of television services by telephone network operators. In the UK and the US, cable television network operators are permitted to offer telephony services and telecommunication network operators are required to provide interconnection to the telephony network (Cave). A similar policy is being followed in Japan, but with the disadvantage that cable television has been underdeveloped due to costing rules that demand high prices and policies that treat cable as secondary to broadcasting (Nambu). On the European continent, the northern countries have achieved substantial cable television, in systems that are most commonly owned by telecommunication network operators (Cave) but which are operated separately, i.e. distinct infrastructure and customer billing. The southern European countries have a low penetration of cable networks and face the choice of whether to encourage the creation of separate cable television capacity, to upgrade the existing telecommunication network for television, or to ignore cable altogether (competition to broadcasters may be achieved through satellite DTH).

Should these services be offered jointly or separately?

Engineering cost estimates suggest that an infrastructure offering both cable and telephony services is less expensive to build and operate than the upgrading of either type of existing network for the development of new services (Cave).

The costs of upgrading an existing cable television network for telephony are somewhat lower than the costs of upgrading an existing telephony network for cable television, but the resulting average costs of a cable television network with telephony are higher than the costs of an upgraded telephony network (this is due to the higher average costs of the stand-alone cable network) (Cave). The differences are not large and thus do not clearly dictate which path should be followed.

The consequence of these engineering cost estimates is the suggestion that the joint provision is preferred on the grounds of engineering cost (Cave).

Do regulatory considerations demand separate operation and regulation of the two services?

Separate operation, with asymmetric regulation of service offerings (e.g. either prohibiting telephony operators from offering television services or cable television operators from offering telephony services) is a structural solution to the possibility of anti-competitive behaviour by incumbent operators (Cave).

Joint operation requires that any anti-competitive behaviour by operators be addressed as it occurs through behavioural rather than structural remedies. Generally speaking, it would appear that, in Europe, mechanisms exist for addressing the possible forms of anticompetitive behaviour (Cave).

Given the engineering cost estimates, the existence of competition from wireless telephony and satellite DTH television, and the existence of behavioural remedies to possible anticompetitive behaviour it would appear that symmetric rather than asymmetric regulation is the preferred alternative (Cave).

Regulation of interoperability

The achievement of interoperability (end to end provision of a given service in a consistent and predictable way) is often regarded as a *desideratum* of the global information infrastructure. Regulation aimed at this goal may, however, limit the incentives to innovate by developing differentiated service offerings.

- The present approach of the UK regulator, OFTEL, to this issue is to intervene to enforce interoperability only when the risk of discouraging innovation is low and the gains from interoperability are high (Walker).

- Practically speaking, this means that OFTEL plans to distinguish service classes subject to varying degrees of stringency in the requirements for interoperability and asymmetry between the actions of the dominant incumbent network operator and non-dominant players (Walker).

- In particular service markets where major externalities are absent and there is little possibility of the dominant network operator entrenching its position, differentiation, even if it leads to lack of interoperability, will be allowed to provide an incentive for innovation (Walker).

- OFTEL will rely upon the development of the standards making process and pre-announcement rules on standards to allow interoperability to be achieved while reserving the possibility of more direct intervention should problems emerge (Walker).

Content regulation

In the growth of the global information infrastructure, countries are increasingly confronted by the existence of information content perceived as harmful by national laws and norms. This material includes pornography, politically offensive or racially derogatory information as well as material that may be libellous or defamatory of individuals. The existence of different national laws and norms regarding the extent and nature of harm presented by this material creates a significant challenge for international co-ordination that has, as yet, remained unaddressed.

- The US Congress in enacting the Telecommunications Act of 1996 has taken a first step toward content regulation with accompanying controversy due to the first amendment to the US Constitution (Wadlow).

- The main goal of the 1996 Act is to protect minors from material regarded as harmful in the US (sexually explicit and violent) and this goal is implemented through the requirement of parental blocking of television programmeming based on a “voluntary” industry rating system and the prohibition of the distribution of “patently offensive” material to minors using the Internet. The latter provision is being contested by the American Civil Liberties Union (Wadlow).

Achieving confidence and trust in the use of shared information

The increasing need of individuals to share information over electronic networks is complicated by concerns about security and authentication. When is privacy assured by the use of a particular technology and under what conditions can we be assured that a particular piece of information is in violation with regard to its content and authorship (Collins)? Several issues must be addressed both with social and legal mechanism if we are to assure a higher degree of confidence and trust in the use of electronic networks for information sharing.

- The design of processes and systems that support the sharing of information is becoming a vital factor in societies' ability to trust the infrastructure of the Information Society. These methods will need to be reinforced by the extension or revision of existing laws and regulatory structures (Collins).

Summary

The pervasive transformation of business and regulatory relationships due to progress in the development of the information society was apparent throughout the workshop. Many of these changes require a substantial rethinking of existing rationales and practices in business and in government as well as a need for new interpretations and conceptual tools for academic study of the process of change.

In the wrap up session to the workshop, two of the concerns raised in the opening session were particularly evident. The first was that the current state of our measurement techniques created a substantial risk that we may either be missing or inappropriately responding to the transformations that are underway (Freeman). This concern was highlighted in the discussions of intellectual property and regulatory transformation. In the area of intellectual property the movement toward stronger intellectual property regimes is premised upon the belief that these will help accelerate innovative and competitive performance. Yet, it was clear from a number of the presentations that the speed of transformation itself is sufficiently rapid to create adjustment problems and that there are significant risks that a stronger intellectual property rights regime can be a route toward augmenting market power rather than competition (Barton, Kahin). This raises the important question of whether the use of this regulatory structure is, in fact, achieving the aims which, in principal, it claims to support (David).

There was a greater optimism that regulatory action, if it was appropriately timed and acted in concert with market- and business-led processes can make a major positive contribution. The example suggested in support of this, is the promulgation of the GSM standard, which occurred despite the existence at one point of six different standards, none of which had a clear market advantage (Eckert). The role of a single authority setting a clear, although not obligatory path for the market is attributed to the global success of this technology (Eckert). Yet this example also suggests the difficulty of using existing measures for policy action. When is the right time for such co-ordinating intervention to occur and how can the losses from unco-ordinated action be quantified in ways that are compelling enough to suggest action within the limitations in capability and speed with which the policymaking process can act. This example highlights the need for measures to be policy relevant and comprehensible (Rutanen). There is also a clear need for some rethinking of the regulatory process. Many of the current mergers, regardless of their vertical or horizontal character, are cutting across the remits of existing regulatory authorities and creating substantially new challenges in reconfiguring political institutions to deal with new industrial structures (Eckert).

The second concern raised in the opening session that carried through to the wrap-up session was the need for greater attention to broadening the public and policy maker understanding of developments beyond the relatively small community of those "in the know" (Mansell). The existing policy agenda is strongly influenced by the need to accelerate job creation and economic growth and there are many in the policy community that regard information society issues as peripheral to these central concerns. Developing an understanding of how information and communication technologies can aid in the profound structural transformation underway as we move toward the information society is an area where much more work is needed (Rutanen). Reviving interest in the problems of technology transfer is essential, both within nations in the improvement of higher education to teach the skills that are relevant to industrial needs and between nations in assuring that what is now being learned about business and other organisational transformation becomes available to developing nations (Butler).

APPENDIX : SESSION REPORTS

Session 1 -- Summary

The Changing Nature of the Market in the Information Economy: "Networked" Enterprises and the Impacts of Networks on Industry Conduct

Jiro Kokuryo

The role of "customer to customer" (C-to-C) interaction on computer networks

Jiro Kokuryo addressed the issue of customers' interaction within an electronic communication environment. The traditional ways of communication between suppliers and customers (i.e. the one- or two-way interactions) have already been addressed by the relevant literature. In cyberspace, however, interactive communication among customers accelerates and impacts upon the nature of the information society. The following factors have contributed to this phenomenon: (a) more "open" computer networks and system architectures; (b) the physical existence of state-of-the-art communication channels; and (c) the sharing of common language, culture, and communication tactics and routines among electronic subscribers.

The research conducted by the author looked at the involvement of and interaction among individual and corporate users in electronic forums. Five types of C-to-C interaction were identified: (a) interaction leading to the formation of reputation on electronic communication channels (e.g. bugs and viruses on computer programmes); (b) interaction that contributes to user support in trouble-shooting; (c) interaction that leads to product development (e.g. users organise themselves in electronic forums to convert a content to another language); (d) interaction as a goal in itself; and (e) interaction as an effect of network externalities. Moreover, the empirical evidence suggested that whenever manufacturer representatives attempted to intervene or manipulate users' forums they were resisted by users who resented any "exogenous" interference by the manufacturers. At the same time, knowledgeable users who initiate electronic discussion groups and have contacts with manufacturers can act as intermediators in times of crisis. Even more so, they can promote the use of certain products as is the case with the Macintosh computer systems which enjoy enthusiastic support by many user forums.

The above discussion brings to the fore issues regarding consumers' psychology in electronic networking and the subsequent marketing responses of firms who are most affected by this phenomenon. Furthermore, questions need to be asked regarding the extent to which this phenomenon (i.e. C-to-C interaction) impacts upon the commercial development of communication networks or is simply a social side-effect appearing at one end of the consumer spectrum (i.e. among younger users) which nevertheless has a positive impact on raising consumer awareness about information society and economy.

Brian Kahin

Heterogeneous networks and the push for policy bandwidth

Brian Kahin started his talk by asking the questions "*what do we expect policy makers to understand ?*" and "*why is policy making so hard ?*". In his attempt to analyse the problem he made the following observations: (a) technology is moving too fast; (b) the market is moving too fast (see also the presentation by S. Greestein on the same topic); (c) policy developments are delayed due to the limited capabilities of policy makers (in the US) to synthesise knowledge from different areas and to co-ordinate competencies across jurisdictions. In essence the problem is one of jurisdiction and competence co-ordination.

The issue of "convergence" is multi-dimensional and includes convergence in technologies, markets, and policies. Convergence is promoted by (a) the availability of purer, global, and richer information; (b) the extended (and occasionally free) access to software and standardised hardware platforms; and (c) the software-driven intelligence in communication networks which customises and differentiates their scope and use. In fact, one task for policy makers is to understand the different type and scope of networks, that is the dynamic process of their emergence not only as engineering artefacts but also as customer- and industry-driven services.

The Internet is the market of the future and is built upon the three-dimensional framework of information-computing-communications. However, the following issues deserve particular consideration: (a) the size of transaction costs for the distribution of information; (b) the issue of technology convergence; (c) the extent and nature of globalisation of network access and use (for example, do users participate on an equal basis); and (d) the methodological problem arising from the fact that each of the tree domains has its own values but there is a need to develop a common set of values. For example, in the Internet intellectual property rights play no role. In the case of the software industry, however, they still play a major role. Is there room for a third role? And if so, is it likely to materialise in the light of efforts towards setting common standards for global electronic commerce? Such problems imply that regulators have a long way to go before addressing these issues from a new perspective rather than from conventional thinking.

Yasunori Baba

A new technological enabler for cross border networks: The lessons from Boeing 777 model

Yasunori Baba talked about the effective utilisation of ITs in product development. In particular, he presented a case study of the use of the new generation of 3-D CAD systems in the development of the Boeing 777 project by a joint team of American and Japanese engineers. He argued that in order for firms to effectively utilise new technological tools they need to reconsider their organisational structures and management practices from a new perspective.

The 3-D CAD system provides for interactivity and concurrent engineering among project participants. In this way, it supports and contributes to the diffusion and production of new knowledge. However, Baba argued that the successful implementation of the 3-CAD system was also associated with the complementation of the Western "systemic rationality-oriented" approach with the Japanese "human-oriented" approach. In that sense, face-to-face communication and co-location of designers and engineers in the project were equally important factors which complemented the utilisation of codified knowledge

embodied in ITs. This was particularly obvious when Airbus decided to follow Boeing's strategy. The presence of high intangible costs (i.e. the costs of "unlearning" previous ways of conduct) make the estimation of total costs a difficult task. The building of an appropriate methodology able to calculate both the tangible and intangible costs is a task for future research.

Richard Cawley

Market developments in the information economy and the role of public policy

Richard Cawley started by presenting an optimistic scenario according to which the communication revolution is expected to have drastic effects in all aspects of economic and every-day life (work, home, education, governments). He strongly emphasised the theme of *convergence* and the significance of the Internet.

Since each of the traditional sectors (i.e. telecommunication, broadcasting, distribution and access to information) is, so far, independently regulated, a task for policy makers is to develop a *systematic policy* and regulatory framework able to deal with the issue of convergence. However, European regulators are far behind in terms of understanding the magnitude of changes in the marketplace and decide on communication regulation as if it still all were around hardware equipment and public networking. For example, HDTV (High Definition TV) is not the same as the Internet. The former needs further forward integration for markets to take off while in the case of the latter, people are already prepared to purchase computers and there may be no need for a further boost.

He gave particular emphasis to the potential for electronic commerce and argued that despite positive projections, decisions on critical issues such as standards, interoperability of transactions, and encryption codes are still pending. Another issue is taxation where questions are raised with regard to its type, scope, and method. For example, taxation on electronic transactions poses problems in terms of tracing the transactions and relevant jurisdictions. The alternative of "bit" tax raises both technical as well as economic issues. The former relate to the biases introduced to favour compression techniques as a means of minimising the effects of such a tax while the latter refers to the "value" of information as tax will be imposed on the physical transactions counted on a bit basis irrespective of the usefulness of their information content.

Finally, the Internet has brought to the fore the issues of network bandwidth resources and the most economic ways for residential users to have access to electronic space. Subsequently, issues of network development, investment, and pricing as well as the timely availability of fast alternative technologies, such as ISDN and ATM, or combinations of existing networks (i.e. hybrid fibre-coaxial) for accessing the Internet are currently under debate particularly in US policy forums.

Shane Greenstein

Understanding industry structure in computing

Shane Greenstein argued that an increasing number of technical possibilities in computing technologies has not been followed by equally increasing market possibilities and that consumers do not respond immediately to technological advances in the computer industry. Still, if market relationships do

not change dramatically, then why do some markets change more frequently than others? To answer this question, Greenstein looked at the forces of inertia and change in the industry. A key element is that most of his observations regard computer platforms, not firms.

Among the forces of inertia he noted were (a) the fact that components (including all hardware, software, and trained labour) are long lived assets and, thus, new technology can easily find its way into computing as long as new components enhance and preserve the value of previous investments; (b) market concentration, which is maintained due to the existence of high endogenous sunk costs in both engineering and marketing areas; and (c) the persistence of buyers and sellers to invest in a platform, which has a self-reinforcing effect in developing a critical mass for a specific product. A first observation from this type of analysis is that the decentralisation of a platform due to the involvement of many small and large firms leads to a long-lived equilibrium in platform concentration and persistence because no firm can, on its own, dictate standards to developers.

The forces of change in the computer industry include (a) the emergence of new platforms, which due to the large marketing costs for their commercialisation are restricted primarily into the technical arena; (b) the mobility of existing platforms through the cost-effective re-use of some of their technological components in new market niches; (c) the vertical disintegration of firms that participate in a current platform; and (d) the competitive crashes which rarely occur but are extremely disruptive as in the case of IBM-compatible PCs and the most recent client-server architecture. The latter also demonstrates the important role played by users in the process and timing of adoption and diffusion of new computing technologies. As Greestein argues "*Vendors invent and sell. Buyers co-invent and customise. The vendors and technologies who succeed are the ones who find ways to lower their buyer's co-invention expenses"*.

The persistence of incumbents is likely to continue. No one can guess the direction of technology and the changes in distribution of power among firms, which make the work of policy-makers even harder. There is little point for policy intervention to reduce market concentration if there is an ubiquitous tendency among users and producers for a single platform to dominate. A final issue is the role of competition in preventing abuse of dominant position by a firm within a platform. Here, government's industrial policy may have a negative impact as it is likely to be unable to take into account the rapid changes that take place in the market world-wide and cause lock-in effects.

Staffan Hulten

Discussant

Staffan Hulten provided a framework for drawing together the presentations. He identified two major areas of interest. First, the *strategic commitment* that takes place in the IT industry among producers, users, and policy makers (although the latter was hardly discussed); and second, the overall *downstream development* of the IT industry.

The strategic commitment issue attributes the following distinct roles to producers and users of IT technologies and networks:

Producers	Users
• Pre-announcement of strategic technologies (before getting to the market)	• Testing (leading users interact with producers)
• Perform R&D	• Co-invest and co-invent
• Develop production capacity (e.g. Sony got the VCR ahead of its competitors because it had an already established production base).	• Show repeated purchase loyalty
• Outsourcing and the importance of standards (e.g. the case of Macintosh computers)	• Users' support and C-to-C interaction
• Sponsoring	
• Supply of peripherals	

In his idea of the IT trajectory, Hulten identified as driving forces:

a) hardware, which increases the capacity to store information;

b) software, which follows a similar pattern in terms of handling information;

c) the Internet, which has a high power in the diffusion of information; and last but not least,

d) the use of information as exemplified by the cases of Boeing 777 and C-to-C interaction.

Then he raised the question *"What is so special about IT today and how much is actually new?"*. Users and consumers play an important role along different IT trajectories but so they did in the appearance of the car engine 100 years ago. Rather, the distinguishing characteristic of IT is that it can lock-in users to particular development paths (as in the case of Boeing 777) and at the same time help them develop technological capabilities.

Rowan Douglas

Discussant

What are the real drivers behind the development of networks? It seems to be business to business communications more than anything else. If this is the case, then to what extent can residential users influence the direction and scope of network development. Should any distinction be made between classes of business users (i.e. small, large, global)?

In the light of the last remark, what would the likely policy reaction by large national players be if small countries like, for example, Bermuda or Singapore, want to become "information islands" (i.e. a favourable point to register software and locate information). How will larger states be able to compete with smaller states who also can enjoy the support of small, more flexible, and innovative firms from all around the world?

Brian Kahin answered this question by referring to the economic dependence of smaller states on larger. As commerce becomes globalised, smaller markets cannot exist alone but instead depend upon larger countries who therefore have substantial influence on the actions that smaller states can take.

Session 2 Summary

Intellectual Property Rights: Innovation and Market Dynamics

Paul David

Chair, introductory remarks

Paul David framed the context for the session by drawing attention to the problems of IPR and disclosure in the ICT sector. IPR is generally presented as a necessary instrument to spur invention, but, inevitably, it leads to monopoly powers over technological ideas. This is the trade-off. When dealing with ICT, all of the ambiguities regarding IPR in other fields apply, but there are also unique factors, many of which stem from the global context in which ICT is developed and applied.

Robert Anderson

R&D as a bazaar economy

In the ICT sector at least, IPR is not the real problem. Rather, it is a symptom of the much larger problem that firms are finding it increasingly difficult to keep up with the escalating rate of change in technologies and markets. As well as not being the problem, therefore, IPR is at best only part of a solution.

The main contemporary characteristic of R&D in ICT is complementarity. Most of the products of any given ICT firm are marketable only if they are complemented by the products of other firms. The marketplace for ICT products and services must be constantly expanded. Typically, ICT firms create markets for other firms as well as for themselves -- as when Orange creates business for BT. The main strategic objective of ICT firms is to turn competitors into "complementors".

As a result, it is no longer possible for a firm to do R&D in isolation, and there are very few entrenched positions on the ways technology will develop. The problem in this environment is not how to obtain protection for inventions, but how to get them on to the market fast enough. This involves complementary actions by otherwise competing firms and spells the demise of "fortress R&D" attitudes bolstered by rigid IPR regimes.

For the most part, furthermore, IPR regimes for ICT are trying to protect the unprotectable. ICT R&D produces new forms of knowledge, much of which is methodological. Firms are constantly learning how to conduct the R&D process faster and better. Most of this methodological knowledge is held in the minds of employees and can not be protected by patents and copyrights.

The "bazaar" is a useful concept in operationalising complementarities. Traditionally, the function of the bazaar is not just the distribution of utility but also of transactional information. The bazaar breaks markets down into sub-sets -- "clientisation" -- and uses bargaining as a way of building up

trust over time. It provides an information management paradigm that compensates for uncertainty by promoting complementary relationships.

Jens Gaster

The harmonisation of Copyright and related rights at the European and world-wide levels

There are many conflicts between different, historically entrenched legal approaches to copyright and neighbouring rights. The two main approaches reflect the legal traditions of "common" and "civil" law.

In civil law traditions, IPR rests on a moral argument concerning "author rights". In common law traditions, IPR is conceptualised in terms of economic control over assets. This leads to a concentration on ownership (including corporate ownership) of the "copy" right and on "fair use" provisions. Basically, the civil code emphasises personal rights, and the common code emphasises economic rights.

In the EU, there is a steady movement towards a convergence of these two concepts. The goal is to develop "umbrella" solutions. The approach is to define an "availability right" that provides a bridge between IPR regimes in the common and civil legal systems.

To demand major, much less "on-going", changes in national and international IPR regimes is not realistic. Legal provisions always lag behind technology and markets. The process is always adaptation rather than revolution. Lawyers cannot possibly revise laws fast enough for them to be always co-ordinated with technical change. Instead, they concentrate on establishing broad principles that allow for flexible interpretation. The problem of IPR protection for data-bases is a case in point. The principle to be decided is to what extent a data base can be considered an "investment", thus entitled to forms of legal protection appropriate to investments. The situation is further complicated in ICT by the networking aspects. The international nature of networks makes it difficult to determine which national laws apply.

Brian Collins

Information: The processes that support sharing

Information acquires value to the extent that it is shared, but decisions are usually made to direct information flows to specific receivers. In this way, information acquires specific values based on the relationship between information providers and receivers.

The hyperlink capability of the WWW provides a major information management problem in that the "contents" are contained in the text. There is a need for new approaches to information "filtration" in order to cope with information saturation and overload.

The concept of "vital interests" in information has a long history. Most established vital interests are those associated with the military and national security agencies. New types of vital interests relate to commerce. In this instance, information must be managed in a way that is conducive to establishing the trust upon which commercial relationships depend.

There is a need to establish new "reward" incentives for information sharing. New criteria are needed to set the appropriate domain boundaries, based on trust relationships, that determine who needs to know what under which circumstances. Furthermore, the trust element should be designed into ICT systems.

John Barton

Paradigms of intellectual property/competition balances in the information sector

The definition of IPR is much broader than copyright and patents. It also includes derivatives of copyright laws (as for data bases), "trade secret" license contracts (i.e. between suppliers and users of pre-packaged software), and arrangements that provide exclusive access to information to specified parties.

There are three points of conflict between current IPR regimes and ICT:

(1) Scope of protection

We have gone too far in favour of IPR protection and have moved away from creating incentives to technology creation. Technology development is incremental and the rights to an invention need to be set out such that they provide incentives for later input by other inventors and innovators. This is inhibited if the originator of the IPR is given too many rights, thus acquiring an incumbent advantage. Software suites for the design and maintenance of aircraft, for example, (as in Baba's case study of Boeing) will eventually become basic barriers to market entry.

Trade secrecy often comes into conflict with the rights of the individual. An individual who learns certain skills while working for one firm should not be prohibited from becoming employed by another firm on the grounds that these skills constitute trade secrets. In IPR terms, transferring skills is not the same as transferring a technology as such.

(2) Linkage and leverage

Linkage and leverage become important in that IT incumbents typically acquire market dominance. IPR is a form of regulated monopoly. Problems arise if firms with market power in one segment are then able to transfer this power to new business areas -- e.g. ownership of an operating system may confer an incumbent advantage when marketing applications software.

(3) Consortia

Consortia structures involve cross-licensing agreements and patent pools. The rationale is that every ICT firm knows that it owns IPR that competitors are infringing. Decisions to pool or cross license are essentially agreements between infringing firms not to prosecute each other. The structure of these pools may discourage innovation and create barriers to entry.

The incentive to sue for infringement appears to increase if the IPR owner is not making money. If losses increase so does the incentive to sue competitors over IPR. This raises the

possibility that invalid patents can be just as effective as valid ones due to the costs of litigation.

Cristiano Antonelli

Discussant

Antonelli raised two main questions. First, "Does information include knowledge?". This determination is crucial in economic terms where rights of ownership are concerned. To the extent that information includes knowledge, it displays public goods characteristics. To the extent that information is simply data, property rights apply. The second question was "Do we really need IPR?", at least in the ICT industries.

Sam Paltridge

Discussant

Paltridge stressed that we should situate our ideas about IPR in the context of what was new about the ICT environment. He pointed in particular to the pace of change and involvement of the user in change. Beta testing of new software by users, for example, was now common practice. He pointed also to the ease of information replication and distribution, stressing the implications of ICT networking for increasing public awareness of the information that is available. Paltridge raised the IPR implications of domain names in terms of the potential market power of certain domain name owners or allocators -- e.g. "Who owns .com?".

Franco Malerba

Discussant

Malerba observed that the role of IPR extends beyond information, data and knowledge to competencies. IPR affects the development of industrial and public policy-making competencies. He stressed the need to examine competency-building in product and industry life-cycles.

Within this context it is important to understand three basic points:

1. Choices about intellectual property protection are essentially a means of determining the strength of appropriability in the process of knowledge generation. This is important because of its influence on market structure, both in static and dynamic terms. For example, the scope of protection shapes how knowledge will be accumulated.

2. The nature of IPRs is an important determinant of product life cycles, narrower protection is likely to accelerate life cycles while wide protection is likely to prolong life cycles.

3. IPR shapes the linkage between products and markets by determining how goods can be conveyed and what degree of vertical control can be exerted in a market structure.

Thus, IPR is not only about the distribution of rents but also about the development of capabilities. For example, the Japanese IPR regime in software has played a significant role in the accumulation of software capabilities in large organisations that deliver software as a part of business service rather than as a distinct product.

Session 3 Summary

Opportunities and Potential for Innovative Small Firms

Charles Steinfield

Business to business transaction in the information society

Steinfield began his review of business to business exchanges with a brief review of "transaction cost" theory and, in particular, the issue of how make or buy decisions are influenced by co-ordination costs. In this context, the role of electronic networks is considered to be (a) the elimination of delays in supply as a result of timely communication, and (b) the creation of tighter integration or more tightly coupled linkages. Steinfield then confronted this theory with empirical results from a study of 250 small, medium and large firms in the fields of advertising, apparel, pharmaceuticals and publishing. Information was gathered about in-house production, outsourcing and the use of electronic networks. The key findings include:

1. In-house production is positively associated with electronic networking, i.e. the use of networking is more likely to be employed in inter-firm relationships such as outsourcing if the firm is already engaged in in-house production and this production employs network techniques.

2. The use of electronic networks does not reduce transaction costs.

These two findings are somewhat surprising and are inter-related. They indicate that electronic networks are easier to implement internally than externally, and that the major benefit of using electronic networks is more likely to be non-cost related, e.g. product quality, rather than cost reduction. Further findings include:

3. Transactions of intangible goods and services are more likely to use electronic networks.

4. Electronic networks are unlikely to substitute social networks, instead, they complement social networks.

These two findings are less surprising; they tend to reinforce some common beliefs about the limitations of electronic networks in businesses and society.

Brian Hoyle

Innovative experiences in a small global information technology company

Hoyle addressed the session theme by relating and generalising from his own experience as an entrepreneur in mapping information system software. He was particularly concerned with the issues of how small software firms innovate, globalise and obtain government support. The following issues are of particular importance:

1. Successful exploitation of technologies requires a range of skills, including technical, financial, managerial, organisational, legal and marketing.

2. Innovation has to obey the same market rules as other business activities, e.g. a clear marketing plan; technology is not enough!

3. With the help of Internet and the growing market for intangible goods like software, global market entry by small firms is becoming an attractive and feasible option.

   (Nevertheless, for small firms producing tangible goods where the market is isolated by transport costs or language barriers, they may find it easier to exploit a local niche market in which to grow to a self-sustaining level).

4. Small firms' positions are likely to be jeopardised by large and powerful organisations, such as service providers in the case of domain names, through lack of clear laws and legislation.

Anne Leeming

Innovative IT systems - A skills approach

After a review of IT history, the speaker introduced the main problem in IT development as being related to a lack of vision as to the social context in which information systems are employed. All too often, computer professionals lack business, managerial and social competencies that are necessary to make information systems useful. The problem is not to create systems that are computable but that are useful. These problems are complicated by the stereotyping of computer professional skills and the creation of an image of computer professionals that is generally discouraging to the entry of young women in the profession. In recent years, the number of young women entering training for the profession in the United Kingdom has plummeted. Using a skills approach, the speaker identified two types of need, which are particularly important for the future development of IT. These are:

1. The need to adapt to new business focus from technology-push to market-pull:

   this can be achieved in the training of computer engineers and university graduates by emphasising social sciences and the commercial aspects of IT. This is similar to the earlier speaker, Brian Hoyle's point that a range of skills are needed for successful exploitation of technological innovation.

2. The need for suppliers to develop fast response to demand for systems.

Despite the huge rate of technological development in ICTs, the progress of transferring superior technology into applicable and user-friendly business systems is slow. This indicates that, in the field of ICTs, the main problem is not simply one of demand (market development) falling behind supply (technological innovation), but rather a mis-match between these two.

Ken Guy

Policies for SMEs in the global information society

Guy opened his presentation with an introduction to the activities of his company Technopolis, an innovation policy consultancy working in four main areas: policy evaluation, strategy, comparative analysis and operation and implementation. Next, a review of government programmes currently available for SMEs was provided, and the situations of SMEs analysed. Specifically, the following points were stressed:

1. Understanding SMEs' technology acquisition and application *process* is a useful way of understanding SME *needs* for technologies. This process includes fact gathering, analysis, adoption, utilisation and learning.

2. SMEs' technology needs satisfied by outside sources of expertise differ with the technological sophistication of the firms involved. According to their technological sophistication, SMEs can be categorised into low-technology SMEs, "Bootstrap" companies, technological competents, research performers.

3. Government support schemes are varied, ranging from IT generation, IT diffusion to bridging actions. However, some diffusion mechanisms are losing IT specificity as IT becomes more pervasive.

Guy devoted considerable attention to the third of these points, arguing that government IT policies were still excessively focused on the diffusion process while there were important examples of government policies and specific institutions that were developing methods for the "transformative" use of IT in re-engineering business processes, developing new product markets, and restructuring company activities. He suggested that it was increasingly necessary for government policies in this area to be based on "holistic" policies with regard to how IT technologies are used rather than exclusively emphasising the message that more IT would be better in terms of productivity and competitiveness.

Inuk Chung

Discussant

Chung stressed the importance of "right sizing" in business with distinct differences in capabilities and specialisation between smaller and larger organisations. This problem is very significant in the information and communication technology industries because of the difficulties of predicting the course of market development and the pace of innovation.

Horace Mitchell

Discusssant

Mitchell examined the experience of his organisation, the European Telework Development Initiative in constructing a social network that would support the entry of small innovative firms in electronic commerce and other commercial network applications. Mitchell stressed the cumulative

process the smaller organisations go through in developing their awareness and, eventually, understanding of commercial network applications. In this regard, he suggested that the name of his organisation might be considered optimistic since teleworking was at the last stage of the development process. Network development began with tele-cooperation, facilitating and interpersonal interactions, proceeded next to develop commercial opportunities through some form of tele-commerce and only after knowledge had been gained in these earlier stages was tele-work likely to be seen as a major opportunity and desirable path for future development.

Mitchell strongly emphasised that Europe is still at the beginning of the information society, citing the recent Booz Hamilton study that only about 2 per cent of Europeans had Internet connections. Mitchell's view of how development would occur emphasised the differences between the "institutional" character of large organisations and smaller organisations. The means of linking the two is the identification of individuals who are capable of imagination and vision, a relatively rare quality. Two basic types of these individuals may be identified. One type is strongest at marketing innovation while the other is stronger in creative and imaginative processes ("imagineers"). Only by successfully combining these competencies is success likely to be achieved in any size of organisation.

David Audretsch

Discussant

Audretsch made five observations in an effort to suggest a framework for thinking about SME issues.

1. There is a dichotomy between SMEs as producers and users of ICTs and recent developments indicate that the issues of SMEs as information and communication technology users is the most important issue from the viewpoint of job and wealth creation for society as a whole.

2. Information is becoming increasingly cheap while knowledge is still very expensive. This observation suggests the continuing importance of SMEs in mobilising specialised competence and the "localised" quality of knowledge that is most often the basis of SME success.

3. It is increasingly important for SMEs to reconcile the issues of localisation versus globalisation. Coherent business plans usually have good insights into how to reconciles these issues.

4. There is a paradox in the role of SMEs as innovators. Most SMEs are technology users rather than producers and face the problem of acquiring information inputs and developing knowledge.

5. Finally, we should not be discouraged by the difficulties that SMEs face as one of the reasons to be interested in such organisations is that some of these organisations grow to become the major institutions of future generations.

Session 4 Summary

Roles of competition and innovation policies in the Information Economy

Christian Micas

Mergers and acquisitions trend in the information and communication industries

Micas analysed the main trends in mergers and acquisitions in eight information and communication industries. After presenting facts and figures for the period 1994-96, he discussed the driving forces behind this phenomena which included technical progress, liberalisation, globalisation, rise of the stock markets. The "convergence" element of technical progress appears to be playing a relatively minor role compared with the other three developments.

In the period 1994-96, in eight ICT industries (On-line services, Computers, Telecommunication equipment, Data communication, Software, Cable-TV, Audiovisual industry, Telecommunication services) mergers and acquisitions increased at an average annual growth rate of 65 per cent.

Services

The services industries had the highest degree of merger and acquisition activity. As a consequence of the Telecommunication Act of 1996, there has been an explosion of merger and acquisition in the telecommunication services in the USA. Cable-TV also has been the subject of major consolidation. In the audiovisual industry there are also major changes in the US structure of ownership. While some action has occurred in Europe, this has been less frequent and smaller in scope.

Hardware

In the area of data communications merger and acquisition activities are boosted by the growing PC connection to network and by the rapid increase in stock market capitalisation which provides resources for stock-based acquisition activities. The telecommunication equipment and computers industries have experienced relatively few important mergers or acquisitions in the 1994-96 period.

Software and on-line services

The software industry is characterised by a large number of mergers and acquisitions and acquisition values have been a high multiple of turnover, reflecting expectations of very high growth potential. On-line services are characterised by few, but very important, mergers and acquisitions especially in 1994 and 1996.

Conclusions

Changes in corporate environments created appropriate conditions for the explosion for A&M. We can expect further industrial consolidation especially in Europe with the development of the process of liberalisation. There seems to be a trend towards multimedia convergence, as markets are growing more acquisition do not imply more concentration. He points out that it is not clear if the positive effects expected from the massive re-organisation are counterbalancing it by the fact that in the short time the increasing allocation of firms investment capacities in acquisitions rather than on tangible assets may create negative effects.

Martin Cave and Peter Crowther

The problem of asymmetric regulation

Cave presented the joint work beginning with the question of whether it is appropriate to regulate telecommunication and cable television industries jointly. He identified three possible approaches: (1) the prohibition of joint ownership and operation; (2) joint ownership; (3) asymmetric regimes. In assessing the merit of these alternative policies, it is useful to consider engineering and regulatory cost. From the engineering cost viewpoint there are substantial economies of scope present in the joint ownership. The stand alone costs are compared with the cost of adding a service to an already existent network and the cost of *de novo* construction of a joint services network. Most of the economy of scope resides in the sharing of trench and duct so that when the starting point is the *de novo* construction of a suitable network, symmetric regulation shows cost advantages.

The issue is more complicated from the regulatory cost viewpoint. If one adopts as a starting point the current state of European competition law, what are the possibilities for anti-competitive actions and remediation of these actions when a cable television operator is entering a market where there is already a dominant PTO which may itself be participating in cable provision? There are many possibilities for anti-competitive behaviour in these circumstances. One possible response is therefore asymmetric regulation. Alternatively, however, he compared the list of possible anti-competitive behaviour with the remediation approaches that have been taken by the European Court of Justice towards cases of this kind. His conclusion is that EC competition law has principles for dealing with the anti-competitive behaviour that may arise in symmetric regulation. There are, nonetheless, some ambiguities in the legal treatment of such behaviour.

Conclusions

Given economies of scope and the possibility of remediation of anticompetitive behaviour, the justification for asymmetric regulation must be a very high priority to infrastructural competition. However, given the north-south differences in cable television penetration, a common regulation at the European level may have positive consequences in some countries, but negative in others.

Tsuruhiko Nambu

Reviewing the years of regulated competition in the japanese telecommunication industry

Nambu analysed the changes in the Japanese telecommunication industry from the perspective of regulation and competition since 1985 when NTT was privatised. He focused on four issues: (1) competition in the local loop; (2) competition among technologies; (3) uncertainties created by the divestiture argument; and (4) the interconnection and accounting problematique.

Japanese telecommunication regulation (1985) allowed entry in local loop competition only to Type I carriers (carriers who own telecommunications facilities for their own use). The Ministry of Post and Telecommunication expected new market entry in the local loop, but this did not happen. As a consequence, no rate rebalancing has been achieved and the MPT argued that NTT was able to cross subsidise from long distance to local service to discourage such entry. For example, the electricity companies that potentially could enter in the local market did not find it profitable. Furthermore, due to the ambiguous guidance of the bureaucrats, the electricity companies failed to enter the long distance market because they thought that they could not interconnect nation-wide.

In Japan cable television did not develop as a competitor to incumbent PTO due to the strict regulation regime. In 1994 MPT partially deregulated the CATV industry by relaxing the narrowly defined business area and restraints on foreign investment. The wireless telecommunication system was also strictly regulated leading to high prices that slowed the development of the system. Several years ago the system was deregulated and the marked has been rapidly growing since.

The delay until 1996 of the restructuring of NTT has created substantial uncertainty about the future of Japan's telecommunication infrastructure, which has impeded investment and entry. Last year NTT was reorganised as a holding company with two regional companies and one long distance company as subsidiaries, with somewhat uncertain consequences for the future. For example, the Japanese cost accounting system is unique for telecommunications, making it difficult to know how interconnection issues will be resolved as competition increases.

Peter J Walker

Interoperability: Help or hindrance to the information society?

Walker discussed the concept of interoperability in the context of public policy for telecommunication. Is interoperability a necessity for the information society? Does interoperability widen the availability and ubiquity of telecommunication services? Or does it restrain innovation? What is the role of voluntary regulation in achieving interoperability?

Interoperability can be achieved in the following ways: (1) voluntary adoption of formal standards; (2) voluntary adoption of consensus standards; (3) adoption of *de facto* standards; (4) regulator mandated application of standards.

Governments should regulate for the sake of interoperability standards where market failure exists. The possibility of market failure is possible due to the existence of line externalities or the existence of market power exercised by an incumbent dominant operator.

To implement interoperability regulation, Walker proposes a taxonomy for telecommunications services, identifying enhanced services and network services as categories for which different standards of interoperability should apply. For example, in the case in which a network operator has a dominant position and a new service is a network service (it is based upon capacities that require the operation of a network to realise) and is co-operative (it requires the interworking of networks to be realised as an "end to end" service), OFTEL has concluded that regulatory intervention in favour of interoperability should occur. In practice, this will require the incumbent dominant operator to offer to interconnect such new services on the first day of retail availability.

Walker then considered the problem of interoperability in the case of customer interfaces. He suggests that there is no need to mandate interoperability in this area. However, to prevent discrimination by the dominant network operator the operator must publicly declare the interface they used so that apparatus manufacturers can adopt compatible interfaces assuring terminal portability as a business decision.

Clark Wadlow

The Telecommunication Act of 1996: Reducing regulation to spur competition

Wadlow's paper was presented by Mr. John Edwards of the London office of Wadlow's firm, Sidley and Austin. References hereafter will be to Mr. Wadlow.

Wadlow offers an analysis of the US Telecommunication Act of 1996 which attempts to address the realities of today's converging markets by eliminating regulatory barriers and encouraging competition in virtually every sector of the communication industry. Perhaps the most significant feature of the 1996 act is that it overturned the restrictions contained in the 1992 AT&T antitrust consent decree that led to the creation of the seven regional Bell operating companies. Under the new act the interexchange carriers (IXC), including AT&T are free to enter the local telephone market almost without regulatory restriction.

The terms of entry are to be the result of negotiation between the IXC and the local telephone company. The regional operating companies are immediately permitted to provide long distance service outside their local service area and to enter into manufacturing. Competition is required before they can provide in-region long distance service. Wadlow points out that a consequence of the new act has been major consolidation among incumbents.

The act also addresses competition in the video marketplace. Telephone companies are now permitted to provide video services through a new cable television system, available frequencies for "wireless cable", and through the "new open video service". The sole remaining prohibition is that telephone companies cannot simply acquire control of existing cable systems within their service areas. At the same time the cable TV system has been deregulated, so that the cable industry will once again be free of rate regulation, except for basic broadcast service, as soon as there is competition from a local telephone company or three years after enactment.

Wadlow notes that there are critics of the new act. However, he argues that the development of competition in the various markets requires time for negotiations and large amounts of capital and consequently one year is not enough time to assess the achievements of the new act in promoting competition within the telecommunication or related industries.

Timothy Bresnahan

Discussant

Bresnahan highlighted the uncertainties facing the regulatory process and the alternatives of adopting a more experimentalist approach in the absence of sufficient knowledge to develop a planning framework. Bresnahan suggested that regulation is increasingly about choosing processes rather than prescribing outcomes. He also suggested being very careful in the area of vertical integration where the computing industry indicates that more rather than less competition was created by vertically concentrated structures due to their ability to accelerate the pace of competition and steal rents from incumbent players.

Bresnahan also cautioned against a facilities-based theory of natural monopoly noting the market power could arise from marketing and other non-material mechanisms as well. In this regard, it is of increasing interest to consider the pricing methods and repackaging strategies that are being employed by incumbents in areas where software is the product or is a larger share of the revenue and value added.

Finally, Bresnahan noted that Microsoft is not the only company that has an established market position that is likely to be creating the ability to impose terms and conditions on other parties, suggesting that Cisco has a similar if not stronger position.

Gerard Pogorel

Discussant

Pogorel noted that the main buzzwords used over the last 15-20 years to describe the future were not very successful in describing our current situation. Innovation, deregulation, competition, globalisation and convergence aren't happening in ways that were so confidently predicted in the past and there are real possibilities for unexpected outcomes to occur in the future.

For example, although we have been proclaiming the future of competition for 15 years, we are still talking about processes to simulate and stimulate the market. Regulation is not becoming less but rather more complex. Globalisation is a chimera in light of the remaining enormous differences in regulatory frameworks and purposes and there is very little evidence that regulatory structures in, for example, the EU are converging. The evidence for market convergence flowing from technological convergence is particularly weak as Micas noted. Although there are counterexamples in the merger and acquisitions area, the great competitive battles that were supposed to emerge failed to do so and the winner was often some other company entirely, e.g. the IBM Apple war was won by Microsoft.

SUMMARIES PROVIDED BY SPEAKERS

R & D knowledge creation as a bazaar economy

Bob Anderson, Rank Xerox Research Centre

R&D can be viewed as a prototype implementation of a knowledge economy. In high (especially digital) technology industries, the rapid pace of innovation is increasingly rendering established models and practices of knowledge production and distribution ineffective. In this paper, I propose that a more apposite (and interesting) approach might be to treat R&D in those domains as participating in a global knowledge bazaar. A sketch of this reasoning will be presented together with an analysis of some of the implications for the management of R&D of adopting this view.

A new technological enabler for cross-border networks : The lesson from the Boeing 777 Model

Yasunori Baba, University of Tokyo

Nowadays many industries face competitive markets where product variations must be developed but lead time and development costs must be reduced. In this situation, New CAD/CAM/CAE technologies coupled with standardisation of data format have begun to change the concept of product development and to give birth to concurrent product development on the digital networks. Armed with those technical features of full visualisation and a digital pre-assembly of components and a simulation capability, an IT-supported work environment improves the co-ordination and communication among engineers through an integrated 3-dimensional database and a networked information exchange.

This paper discusses possible IT contributions to product development, as well as organisational requirements for its successful adaptation. In order to implement effectively the new technological enabler, firms need to reconsider the meaning of organisational networks from a new perspective. Accordingly, function and effectiveness of cross-border networks are expected to change significantly.

As for a case study, the leading firms in the introduction of these technological/organisational transformation are US firms such as Boeing whose 777 project is described in this paper. Also, the paper touches on the case of Japanese firms since the firms in automobile and shipbuilding industries have begun to follow the Boeing 777 model in a collective manner.

Paradigms of intellectual property/competition balances in the information sector

John H Barton, Stanford Law School

This paper will present a series of paradigms exemplifying the relation between intellectual property rights and competition policy in the international information sector. One group is based on the international competitive implications of intellectual property rights themselves, e.g. the ability or not to protect databanks, and the implications of differences among national standards for such protection. A second group focuses on the ability to use intellectual property rights over standards or interfaces as a basis for tying arrangements to extend power from one market to another, and the ways in which these linkages might be more or less difficult to manage at the international level. And a third group arises from

the network of intellectual property cross-licences that affects entry into certain of the hardware markets closely associated with the information sector. In each area, the paper will attempt to structure the specific competition-intellectual property policy issues in enough detail that they can be used in defining the economic studies needed to evaluate the wisdom of an international response.

Asymmetric regulation of telecommunications and broadcasting

Martin Cave, Brunel University and Peter Crowther, Copenhagen Business School

The paper investigates the combined regulation of telecommunications and cable television companies from a competition law and policy aspect. Practice and debate within the European Union and elsewhere identify a variety of possible approaches, including separation (the prohibition of joint ownership and operation), joint ownership, and asymmetric regimes in which the provider of one service, say cable television, is permitted to provide the other, telecommunications, while the reverse does not apply.

The paper will investigate the merits of these policies from the standpoint of their effects on competition and consumer welfare. This will involve, first, an analysis of different regulatory starting points observed within the EU and of the costs of moving from one configuration of supply to another. Regulatory policies adopted in member countries will also be reviewed.

We will then set out a framework familiar in competition law analysis, based upon the notion of foreclosure, within which it is possible to evaluate the effects of regulatory policy adopted in different circumstances. This will then be set in the context of current European Commission practice in related sectors. The paper will conclude with an attempt to match appropriate policies to alternative starting points.

Market developments in the information economy and the role of public policy

Richard Cawley, European Commission DGXIII

Governments and public agents play a large number of roles in the information economy. They act as rulemakers and regulators in many of the communications sectors and they have substantial influence in the broad activity areas of work, the home and education. They spend substantial amounts of money on R&D, education and training, regional policy and public goods which have a significant information component. They have a significant impact on the rules and prices that are set in labour markets. They tax economic activities and people and are concerned about their ability to maintain this spending and redistribution function. Moreover governments and public agents produce and consume information and have a substantial impact on controlling information flows in connection with cultural and consumer concerns and in the pursuit of criminal activity.

The paper attempts to characterise some of the major market developments in key sectors, including the main communications sectors but also in economic sectors with substantial embedded or traded communications components. It also examines some of the major policy issues, in particular at a regional or European level, and highlights where research could make an important contribution. The issues include the implications of an increasing overlap between telecommunications and Internet, television and broadcasting policy, the role of competition policy in network and content sectors, public interest issues, employment and sectoral questions, and electronic commerce, taxation and money. A

supplementary annexed paper deals with a descriptive account of the full spectrum of policy initiatives on Information Society at a European level.

Information: The processes that support sharing

Brian Collins, University of Glamorgan

The paper discusses the issues that are facing society as a result of major technological capability becoming available that allows information sharing on scales unprecedented in our history.

Information is now viewed as the "Fourth Resource" along with capital, people and plant. It has properties that make it different from the other traditional scarce resources, and there is no standard, agreed definition of the word "information". Yet it is one of the most popular adjectives in describing changes that are occurring in society. It is used to qualify words like "superhighway", "society", "revolution" and "overload" and yet it certainly means different things in each of these contexts. It supports the concept of knowledge, but in order for knowledge to exist there must be a "knower" and for knowledge to be useful to society it must be shared by the knower with another "*cognoscenti*".

The paper will address amongst others the following questions:

- What are the possible processes and rules for sharing, ranging from "totalitarian secrecy" to "publish and be damned"?
- What are the economic issues of choosing to share information?
- Who owns the rights and duties of care of the processes of sharing personal information such as health records or criminal records?
- How do different countries and societies view these issues?

The harmonisation of copyright and related rights at the European and world-wide levels

Jens Gaster, European Commission (DGXV)

Intellectual Property Rights (IPR), and in particular, copyright and related rights, are of the utmost economic importance in the context of the Global Information Infrastructure (GII). In the EU alone the copyright and related rights based industries account for some 5 per cent of GDP.

Much of the infrastructure of the GII will be protected by industrial property rights such as patents, as well as copyright protection for computer programmes. However the infrastructure is of little value without the services and content provided through it. That content will to a large extent be the subject of copyright and related rights.

Traditionally there have been different approaches to IPR throughout the world. As regards Europe, we have already achieved considerable progress towards harmonisation of those differing approaches with the adoption of 5 EC Directives since 1991 (computer programmes, related rights, satellite and cable retransmission, duration, databases).

Following an extensive consultation exercise beginning in 1994, the adoption of a Green paper in July 1995, and an international conference held in Florence in 1996, the European Commission published a Communication in November 1996. This sets out four areas for priority action by the European Legislator (right of reproduction, communication to the public, including making available, distribution right, and legal protection of technical devices).

Turning to other fora we have the Berne and Rome conventions administered by WIPO, and the TRIPs Agreement administered by the WTO. Recently, in December 1996, two new treaties were adopted under the auspices of WIPO on copyright and on performers and phonogram producers' rights in the digital environment. Further treaties are likely to be negotiated soon.

At the global level, therefore, minimum levels of protection have been established in certain areas. We believe in Europe we must go beyond this. The existing levels based on the *acquis Communautaire* grant strong protection for copyright and related rights throughout some 30 European countries, but there is still work to do.

Policies for SMEs in the global information society

Ken Guy, Technopolis Ltd

Countries around the world have developed sophisticated policy mechanisms to support and promote the development and use of Information and Communication Technologies (ICTs) by SMEs. In this presentation we review the range of mechanisms on offer, describe some examples, and tease out lessons for the future.

Heterogeneous networks and the push for policy bandwidth

Brian Kahin, John F Kennedy School of Government

The Internet has become a focal point for new business models and radical change in the economic landscape. Understood best by Internet and software entrepreneurs, the changes are too complex to model and often paradoxical. Information becomes purer -- more "information-like" -- while it also becomes networked and network-like. Context, community, and other hybrid forms of value assume new importance in the marketplace, but defy modelling. Policy development in this environment loses its bearings and becomes overwhelmed by complexity and change.

This paper attempts to provide a general framework for addressing the policy development problem. It looks at the fundamental elements of technological and market change around the Internet, as well as the second-order changes they suggest. It then considers how these changes challenge fundamental economics and policy principles in classical information infrastructure industries. Finally, it looks more closely at specific challenges posed to different intellectual property regimes.

The role of "Customer to Customer" interactions on computer networks

Jiro Kokuryo, Keio University

This paper discusses how computer networks provide channels for customer to customer (C-to-C) communications and how such interactions change the dynamics of the marketplace.

The author identifies three primary patterns of communications involving sellers and their customers in the market. First, is traditional mass marketing communications employing one-way media from the seller to the customers. Second is "one to one" marketing based on two-way interactive communications between the seller and the customers. Third is the C-to-C interaction in which customers directly communicate among themselves.

A classic C-to-C interaction is reputation and word-of-mouth. While these have existed for a very long time, the computer network accelerates the speed and the quantity of information flow. This has profound implications, for example, for the future of advertisements.

Another important example is product support. Today's PC users rely on help from their friends rather than telephone support from manufacturers which tends to provide less-than-adequate service. We can appreciate the economic significance of C-to-C interaction by imagining how much manufacturers would have to spend on the user support personnel if C-to-C self-support did not exist.

C-to-C interaction may develop into customer participation in product development. A case research at Keio Business School describes how users of the Hewlett-Packard miniature computer voluntarily organised themselves on an electronic bulletin board to make the machine accommodate Japanese.

We also conducted quantitative research on the nature of C-to-C interaction via electronic bulletin boards. The research indicates the importance of "heavy users" -- users of products that take initiatives in forming and operating user groups -- in the creation of active C-to-C interaction. The research also suggests that over-presence of sellers tends to mitigate C-to-C interaction.

Co-ordination modes and producer-supplier integration: Empirical evidence from four industries

Charles Steinfield, Michigan State University

A fundamental assumption of transaction cost economics is that firms make goods and services rather than buy them to reduce costs of co-ordinating with their suppliers. The goal of the present paper is to identify conditions under which firms use (a) in-house production, (b) electronic networks, and (c) interpersonal networks to co-ordinate with suppliers of important goods and services. We examine whether the use of inter-organisational electronic networks encourages producer firms to co-ordinate acquisition of production inputs through markets or discourages this kind of competition in favour of producing inputs in-house. Finally, we examine the influence of these three modes of co-ordination on the success with which producer firms acquire important inputs. The findings support transaction cost notions that firms choose an in-house strategy to avoid the threat of opportunistic behaviour. However, contrary to much recent speculation, use of electronic networks for transactions was not associated with increased outsourcing. Rather, all three modes of co-ordination were complementary. Only interpersonal connections were associated with better outcomes, however. The paper concludes with a discussion of the implications of these findings.

Interoperability -- Help or hindrance to the information society?

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The paper addresses the subject of interoperability in telecommunications network services. It evaluates the benefits that flow from interoperability of services across a network, in particular noting the impact that interoperability has in a networked industry where externalities exist. It contrasts these benefits with the negative effect that could flow from limiting service innovation. While voluntary adoption of interoperable standards is commonplace, the role and scope that regulation should play in imposing interoperability is less clear. It is suggested that regulation is appropriate where there is market failure, in particular where there are significant network externalities and where there are competition issues arising. However the scope of regulation should be limited to those services provided by public telecom operators which cannot be provided by others and which also require the active collaboration of both originating and terminating networks. This is demonstrated to promote competition in both network services and enhanced (value added) services.

It further argues that in the absence of widely accepted standards, competition can be distorted by standards created by dominant companies and that fair competition demands an open standards making process for interconnection services. The same does not seem to be appropriate for other network interfaces, though adequate declaration by public operators of their interfaces is essential to the operation of wider telecoms markets.

CONTRIBUTIONS BY SPEAKERS

Competition and Innovation in the Information Society

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Introduction

For some little while now, with a mixture of bemusement and concern, I have been watching as two new (well, relatively new) ideas have struggled to get into vogue in Xerox. The first is the claim that there is a fundamental tranformation going on in the basis of Western Economic structures (in the Mode of Production no less). Value creation is increasingly centred on the application of intellectual capacities not material and organisational ones. We are witnessing, or so the claim goes, the emergence of a *Knowledge Economy*. The second, intimately connected to the first (at least in some minds) is the notion of Intellectual Property Asset Management. (Nonaka,I. 1991; Takeichi, H. & Nonaka, I. 1995). Here the realisation is that since increasingly the primary locale of what gets added in any "value added" process is in the heads of employees, and thus capable of walking out of the gate at will, such *intellectual capital* must be given just as much management attention (and hence just as much management) as any other vital asset.

The reason I am *both* bemused and concerned is not that I doubt the reality of the changes being picked out (though I do try to be a little less portentous about them). It's just that from my perspective (where I find myself scrabbling about on "the glass carpet" of R&D), *there's always been a knowledge economy*; and *intellectual property asset management is about as good a job description as any for my role*. For me, being encouraged to think about my daily activities as managing intellectual assets and participating in a knowledge economy has all the hallmarks of Mr Jourdain being asked to contemplate the wonder of his speaking prose (and is likely to be just as debilitating as that would have proved).

In my opinion, the significant changes are not to do with form of the innovation production system (that is, from a material to a knowledge basis). Of course R&D is in the knowledge production business. Rather, what seems to be fundamentally different now is what you might think of as *the second order derivative for innovation* (the rate of change of the rate of change) - its cycle time, if you will. Notice I am not talking about invention. Invention has to do with the generation of new ideas and putting them into practice. Innovation has to do with assaying and realising the commercial (and other) value which such ideas might have in and for some relevant domain. Innovation, then, involves another (and very long) step beyond invention. In the marketplaces within which the outcomes (and I'll stay as general as that for the moment) of the R&D I manage are deployed, both the pace and the acceleration of innovation are startling; nay terrifying.

Here is a schematic presentation to make what I am saying even more clear:

Shelf lives of technologies

Span	Millennia	Centuries	Decades	Years	Months
Technology	wheel	pocket knives	xerography	personal computing	Internet

The first two cases should, I hope, be unproblematic. While it is certainly true that wheel technology has undergone significant changes, the rate of such change has been relatively slow. What, for example, in the past 2000 years has really changed with the wheel (as opposed to the technology of steering) other than the invention of the spoke and the pneumatic tyre?[2] The Swiss Army Knife has not changed at all since it was first invented and produced in the late 19th century (Lewis, T. 1996). Xerography too has been stable over a reasonable period since its first productisation by Chester Carlson in the 1930s (Mort, J. 1994) What changes there have been have mostly been refinements and improvements and have not led to fundamental revolutions. The revolutions affecting xerographic products have come from alternative technologies and have taken place *in the marketplace* not in the technology. In that sense, xerography has had a "shelf life" of at least 5 decades. In the PC world by contrast, Moore's Law has meant that we have had to think in terms shelf lives of a few years rather than of decades. Processors that were "leading edge" just two years ago are now consigned to the scrapheap as we rush headlong towards the teraflop chip and its mindboggling "zorch". If that were not enough, the evolving phantasmagoria known as the internet seems to be moving us down an order of magnitude once again. Here as we can see in the speed with which the "browser wars" were fought and won the emergence and dissemination of Java and similar languages, and the growth, maturation, and decay of "internet businesses", the unit of change is months, not years. Verily, Harold Wilson's dictum that a week was a long time in politics will soon apply to the Web economy.

Now I don't want to overplay all this. One can very easily get *very very* giddy about the internet and the "opportunities" it holds. In all likelihood, it will turn out to be neither the New Jerusalem nor the South Sea Bubble many are predicting. Nonetheless, something is going on here which is accentuating aspects of innovation in digital technologies. Let me summarise what I think they might be:

No entrenched positions

Actually, what I mean is no entrenched position lasts for long. It is a continual scramble to find a position which can be "protected", an "edge" which can be sustained. As Java, Netscape, Psion, the Pilot and the Nokia Communicator have shown, not even the combination of Compaq, Intel and Microsoft is invulnerable. Though in turn what all of these have also shown is just how ruthless those who hold dominating positions can be (and perhaps have to be) to retain their pre-eminence. Running faster is not simply a requirement for success. It is the name of the game.

Donne's rule rules

Perhaps more than in any other marketplace, here no-one can do everything for themselves. Everyone needs partners, alliances (see the previous point), or in that horrible Harvard neologism *co-opetitors*. This is one of the direct consequences of the second derivative. Given the rate of change in the rate of innovation, no-one can predict the whole range of skills which will need to be amassed to create

and take advantage of the next revolution but one (and thinking about the next but one is what everyone is doing. The game is over already for the next).

Protecting the unprotectable

This is possibly the deepest change and certainly the one for which we have been least well prepared. Our standard model is one of defensive assurance through asserting patent protection for key intellectual property. However, more and more the key enabler for the realisation of business value lies not in the distinctiveness of the technology but in the *market connectedness* of the delivery organisation: that is, on its ability to understand the marketplace, spot the opportunities and move quickly and effectively to assemble the components to cash in on them. It is hard to imagine how to protect market connectedness. Nor, in one sense, would one want to. Being market connected, demonstrating that you are market connected, is one of the signs and signals of the successful. As Zero Mostel memorably advised in *The Producers*: "If you've got it, Baby, flaunt it!".

In sum, as the character of competition in emerging digital marketplaces evolves so our classic model of "fortress R&D" hedged about with patents and Non-Disclosure Agreements is rapidly proving otiose. We are having to be more entrepreneural, flexible, responsive, willing to tolerate the ambiguity deriving from competing in one sphere and being allies in another. A perspective on forms of knowledge is emerging along with this. Though some of them might be intellectual property in the traditional sense, they are actually based upon a different conception of how and where competition for knowledge might be organised. The upshot is *not* reduced competition for knowledge; far from it. It is, rather, that the character of the competitive space has to be re-drawn. The manager in R&D has to approach the management of intellectual capital and participation in the knowledge economy in more flexible and perhaps even more sophisticated ways than in the past. A much more subtle view of the relationships in the marketplace is needed as is a different way of defining the market itself. The next two sections take up these suggestions. [3]

Value and innovation

Here is a set of propositions summarising what I suppose to be the conventional wisdom on innovation and value creation within commercially-driven organisations. [4]

1. The process of defining, creating, articulating, instantiating and deploying valuable new knowledge is innovation. Innovation takes place along the whole value chain (c.f. above).

2. The primary metric of value is potential increase of profitable revenue streams.

3. Innovation which is commercially valuable may be technological or processual. Technological followers often gain advantage from process innovations.

4. Business Groups or Business Teams (internal or external) who make offerings in the marketplace are in the first instance the innovation consumers.

5. For a BG, the value proposition for innovation concerns its contribution to creating or maintaining a sustainable competitive advantage.

6. Value propositions for innovation are realised through market-like mechanisms and structures and assessed in their terms.

7. The only sustainable strategy for innovation producers/suppliers is to engineer a constant expansion of the need for innovation. Assuming the market is zero sum, and competing on that basis, will ultimately be catastrophic.

A "value net" for innovation

One way to set out the relationships in any marketplace is to map the value chain (suppliers/producers/customers) against the competitive space (competitors/complementors). Adam Brandenberger and his colleague (Brandenburger, A. & Naleboff, B. 1995) have called this particular device a "value net". In this way the two main relationships (transactors and competitors) in a market can be drawn out. Schematically, the value net looks like this.

Schematic Value Net

What the value net representation brings to the fore is the potential alternative or *side relationships* along edges other than those defined by competition and the value chain. Exploiting these, or so it is said, offers the opportunity to re-shape a market.

The innovation value net

It seems trivially easy to identify the players in the complete innovation value chain:

scientific community → R&D → development → manufacturing → marketing → sales & support → end-customer

Of course, from the R&D perspective, the first instance customers are the development groups who take the prototypes, designs, specifications and other deliverables created by the research teams.

The competitive space is not quite as easy to map. Who are the competitors and complementors for innovation? Competitors are defined by those whose presence in the market causes a reduction in your capacity to sell your product. From the R&D perspective these could well be the proponents of the extant product set, outsourced contract R&D, consultancies, supplier R&D. Complementors are defined as those players whose presence in the market enhances the attractiveness of your own product or whose participation in the market makes yours more successful. For R&D, these are likely to be the marketing and strategy groups (i.e. the big picture guys), the Corporate Office (the long term vision guys), development teams and, of course "marketplace competitors". Interestingly, external R&D groups (even universities!) could be complementors if deploying their products requires an internal R&D operation. [5]

Let me put some flesh on these bones and construct a value net for a specific R&D project within my Lab.[6] This project is concerned with identifying the range of services (*always* (wrongly) called "valued added services") which might be made available through the networking of our high-end reprographics engines. I won't go into exactly what kind of network services we have in mind (for obvious reasons), though I doubt if there is anything world shattering in our plans. The project involves a co-operation between ourselves (RXRCC), the Operating Company who "owns the customer" (RXUK) and the customer (Establishment Printers). We have been studying the current work and business processes at Establishment Printers and identifying the opportunities and risks which networking their 18 Docutechs (a Xerox product which produces up to 120 pages per minute and sells at about £1m a time)

might bring. Together with the Product Development Group, we have also been defining the requirements for network services of the kind we have in mind.

Of course, from the Development and Business Teams perspective, things can look somewhat different.

Looking at the value net for innovation, it is clear that just as in any marketplace R&D has to be able to answer two questions:

1. What is the value proposition being offered at that point on the value chain -- i.e. what's the value added of this particular innovation offering?

2. How can competitors be turned into complementors?

In the context of a rate of innovation in digital technologies such as that described earlier, it seems clear to me that it is the latter which is the crucial concern. What is emerging in the R&D marketplace is a set of market structures which seem to have been designed to facilitate complementary relations rather than competitive ones. Such structures are amazingly correlated with those described by anthropologists as definitive of bazaars (Geertz, C., 1992).

R&D as a bazaar economy

There are many different kinds of markets and market structures. This is an important point to recognise. Saying there are many different kinds of markets is not the same as saying there are many different versions of the market (or perfect competition as it is usually defined in Economic theory). The stockmarket or the money market may well approximate quite closely to the tenets of the perfect market model. But that should not make them paradigm marketplaces.

The reason for this is relatively easy to grasp. The perfect market or "free market" is predicated on four axioms:

1. A multitude of buyers and sellers trade in the market.

2. Any market actor can trade in any commodity.

3. There are no impediments to moving between commodities. This is the so-called "frictionless" aspect.

4. There is perfect information in the marketplace. Information is uniformly distributed and exhaustive.

Perfect markets are also temporally short sighted. But this is not seen as a significant assumption (wrongly in my view).

Financial markets are reasonable approximations to the model described by these axioms. To accommodate almost any other "market", one or more of the axioms has to be relaxed or re-interpreted. What has to be adjusted to enable us to describe the operation of a bazaar? To begin with, of course, everyone in a bazaar (bazzaris) is a rational economic calculator. They are looking for maximum utility and profit though they usually do so over the course of a number of connected transactions a viewpoint which marks them off from perfectly competitive markets. Second, of course, the price settled in the

marketplace is a function of supply and demand. But this function is very much a fuzzy one. To begin with, it is temporally lagged and temporally projected. It takes time to respond to events and often such responses are geared to signals and signs more than to the events themselves. Then there are factor costs. As with all markets, factor costs do reflect factor inputs and their proportionalities. Alongside these, there are the opportunity costs surrounding the relative inflexibilities of resource which are built into its structures. In bazaar markets, traders can only with difficulty shift between commodities to trade in. It takes time, effort and resource to set up the chains of supply and distribution required to participate in the market for any individual commodity. Bazzars are definitely *frictional markets*.

What all of these add up to is an overriding concern with *information* and with managing uncertainty about *information flows* rather than utility flows (the focus of standard theories of the market). It is information about utility values rather than mechanisms for its distribution which defines the bazaar. And, unlike in the standard case, in the bazaar information is always poor, scarce and mal-distributed. The mechanisms by which information circulates are chronically inefficient, but turn out to be all the more functional for that. The point is that those who trade in bazaars know these things to be the case. They form the background, the context, the frame of reference against which the bazaars' economic institutions are understood. As Clifford Geertz remarks, the institutions of the bazaar constitute an actor level response to system level deficiencies.

The arts of the bazaar are those of information acquisition and accumulation. Bazaaris do not exercise options. They are trying to discover what their options are. In the bazaar, information is all. And everyone knows it.

The bazaar, then, is characterised by pervasive uncertainty and search for knowledge. Who are the buyers? Who are the sellers? What is the price? What is the quality? Can the goods be supplied? And when? Faced with these uncertainties, [7] *clientelization* and *bargaining* are rational responses which reduce and manage the search space. Bargaining with clients is how the bazaaris carry on. What clientelisation achieves, of course, is a structuring of the potential search space. Transactors are pre-defined as those with whom one trades and those with whom one doesn't. It also contributes to a second dimension of the search; not just with whom to trade but where to trade since clientelisation allows for the extension of the division of labour and its associated specialisation.

Bargaining is the modality of information transfer. In bazaars, bargaining is multidimensional and intensive. The latter refers to the practice not of collecting alternate bids in the market but exploring in depth the constraints on a particular offer. In addition, all aspects of the transaction are open to bargaining: the price, the quality, the credit arrangements, delivery times, and so forth.

The digital R&D bazaar

The twin aspects of clientelisation and bargaining are at the heart of the increasing use of research contracting and research consortia in the digital innovation marketplace. Contracting ties the value chain together over time with all the parties being each others clients in some sense. And while the apparent formality of the contracting process might seem to contrast with the relative informality of the bazaar, the intensity, extensiveness, and personalised characteristics of such negotiations make them very bazaar-like indeed. The pace of innovation means that what the contracts defined is constantly under review and constantly being re-negotiated. Given the potential for instability generated by the technological forces, the economic structures (contracts and clientelisation) impose a measure of predictability. They make it possible, for example, for an R&D manager such as myself to invest in lines of research for which no marketplace opportunity yet exists. I can do so because I "know" that my current

customers will in all likelihood be my future customers. I know and trust they will buy from me. They know and trust I will be there to supply them.

How does this help with the competition in innovation issue? If we go to the DPP example, here we were faced with two possible internal competitors -- product marketing and the current product set both of which could well have been committed to not adding new services to their product. If they was likely to consider this option, they might have chosen to hire a Consultancy to provide the analysis required. Clearly, though, print industry marketing was a complementor since proposing a new set of services to be initiated in their industry was something they were looking for. Similarly, Establishment Printer's own internal development and strategy groups were complementors since if we were able to demonstrate the viability and business value of networking, then there more real opportunities for Establishment Printers to steal a march on its competitors. Their analysis of their future began to depend on our carrying out of our project. Access to Establishment Printers means we could propose an ongoing set of transactions around the findings of this project thus converting the Development Team and others from a one-off customer to a client. Positioning the DPP project in this way within its marketplace transformed product marketing and the Development Team into complementors. They now began to talk in terms of "mid-life kickers" and the opportunities which our project might give them to further enhance their product with technologies drawn from elsewhere within and outside Xerox. Such technologies, or course, are or were potential competitors to the ones we will be proposing. Thus far we have succeeded in turning them into complementors. It remains to be seen when the Development Team do their value engineering whether they stay that way.

Thus far, I have been using the parallel between R&D and bazaars as a somewhat tendentious image. However, I think it is more than this. If we look closely at the constraints on information to be seen within any bazaar, we will soon conclude that they hold for R&D too. They are constraints on: the quality and quantity of information; the distribution of information; and the mechanisms for information flow. Indeed, clientelisation of innovation is a strong and very effective response to them.

Conclusion

The innovation marketplace is a bazaar. It operates increasingly on principles which work for bazaars. This tendency will only increase as the rate of change of digital technology picks up. This is because such increases in the second order derivative for innovation are inherently destabilising in the sense that they increase uncertainty, And it is uncertainty that the social institutions which characterise bazaars are designed to counterbalance. R&D managers (and their contracting partners) will increasingly adopt the roles of bazaaris with clientelisation and bargaining as the *modus operandi*. In so doing, not only are the elements of a temporally and organisationally extended value chain tied together but potential competitors are transformed into complementors.

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A New Technological Enabler for Cross-border Networks: the Lesson from the Boeing 777 Model

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1. Introduction

Now, many industries face competitive markets where product variations must be developed but lead time and development costs reduced. In this situation, New CAD / CAM / CAE technologies coupled with standardization of data format have begun to give birth to concurrent product development on the digital networks. Armed with those technical features of full visualization and a digital pre-assembly of components and a simulation capability, an IT-supported work environment improves the co-ordination and communication among engineers through an integrated 3-dimensional database and a networked information exchange.

The effective utilization of ITs in the product development process is part of a larger trend in which Japanese "human-oriented" approaches are being integrated with Western "systemic-rationality-oriented" practices. The core of Japanese competitiveness has been attributed to continuous improvements made by multi-skilled workers who have utilized their shop-floor experiences, extensive interactions among different groups of engineers and workers, as well as the effective introduction of microelectronics technology in the manufacturing site. The knowledge and skills are improved through an accumulation of experiences gained through direct contacts with products and through active inter-personal interactions. This human-oriented approach has enabled Japanese firms to flexibly interpret and apply technologies to varying environments. The implementation of concurrent engineering has been based on the smooth information exchange between design engineers and manufacturing engineers. In this human-oriented approach, computers were introduced only as a supportive tool.

However, changes are taking place in both the information technologies and the economic environment, which are affecting the competitiveness of Japanese best practices. The first notable changes are the rise in the standard of computer capabilities and, in particular, the possibilities offered by decentralized computers forming communication networks that cross national boundaries. From the economic standpoint, there is the entry to the world market by newcomers such as China, Eastern European and other newly industrializing Asian countries, where labour costs are much lower than in Japan. In addition, because of the increasingly intensifying global competition, standards of competition with respect to the speed and efficiency of product development have been raised to unprecedented levels.

In the Western systemic-rationality-oriented model, however, development and production processes are integrated through the intensive use of information technologies. These processes reflect the Western model of problem solving which is based on pragmatism and an intellectual tradition of analytic rationality (Rorty, 1982 ; Hartshorne and Weiss, 1978 ; Simon, 1996). In this model, possible options are analyzed using clearly defined objectives and the decision-making becomes a rational process that follows the comparison and review of these options. The state-of-the-art of this "systemic-rationality-oriented" model is the management of processes in a decentralised computer environment that utilizes digital information. Theoretically, this approach enables the establishment of a global production system, in which real-time integration of the worldwide development and production activities can be achieved.

Although for a number of technical and organisational shortcomings the potential of information technologies has not been fully realized in the creation of a worldwide development and production system, technical and managerial changes are taking place that will enable the creation of such a system. Part of the technical limitations that prevented effective support of the Western manufacturing and product development model are being solved through new generations of ITs such as three dimensional computer aided design (3-D CAD). Also, the introduction of new organisational systems such as the simplification of organisations and the downward transfer of managerial authority are being driven by the need for faster and more rational decision making processes.

This paper discusses IT's possible contributions to product development, as well as multiple requirements for its successful adaption. In order to effectively implement the new technological enabler, firms need to reconsider their organisational structures and management from new perspectives. Accordingly, the function and effectiveness of cross-border networks are expected to change significantly.

Certainly, this paper has implications for the manufacturers of OECD countries. US firms appear to be the leaders in integrating the US and Japanese approaches. Leading US manufacturing firms have begun to adopt aspects of the Japanese model (Nii, 1994; Ellison, et. al., 1995; MacDuffie and Pil, 1996). Japanese manufacturers, on the other hand, appear to be lagging behind the US firms in the effective implementation of ITs (Baba, Takai and Mizuta, 1995 ; Baba, Kuroda and Yoshiki, 1996). Although both sets of firms take different approaches, it appears that they share the same future goal. This paper argues that considering possible convergence of the US and Japanese approaches, the new generation of 3-D CAD systems play the key role to successfully introducing the emerging paradigm of product development (Baba and Nobeoka, 1996; Baba, 1996).

The next section reviews the evolution of CAD technologies and it defines the key aspects of the new generation of 3-D CAD systems. Section 3 describes the conceptual model for product development, one by the new 3-D CAD systems. A brief description of the Boeing 777 project is provided in Section 4 as a leading example of how the new generation of 3-D CAD systems can be effectively utilized. Section 5 touches on the necessary managerial changes for successfully realizing the benefits of the new CAD systems in the product development process.

2. The evolution of CAD tools for product development

In order to consider the influence of CAD on the product development process, it becomes necessary to describe both the evolution of CAD tools and to define the specific characteristics of the newest generation of CAD tools that will enable the realization of a more effective product development process (Aoki, 1996 ; Chiba and Nishigaki, 1996). Table 1 summarizes the three stages in the evolution and the application of CAD systems to product development.

Table 1 An Evolution of CAD Usage in New Product Development

Stage	I. Introduction	II. Diffusion	III. Integration
CAD System	2-D/3-D mixture	2-D/3-D mixture	3-D
Primary purpose	Efficiency in drawing data transfer to NC machines	Diffusion and learning more efficiency, and smoother data transfer	Real concurrent engineering
Relationship with traditional product development process	Support for efficiency in drawing and data usage for NC machines	<------- (same)	Fundamental change in process
Period (in the case of Automobile)	1970-1985	1985-1995	1995-

Source: "A New Technological Enabler for Cross-border Networks: the Lesson from the Boeing 777 Model" by Kentaro Nobeoka, Professor, Kobe University

It is understandable that CAD usage diffused gradually in the firms since the diffusion period; the benefits of CAD tools to designers and engineers continued to increase from four perspectives. First, designers and engineers gradually learned how to use CAD tools more effectively and efficiently. Salzman (1989) has reported that it usually takes a relatively long period of time for them to learn to make the most of CAD tools. Second, the CAD technologies continued to improve regarding user interface, speed, and stability of the system. Combination of the learning by users and the technological improvements gradually improved the benefits of CAD tools over manual drawing boards and helped diffuse CAD systems.

Third, there was a continuous improvement in data transferability from one site of application to others. It became much easier to transfer design data into NC data, and became less time-consuming to create a CAE model.

Fourth, because the benefits from CAD tools are greatest when designers can re-use existing drawings, the potential for realizing benefits from CAD increased as more designs were incorporated into a digital library. Therefore, the benefit of the CAD tools for designers and engineers improved as a function of time and experience of their usage, and CAD tools continued to diffuse during the second stage.

However, in spite of these improvements, CAD tools were not regarded as an integrated product development tool during this stage. One of the major reasons for the lack of integration was attributed to the mixture of two- and three-dimensional CAD applications which were determined by the different attributes of individual components within a single product. Also, from the viewpoint of the efficiency of design drawing, many types of components do not benefit much from 3-D drawings. It takes much longer to design components, at least until the designers and engineers become fully accustomed to the 3-D tools.

In the third stage of the evolution of CAD usage, which is called the integration stage, all components are designed using 3-D CAD tools, which usually feature 3-D solid modeling such as CATIA and IDEAS. The same 3-D CAD data are used by all of the engineering functions including styling and component designers, analytical engineers, and manufacturing engineers. The 3-D data that are created by

design engineers are shared and used by manufacturing engineers. In addition, all of the components are digitally pre-assembled as a finished product in an early stage of the development project before a real prototype becomes available. Finally, the integrated CAD systems incorporate the communication capability for sharing the latest digital data among individual computer terminals. Therefore, all of the engineers involved in a development project can monitor the latest design that is being worked on by their colleagues.

This paper focuses on the influence of the third stage of CAD systems on product development. Whenever this paper uses a term like “the new 3-D CAD systems,” or “3-D CAD model,” we refer to the third stage of the CAD systems.

3. The 3-D CAD product development model

In order to clarify the influence of CAD systems on knowledge creation in the product development process, it is beneficial to recapitulate some aspects of human thinking. In solving problems, people use several types of logic and reasoning. We classify the logical forms into the following three forms: deduction, induction, and abduction. The first two are used in most categorizations of human logic while the third one, abduction, was originally advocated by C. S. Peirce, a 19th century pragmatic philosopher (Hartshorne and Weiss, 1978).

In the abductive reasoning process, a person articulates a hypothesis that he or she believes provides a consistent explanation to the various observed data. (Sebeok and Umiker-Sebeok, 1980). In the context of our present discussions, then, the fact that recent engineering research on design argues that designing new products can be beneficially recognized as an abductive reasoning process becomes very important (Yoshikawa, 1993 ; Nakajima, 1995,1996). In the following, we will illustrate how computer systems support the human knowledge creation process. We argue that (i) the earlier 2D-CAD systems support deductive and inductive reasoning processes through their analytical data processing capabilities and (ii) the 3-D CAD have begun to partially support the abductive reasoning process of designers and engineers, as well as the deductive and inductive reasoning processes.

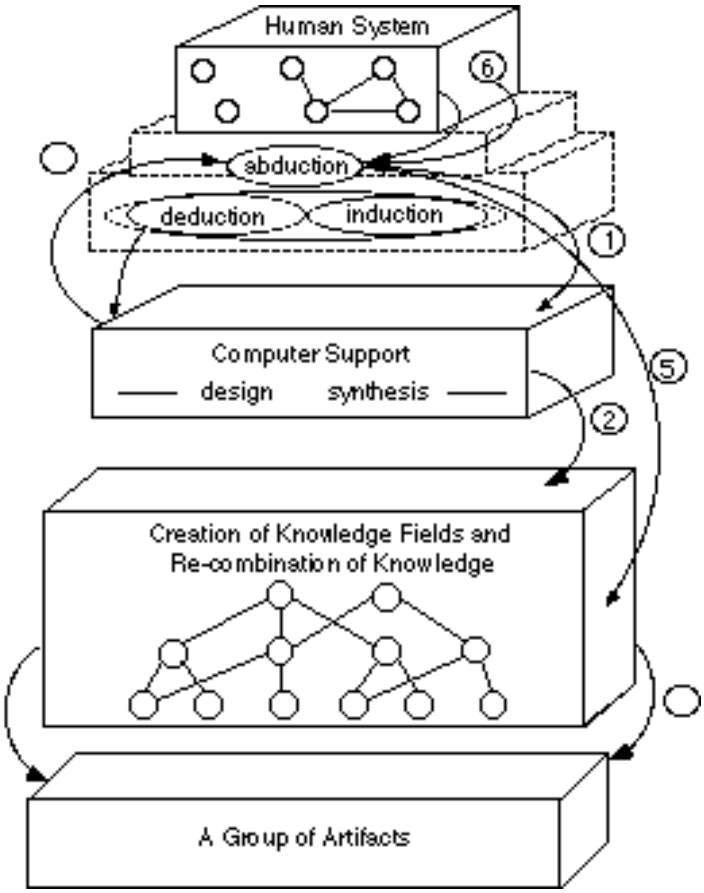
Although the abductive reasoning or capabilities for articulating proper hypotheses are attributes uniquely equipped with human thinking (see Line 1 Figure 3), the new 3-D CAD systems embedded in proper organisational and managerial settings, can support an engineer's abductive reasoning process (see Line 2 in Figure 3). The key technical features of the new 3-D CAD systems that enable the support of abductive reasoning are full visualization of products, simulation (e.g. digital assembly), and shared data bases.

First, full-visualization of products in 3D-CAD enables designers and engineers to engage in more advanced hypothesis formation than in the 2-D CAD tools (Young, 1987; Adler, 1989; Robertson et. al., 1991; Robertson and Allen, 1992 and 1993). 3-D design enables engineers to effectively create and compare designs to their design objectives (Salzman, 1989). Also, under the 3-D environment, all the information is expressed in a commonly set framework, so that everyone concerned with a project can quickly and flexibly respond to each other.

Second, the new 3D CAD system has advantages in its ability to quickly carry out a number of iterations in the formation and verification of an hypothesis. Analysis and simulation functions built in the new 3-D CAD systems enable quicker verifications of various hypotheses than experiments with real prototypes. This process improves outcomes of knowledge creation, just as in a poker game the probability of having a stronger hand increases by playing more games and shuffling more times. This

capability contributes to abductive reasoning through the expansion of deductive reasoning premised on hypotheses. This simulation can reduce the number of design problems that might occur later in the development process.

Figure 3: 3-D CAD Model



Source: "A New Technological Enabler for Cross-border Networks: the Lesson from the Boeing 777 Model" by Kentaro Nobeoka, Professor, Kobe University

Third, the 3-D CAD systems also support the type of organisational knowledge creation (Nonaka, 1994; Nonaka and Takeuchi, 1995; Nonaka and Baba,1992; Niwa, 1995; Ueda and Niwa, 1996; Nonaka, Umemoto and Senoo, 1996;) by facilitating interactions among designers and engineers and improving the degree of their collaboration. For instance, sharing design ideas with other engineers enables an engineer to confirm a design from a variety of different viewpoints, and to resolve design conflicts with others. Furthermore, the presentation and briefing capabilities which are made possible using the simulation functions of 3D CAD increase the ability to communicate key trade-offs to other functions within (e.g. marketing) and outside the firm (e.g. suppliers and customers).

Knowledge obtained through such computer support can be molded into a unified expression and stored as frozen knowledge in a database (See Line 3 in Figure 3). As in the case of the 2D-CAD model, the product data are initially transformed to the concrete artifact, the targeted product of a project, by transferring NC data into CAM equipment.

In the 3-D model, however, the abductive capabilities of designers and engineers as well as the organisation may be improved through their experiences with product development in the computer-supported environment (See Line 4 in Figure 3). Acquisition of design and engineering knowledge from what is being designed or manufactured enhances an individual's and subsequently an organisation's abductive capabilities on the product development (Brown and Duguid, 1991; Weick, 1991; Simon, 1991).

Therefore, in the 3-D CAD model, the knowledge fields on a specific product are firstly created, and pieces of knowledge are constantly re-combined and re-integrated through abduction. Consequently, the systematized knowledge can take the appearance of a group of artifacts (See Line 5 in Figure 3). This advantage is due to technical conditions that relationships among sub-systems are clearly defined in the assembly feature of the 3-D systems and hence the recombination of the sub-systems is easily accommodated. This capability is particularly useful in the development of a series of product lines that utilise the same sub-systems differently. For example, firms can enter various product market segments efficiently as shown in the case study of Boeing later in Section 4.

From the viewpoint of technology management, the strategic utilization of the 3D-CAD model certainly results in increased returns in product development and decreased marginal development costs (Arthur, 1989). Since industries face competitive markets where more product variations must be developed and products are constantly becoming obsolete, capabilities that enable the development and accumulation of integrated systematized knowledge are important competitive tools (Nobeoka and Cusumano, 1996). Undoubtedly, we should proclaim that the emerging 3D-CAD model becomes an indispensable technological element.

Finally, we should point out that the importance of the human's role in abduction will remain unchanged. (See Line 6 in Figure 3) Sharing the unified expression of knowledge by all those concerned is made more effective by the use of 3-D CAD. However, in order to systematize individual abductions so that they bring about concrete results, the individuals must make a conscious effort to understand the intentions of other members in the team and develop a common perspective and mental model. There must be face-to face communication through co-location to establish their objective. From this standpoint, it is understandable that Boeing (see Section 4) and Microsoft (Cusumano and Selby, 1995), which have among the most advanced computer-supported environments in the world, emphasize co-location of project members.

4. The case of Boeing 777 development

One of the best examples of a successful implementation of the 3-D CAD Model is the development of the Boeing 777. The project was conducted as an international joint development led by Boeing and involving five Japanese aircraft manufacturers. Although there have been a number of case studies written on this project, this discussion will focus on how the 3-D CAD model was implemented and how it changed the way the organisation works (Takimoto and Tajima, 1995; Nii, 1994; Kanemaru, 1996; Honda, 1995; Hayashi, 1994).

Boeing uses the term "preferred process" to describe its new development process, which was first implemented with the development of the Boeing 777. The main features of this new process are: 1) concurrent product definition; 2) design build teams, 3) digital product definition; and 4) digital pre-assembly. The first two features are associated with organisational and process changes while the latter two features are associated with the 3-D CAD systems.

Concurrent product definition (CPD)

Concurrent product definition involves the determination of the key design features for each component. As a core element of achieving concurrent engineering, it was conducted through concurrent operations between different design groups and between various functions such as design, test, production and materials. Interferences between components, manufacturability, and product functionality were considered by all relevant project members from the very beginning of the project. Most project members from both Boeing and the suppliers were located in Seattle during the CPD stage.

Design build team (DBT)

Beginning with the CPD stage, many teams were created to facilitate smooth co-ordination between various functions. In the 777 project, in total, more than 250 teams were created. While most of these DBTs were focused on specific component areas, there were also teams created for specific engineering issues such as aerodynamics.

A hierarchy of DBTs was settled in order to systematically manage the project. There were upper-level DBTs that contained leaders of lower-level DBTs. Although this hierarchy of DBTs was created, it was much more flexible than the product development organisations that had been previously used at Boeing.

Digital product definition (DPD)

All components were defined using 3-D CAD data and these digital data were considered as the only medium for component definition in the 777 project. The latest data were available to most project members in order to have real-time co-ordination between them. Access to data was determined by managerial level and group membership.

Digital pre-assembly (DPA)

Digital pre-assembly was conducted from the very beginning of the development process. In order to simultaneously check for interference and manufacturability problems, digital pre-assembly was conducted even when there was only a rough idea of the size and shape of the component.

The four characteristics of Boeing's 777 project described above represent a combination of both Japan's human-oriented and the US systemic-rationality-oriented approaches. Before implementing the new development process, Boeing conducted an activity it called "learn the Japanese way" in which it extensively studied the Japanese manufacturing and development model through visits to Toyota and other companies. In this study, Boeing learned the importance of cross-functional teams that are created at the very beginning of the project, which Toyota calls "front-loading." The front-loading of activities enables the inclusion of other functional perspectives at the beginning of the development project. In past

Boeing development projects, design engineers who held a great deal of power in Boeing were allowed to conduct their work in a designer-centered fashion with little regard to downstream processes. One purpose of implementing the DBTs was to remedy this power relationship so that the designers and the production people could exchange information and ideas on an equal footing from the early stage of development. The introduction of DBTs and the CPD enabled the concurrent drawing of designs, production instruction charts, and tool charts.

However, Boeing went beyond the traditional Japanese knowledge creation model, partly since it was armed with much more sophisticated CAD systems than most Japanese firms. Digital pre-assembly facilitated cross-functional communication. According to some Japanese automobile engineers, even when they want to discuss design issues at the very beginning of a project, manufacturing and testing people sometimes cannot participate in the discussion unless they have a physical representation such as a prototype or a view of a digital pre-assembly.

An additional problem often found in Japanese firms and that was handled well by Boeing concerns the distribution of power among project members. In the Japanese projects, the more experience an engineer has, the greater respect the designer receives and thus the more likely his recommendation will be implemented. Although often experience and correctness are related, in some cases experienced people make mistakes. In Boeing's DBTs, the digital pre-assembly and simulation activities made it possible to make decisions more on the basis of logic than just experience.

The performance of the Boeing 777 project was in many ways superior to past Boeing projects. First there were 75 per cent fewer design changes than in previous projects. Both design changes for design improvement and those for design error corrections were reduced. A large portion of the changes for design improvement are typically caused by demands outside the design function; they ranged from manufacturing to customer services changes. The CPD and DBT activities enabled a reduction in this type of design change. Design error corrections, which are typically caused by parts interference, were reduced through digital pre-assembly.

Other benefits included reduced engineering hours and a reduced number of prototypes, including mockups. Although the work load for project designers increased since they were responsible for both producing 3-D drawings and for producing the final design that incorporates manufacturing requirements and testing results, a reduction in engineering changes enabled a reduction in the number of total engineering hours. Further, a full-scale mock-up was not needed.

Finally, the development method used for the 777 project has made it easier to develop subsequent aircrafts that are similar to the 777 model. While reuse of a component design was easy when engineers use 2-D CAD, the new 3-D CAD systems featuring digital pre-assembly make it possible to reuse sub-assembly designs. The basic aircraft with a 300 passenger capacity and a 5 000-mile cruising range was first developed in May 1995. It was followed by a long cruising-range aircraft with a cruising range of 7 000 miles in December 1996. A stretched-body aircraft with a more than 350 passenger capacity is planned to be completed by May 1998 (Handa, 1995). Effective applications of the systematized knowledge to multiple products are becoming a more important factor for competition in many other industries also (Nobeoka and Cusumano, 1996; Nobeoka, 1996).

Although the development of the Boeing 777 aircraft is an excellent example of the 3-D CAD model which we are advocating in this paper, we also recognize that there are some characteristics of aircraft development which make the 3-D CAD model easier to implement than in other industries. In the aircraft industry, the design architecture and the structure of components are relatively standardized. A standardized manufacturing and assembling structure exists which is called work breakdown structure

(WBS) and it is shared by most firms in the industry. In the WBS, all the work required for aircraft development is broken down into a tree structure. Through experience in joint development projects, both domestic and international, in which the main contractor subcontracts work to co-operating firms, a common WBS has emerged among many firms. This WBS includes standard individual operations, standard durations and standard combinations of different operations. This WBS has probably made it easy for Boeing to introduce the 3-D CAD model not just internally but with all of the co-operating firms and suppliers.

5. Conclusions and implications

This study argues that the new 3-D CAD systems are playing a central role in the creation of new product development models. Earlier versions of CAD systems were considered as tools that improve efficiency within a traditional product development process. However, the new 3-D CAD systems have the possibility to improve the capabilities of engineers, which has been regarded as a critical element in a firm's product development activities.

The most important current issue is how firms can make the most of the new 3-D CAD systems. In order to understand its benefits, this paper proposed a conceptual model which identifies the new 3-D systems in terms of their contributions to in product development. In the 3-D CAD model, ITs contribute not only to the efficiency improvement of inductive and deductive reasoning processes, they also contribute to the abductive reasoning process at both the engineer and organisation levels.

The leading firms in the introduction of the new 3-D CAD model are US firms such as Boeing whose 777 project was briefly described in this paper. While many US firms have been implementing the Japanese "human-oriented" approach, many Japanese firms have begun to implement the Western "systemic-rationality-oriented" approach represented by the technological characteristics of the 3-D CAD model. We consider this situation as the beginning of an era for mutual learning between the US and Japanese manufactures.

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Paradigms of intellectual property/competition balances in the information sector

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1. Introduction

To meet the challenges imposed by the emerging international information industry, we are now attempting to rethink intellectual property rights -- probably more deeply than at any time since the invention of printing. In this emerging world, we are seeing new linkages between intellectual property law and competition law, for intellectual property rights may be used to provide exclusive rights over operations and activities (e.g. computer programmes) as well as over information and entertainment products as traditionally conceived. This paper presents a series of three paradigms to explore these linkages and examines their implications for the law relating intellectual property and competition. It does not attempt to answer the question whether or when the activities involved in a specific paradigm should be regarded as anticompetitive; it rather attempts to define those paradigms that deserve careful economic analysis by statistical or microeconomic theory tools.

For the purpose of this paper, intellectual property law includes (1) patent law where this law affects the use of particular information technologies, whether of software or of hardware, (2) copyright law that affects such technologies, (3) derivatives of copyright law such as database protection,[8] (4) relevant trade secret law, including, for example, the contractual provisions included in a shrink-wrap license or the installation programmes of computer software, and (5) exclusive grants of access to government information that may have the same effect.[9]

Competition law includes, of course, the economic principles regarded as embodied in the United States Sherman Act and Articles 85-86 of the Treaty of Rome. But this paper uses a somewhat broader scope. Most important, on the theoretical level, it naturally assumes that a consumer can be benefitted by obtaining a product at a lower price, as reflected in traditional allocative principles of competition law, but it also assumes that a consumer can benefit from a new generation of product. This effort to incorporate technological progress implies a view of the interface between intellectual property and competition law as one in which a balance must be made between market structures that benefit consumers through lower prices and market structures that benefit consumers through more sophisticated products. Moreover, there may be a need to balance between incentives that encourage one generation of product and incentives that encourage multiple generations of products.[10] And, on the practical level, the paper is indifferent as to whether a particular balance between intellectual property and competition principles is legally implemented in intellectual property law, in competition law, or elsewhere. For example, a judgment that the reverse engineering of software is legitimate (or not) may be implemented by saying that copyright law does not (or does) regard such reverse engineering as an infringement, or by saying that a contractual prohibition against such reverse engineering does (or does not) violate competition law principles.

Finally, for purposes of this paper, the international information sector is regarded as including all those sectors that reasonably directly affect the international flow of digitized information. The internet and the materials circulated on it are certainly the central focus. But, among the factors directly affecting that system are the software industry more generally, the digitized information industries, the computer sector, and the international telecommunications sector.

In describing the paradigms, the paper begins with those directly deriving from the scope of intellectual property law, moves to those associated with tying and linkages from one market to another, and concludes with those associated with cross-licensing within an industry. But it first considers the special characteristics of *international* intellectual property/competition issues.

2. A little international background

Intellectual property rights are territorial. This makes it relatively easy to achieve market division, at least as a legal matter. One simply assigns licenses under U.S. intellectual property rights to one firm and under, say, Canadian intellectual property rights to another firm, and each firm can use its rights to protect itself against imports from the other, *United States v. Westinghouse Elec. Corp.*[11] Within Europe, this market division is a primal evil, e.g. *Nungesser v. Comm. (Maize Seed)*.[12] In a broader context, however, jurisdictional limitations make it very difficult for the competition authorities of a single nation to respond to the problem.[13] Globally, to the extent it can be made effective, it permits price discrimination, thus increasing the monopoly rent to the holder of the intellectual property right and also permitting a price discrimination in favour of poorer nations with more elastic demand curves. Looking ahead, the spread and growth of intellectual property rights will permit this type of market division to be more widely attempted, but the realities of international information flow may undercut the price discrimination. The result is likely to have implications for the rent available for an information entrepreneur and for the prices paid for information in the developing world.

What will also be seen is differential protection levels among different nations. In spite of the efforts of the international community exemplified in the TRIPS agreement,[14] there are likely to be infringement havens, in which information can be more freely put onto the Internet, broadcast, or widely copied. And there will also be nations or groups which deliberately build a stronger protection for one kind of information and may seek to favour the access of their own firms; Article 11 of the European Union's Databank Directive[15] is a clear example. Indeed, this is one of the reasons why the United States sought to push an international database agreement last year.

Many of the issues here are, of course, issues of policy and of efforts at harmonization. There are very important questions as to whether internationally-harmonized intellectual property rights are likely to be more or less protective than those defined at a national level. The various interests are represented in quite different ways at the international level, and at the national legislative, administrative, and judicial levels. But there are also important competition policy questions: for example, should there be any form of defense available in competition law when a firm argues that it is severely hurt, in comparison to its international competitors, as a result of differential intellectual property standards or price differences maintained through territorial divisions based on intellectual property rights.

More broadly, the Uruguay Round clearly showed that those nations with strong intellectual property industries (including information industries) are interested in globally strengthening the level of intellectual property protection. This is a very rational response to a situation in which information and technology are becoming the fundamental form of wealth. This new merchantilism can also affect competition law: What are the risks that national prosecution authorities will shade competition law

judgments to protect, not weaken, their own national firms' positions of global market dominance deriving from intellectual property rights? We are likely to face important and difficult questions that combine not just intellectual property and competition policies, but also trade policies.

3. The first paradigm: Breadth of intellectual property rights themselves

Every form of intellectual property right is a distortion of free-market principles. In the absence of intellectual property rights, one would be free to copy and market a patented invention or a copyrighted work, and the price of the work would become the marginal cost of the copying and production (a cost that, in the case of many information products, is tending to zero). We deliberately, however, prohibit such copying in order to permit an inventor or author to obtain a monopoly rent and thus create an incentive "to promote the Progress of Science and useful Arts,"[16] -- and one of the basic problems of intellectual property is to define a scope and term for this protection that offers a reasonable balance between the benefits of new products and works deriving from the incentive and the benefits of marginal cost pricing deriving from the freedom to copy.

Some aspects of this balance have relatively limited practical consequences -- except in the case of a few specific products for example, there is little rational basis for arguing that the current patent or copyright terms are too long or too short and it would be very difficult to devise a helpful empirical study examining the value of longer or shorter terms in different sectors. (It does, however, seem absurd to have a 75-year copyright term for computer software![17]) However, some issues of the scope of intellectual property rights directly involve industry structure and therefore have profound competitive consequences, some of which can certainly be usefully explored in an analytical or empirical fashion. And national governments will be tempted toward a merchantilist position in these scope issues; the homes of the currently powerful international actors generally preferring options that favour the intellectual property incentives over competition.

One of the most important of these is the computer programme reverse engineering issue mentioned above. Suppose the law clearly permits the owner of a computer programme to prohibit decompilation and structural analysis of a computer programme. This can be done by appropriately defining the scope of copyright coverage of a computer programme, by prohibiting the marketing and use of the computer programmes designed to defeat any forms of protection that might be built into the computer programme to be analyzed, or by permitting enforcement of shrinkwrap or similar contracts prohibiting decompilation.[18] Whatever the legal technique, the holder of the original programme can use this prohibition to build a barrier against the ability of others to understand and improve on the programme. This strengthens its market position and, of course, increases the incentives for writing such a programme in the first place. Under this approach to the law, the software industry is more likely to be dominated by a few powerful actors and their power is likely to be less vulnerable to product improvement. Under an alternative approach, under which software engineers would tear apart other firm's programmes and seek to develop and market improvements, there would likely be more firms, more new products, and more turnover among market leaders, and perhaps less incentive to invest. Not surprisingly, the larger, more established firms tend to prefer the stronger coverage; their smaller competitors would prefer the weaker coverage. Is there an economic basis for making this choice?

Another version of this paradigm is raised by the possibility that intellectual property rights might extend to standards. An obvious copyright example is *Lotus Devel. Co. v. Borland Intern., Inc.*,[19] in which the question was whether the commands used in a widely-sold spreadsheet programme were protectible or not. If they had been held protectable under copyright, then the holder of this copyright would have been able to use the network externalities to protect its position against competitors whose

programme would require users to learn a new command set. By holding this standard not copyrightable, the U.S. court permitted greater competition in the spreadsheet market, at the cost, of course, of incentives for writing such programmes. Again, is there an economic basis for choosing one principle over the other?[20] The argument against extension of copyright exclusivity to protect standards is significantly stronger in cases in which the need to meet the standard is imposed not simply by personal choice (as in the case of the Lotus spreadsheet commands) but by interoperability concerns. Thus, there is probably a greater willingness to respond to competition concerns when an intellectual property right provides a mechanism of control over a standard adopted by an industry committee, as in the case of *Dell Computer Corp.*, where the existence of the patent was not disclosed at the time the standard was negotiated.[21] This conflict has also been extensively debated within the European Telecommunications Standards Institute, where special procedures have been developed to try to balance the concerns of intellectual property rights holders and those who would be compelled by the standards to obtain a license from a particular rights holder.[22]

Other important examples of this paradigm of balancing incentives for research against the benefits of competition in defining an appropriate scope for intellectual property rights arise in the control of data and of databases. A straightforward example is the recent U.S. case of *National Basketball Assn. v. Motorola, Inc.*, [23] which permitted use of a hand-held pager that supplied information about ongoing sports events with about a two to three minute lag and updated every two to three minutes, through reporters who watched the games on television or listened to them on radio. The court distinguished a 1918 case in which a news service was held not entitled to take information from a competing new service on a regular basis.[24] The pager (or the reliance of one news service on another) provides a consumer benefit, but weakens the incentives for the developer of the initial information. Because there are still substantial investment costs in assembling a database, and because most nations' legal systems do not extend copyright law protection to information itself (as opposed to the expression of that information), there have been proposals, and some law, for *sui generis* coverage for databases. The new European Database Directive creates such a right in a form balanced in favour of the intellectual property interest. Much the same result was achieved by the court's reading of a form license agreement contained in the package in *ProCD, Inc. v. Zeidenberg*.[25] Although the Directive permits "extracting and re-utilizing insubstantial parts of the [database] contents,"[26] it poses concerns about the ability of a customer/competitor to develop applications that involve access to large portions of the database. For example, should a service that offers access to digitized weather maps be entitled to prohibit (or require a license from) a firm that combines the digitized data for a large area with certain of its own data and a proprietary computer programme to provide precise long-range weather forecasts for a large area? Where is the best balance between the incentive for providing the original service and the benefits of more free use of the information assembled by the original service? And, should concepts of the political and intellectual benefits of access to information be taken into account in making the more specifically economic analysis?

4. The second paradigm: Leverage from one market to another

In the examples just presented, intellectual property rights strengthen a market position against later innovation, in a way that poses a balance between the incentives for the initial innovation and the benefits of the subsequent innovation. Parallel issues can arise with the use of power in one market to leverage into a position in another market, and are likely to be crucial in the future international information industry. This industry is likely to see such rapid evolution in markets and products that the essential dynamic of competition will precisely be leverage from market to market. Moreover, dominant positions are likely to be common in specific subsectors, because information products are likely, in general, to be expensive to create, and cheap to reproduce and distribute. And, as in the previous case,

governments of nations with strong firms are likely to favour legal accommodations that strengthen the positions of those firms.

These are, of course, traditional competition law tying questions; yet they involve particular kinds of market structures and they affect the magnitude of the research/programme writing incentives. Analysis of the role of intellectual property rights in conferring market power to be used in tying analysis has long been a staple of antitrust analysis.[27] In the information industry, the "classic" examples of this issue are the various arguments that have been made against Microsoft's use of its strong position in the personal computer operating system sector. Is it an antitrust violation if Microsoft creates operating system programme features that make it significantly easier for a programme user to obtain access to the internet through a Microsoft interface? Or make it significantly easier for a Microsoft applications programmer rather than a competitor to produce a word processing programme? Whether or not these linkages should be regarded as troublesome in the actual Microsoft context, there is a clear possibility that linkages of this type can be genuinely anticompetitive.[28] Admittedly, some of these linkages should be regarded as just mechanisms of obtaining a license fee in a way that can price discriminate and collect some of the surplus under the demand curve.[29] The markets involved, however, are responsive to much more than price, and a firm that can establish an early strong position in a market may be uniquely favoured against competitors. Learning curve effects may favour it as it amortizes its research costs and reduces its product prices in a market that may last only a product cycle or two. Network externalities may favour it should the standards associated with its product gain market power through consumer familiarity or through third party reliance, as exemplified by the growth of internet servers that use specific features linked with a particular internet connection programme.

Another version of this leverage paradigm is exemplified by the Sabre case, in which American Airlines was found not to violate antitrust law in using its computerized reservation system as a way to favour presentation of American flights to travel agents.[30] Similarly, as analyzed by the European Court of Justice, the leading European case directing compulsory licensing was an extension of power from one information market (that for television programme information) to a different market (that for compiled programme information including data on all stations).[31] More generally, to what extent can or should intellectual-property based control over an information resource be used to leverage power in a product market? As the information economy grows, and comes to include more and more information of commercial value (including database information), control of databases may amount to significant market control. When can internal databases be used this way? What about exclusive agreements between a database firm and a commodity economy firm?

These are closely related to questions in which the market power giving rise to the leverage derives from regulated monopoly access to specific markets. Such access is certainly not the same as an intellectual property right, but the difference may not be great, and may sometimes be narrowing. The classic example of the use of power derived from a regulatory monopoly is posed in the litigation over the breakup of AT&T.[32] The concern is that a firm with a regulatory-based monopoly controlling access to consumers that is allowed to offer a service in a related market, e.g. value-added services, will be in a position to discriminate against other firms in providing access to consumers or to cross-subsidize between the regulated and the unregulated sectors of its operation. Perhaps the competition being created in the United States at this level[33] will eliminate the issue in the specific instance; yet not all the world is regulating telecommunications in the same way as the United States. Moreover, the telecommunications industry is concentrating globally, as many national telecommunications operations are being bought by multinational telecommunications firms. And there are national differences in analysis. In analyzing the British Telecommunications-MCI joint venture, Europe emphasized a potential competition analysis looking to the protection of competition in the market being entered by the joint venture,[34] while the United States emphasized the risk that the relationship might disadvantage other firms in their

interconnections to the British market.[35] It would be very surprising if there were not many such questions in the future and if some did not involve monopoly positions more closely viewed as intellectual property rights.

5. The third paradigm: Pools and cross-licensing

A final concern is posed by the issue of very fundamental and far-reaching patents on methods of doing business and on software design features. Examples of these include patents on a system of multiple interactive self-service terminals that provide audio-visual sales presentations and dispense goods and services from multiple institutions,[36] and on a uniform system for verifying and tracking articles of value.[37] Because of the character of software, some of these patents may read on essentially all activities within a specific sector.

Conceivably, in a few cases, these intellectual property rights will be used in an effort to monopolize the sector -- or there will at least be issues of evaluating mergers that bring together important combinations of patent rights. In addition to raising competition law questions, these will involve questions whether monopoly is acceptable in an area that affects the flow of information and the ability to participate intelligently in the political process.

But the more likely use of such basic patents is exemplified by the semiconductor sector (which is certainly at the edge of the information industry). This is the likelihood of formal or informal cross-licensing. It is at least a reasonable hypothesis that the participants in the semiconductor industry all hold patents that all other members of the industry infringe. Firms respond quite understandably through explicit cross-licenses. Sometimes, they may instead simply choose not to sue others for infringement because of fear of countersuit; such an arrangement is essentially a tacit cross-license. So far, whether there is a competition law problem depends on whether the terms of the cross-licenses significantly reduce incentives for research (as for example were there an agreement among all industry leaders to cross-license all *future* technologies).[38] The issue comes if the patent rights -- many of which are rarely used against one another -- are used to prevent entry by new firms into the business.[39] (Note that the cost of litigation is an entry barrier, so that the patents can be economically effective even if they are legally invalid.) Is this simply a protection of an oligopoly rent that can be viewed as a reward for past research and incentive for future research? Or is it the use of a patent structure to create barriers to entry and protect an oligopoly in a way that should not be accepted because the barriers to entry bear little actual relationship to research incentives?[40]

If this interpretation accurately characterizes the semiconductor industry, this very puzzle will have important direct effects for the international information industry, because many forms of information may well end up embedded on chips made by the industry (or other products made by a similarly organised industry), and the possibility of information-firm entry into certain sectors may be affected by this patent and licensing structure. Moreover, whether or not this interpretation is exemplified in the semiconductor industy, it is plausible in many software sectors, as the number and scope of basic software patents lead to the same pattern of mutual infringement. In the software case, in contrast to the semiconductor case where there are substantial capital costs to entry, the intellectual property barrier might even become the fundamental way of preventing entry into a sector in which we might well want much more competition. And in all these cases, there may be international enforcement issues, for the members of the formal or informal cross-license will be spread among several nations.

6. Conclusion

These intellectual-property v. competition-law issues -- defining an appropriate scope for intellectual property rights, dealing with use of such rights as part of a tying/leverage relationship between markets, and dealing with sophisticated cross-license situations -- are not fundamentally new in concept. They have all been raised before in competition law doctrine. Yet, the analysis must go well beyond the insight that many license provisions that were once regarded as anticompetitive are better regarded simply as reasonable ways to collect a monopoly rent. The markets are more complex and dynamic and the inportance of entry barriers such as learning curves and network externalities too great. Moreover, in international markets, the nation with the most clear legal authority may have merchantilist disincentives to act.

The stakes for global freedom of access to information are enormous. Solid economic analysis would be highly beneficial, and the plausibility of the paradigms suggests that they may define an appropriate agenda for discussion in new international competition law arrangements.

Understanding industry structure in computing

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In this short paper, I outline a few key concepts to help understand long run economic forces for structural change and stasis in the computer industry. The basic goals for most of this discussion are to explain *why things happen* instead of *what should happen*. I then conclude by comparing open policy issues against the historical patterns of change in the industry.

Introduction

To the uninitiated and even the old-hand, the computer industry is an intimidating agglomeration of firms, markets and buyers, all changing rapidly in response to the latest innovation or recently-invented application. Technological opportunities arise rapidly, altering the technical landscape more rapidly than in any other industry. Established firms feel perpetually under siege, particularly when they compare their lot in life to other firms in other industries. The computer industry's structure seems caught between forces for inertia and for change, with the latter having an upper hand.

Change comes in two broad places, in technical frontiers and in market relationships. One might think of technical frontiers as the menu of choices. Market relationships are closer to the products and technologies actually chosen by most buyers. As is often remarked, the menu changes rapidly and often, but market relationships less often. Why, in the face of a rapidly changing menu of choices, do buyers continue to make many of the same choices year after year? Why do the same firms and products seems to re-appear in computing in spite of extraordinarily rapid technical change? When change to market relationships does occur, what does it tell us about the forces for stasis or change?

Consider the factors pushing market relationships in different directions. On one side might be called the forces for inertia. These keep previous investment in place, and foster the illusion of gradual change (if at all) to long-time computer vendors and users. The products and the applications follow from a long technical genealogy and sometimes from long organisational continuity. Most of these are associated with standard platforms and market arrangements for the delivery of components. Often the same firms, the same technologies, the same customers and the same applications are still there, perhaps a bit different and better today than they were a decade ago or two decades ago, but essentially unaltered in many important respects.

On the other side might be called the forces for change. These disrupt existing structures, provide new technological and commercial opportunities for users with unmet needs and entrepreneurial firms with imaginative new ideas. These forces expand the range of applications associated with computing, leaving pundits breathless. New market segments arise. Products take on new and previously unforeseen functions. Due to previous and anticipated changes, many long time users and firms feel perpetually under siege, overwhelmed by change and unable to predict its direction.

One cannot hope to develop a comprehensive understanding either of the long run forces for change or stasis in one paper. In this short paper, I outline a few key concepts to help in that endeavor.

The basic goals here are to explain *why things happen* instead of *what should happen*, the latter being much more policy-oriented. However, and I will make a few comments on policy issues at the end.

This review necessarily skims several books worth of important detail and theory, liberally drawing on recent collaborative research with Tim Bresnahan (Bresnahan and Greenstein, 1996, 1997a, 1997b) as well as other related work. The curious reader should feel free to ask either of us for copies of these longer pieces or to seek out copies in published materials.

The forces for inertia

Why, in the face of a rapidly changing menu of choices, do buyers continue to make many of the same choices year after year? Why does new technology turnover faster than new firms?

Platforms and other lay of the land

The computer *platform* is an important organising device for market-mediated technical change. A platform is a cluster of technically standardized components which buyers use together to make applications.[42] "Components" include not only computer hardware but software and trained labour. All important computing has involved components which are sold in markets (hardware and some software) and components which are made by buyers (training and mostly software). Many of these components are long lived assets. Thus, new technology can most easily find its way into computing when new components enhance and preserve the value of previous investments in computing platforms. Hardware components may advance, for example, without the need to change software or human capital. Thus, platforms tend to persist, whether for cost-minimizing, co-ordination failure, or strategic reasons.

Firms tend to sell groups of compatible product offerings under umbrella product strategies for platforms. Important computing platforms today include the IBM 3090, the IBM AS/400, the DEC VAX, the Sun SPARC, the Intel/Windows PC, and client/server platforms linked together with well-known computing and communications hardware (e.g. from Compaq, Sun, DEC, IBM, Cisco or 3Com) and software (e.g. using software from Oracle, IBM, Microsoft, Sun, Netscape, SAP). Even though these labels may have proprietary names associated with them, such a label may stand in for a complex, often unintegrated and decentralized, market structure. Many of the largest and most popular platforms for client/server today include many different computing and communications equipment firms, peripheral equipment firms, software tool developers, application software writers, consultants, system integrators, distributors, user groups, weekly news publications, and third party service providers.

The economic forces centered around a platform tend to work strongly within computer industry *segments*, where segments are distinguished by the types of computer applications demanded by users. For most of the last 30 years, most segments were distinguished first by the size of tasks to be undertaken and by the technical sophistication of the typical user. A decade ago it was agreed that segments were distinguished by size, from big to small in the order of mainframes, minicomputers, work-stations and personal computers. Users were either technical (e.g. a trained engineer or programmer) or commercial (e.g. a secretary or administrative assistant), which closely corresponded with the degree of sophistication and other features of the software or hardware.

The most interesting development today is the blurring of these old distinctions, an event which might be called "The Competitive Crash". The networking revolution is primarily responsible for blurring these once-familiar distinctions, making it feasible to build client/server systems for virtually any type of

user in any size category, building platforms out of sub-platforms. Whether it is cost-effective do so in every situation is open question. Judging from many recent reports, in many situations it appears to be[43]. One cannot hope to fully explain this blurring in a single stroke, as it resulted from complex and varied forces. More important for policy making, these changes probably set the stage for policy issues in this industry for the next few years.

A well-developed body of competitive analysis has arisen to explain how platforms and segments operate. These forces are particularly strong in segments serving commercial users rather than technical users. Since most of the policy issues also arise in the commercial segments of computing, this is where we will focus.

Concentration

Segments in which there are endogenous sunk costs (ESC) will have a concentrated structure even if there is a great deal of demand. This pattern does not depend on how sellers interact strategically.[44] The key to the analysis is the definition of endogenous sunk costs. These are expenditures undertaken by sellers to make their products better for users. (In computing it will be R&D, servicing, product development, support networks, and product enhancement, all geared toward enhancing systems making up a particular platform.) Endogenous sunk costs are irreversible, raise the value of the platform, with no potential bound, appealing to a large fraction of potential customers.

Fragmented segment structure is impossible when ESC are important. If the segment structure were fragmented, a firm could invest in ESC, drawing many customers to itself. Any other competing platform would have to do the same or lose its relative attractiveness. Thus, there is a tendency for *all surviving platforms* to be those with high ESC. Otherwise, low-ESC platforms are relegated to niche status or death. What happens if market demand grows? Instead of simply supporting more firms and thus more competition, a larger market will have higher ESC, but still only a few firms. For better or worse, more ESC goes into high product quality and other things valued by buyers, not less concentrated segments.

Notice, these observations are principally about platforms not firms. Expenditures to make a platform more appealing raise the demand for every component of the platform. It does not matter who actually makes these expenditure. If cloning firms or peripheral makers (or even user groups!) succeed in enhancing the value of the platform, then demand for the platform would be raised. As a result, ESC theory can only be deployed to explain concentration of platforms, not necessarily of firms.

We can learn two general lessons about computer industry structure. First, concentrated segments arise due to broadly compatible platforms and its combination with a marketing organisation to support customers' use of it. The second general lesson is closely related but very frequently overlooked by observers of this industry. The creation of a platform is not merely an engineering feat. Instead, the creation of a platform involves a *commercial* invention. The forces leading to concentrated structure in computing are to be found in market events not solely in engineering-driven technical change.

Standardization

Computing platforms must adopt technical standards in order to make systems work well. In general, buyers and sellers of technology make platform-specific investments, where these standards are

taken for granted. At least some of the platform-specific investments are long-lived and influence the costs and benefits of technical and market decisions made over time.

The heart of this theory is a story of positive feedback among the stakeholders in a platform.[45] Mutually reinforcing behaviour arises when standards co-ordinate behaviour in a static sense, but also when it co-ordinates technical change and investment activity over time. Buyers, sellers, designers, or third-party software vendors make long-lived platform-specific investments in a platform, which tends to keep platforms in operation for long periods. For example, many of the standards in the IBM 360 (introduced in the mid 1960s) survived in the IBM 370 and its descendants, the 3090 and so on. Many firms, vendors, users, programmers and other important players have a stake in continuing the use of the standards used within this platform.

This theory has implications for the origins and ending of platforms. Just as platform standards are hard to stop, they are hard to start. A platform needs a "critical mass" of adopters and a critical mass of complementary software (and sometimes other components). "Positive feedback" underlies survival of existing standards and "getting over a hump" of acceptance for new standards. If a new standard does get "over the hump" then positive feedback forces quickly favour it. This problem so conditions a firm's behaviour that it will take great pains to overcome its limitations.[46]

The literature on standards persistence has hotly debated whether, in an uncertain environment of new technology, it may be difficult to co-ordinate platform-specific investments. Stated broadly, this is plausible (and common in the literature). Yet there are many variations. Theories differ on exactly which agents have difficulty co-ordinating which decisions. These differences are not trivial, because each type of assumption leads to very different policy conclusions about the desirability of persistence. Sellers' role in persistence is variously interpreted as efficient co-ordination or exploitative preservation of a monopoly position.[47] Due to the goals of this paper, I will leave these policy implications aside for now.

Focus on the platform, not the firm

The overriding message is that industry structure can be understood if one focuses on platforms, not necessarily firms. Consider the insights this yields: During the early years of this industry, the firm and its platform were nearly synonymous. For example, IBM kept tight control over its proprietary technology embedded in the system 360/370 and it descendants. IBM directed many of the changes that occurred. With time a rather substantial third party software and peripheral market grew up around the platform, though IBM managed to retain a large degree of control over the standards.

In more recent experience, say in the PC market, the dominate platforms became less centrally controlled. The most popular platform in the late 1980s was the descendant of the IBM PC, often called "Wintel" for the operating system, Windows, and the microprocessor manufacturer, Intel. From the beginning this platform involved thousands of large and small software developers, third party peripheral equipment and card developers, and a few major plays in the hardware industry (e.g. at various times it was IBM, Compaq, Dell, Intel) and sofware industry (e.g. at various times Microsoft, Lotus, Novell). Control over the standard has completely passed from IBM to Intel and Microsoft, though neither firm can yet unilaterally dictate standards to developers. Indeed, the fight between software and peripheral vendors and Intel and Microsoft continues today (with Microsoft doing much more of the fighting).

The complex and changing sponsorship structure of the PC tells us about the robustness of the positive theory of platform concentration and persistence. Rapid and co-ordinated technical progress has kept this platform in a dominant position for a decade and a half, which covers many generations of

products. The equilibrium supply of *platforms* is concentrated. In equilibrium, existing platforms tend to persist. These outcomes occur whenever buyers and sellers jointly value compatibility, in a wide variety in industry structures, even those in which the equilibrium supply of firms is not concentrated and those in which firm persistence is in doubt.

How do these ideas apply today? The emerging client/server platform has not yet standardized around a few key components, leaving many unsure about who controls it. Amidst this confusion vendors fight for control over pieces of the emerging standard. Intuit would like to determine standards in home-banking, Netscape in web browsers, Oracle in network design and databases, Sun in web software design, Microsoft in virtually every aspect of client/server software but particularly user-interfaces, IBM/Lotus in shareware, and so on. Their strategies overlap and conflict over the platform. It is a condition of life living inside a platform. All firms want to sell products and all firms want to use competitive success to acheive control of the emerging platform. Each of these firms would like to be the firm in a position to control the design of the technology for years to come. These conflicts shape an important part of every firm's product design and distribution strategies.

The forces for change

Most disruption to market relationships comes from outside a segment. Yet, if historical patterns are any guide, such events occur infrequently. More to the point, attempts at such disruptive entry were somewhat common, but their success was not. The interesting and somewhat puzzling question is this: Since the menu of technical options changes so often and so rapidly, why is it that radical disruption to market relationships does not occur each year? What does it take to make a successful disruption to existing market relationships?

New platforms

Consider the *founding* of whole new classes of computer platforms, like mini- or microcomputers. From a narrow technical perspective, these were radical developments, taking advantage of expanding technological opportunity to introduce whole new classes of products. From a competitive perspective, however, there has been very little disruption associated with these events. Foundings have tended to avoid competition with existing computer platforms, instead creating new segments for previously unserved classes of demanders.

Established commercial platforms are very difficult to dislodge due to the strong ESC and backward-compatibility forces in commercial computing. We observe foundings where these entry costs are lowest. Since commercial computing platforms need expensive marketing campaigns, it is cheaper to start a new platform in the non-commercial (i.e. technical) arena. Of unserved users, technical users' needs tend to be fewest, particularly when previously unserved classes of users do not demand that all platform components work well right away. Hence, new platforms have typically served technical demands by such users as scientists and engineers.

The historical record will not necessarily support an argument that firms understood this strategic argument *ex ante* and deliberately avoided established platforms. It is probably a better theory that industry equilibrium selected those firms that found cost- and competition-avoiding strategies. That said, by the late 1960s and early 1970s, new entrants into the minicomputer industry understood our strategic logic very well. For example, Hewlett-Packard's entry into the technical minicomputer business was very cognizant of the costs of competing for commercial customers and the marketing strengths HP,

the instrument company, already had with technical customers. It also accounted for the formidable competition HP might expect from established commercial providers.[48]

Mobility of platforms

Some entry costs are lower when platforms move from an old customer base to a new one. Examples of *mobility* in computer platforms include the creation of the commercial superminicomputer from the technical minicomputer and creation of the office PC from the hobbyist microcomputer. If platform components have already been built, firms and users may avoid the long delays associated with designing a completely new platform. Mobility of an existing platform to a new kind of use costs less than the creation of a new, fully capable, platform. Simply put, many of the existing components of the platform can be re-used. In general, the re-used components are usually technologies; firms must make new investments in marketing connections, service networks, and so on.

Even with these lower costs, any entrant platform must sell to an existing platform's main customer base. Thus, it confronts the ESC and standardization forces leading toward persistence of the opposing platform. Often a platform moves to a new use that was previously badly served, rather than to serve the main body of customers in a pre-existing segment. Commercial superminicomputers, for example, served customers much like traditional mainframe customers, but in smaller departments or firms.

The conflict between the entrant's lower costs and the incumbent's advantages can be resolved in a variety of ways and neither factor dominates in general. Platform mobility can lead to partial competition between platforms and to the expansion of the range of commercial computing uses.

As with foundings, mobility has brought the industry closer to disruptive competition, but it tends to avoid direct competition with incumbent platforms.[49] Unlike the analysis of founding, potential entry of mobile platforms necessarily comes from existing platforms; hence, the structure of industry-wide supply is a key determinant of outcomes. In historical experience, mobility is rarely competitively disruptive to established dominant platforms. We will talk about the exception momentarily.

As an example of a less disruptive platform, consider the entry of the commercial minicomputer. The development of distinct minicomputer and mainframe segments left a gap among small commercial sites, such as medium-sized firms or departments in larger firms. Mainframes were too expensive and minicomputers lacked software and other support services. The invention, by entrant DEC, of the commercial superminicomputer was the breakthrough[50]. From a hardware engineering perspective, DEC's supermini platform, called the VAX series, was very similar to its technical-ancestor, the PDP series. However, from a marketing standpoint, the supermini category was new[51]. DEC co-ordinated development of the components of a commercial platform, including software, service, and support. Over the next few years, many different firms became part of the VAX network, providing software, service and so on.

The virtue of the superminicomputer over a mainframe was its combination of convenience, capacity, reliability, and low cost for small applications. A moderately sophisticated user could avoid centralized management and save on the servicing costs. This initially appealed to experienced users who were unsatisfied with the 360/370 platform, which presumed that users would be willing to pay for considerable service and customized support (Inmon [1985], Friedman and Cornford [1989], Cortada [1996]). It also appealed to geographically remote divisions in large organisations who did not want to contact a centrally managed mainframe through low-grade communication links. After an initial period of

innovation in the components, superminicomputers began to be adopted for the simpler commercial uses left behind by mainframes. These systems also began to compete at the margin for some mainframe sites.[52] Over time, the supermini segment took on increasing ESC and backward-compatibility equilibrium features, with corresponding tendencies toward concentration and persistence.

This entry into commercial computing was cheaper than the creation of a whole new platform because it involved the mobility rather than the *de novo* creation of platform components (e.g. hardware). It was more competitive than a founding because there was less product differentiation between existing and entrant platforms. Superminicomputing impinged on the mainframe's traditional commercial customer body, but did not retain all the size and capabilities of the mainframe platform.

Potential entry and the future

The main competitive elements of platform mobility are as follows: All of the participants in existing platforms, both buyers and sellers, approach new opportunities after long periods of investment in platform specific components. It is very costly for a new platform to recreate the same investments that are found with old platforms. Thus, a mobile platform will have the highest likelihood of getting over the "acceptance" hump if it serves a completely new, undeserved set of users. After some investment in components, a platform has sufficient capabilities to move toward somewhat more contested bodies of demand. There is no reason not to extrapolate this process: if a new platform succeeds, it can eventually grow strong enough to move into another platform's main market.

Much of the story here is reminiscent of "capability mobility" theories of firm entry. In those theories, existing **firms** move capabilities from one market to another with a variety of different mechanisms.[53]

There are two important novelties to the mobility of platforms, however. The first is the distinction between a platform and a firm. Unsponsored platforms share some but not all of the behaviours of firms. The second, perhaps more important distinction is that entry of platforms requires a comparison across segments. Mobility of platforms depends on the particular markets which might be entered and the particular firms which might enter them. Mobility of platforms also depends on the relationship between a whole cluster of markets, both technical and commercial, both platform-specific and generally service oriented. The stock of potential entrants into commercial computing depended historically on the creation of new technical computing segments.

Thus, as the computer industry has matured, so too have the possibilities for mobility of platforms. From the perspective of any given segment, there has been an increase in potential competition from outside firms and possibly mobile platforms. From the perspective of any established platform, there were more opportunities to someday expand into anothers' segment.

Vertical disintegration

As noted, it is rare in the computing industry of today for any firm to fully control all elements that go into a dominant platform. This raises many difficult questions about how to interpret firm behaviour in segments that have experienced vertical disintegration.

When different firms possess roughly equivalent technical skills and supply complementary components, technical leadership is easily divided among them. It is quite difficult to maintain leadership

over a platform under such conditions. In this type of world, firms seem to take one of several strategies. One strategy is to act as co-ordinator for a whole array of third party vendors, all of whom commit some resources to a new platform. This strategy hopes to retain the advantages of speedy product introductions without sacrificing too much control over a product. For example, IBM's Rochester team developed the AS/400 in record time (for IBM), emphasizing use of outside suppliers for many components, value-added resellers as distributors, and rapid feedback from customers. The platform was immediately popular, and in more recent times, this system has allowed IBM to become the largest commercial minicomputer vendor[54].

Most firms, however, rarely have the opportunity (or the resources) to introduce and co-ordinate an entirely new platform. Instead they must make peripheral components or software for a platform that is already in existence or under development. The long term strategic issues for these firms involve the frequency of their up-grade cycles and the extent to which they can use proprietary standards. Firms must decide whether they ought to respond to firms who alter their complementary products, whether they ought to merge with other firms to cover a wider set of products within a platform, and whether they ought to build products for more than one platform. These types of issues form the central strategic issues in virtually all firms.

The interesting feature of all of these decisions is that these inevitably have important platform-specific elements to them, involving issues of control and platform development. Thus, even in a vertically disintegrated industry, the day to day existense of most firms becomes intertwined with the platform-wide issues over platform development.[55]

Competitive crashes

Many have inferred from the experience of the PC market that competitive crashes are frequent and easy to accomplish. Coincidences of circumstances like those underlying the entry of the PC do not arise with any great frequency in computing.

In the PC industry, by 1980 the personal computer market had already grown, largely to satisfy a hobbyist demand. The existing "8-bit" architectures, which had not been developed by IBM, had aged technically more rapidly than expected and needed to be replaced with a "16-bit" hardware architecture that would permit larger and more powerful programmes. This need could have been met by a variety of responses from existing or new firms.

IBM's strategy combined two elements in an "open architecture." Abandoning the vertically integrated strategy it had used in other segments, IBM used other firms technology in key areas such as the microprocessor, the operating system, and many applications. For example, in hardware, IBM depended on Intel for chip designs and chip production. In software, they relied on Microsoft for the operating system. The invention of key platform components was intentionally divided so IBM could introduce its system quickly[56]. The architecture was open in a second, distinct sense. Any firm could add hardware or software components to an IBM-compatible PC, and eventually any firm could make an IBM-compatible computer.

The strategy led to a quick introduction, a marketing splash, and spectacularly large hardware sales for many years. IBM's marketing capability and reputation helped overcome the advantages of the incumbent platforms.[57] Growth was rapid. By the mid 1980s the hardware dollar sales in PC platforms equaled sales in mainframe platforms and exceeded it by the end of the decade. The competitive effect

was also substantial. After IBM introduced the PC, the number of platforms available to buyers decreased in a short time.

This was the first competitive replacement of an established computing platform by another. The rarity of such events illustrates the remarkable coincidence of circumstances in this instance. First, there was an entrant with a strong market and marketing position, from outside the segment but within the industry. Second, the entrant could come in without undercutting its position in existing segments. Third, the incumbent platforms were facing an abrupt and technically uncertain transition in their architecture, in this case from 8-bit to 16-bit computing. Fourth, the entering platforms' open architecture and vertically disintegrated market structure met the market need for rapid technical advance.

More generally, changes in vertical industry structure underlie entrant success in recent experience in client/server platform. Quickly executed mobility-based entry is easier in a vertically disintegrated market. Individual platform components rather than whole platforms can move to new segments. So it was that the creation of a vertically disintegrated platform to serve traditional mainframe customers, called "client/server," opened up entry opportunities for a wide variety of components. The client/server platform takes the best of existing microcomputer platforms and the cheapest of powerful computer platforms. A wide variety of firms compete to steer the direction of the newly assembled platform. This has led to a new kind of competition in which a very new kind of computer firm succeeds.

From the 1960s through the early 1980s, foundings and mobility expanded the range of computer market segments, ultimately offering capable computers for both technical and commercial uses. Through the 1980s, all these different market segments advanced in parallel, with different kinds of customers, technologies, and supplying firms. In the 1990s, components that had been built up in different segments combined into new platforms and moved into competition with some of the longest-standing commercial successes.

The recent transition in the industry was the inevitable but very difficult to foresee consequence of long term trends. First, inevitability: The supply of potential entrants grew secularly as platforms serving different kinds of uses grew up in distinct segments, out of competition with one another, and developed distinct technical and market capabilities. Vertical disintegration arose because small firms initially could take advantage of economies of specialization, especially related to rapid changing technical possibilities in component markets. Second, difficulty to foresee: Could IBM, the traditional dominant firm, have headed off the competitive threat? Probably not. The key damage was done long before IBM knew there was a threat, which was long before the potential entrants themselves knew they were a threat. Thus, the demise of IBM's position occurred due to the changing nature of competition and competitive equilibrium in the industry.

The diffusion of client/server platforms

It is impossible to understand the competitive crash without understanding the pattern of diffusion of client/server technology. Doing that requires some understanding that users invent in order to make the new technology useful. As a co-author, Tim Bresnahan, and I have coined the term, users do much "co-invention". If you are interested, feel free to read the original study of the diffusion of client/server to large-scale computer users.[58] Here I summarize recent understanding about how this new platform is diffusing.

Tim Bresnahan and I examined the diffusion of client/server to large-scale users. Why? First, the marketing folk know who they are, where they live and the name of their managers. One of these

marketing firms, Computer Intelligence Infocorp, provided us with very good information about centrally managed computing facilities. Though we examined the behaviour of over 12 000 establishments, we had a pretty good idea about what most of them were doing and why. They were corporate warehouses, data centers for inventories and large on-line transactions, large scale simulation and so on. This is hard data and we cannot do research without data.

Second, this was an interesting and complex place to examine the diffusion of client/server computing. These users tend to have complicated applications supported by centrally managed professional staff and large supplier networks. Many of the suppliers of software were IBM, Computer Associates and other well known firms, as well as smaller third party vendors and in-house support staff. If we could analyze the behaviour of this set of users, we could take the same insights to simpler situations without too much trouble.

Third, mainframe users occupy an important place in computing. Centralized computing facilities came into being decades ago when prices were higher and functionality was lower. These have often been the places that first developed some extremely important applications -- e.g. on-line transactions processing, financial modeling, payroll and check-writing, and so on. Thus, the behaviour of these users tells us much about the diffusion of technology to some extremely important places in the economy.

We started in 1988 because we did not see the point in starting an analysis of client/server much earlier. We stopped with 1994 because we started this project in early 1995. (It just took us a while to analyze and organised the data on over 12 000 establishments.)

For the most part, establishments fell into one of four categories -- bold, curious, cautious and gone. The bold establishments did two things. They experimented with client/server systems quite early. Then sometime later these type of users retired their mainframes -- virtually all of them by 1994. The curious were not so fast to experiment, but did not resist client/server for long. Most of these establishments begin to experiment with client/server sometime in the early 1990s. However, by 1994 very few of them had retired their mainframe. The cautious did not experiment with client/server, nor did they even consider retiring their mainframe. As of 1994, these users intended to stay with mainframes, up-grade them as they always had, and so on.

The gone are a more mysterious group. They stopped answering the surveys from CII. We cannot be sure why, but it is easy to speculate. Some of them belong to firms that went bankrupt. Some closed the computing establishment and moved it elsewhere. Some simply got tired of the surveys. We cannot say much about them.

Why did buyers fall into different categories? Why did some experiment early and other's late? The answer turns on "coinvention," the amount of invention the users must do after they adopt their system. Some users had to do much and some had to do little.

The bold have one thing in common: they have very low co-invention expenses. This occurs for a variety of reasons. Their computing organisations tend to be simple. That is not the same as saying their computing needs are simple. It means that their computing tends to be done in small groups and it tends to be non-synchronous (e.g. unscheduled). These buyers predominantly use computers for simulation and numerically intensive tasks, not data-warehousing or other communication-intensive tasks. Most computing also does not require simultaneous and extensive co-ordination of hundreds of employees.

In addition, the bold are usually scientists and engineers. Despite much idiosyncracy in their needs, the bold do their own co-inventing and rely less on market solutions. These users easily moved to client/server.

The curious tended to be a more heterogenous group, distinguished mostly by their willingness to try a piece of client/server while not swallowing the whole entirely. They might have more complicated establishments than the bold, because they had some mix of back-office accounting and on-line delivery of information. The curious have a few applications that resisted the new platform and a few that did not. They usually had a few idiosyncratic applications -- either written by in-house staff who have since left or by a small national mainframe software vendor who has since moved to greener pastures. These applications could not be easily moved off the mainframe and recreated on a new platform.

The curious eventually made some effort to benefit from client/server. However, the co-invention costs associated with customizing all their computing on the new platform were considerable and usually prohibitive.

Virtually all of the cautious look alike, and yet each was complicated in its own idiosyncratic way. Their computing facilities run idiosyncratic and extremely valuable on-line applications (e.g. reservation systems). The computing applications are tied closely to the functioning of the organisations (e.g. banking services), and they co-ordinate hundreds of employees' actions. At these establishments, the costs of even the simplest experiment on client/server are very high. These users cannot change to client/server, even if they really wanted to.

All in all, co-invention costs are driven up by three factors: the complexity of the computing, the idiosyncracy of computing demands at establishments, and the thickness of vendor markets for software tools. The first two are features of buyers that change very slowly. The last one, a feature of the client/server industry in its early years, has gotten better over time.

The implications for client/server

Co-invention explains why the experiences of the bold offered only limited lessons for the curious and cautious. Engineers and scientists tended to be among the bold, while commercial users tended to be among the curious and cautious. Is it any wonder that vendors, who had early success with the bold, completely underestimated the difficulty of the transition to client/server with the commercial users? It seems that the old segmentation between scientific and commercial users has not completely disappeared and might, therefore, arise again in client/server.

The appropriate business model changed in client/server in the last few years. In the early years, the sales were made from computer engineer to computer engineer. Many engineering firms and software start-ups thrived in this situation. Many of these firms, from SAP and Cisco to Oracle and Sun, are now trying to make the transition to providing products for a commercial user. Commercial users prefer the reassuring handshake of a large firm and a salesmen in a suit, which plays to the comparative strengths of traditional firms such as IBM and Anderson Consulting. These traditional vendors could get into this game late and still do well, despite the ESC build in favour of the old firms. So too will many third party consultants and vendors who translate lessons of the past into the tools that users need today. Again, this is an open question.

Formulating policy

Despite the size, complexity and technical turbulence of the electronics industry, market relationships in the computer sector tend to follow a few important patterns. Market segments tend to be organised around platforms. A small number of platforms tend to dominate any platform at one time and tend to dominate it for a long time. New platforms tend to be founded within engineering markets first before moving, if at all, to commercial customers. Dominant platforms do not get easily dislodged, once established, and if they receive competition from anywhere, it is from previously distant platforms. Disruptive crashes of market relationships tend to be rare because so many forces prevent established platforms from losing their preeminence.

While the main thrust of this investigation has been positive in focus, there are many implications for policy formulation. Below I compare some of the common arguments for/against *what ought to happen* against *what tends to happen in practice.*

The emergence of dominance after the competitive crash: Todays' competitive crash seems to be one of those rare disruptions to market relationships. Its rarity makes the future both easy and hard to predict. Eventually, there should arise only a few dominant platforms that persist over long periods. For now, however, market boundaries will blur until the diffusion of client/server systems determines how the platform will segment users, if at all. It is not yet apparent which early standards will persist, unify and co-ordinate different firms and users, or fade away. As of recent reports, different types of users approach these blurring with different adoption behaviour, relying on their own action and the co-invention provided by market-oriented vendors. This suggests some segmentation in the future, but it is far from determinative. *One should expect policy makers to eventually face issues associated with the competition for dominance of the new platforms in client/server.*

The persistence of incumbents: As one thinks about formulating policy initiatives during (what now appears to be) this era of transition to client/server, historical patterns provides some guidance. First, there should be a presumption that existing market relationships will persist into the future. This is not the same as saying the industry will remain technically static or that all relationships will persist. Certainly incremental advances will be incorporated into existing platforms by existing vendors, if at all possible. Radical disruption in predominant market relationships is rarely, if ever, in the interest of most established vendors or their customers. The economic factors encouraging that pattern have not disappeared in the new era, so the pattern associated with it is not likely to disappear either. Claims by IBM, Microsoft, Intel, Sun, and several other leading firms who potentially control key components in future client/server platforms, that they are under perpetual competitive siege, must be taken with appropriate measure. None of these firms would stay profitable if they failed to innovate, but none of them would lose market share immediately if they made a minor incremental technical mistake. *One should expect policy makers to eventually face issues associated with the persistence of dominant platforms in client/server.*

On predicting the direction of technical change: Policy discussions should not be conditioned on speculation about changes to the menu of new frontier technology. Any particular guess about technical direction is bound to be wrong[59]. The menu of technical options represents, at best, an enormous superset of the potential commercial options under consideration by users and vendors. At best, several patterns can frame analysis. First, there are strong biases toward adding incremental technical advances into existing platforms and away from radical new platforms. Even with that bias, it is often quite difficult to predict which new technologies are easily incorporated and which are not. Second, the list of potential entrants from a technical standpoint is always large; the list of feasible entrants from a commercial standpoint may be quite low. Thus, to all but the analyst with the most finely-tuned crystal ball, it will be difficult to distinguish between what is really under siege and what is not, who really has commercial

momentum and who is losing it. The firms themselves find this difficult to do, for all the reasons discussed above; it is no wonder that government policy makers find it even more difficult to do. Similarly, what may be appropriate in one era and with one set of platforms, can become outdated quickly, as the next era's platforms come with different users, firms or technical foundations. *One should advise policy makers to resist making decisions about the competition client/server based on technical guesses about the future of client/server platforms.*

The use of structural reform as a policy instrument: Governments have been known to attempt to deconcentrate markets where firms appear to have monopolized or attempted to monopolize a product market. These actions may arise either due to concerns about the inherently large size of a firm or its behaviour. Clearly, these interventions are unwise if they simply target the market features that arise endogenously irrespective of government policy. In other words, there is no point in reducing the degree of concentration of a market (as an end in itself) if concentration is bound to arise under most circumstances due to the strong tendency of a single platform to dominate. Similarly, policies aimed at harming established firms (rightly or wrongly accused of monopoly behaviour) may only give rise to another firm who achieves similar ends. This would suggest that policies should take a cautious approach to structural reform if there is any reason to doubt its need. If political actors are not unified in their view about the need to reform market structure, then a cautious approach seems warranted. Or alternatively, if structural change is strongly desired by the political process, then a policy encouraging radical change should not necessarily break up an incumbent. Instead, it could favour policy initiatives with a broad presumption in favour of encouraging platforms from potential entrants, even those entrants who are unforeseen and not yet imagined. Indeed, there could be a presumption that the important potential entrant may be firms associated with a platform outside the purview of a typical outside observer or policy maker. *One should advice policy makers to presume that there will always emerge a dominant platform, so the best policies are those which minimize the social losses associated with such inevitable dominance.*

Communications in vertical relationships: Policy initiatives typically target vertical relationships among firms, specifying the scope, breadth and type of communication that is permissible, often with the intent of opening up the market to new entrants. However, in a market where vendors invent, while buyers co-invent and customize, close contact between buyer and seller facilitates communication of problems. This communication aides in finding solutions to bottleneck problems. While the concentrated structures of the typical platform seem to invite scrutiny, an unheeded rush to reduce close contact between buyer and seller seems counter-productive for co-invention activity between buyer and seller. *One should advise policy makers to maximize channels for communication, as this aides seller/buyer co-invention activity.*

Regulating firm contact in vertically disintegrated markets: The fight for control of technical standards is an important facet of competition between vertically disintegrated firms producing for the same platform. This fight is simply a fact of life. It pervades virtually every phase of market development -- e.g. institutionalized standardization committees and related decision-making bodies, joint-product development and marketing agreements, and contractual arrangements between ostensible upstream/downstream suppliers. This fight cannot be wished away or ignored. The principal social expense of these fights seems to be a reduction in co-ordination of technology within a single platform. The principal social benefit is the check it places on the ability of any single firm to determine the direction of technical change exclusively for its own benefit. These are difficult trade-offs to put into practice in the regulation of contractual relationships between vertically disintegrated parties, particularly if the only instruments for these policies are broad legal prohibitions and restrictions against commercial contractual forms. *One should advise policy makers that it is inevitable that they will face issues associated with regulating the vertical relationships among firms within the same platform.*

The essential facilities argument: Recent discussion proposes to treat certain parts of the computer system market in the United States, particularly operating systems, under the doctrine of "essential facilities." For example, see the discussion as described in Reback et al (1994). These proposals seem to imply that the computing market merited the same scrutiny and policy infrastructure as found in local telecommunications markets. These policies would require frequent revision and updating after their introduction, and close monitoring by an appointed government agency. There are many dimensions to these proposals and there is insufficient space to cover all aspects. They presume, however, that the established leader of a platform will persist, so that establishing a centrally managed governance structure is feasible. In markets where the menu of technical choices changes rapidly and unexpectedly, and where the market relationships persist for long periods and then change suddenly, it would seem to be costly to execute these proposals well. In today's era of competition for control over a new platform and rapid technical change, it is hard to imagine a government agency with sufficient speed and alacrity to respond to new or unexpected technical or commercial challenges. *It is unlikely that even the most carefully crafted proposal for regulating a critical facility in computing will remain effective over long periods, as they tend to be based on the assumption that established platforms and competitive structures associated with them will persist forever*.

Platform competition as a check on vertical relationships: Does competition between platforms limit the scope of potential abuse of vertical relationships by a firm who dominates vertical relationships within a platform? This question goes back at least to the IBM antitrust trial in the United States, but has many antecedents (Fisher et al, 1983). The historical record gives a mixed blessing to these concerns. On the one hand, there seems to be a reasonable presumption that platform competition does not limit vertical relationships, at least in the short run. Established platforms cannot easily be dislodged, except by unexpectedly mobile platforms in rare circumstances. While there are many reasons for and against regulations of vertical relationships in complex technologies, there seems little reason for a broad presumption that the threat of potential entry from another new platform will alone restrain behaviour. On the other hand, the entry of client/server platforms seems different from the past. First, it is not yet a platform largely defined around proprietary standards, so the lessons from the era of proprietary platforms may be inappropriate. Second, client/server's own development took advantage of vertical disintegration in the PC market. Until such time as standards are clearly defined, threats by buyers to use different combinations of components to form client/server arrangements may provide a competitive threat for existing combinations. *Policy makers cannot draw any broad conclusions yet about the effectiveness of using platform competition to discipline anticompetitive behaviour in the emerging client/server platform.*

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Innovative IT systems -- A skills approach

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The information technology industry is about half a century old. At its birth only a tiny handful of people understood the workings of a computer and even fewer were able to forecast its potential impact on business. Famous unfortunate quotes abound, but one by Thomas Watson of IBM, in 1943, that ".. there is a world market for maybe five computers" is not untypical of early comments.

During the intervening years all sectors of the economy have grown to depend on the microchip; however not many companies really understand how to control its impact or how to achieve the potential that systems based on IT could deliver. Many senior managers worry about controlling the monster of IT spend and some still remain cynical about whether there ever will be any value. David Jones, CEO of Sharelink, summarised the current situation neatly in autumn 1996, when he said "The IT industry is primarily concerned with the transfer of a set of new technologies to an alien environment." The business community is now deeply concerned with making the transfer a less painful and more productive one, in all sectors.

The challenges facing the IT industry are growing in number. They have been exacerbated by the recent recession and the identification of the millennium bug, found within not only legacy systems but also in an uncountable number of chips set in an equally uncountable number and variety of machines. Global competition is demanding that companies react to business pressures more rapidly. Economic recovery has lead to a demand for more staff skilled in IT, whose job specifications are dominated by the challenges that have been identified. These can be listed as

1. the need to enhance the value added by IT to business;

2. the ability to adapt to a new business focus: from company push to customer pull;

3. the need to develop a faster response to the demand by clients for new and improved IT-based systems;

4. the growth of a new transaction space -- be it internet or intranet based;

5. the ability of business to harvest the benefits from IT supported change.

Responses to challenges seen as caused by technology have often been based on providing more sophisticated technological products. We can see this in job advertisements targeted at IT professionals, with skills derived from computer science, and managers to operate at the interface between the IT domain and the client. This approach continues to encourage individuals to focus on developing their skills primarily in one domain. We now know that this is insufficient to solve the problems brought about by the increasing use of technology.

As Kling said in 1991: “The dominant paradigms in academic computer science do not help technical professionals comprehend the social complexities of computerisation, since they focus on computability rather than usability.....The social sciences provide a complementary theoretical base for studies of computing that examine or make assumptions about human behaviour.”

A parallel statement on the need for acquisition of a more business focused set of IT skills for business staff is also being made. As well as seeing skills extend across functional boundaries there is a need for companies to foster an increase in skills of creativity, human resource management, business acumen and political sensitivity if businesses are to meet the challenge of harnessing the potential of technology for their benefit.

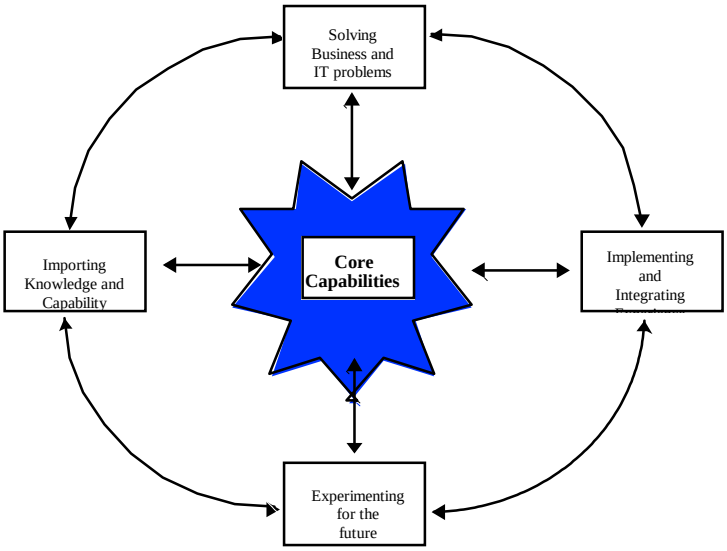
Growing professionalism in IT

The movement to enhance the skills of IT professionals in business, managerial and social competencies, is well underway through the professional associations and the need is recognised by most qualified entrants to the profession. They are learning how to adapt systems to business requirements, how to communicate effectively with clients and colleagues, to listen to their customers and understand their information and/or technology requirements, to use language appropriate to their client, to negotiate and to understand the differences in roles and personalities.

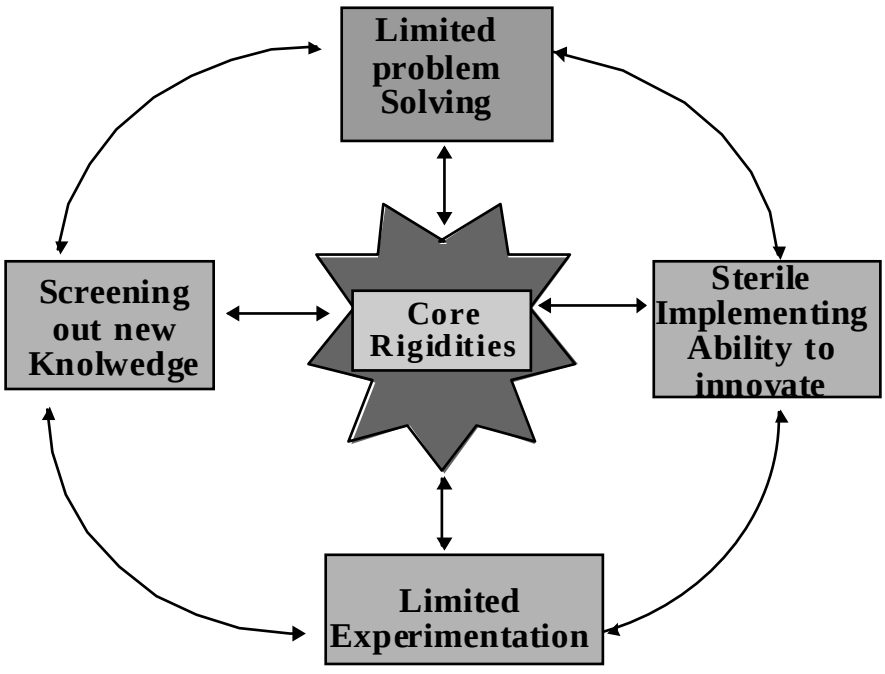
The increase in the range of skills in IT staff is mirrored by the development of IT related skills in business staff. Many companies, such as BA, Toyota, ICI, GrandMet, Glaxo and others have invested considerable effort in working out programmes to develop such skills in their staff. As yet there is not a universally established set; a popular phrase being ‘a judicious understanding of the technology and its potential’. Other skills are IT project management, evaluating investments in IT, ability to manage macro and micro levels of change, to spot opportunities made possible by new technologies; the development of a capacity for innovative thinking and to problem solve in any environment can be added to the list.

Where are these skills to be found?

New skill needs are often sought outside a company but given their current scarcity, attention has to be paid to developing existing staff; their present skills and company experience can be enhanced and supplemented by continuing professional development programmes. This calls for a review of internal barriers to flexibility of working hours and take-up of educational programmes. The following diagram, adapted from Leonard Barton (1995), illustrates the relationships between the various activities:



Even if this status is the desired option, Leonard Barton goes on to show how often such openness fails and turns to rigidity:



Finding staff who can bring in new ways of thinking and a greater variety of problem solving techniques, can also be done by adapting recruiting policies to concentrate on sections of the population not presently working in IT. Research has shown that one major section of the population poorly

represented in the IT arena is women; another is the disabled, who can and do trigger considerable innovation. Women are a large group upon which to draw; many want to work in this field but get disheartened quite soon.

The question then becomes why there are so few women in IT. Again research has shown two major discouraging aspects; the image of the IT professional as overly concerned with technology only, suitable only for 'nerds' and 'anoraks' and providing, for women at least, poor job prospects. A number of women do work in IT; in client-facing jobs, and carry low levels of responsibility and authority; consequently they tend not to get involved in issues of system design and build. This has led to the role of 'women as carers' becoming institutionalised and preventing development of good design. The caring role is sometimes perceived as incompatible with technical capability. There is plenty of evidence to the contrary.

There is a serious impact on the IT industry from limiting the talent pool. The industry is denying itself diversity in intelligence and creativity which it so badly needs. Amy Pearl, in CACM 1995, pointed out that "Many organisations would like to address these issues but lack the connections and knowledge to do so." This lack of diversity must become a professional concern of employers and of women in the profession. A radical review of recruiting and promotion practices, a reskilling in recruiting, promotion and management style, objective identification of suitable candidates, and a reduction of the barriers to change in attitudes are called for.

Professional associations are now addressing these problems in the SME sector. Public and private research organisations such as Business Schools and the ITSF, are working on the precise nature of the skills needed and on means to track them. The next stage is to develop a portfolio of means of delivery which will not cause too great an interruption in working life. While electronic delivery mechanisms are an obvious solution they are only a part of a final package. The human element has to be included and then means of making the solutions acceptable to potential clients.

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Mergers and acquisitions trends in the information and communications industries

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First of all, I would like to thank the organisers of this workshop for giving me the opportunity to contribute to the on-going work on the economics of the information society.

The explosion of mergers and acquisitions in the industries participating in the digital revolution clearly indicate that an important industrial reorganisation is underway. According to my own measurements for eight industries from the information and communication sector, majority and minority interest acquisitions increased at an average annual growth rate of 65 per cent over the 1994-1996 period, amounting to US$ 146 billions for the year 1996.

The purpose of this presentation is to highlight the main trends in the structuring process of industries participating in the building of the information society. The core issue addressed in my work is the relation between the convergence of technologies and the evolution of industrial structure. Will multimedia convergence lead to the development of a vertically integrated multimedia industry or just to the strengthening of technical and commercial links between content producers, broadcasters and network operators? The development of new Internet-based services sets big challenges to the existing situation. Hardware and software companies are also concerned by the issue.

The information and communication industry is not the only one shaken by mergers and acquisitions. Other sectors of the economy also see major mergers, in particular between the Sandoz and Ciba-Geigy, Boeing and McDonnell Douglas (US$ 13bn) or Raytheon and Hughes Defence Electronics (US$ 9.5). It seems that the new corporate manager's motto is "no matter the market you are in, you need to be a giant in this market". The Wall Street Journal recently reported that mergers and acquisitions totalled US$ 1 trillion in 1996 at the world-wide level.[61] In this particular context, another issue is to know if the increasing trend towards mergers and acquisitions observed in the information and communication sector is the beginning of a new industrial paradigm based on the digital chain of information or the beginning of a new concentration cycle as was the case in the mid-1980s or in the 1960s.

To tackle so many complex issues, I will first review the main merger and acquisition trends for eight information and communication industries. In the second part, I will look at the major forces that are generating this wave of deals: impressive progress in digital technologies, world-wide liberalisation of the communication services industry, globalisation of the economy and a particular focus on the role of soaring stock markets. Until now, vertical integration along the value-added chain of multimedia, characterized by the end-to-end digital process of information, has generated only a few important transactions.

1. Facts and figures: increasing trend of horizontal concentrations

As I said previously, world-wide acquisitions reached US$ 1 trillion in 1996. The data I have put together suggest that at least 15 per cent of this total was generated by eight industries from the information and communication sector.

1.1 Methodology and definition

The facts and figures below are based on the analysis of a database, called Allcom, in which I have entered more than 2 100 alliances ranging from loose co-operation agreements to majority acquisitions. This database was set up in 1993 to analyse corporate strategies and trends in the information and communication industry. It is focused on all sectors participating in the multimedia convergence with the exception of the micro-electronic components industry and the consumer electronics industry.

The eight industries for which I will present results are:

1. Audiovisual: content production and packaging, editing, broadcasting activities
2. Cable-TV networks
3. Telecommunications services
4. On-line information services: on-line database, Internet server-based facilities
5. Telecommunication equipment
6. Computers
7. Software
8. Datacom (computer-networking)

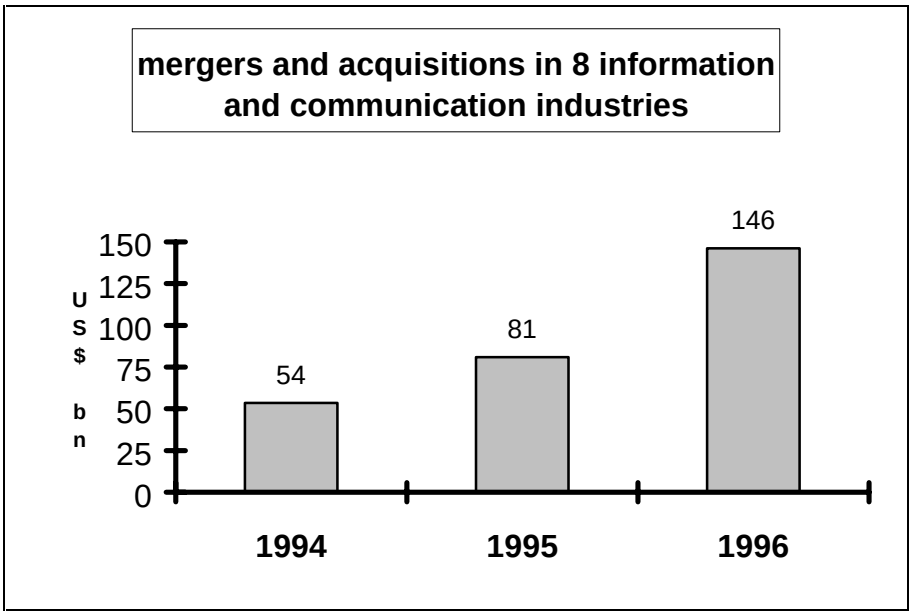
Some 508 majority and minority acquisitions are recorded in Allcom, including 250 for which the financial terms of the transaction were disclosed.

Allcom is not a legal database. This is the reason why the reference date for a given agreement is the day the agreement is publicly released, not the day it is finalised. It means for instance that the BT-MCI merger appears in the statistics of the year 1996 although this deal has not yet been cleared by all the anti-trust and regulatory administrations of the USA and the EU.

The table in Annex 1 gathers the main data upon which this analysis is based.

2.2 Main findings

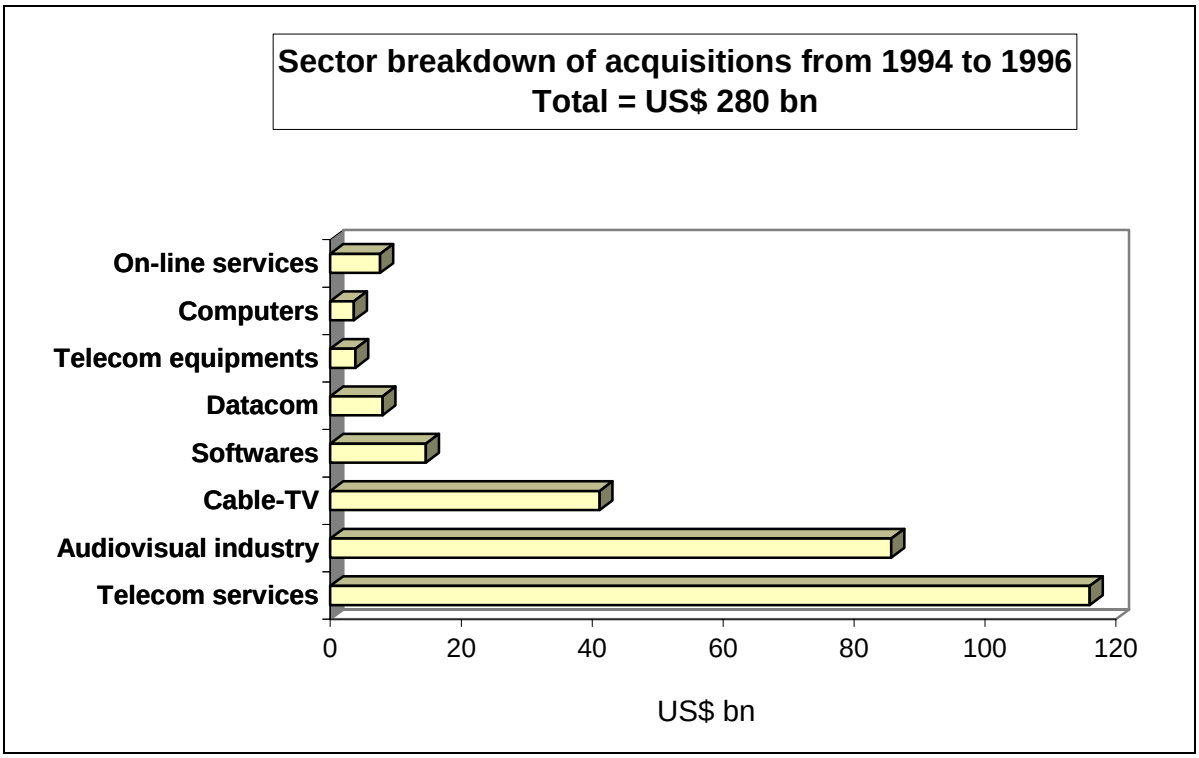
Chart 1



- A dramatic increase from 1994 to 1996: up 51 per cent in 1995, up 80 per cent in 1996, with a total amount of $US 146 bn over the period.
- The number of registered operations grew from 67 in 1994 to 79 in 1995 and 104 in 1996.
- A new wave of mega mergers and acquisitions is breaking through: 0 acquisition > to 10 US$ bn in 1994, only 1 in 1995 and 5 in 1996.

Source: Christian Micas, Telecommunications, Consultancy, Brussels

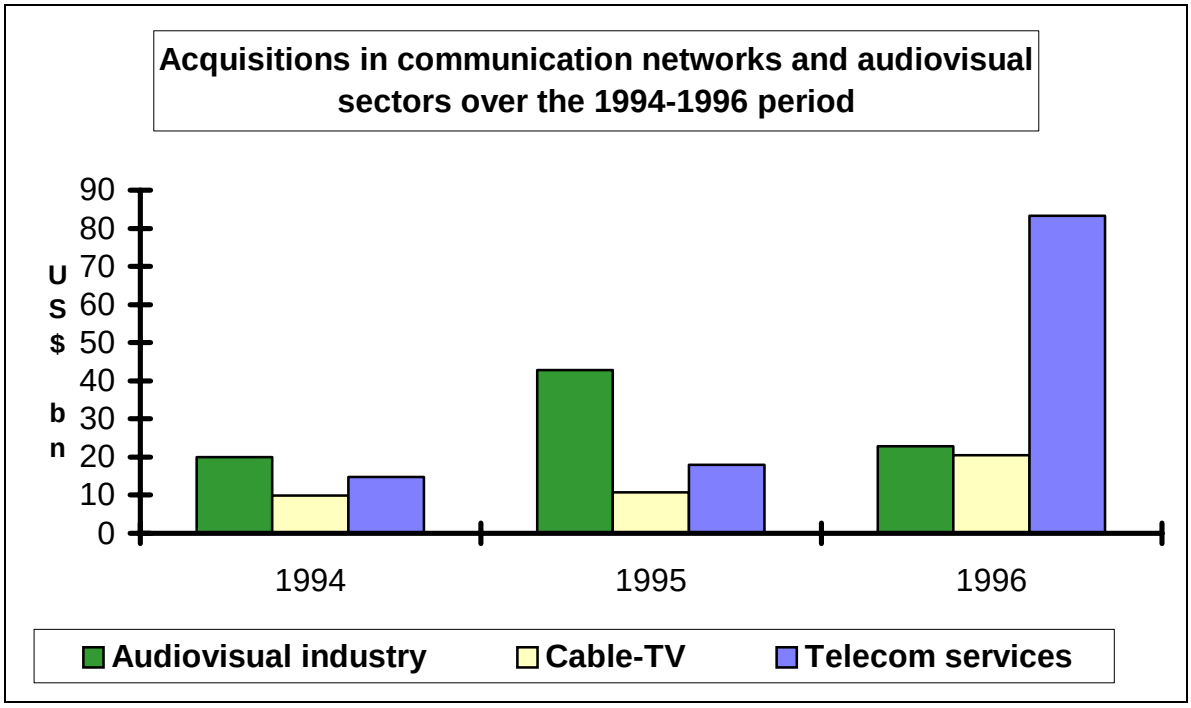
Chart 2



- The service industries have the biggest figures, largely boosted by liberalisation.
- Market growth and stock market capitalisation are important factors to explain this high level of financial activity.
- Datacom, computers, software and on-line services are two-digit-growth industries.

Source: Christian Micas, Telecommunications, Consultancy, Brussels

Chart 3



Source: Christian Micas, Telecommunications, Consultancy, Brussels

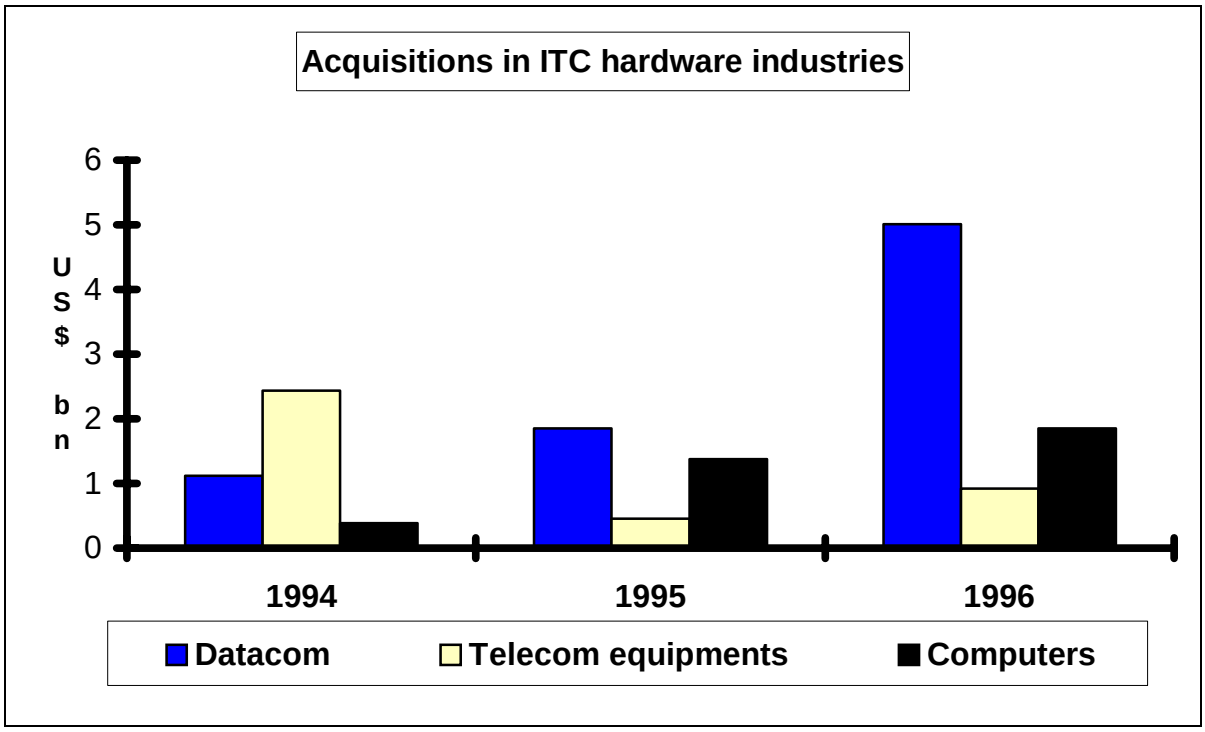
- An explosion of multi-billion acquisitions and mergers in the telecommunication sector:
  - Acquisition of Nynex by Bell Atlantic announced in 1996: US$ 20.5 bn
  - Acquisition of MCI by BT announced in 1996: US$ 20 bn
  - Acquisition of PacTel by SBC Communications announced in 1996: US$ 16.7 bn
  - Acquisition of MFS by Worldcom announced in 1996: US$ 12.4

- Concentration of the US cable-TV industry:
  - Acquisition of Continental Cablevision by US West announced in 1996: US$ 10.8 bn (US$ 5.3 bn for the acquisition + US$ 5.5 bn)
  - Acquisition of Cablevision by Time Warner announced in 1995: US$ 2.6 bn

- Heavy changes in the ownership structure of the US audiovisual industry:
  - Acquisition of Capital Cities/ABC by Disney announced in 1995: US$ 19bn
  - Acquisition of Paramount studios and Blockbuster by Viacom announced in 1994: respectively US$ 9.6 bn and 8.4 bn
  - Acquisition of Turner Broadcasting Systems by Time Warner announced in 1995: US$ 7.25 bn
  - Acquisition of the MCA studios by the Canadian group Seagram announced in 1995: US$ 5.7 bn

- The European continent seems to be lagging behind the US wave of mergers and acquisitions. We can point out however two important deals:
  - The acquisition of three important British cable-TV networks by Cable & Wireless, to be merged with the local subsidiary Mercury, announced in 1996: US$ 8 bn
  - The merger of the TV broadcasting activities of CLT from Luxembourg (RTL) and the German media giant Bertelsmann announced in 1996: US$ 6.5 bn

Chart 4



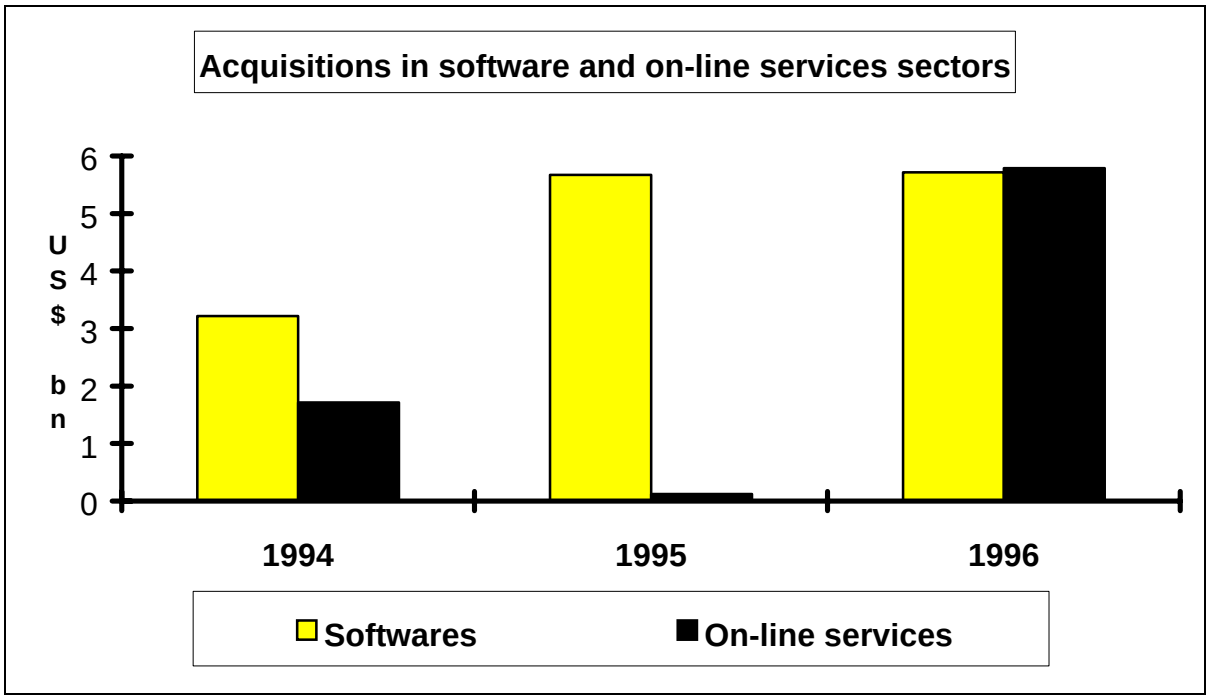
Source: Christian Micas, Telecommunications, Consultancy, Brussels

- Datacom: acquisitions and mergers were boosted by the growing number of PCs connected to networks. The industry is entering a consolidation stage with very important stock market capitalisation. The most important mergers and acquisitions are:
  - US$ 1 bn merger of the American companies Wellfleet and Synoptics in 1994
  - US$ 4 bn acquisition of Stratacom by Cisco in 1996
  - US$ 6.6 bn acquisition of the modem maker US Robotics by 3com in February 1997.

- The world-wide telecom equipment industry reached a mature size after very important deals in the 80s and in the early 90s rendered necessary by huge R&D costs. Some 26 operations of majority and minority interest acquisition were entered in the database for this industry over the three-year period, but only one is superior to US$ 1 bn: the 50 per cent acquisition of Italtel by Siemens in 1994.

- The computer industry is becoming a mass market, characterised by intense competition and very low profit margins. No major acquisitions are to be mentioned with the exception of the purchase of the supercomputer manufacturer Cray Research by Silicon Graphics in 1996 for US$ 745 millions.

Chart 5



Source: Christian Micas, Telecommunications, Consultancy, Brussels

- The important ratio acquisition value/turnover (A/T) in the software industry reflects the high growth potential of this industry:

  - The US$ 3 bn acquisition of Lotus by IBM, announced in 1995: A/T = 5
  - The US$ 1.2 bn acquisition of Cheyenne Software by Computer Associates, in 1996: A/T = 11.5
  - The US$ 1 bn acquisition of Powersoft by Sybase, in 1994: A/T = 8

- In the on-line services industry, the years 1994 and 1996 have been characterised by some major deals that explain the up and down aspects of the graphic over the period:

  - Acquisition, in 1994, by the Anglo-Dutch group Reed-Elsevier of the US firm Mead which runs the on-line legal databases Lexis and Nexis for US$ 1.5 bn.
  - Acquisition, in 1995, of the US group West Publishing, which also provides on-line legal information, by the Canadian company Thomson, for US$ 3.4 bn.
  - Acquisition of the US number 1 commercial Internet access provider, Uunet, by the US business network operator MFS (taken over since by Worldcom) for US$ 2bn.

2. The driving forces behind the growing mergers and acquisitions trend

Corporate management books provide some good reasons to implement a merger or an acquisition: it increases transaction power with suppliers and distributors, and allows cutting out overlapping costs while selling more products through distribution networks. But they are not sufficient to explain the boom of acquisitions in the industries participating to the information economy.

I have identified four factors that push more companies to look for partners :

- steady pace of technical progress and resulting innovations;
- liberalisation of the communication services industry;
- globalization of the economy;
- soaring stock markets.

2.1. Steady pace of technical progress and resulting innovations

The steady pace of technical progress is driving the whole of the information economy. High-speed transmission and switching technologies, digitization of content and more and more powerful microprocessors should allow an increasing number of applications to be distributed on the information superhighways.

To stay at the forefront of technical progress and keep up with market trends, many big companies prefer to buy the technology and the skilled people who developed it. This is quicker and less risky than trying to develop it themselves.

Many acquisitions were motivated by such reasons in the software and datacom industries, like the acquisition in September 1996 by Cisco of the US firm Granite which has developed a Gibabit Ethernet switching technology, or the recent acquisitions by Netscape of small US companies that develop Web technologies.

2.2. World-wide liberalisation trend

The liberalisation of the telecommunications service industry and the resulting competition led the pace of mergers and acquisitions in 1996.

- In the USA, the adoption of the Telecommunications Act in February 1996, allowing local operators, long distance companies, cable TV operators and TV programmers to enter each other’s markets, under some conditions, gave rise to a wave of important deals as we saw earlier.
- In November 1994, the European Union's Council of Ministers adopted the agenda for the full liberalisation of telecommunications, under certain conditions, scheduled for

1 January 1998. It should also have some major consequences on the ownership structure of the European telecommunication industry as national telecommunication operators are being privatised, like Deutsche Telekom or France Télécom.

2.3. Globalization of the world-wide economy

The globalization of the economy has as consequences to increase competition pressure at the national level and to push companies to enter international markets to compensate loss on their home market, thus strengthening again the globalisation trend.

Telecommunications are one of the sectors that is most concerned by the globalisation of the economy:

- International telecommunication networks are being rolled out to link up national networks and to better serve the customer abroad. This development is also spurred by the dramatic growth of the Internet.

- National telecom operators are multiplying the majority and minority interest acquisitions abroad in the fixed and mobile networks. The US Baby Bell are present in each European country in mobile networks or as second fixed network operator, while the European national operators are particularly active in South America, Asia and Central and Eastern Europe.

- The need to develop global and seamless telecommunications networks is also leading to the constitution of an important network of strategic alliances supported by financial links:

  - Concert: BT-MCI
  - Global one: Deutsche Telekom, France Telecom, Sprint
  - Unisource: Telia, PTT Telecom Nederland, PTT Suisses
  - Worldpartners: AT&T, Unisource, KDD Telecom from Japan, Singapore Telecom, Hong Kong Telecom, Korea Telecom.

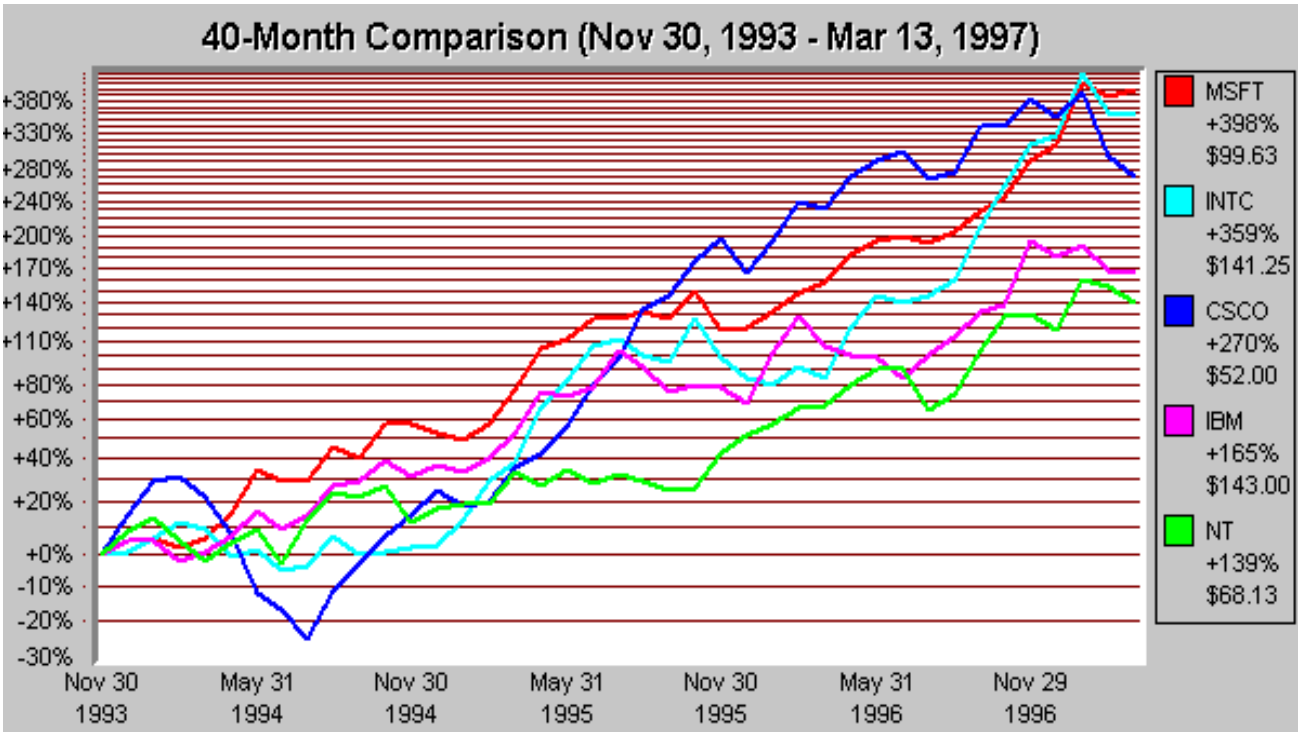
2.4 The soaring rise of stock markets

The dramatic growth of stock markets over the last three years has considerably contributed to foster the recent explosion of acquisitions. The US Standard and Poor 500 index has been almost doubled by two since the 1 January 1994. In Europe, the trends are also upward: over the last two years, the German DAX 30 increased by more than 60 per cent, the British FT-500 index increased by 37 per cent.

The high tech sector presents the best stock performance in terms of price increase (see chart below). For instance, the Cisco share, the US data communications equipment supplier has seen its market capitalisation grow over the last 3 years so that this company is now ranked number 25 of US companies, ahead of industrial giants such as Ford Motor, Motorola or Boeing! Two other stars of the US stock market, ntel and Microsoft, rank respectively number 4 and number 5. It is interesting also to note that Microsoft, with a market capitalisation of US$ 108 bn, has eventually overtaken "Big Blue", ranked

number 8, with a market capitalisation of US$ 78. As for the IBM and Nortel stock's progression, it follows the average stock market trend.

Chart 6



As a consequence of these market capitalisation increases, a bigger proportion of the acquisition value is covered by stock swaps rather than cash. Furthermore the deal is less risky, because a stagnant or diluted stock is less disastrous than a debt that cannot be paid.

The acquisition potential of a given company does only rely on its cash capacities but more and more on its stock market capitalisation.

The BT-MCI case

The MCI acquisition by BT is a good illustration of all that has been said:

- The BT-MCI merger in a new entity called Concert creates a leading global telecom operator.
- It improves its international position and presence in a globalized economy.
- For BT: i) diversification of revenue based abroad;
  ii) ability to build upon MCI's extensive experience in competitive long distance and international markets;
- For MCI: i) it increases financial resources to address opportunities in the new liberalised environment, especially in the local loop;
  ii) ability to build upon BT's extensive experience in local telephony.
- The major proportion of the financial transaction will be achieved through stock swaps, with each MCI shareholder receiving 0.54 per cent of a BT share, plus $6 in cash.

3. Horizontal concentration versus vertical integration

3.1 The value added chain model of multimedia

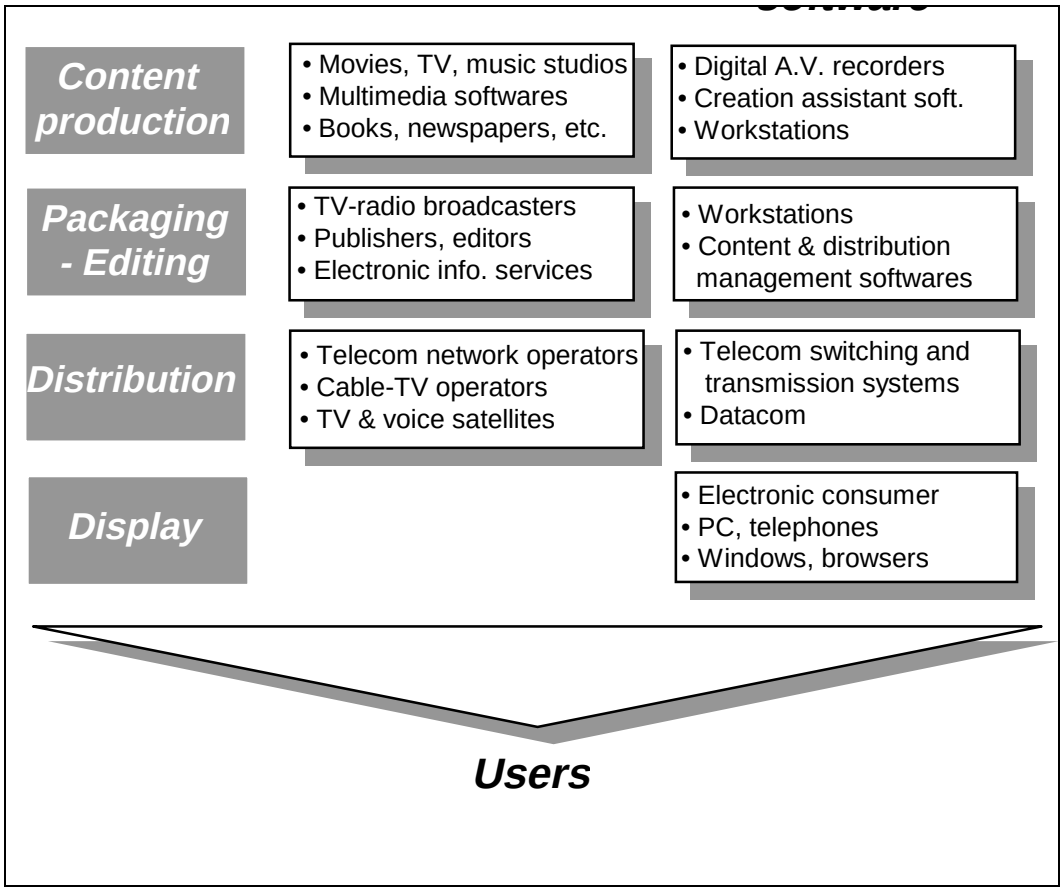
Most of the reviewed acquisitions do not show evidence of vertical integration as regards multimedia convergence. What is going on? And what do we generally mean by multimedia convergence? The diagram below is an attempt to represent the value-added chain of multimedia in terms of functions, related services and hardware/software facilities. The multimedia convergence is the technological process leading to the integration of different type of content (text, voice, image) on a single electronic medium to be handled in an interactive way by the user.

I have voluntarily separated services from hardware and software because there is no evidence of a vertical integration trend between the two of them, rather the opposite as it has been observed with the recent AT&T's spin-offs. However, the emergence of a new industrial structure based on the dominance of the Internet model could raise this issue again with the development of vertically-integrated groups providing software and terminals, digital content and web-casting.

In **hardware and software sectors**, the multimedia convergence appears to be generated more by the development of new competencies than resulting from acquisitions. Oracle is developing software technology for video servers, some companies are already present in all four levels of the multimedia model, like Hewlett-Packard with PCs, servers and workstations, or Microsoft with multimedia CD-ROM, interactive network architecture software, MSDOS-Windows.

Content producers and broadcasting industries have long been vertically integrated as part of giant media groups. The increasing number of acquisitions that are taking place such as Viacom-Paramount, Disney-Capital Cities/ABC or Time Warner-Turner Broadcasting can therefore not be considered as being led by the multimedia convergence.

Diagram 1: the value-added chain of multimedia



The recent rush on **cable-TV networks** by telecom operators, completed by important investments in **mobile networks,** could also be viewed as an attempt at vertical integration, but only at the level of distribution. Companies are competing to provide seamless networks and service packages covering all consumer needs: local telephony, long distance and international communications, mobile telephony and Internet access. But the main result of all these transactions, from an aggregated point of view, is to strengthen the concentration of the distribution network activity.

3.2 Drawbacks and low results

As regards the expected multimedia convergence, the current period rather seems to be characterised by drawbacks and bad news rather than success and optimism:

– following its acquisition by BT, MCI is trying to reduce its 2 US$ bn investments in News Corp's TV satellite project Sky Broadcasting;

- the likely decision by Time Warner to sell its cable-TV networks, in which US West owns a 25 per cent equity stake, will suppress financial links between the two companies;

- TCI-Microsoft alliance troubles;

- the multimedia trials launched in the years 1994 and 1995 are turning out to be costly, technically difficult and not very satisfying in terms of market results;

- Hugues Electronics' digital TV satellite project, called Direct TV, recently downgraded by 23 per cent its market projections.

Uncertain markets, as is the case with interactive multimedia services, cannot be at the source of multibillion dollar acquisitions. For the time being, multimedia convergence is more a technological concept than an industrial reality. One should also keep in mind all that was said in the early 1980s, about convergence between computers and telecommunications. This did not benefit the computer industry nor did it benefit telecommunication equipment manufacturers -- NCR's acquisition by AT&T turned out to be a failure -- but for a few start-up companies which ultimately went beyond the US$ 1 billion milestone -- Cisco, 3Com, Bay Networks -- and participated in the development of the computer-networking market.

Conclusion

Changes in the corporate environment created favourable conditions for the on-going explosion of acquisitions and mergers. In 1996, the way was led by mega deals in the telecommunications services industry as a consequence of the adoption of the US Telecommunication Act. Further consolidation is to be expected in the US market among independent carriers, RBOCs, long distance operators, cable-TV companies and wireless firms. Although no major acquisitions were announced in the telecommunications industry since the beginning of the year, some important deals have been announced in other sectors: acquisition by 3Com of US Robotics, a modem manufacturer, for US$ 6.6 billions, acquisitions of radio stations by the US group Evergreen Media totalling US$ 1.5 billion.

Almost all the reviewed acquisitions tend to strengthen horizontal concentration rather than vertical integration as regards the value-added chain of digital information. Of course, this does not mean that vertical integration is not an interesting model for industry. Multimedia start-up companies and joint-ventures that are currently flourishing tend to link the different layers of the multimedia value-added chain model, thus contributing to the development of a vertically integrated multimedia industry.

Several comments and issues arise from this situation:

1. More acquisitions do not mean more concentration as markets are growing rapidly.

2. Information superhighways do not result from the superposition, through acquisitions, of content, distribution network and hardware. Heavy investments are required in product development as well as in interactive broadband network infrastructure.

3. Will acquisitions pay off? It depends on whether one considers this question from a shareholder's point of view (i) or from a socio-economic point of view (ii):

i) Standard & Poor's stock index indicates that big companies have a higher total return than small and middle-size companies[62]; but a Mercer Management' Consulting study says that 53 per cent of the merged companies formed in the 1990s, or one out of two, are outperforming their rival over a three year period.

ii) From a socio-economic point of view, one may observe that the rationalisation following a merger to cut out overlapping costs generates unemployment. Also, the increasing allocation of firms' investment capacities in acquisitions rather than on tangible assets might be job costly at the macroeconomic level. The question is to know whether positive effects resulting from these massive branch re-organisations will overcome negative short-term effects.

4. As multimedia markets grow, **vertical competition** will become a major issue for competition authorities and regulators. An important point of concern is raised when a vertically integrated company intends to leverage one market in which it has a dominant position in order to dominate another market. A good illustration is Microsoft's on-line strategy built on its dominant position in the PC operating systems with MS-DOS Windows.

5. As the technological and economic environment is evolving, regulators and competition authorities will soon have to develop a **new rationale** to tackle the complex issue of integrated, interconnected systems of switched digital broadband networks combining mass media transmissions. The classic approach based on cross-ownership prohibitions and other differentiated treatment will become unworkable.

Annexe 1: Allcom database

Majority and minority interest acquisitions

US$ billion

	1994	*1995*	*1996*	***1994-1996***
All sectors $ bn	53	81	146	280
Operations	67	79	104	250
Majority acquisitions	43	67	136	247
%	80,63%	83,37%	93,31%	88,03%
Opérations > $ 10 billions	0	1	5	6
Total $ > $ 10 bn	0	19	82	101
% explained by > $ 10 bn		23,49%	56,40%	36,15%
				0
Operations > $ 1 billion	16	19	22	57
Total $ > $ 1 bn	42	67	127	236
% explained by > $ 1 bn	78,54%	83,43%	86,74%	84,23%

	1994	*1995*	*1996*	
Telecom services	15	18	83	116
Audiovisual industry	20	43	23	86
Cable-TV	10	11	20	41
Softwares	3	6	6	15
Datacom	1	2	5	8
Telecom equipments	2	0	1	4
Computers	0	1	2	4
On-line services	2	0	6	8
Check total	53	81	146	280

Source: Christian Micas, Telecommunications, Consultancy, Brussels

Professor Tsuruhiko Nambu, Economics Department,
Gakushuin University, Tokyo

1. Competition in the Local Loop

In the early 80s everyone believed that competition in telecommunications would be limited so that the long distance market and the local telephony would remain monopolistic. Such a prediction has become groundless since technological innovations have been realised to the extent that the incumbent monopolist has been challenged by the newcomers like CATV operators and wireless businesses.

In Japan the Telecommunications Business Law was enacted in 1985, by which a regulatory framework was given to introduce competition in the telecommunications industry. It is notable that entry into the local market was not restricted by the law, unlike the MFJ dichotomy ruling in the US. It could be interpreted that any firm can enter the local loop if it can meet the conditions imposed upon Type I carriers by the Ministry of Posts and Telecommunications (MPT). Type I carriers are defined as those who own telecommunications facilities for their own use. Because entry into long distance markets was encouraged by MPT one could reasonably expect that some firms may have entered providing both local and long distance services. In reality this did not happen.

Subsidiaries of electricity companies entered the local markets in their own regulated business areas. In Japan there are nine electricity companies which are given the status of local monopolies. They have the capabilities to challenge NTT but encountered two difficulties. Firstly, MPT did not allow rate rebalancing as was done in the UK and accordingly the local rate was kept intact: NTT could not raise its local rate. This meant that there was little room for profitable entry into the local market. Secondly, nine electricity companies were already interconnected with each other for the purpose of offering their electricity services and well prepared to provide telecom services jointly in the technological sense. But they found or believed that they had found that interconnecting telecom services across the country was prohibited by MPT. It was not until 1995 that the MPT officer declared on the Regulatory Reform Committee that MPT never banned the interconnection of telecom services among subsidiaries of electricity companies. That must be the case of the Telecommunications Business Law, as there are no formal restriction on that.

Now there emerge several problems of Japanese regulatory disasters, to prevent early or potential threat of entry into the local telephone market.

(a) Rate rebalancing was flatly put aside by MPT. They argued that NTT was a big company and it could cope with the problem of cross subsidy from long distance to local service even when it faced competition in the long distance market. Along with the Business Law, NTT Corporation Law was enacted and NTT was responsible for continuing universal service as it used to be in the days of public monopoly. The focus was always put on whether NTT could be profitable enough to provide universal services. MPT judged that NTT could continue to provide such services by cutting off its organisational redundancy, and that rate rebalancing was out of the question until MPT found adequate proof of efficiency enhancement in the NTT corporate structure.

From the social point of view it is difficult to say whether the Japanese approach or the British approach (where BT was given an opportunity for rate rebalancing under the regime of price, cap, RPI minus 3 per cent) was preferable. But from the viewpoint of an economist, it was necessary to introduce rate rebalancing in order to competition and reshape the telecom industry as a whole. The problem of inefficient incumbent monopolists is another issue to be tackled separately. The confusion created by MPT between squeezing NTT from the regulatory standpoint and restructuring service prices was a source of delay in Japan to inviting local competition successfully.

(b) In the Japanese regulatory system we have had a non transparent, implicit guideline procedure which is often called 'gyoseishido'. This term was often associated with the industrial policy of the Ministry of International Trade and Industry (MITI). No-one knows whether this was successful or not but MPT seems to have adopted this custom when they newly began to regulate the telecom industry. Careful reading of the Business Law is not sufficient to learn the intent of MPT bureaucrats. Other detailed documents have been published and firms must consult with bureaucrats when they make decisions. It is not unwarrantable that electricity companies took it for granted that they could not enter local telephony. Because the local rate was kept unchanged (10 yen per three minutes) the entry of the electricity companies was unprofitable and those companies naturally wanted to enter into long distance business. They argued for reregulation of the telecom industry and the Regulatory Reforms Committee gave a formal opportunity for discussing this problem. It was by accident that an MPT top official confessed that MPT does not intend to regulate entry into long distance business by electricity companies and they can be interconnected nationwide.

This episode gives us an insight into the uncertainties created by the discretions of bureaucrats. If a transparent guideline had existed, electricity companies and others may have begun to supply full line service or at least they may have not different strategies for the telecommunications business. The implicit policy making or not time constrained policy agenda constituted another source of delay in bringing about local telephone competition.

2. Competition among technologies

Be it coaxial cable or optical fiber, wireline technology used to be regarded as a dominant technology for which there does not exist a close substitute. Quite recently however, wireless technology has become a candidate for challenging wireline. It has been developed mainly in Scandinavian countries. The inertia of older telephone subscribers may be the highest barrier to its development, but this would be easily broken in coming years. Cable television providers have become another wireline competitor to the incumbent telephone monopolist. They can make use of economies of scale in providing broadcasting and telephone services. At the same time computer technology development made it possible for a small exchange to compete with the local exchange of the incumbent.

Satellite is another source of potential competition to the old telephone network. There are many problems to be solved for it to be a stable competitor, but its competitive threat is so great as to enhance local as well as long distance competition.

In the face of these new technical opportunities, institutional architecture has played a decisive role in encouraging competition. In the Nordic countries there was no regulation on technology choice, and evolutional development of wireless business has been witnessed in the past 15 years.

After the duopoly review in 1991, the British CATV industry experienced rapid growth and it has become a real threat to the BT telephone network. In the US the 1984 ACT of deregulating CATV has

greatly contributed to increased penetration rates and it paved the way to extending its business from broadcasting to telephony.

In Japan MPT was an efficient brake to this kind of development CATV industry was strictly regulated in several ways.

The tariff of CATV must be based upon the accounting cost and it could not be lowered in order to attract new customers. As a result CATV service was very expensive in order to restrict the number of subscribers.

CATV used to be defined as a rescue service of broadcasting in a limited area. As a public broadcaster it had to observe rules which prohibited entertainment services. Also there existed unprofitable 'local content' regulation. CATV industry could not give a business opportunity in general.

CATV operators did not have the right to access subscribers, which was the greatest obstacle to expanding their business.

In 1994 MPT deregulated the CATV industry to some extent. The narrowly-defined business area was relaxed to permit MSOs in a certain region. Foreign capital restraint was lifted to the extent that foreign companies could contribute up to one third of the total capital. But everything came too late. Now CATV operators are going to start telephone business under the new regime of interconnection with NTT. It is quite probable that they will become competitors to NTT, but Japanese customers must wait and continue to lose out until local competition emerges.

The experience of the wireless industry gives us a clear and simple example as to how regulation can be a deterrent to the healthy development of telephone business.

Until recently there existed price regulations upon wireless services: cellular telephone and PCS. Their prices used to be too high to attract subscribers. It was just a few years ago that MPT lifted such regulation and the wireless markets exploded. This should have been anticipated simply because many countries gave a good example. The Japanese people wasted much time and resources by untimely regulation.

3. Uncertainty created by divestiture argument

This year the argument over NTT divestiture was settled. NTT should be re-organised as a holding company to which two regional companies (NTT East and NTT West) and one long distance company belong as subsidiaries.

The decision to break up or not to break up NTT was postponed in 1985. In 1990 again we did not reach a conclusion and the discussion was postponed until 1996. During that period the environments around the telecom industry completely changed. The dichotomy between local and long distance proved meaningless; technology has been ever changing and no-one can foresee the future; bundling or full line service might be necessary for large operators to survive; entry from other fields like electricity and gas has become a real threat, etc.

It appears that MPT paid little attention to these changes and they continued to insist upon the necessity for divestiture. Be it right or wrong, it created great uncertainty as regards the telecommunications infrastructure. Because the holding company was prohibited by the Anti Monopoly

Law, it was impossible to imagine NTT as an integrated organisation in the name of the holding company. MPT committed a political risk by proposing an idea of restructuring NTT as a holding company along with joining and making the best use of deregulating the Anti Monopoly Law.

It may take a few years to reshape NTT while other countries like the UK, the US and Singapore will not miss the opportunity to develop at a higher speed. We do not have time to lose. How to deregulate regulators is an urgent agenda for us.

Draft Script for March 19th

Lord Renwick, Copenhagen Business School

I am delighted you have chosen London, the birth place, so it is said, of both Capitalism and of Socialism, of both Communism and of Liberalism, as the place to discuss the Economics of the Information Society.

I am told that Karl Marx spent 20 years here, in the reading room of the British Museum, trying to prove that Adam Smith, Edward Gibbon and Thomas Jefferson were all wrong. According to some of my colleagues interested in the history of politics, most of the ideas of Karl Marx, and of those who have followed him, had already been well worked over in the Putney debates of 1647, as those soldiers of Cromwell's New Model army who had not been sent to Ireland to bring the catholics to heel, whiled away the time before their discharge.

Today they tell me that the City of London, with more competing communications and information networks than the rest of Europe added together, is still the City closest to the reality of the arguments on how best to create the conditions for economic growth and prosperity in the global information society.

If I want to look beyond tomorrow into the future of technology I may well think of going to the sunshine of California, but if I want to see high resolution broadband video already earning serious money for live uses, I am advised to put up with the British weather and visit the design houses and advertising agencies attached to Sohonet, here in London.

In Los Angeles I can see Internet newspapers but if I eat in the wrong place in London, my lunch will be disturbed by selected financial news, sent live to the pocket bleepers and data mobiles of many of the other diners.

The Internet is said to be the world's largest zero billion dollar transaction system. Meanwhile I am told that the electronic networks of London handle billions of dollars of transactions every day and that the Bank of England and the Stock Exchange are already grappling with the practical problems of monitoring the financial exposure of banks and broking houses, not merely at open and close of trading, but around the clock.

The technology may be developed anywhere in the world, but London is still the City where most of the rest of the world's dreams of tomorrow are already up and running -- provided they enable the denizens of the City to make money.

The cynics of the IT industry keep reminding me, however, that Whitehall, our euphemism for the powerhouse of Government, is at least as far behind the City of London in its use and understanding of information systems, as Washington is behind Wall Street.

That leads me to the question of how politicians should react to developments, which neither they nor their officials, nor their officials' advisors and consultants really understand.

Should we politicians try harder to understand and plan ahead or should we accept that we can never understand enough and try harder not to interfere?

In 1984, in a study entitled "No End of Jobs", Sir Michael Marshall MP (the retiring Chairman of the UK Parliamentary Information Technology Committee after 10 years) and Philip Virgo (who now helps me run EURIM) described how, in the late 18th Century the English ruling classes reacted to the stresses of industrialisation with a bonfire of taxes and regulations -- and survived.

The French ruling classes tried to plan their way through the same stresses -- and were guillotined for their pains.

They argued, Michael and Philip, over ten years ago, that the pace of change was too fast for bureaucratic response. Moreover, the uncertainty of the direction of change was such that government intervention, however well-intentioned, was likely to do as much harm as good.

Today many technology enthusiasts claim that the anarchic creativity of cyberspace has completely overwhelmed the ability of governments to plan ahead. But it is interesting to note that the fastest employment growth, world-wide, except perhaps for Asia, seems to be among regulators and regulatory lawyers.

I would, therefore, like to add some more questions to those I saw in your draft programme.

The first is whether the growth of government and inter-government regulation is compatible with a truly competitive global information society? The second is whether regulation is actually essential to preserve effective competition in that global information society?

Behind these questions lie others.

Does growth migrate to the best regulated markets or to the least regulated markets?

Either way -- what should be the response of the averagely incompetent state?

And if that state is a supposed Democracy and the choice is between regulated decay and uncertain growth -- should politicians seeking to be re-elected assume that a majority of the electorate would prefer regulated certainty, with winning the lottery their best chance of a better life style, or the challenges of risk and perhaps reward for hard work and enterprise?

What is new, today, is that governments can no longer act in isolation from each other. They too are competing in a global market.

The area of competition missing from your programme is that of competition between governments for job and wealth creating businesses and tax-paying citizens.

We see the debate between Britain and the rest of Europe over the Social Chapter. We read in The Times about the Belgians accusing the Dutch of fiscal piracy because, for example, they offer better terms for personal savings. We see governments all round the world giving tax breaks to attract inward investment and high-spending tax exiles while seeking ways of raising taxes from those who cannot move their earnings off-shore.

How long before we see governments paying similar attention toward encouraging their own indigenous, wealth creators?

I am told that all previous technology shifts (canals, railways, cars etc.) have been accompanied, throughout history, by major population movements. Increasingly these have become international and not just local. High tax localities and governments could thus be left looking after the unemployed, the uneducated and the disabled and the elderly, and on a declining revenue base.

The implication is that global competition to attract and retain wealth creating taxpayers and high spending non-taxpayers mean that Governments can no longer afford to choose merely between raising taxes and cutting services. They have to look again at how they operate. A number of commentators say that no national economy can still support a traditional, centralised, bureaucratic state and remain globally competitive.

Some enthusiasts go on to urge their governments to match the best of the private sector in using new technology to transform the way they operate and to deliver improved public service at lower unit cost, at all levels. Others, more pessimistic, do not believe the nation state will survive, that only city states and regional governments will be able to respond to the challenges entailed. They seek change along a different political dimension.

I detect more than a whiff of wishful thinking in both streams of thought and would merely comment that the need of governments to improve their own efficiency should be at the heart of any programme to cut the cost of government. The issue is how to promote information sharing to provide better service at lower cost while protecting the citizen from abuse.

Some groups like to think they are above this debate. They like to think that they are among the knowledge-workers who will be the aristocracy of the information society. Debates about how to avoid the problem of information "haves" and "have-nots", which assume an elite of highly valued and paid "knowledge-workers", are popular in the academic community.

But might not the falling cost of transmission, and improvement in ease of access to information sources, have an impact on the prestige and life-style of today's "knowledge workers" similar to that which the printing press had on the prestige and protected life-style of medieval scholars?

Remember all the monks and nuns kicked out of monasteries and nunneries during the Reformation? Ponder the future of the inhabitants of the Universities and Research Centres of today. Might not they, too, face major changes in lifestyle as Internet-based brainstorming groups, pirate and leapfrog their publicly funded research projects?

I return to my core question.

Should governments and politicians try harder to understand or should they accept that they can never understand enough to be sure of doing more good than harm?

Do you want us to try, like the French in the late 18th Century, to plan and dictate a way through widespread social pain and disorder as traditional jobs and careers are destroyed throughout the private sector and falling tax revenues will no longer fund conventional public sector services and welfare schemes.

If so, and you work in France, you had better be right.

I am told there are still sufficient Guillotines in working order for when the pain of regulated change becomes more than that which merits mere lorry drivers' strikes and farmers' blockades.

Or do you think our 18th Century Ancestors in London and their colleagues and cousins who drafted the Constitution of the United States in Philadelphia were right: that bonfires of regulation, planning and control can stimulate sufficient growth in new and alternative employment patterns, including new ways of organising public services and welfare programmes, to turn slump into boom and pain into pleasure, for the mass of the population and not just a privileged elite of knowledge workers.

On a more serious note -- I am most honoured to be invited to welcome such an impressive gathering of experts from all round the world to address so critical a range of issues.

I look forward very much to reading your conclusions.

Co-ordination modes and producer-supplier integration: empirical evidence from four industries

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Introduction

A fundamental assumption of transaction cost economics is that firms make goods and services rather than buy them to reduce costs of co-ordinating with their suppliers. According to this approach, firms produce in-house in large part to reduce their vulnerability to opportunistic trading partners who might otherwise take advantage of their dependence. Most economists believe markets would generally be more efficient mechanisms for production, were it not for these costs of co-ordination. Indeed, according to transaction costs tenets, firms exist primarily to reduce the costs of specificity and monitoring contracts (Williamson, 1975).

Information systems researchers have tried to make the case that modern computer and telecommunications networks sufficiently reduce the costs of co-ordination so that firms can get the production benefits of acquiring goods and services in the market without incurring much more co-ordination costs than if they produced these goods and services themselves (Malone, Yates & Benjamin, 1987). There appears to be some consensus that networks are facilitating the rise of "virtual organisations" characterized by smaller focal firms that rely on data networks for both up and downstream transactions (cf. Bradley, Hausman & Nolan, 1993, Malone & Rockart, 1993; Clemons, 1993; Miller, Clemons & Row, 1993). Until recently, empirical research that examined the conditions under which electronic networks are used for transactions or that investigated the effects of such network use on transaction outcomes was confined to a series of widely cited case studies (Malone, Yates & Benjamin, 1987).

While economists consider ownership (i.e. in-house production versus market arrangements) as the key to co-ordination, and information systems researchers focus on data networks, sociologists focus on the role that networks of interpersonal and social relationships play in co-ordinating transactions. According to theorists such as Granovetter (1985), economic transactions are embedded in a rich network of social relationships, and firms acquire from entities where these networks of relationships allow them to transmit reputations, develop trust, monitor behaviour, and reconcile differences. These social networks may be denser within a firm than between a firm and its external suppliers, but need not be so. In any case, according to social network theorists, social networks, rather than employment contracts per se, are the important factor that eases co-ordination. Since these social relationships can also extend past the boundaries of the firm, co-ordination with external suppliers can be as effective as co-ordination in-house if the appropriate social networks exist.

The theoretical frameworks briefly described here lead to different understandings of when firms will use different co-ordination modes and the effects of these modes on co-ordination success. The goal of the present paper is to apply empirical evidence to identify conditions under which firms use different modes of co-ordination with suppliers and the effects these styles of co-ordination have on market structure and co-ordination success. The paper is organised around three research questions. First, we hope to identify conditions under which firms use (a) in-house production, (b) electronic networks, and (c) interpersonal networks to co-ordinate with suppliers of important goods and services. Second, we examine whether the use of inter-organisational electronic networks encourages producer firms to co-ordinate acquisition of production inputs through markets or discourages this kind of competition in favour of producing inputs in-house. Finally, we examine the influence of these three modes of co-ordination on the success with which producer firms acquire important inputs.

While these topics have been prominent in the recent research literatures in economics, information systems, and organisational behaviour, empirical evidence is scattered and the majority of evidence about the role of interpersonal networks on co-ordination and on the impact of electronic networks on make-versus-buy decisions still comes from case studies. The research presented here consists of a national survey of 250 firms in four industries acquiring a total of 16 different inputs.

Adopting different co-ordination modes

Make versus buy decisions

The production of almost any complex product consists of acquiring various raw materials and other components and crafting them, with each step presumably adding value as the product wends its way towards its ultimate consumer (Porter, 1980). In an example from one of the industries treated in this study, the production of women's apparel involves acquiring the key inputs of fabric, trim (buttons, zippers, etc.), garment design, cutting services, and sewing services. A producer firm must decide whether to "make" each of these inputs in-house or "buy" it externally. According to the transaction cost approach (Williamson, 1975), the decision depends upon the relative costs of presumably less efficient in-house production and the theoretically higher costs of co-ordinating with external suppliers to acquire the input.

Most economists believe that were it not for the costs of co-ordination, markets would generally be more efficient mechanisms for production than in-house production or hierarchies. By being able to sell to many customers in a market, a producer could acquire more experience, level the load of production across many customers, and capitalize on economies of scale, all of which generally lead to more efficient production. Similarly, in a market, customers can shop around for the best combination of price, quality, or other desirable attributes and because they have choices, they are not held hostage to the opportunistic behaviour of any single supplier. Competition among suppliers also promotes more efficient production.

The rub is that when purchasing goods and services on the open market, costs of co-ordination can be high. Economists point to the extra costs that outsourcing imposes on co-ordinating the economic transactions themselves. In particular, when outsourcing, firms have additional costs as they search for appropriate suppliers, specify contracts, enforce the contracts, and handle financial settlement (Williamson, 1975). For example, customers can have difficulty specifying what they want and searching through the many alternatives to find the best suppliers and best wares, and suppliers incur costs in advertising the availability of their goods and services to potential customers (Malone et al, 1987). Once

an economic transaction has been agreed upon and goods produced, the customer needs to insure that suppliers are meeting the terms of the contract, for example, by continuing to supply high quality goods according to an agreed-upon schedule. Monitoring through various quality-control programmes is expensive. Once the goods have been delivered, the customer needs to receive an invoice and producers need to be paid. Arranging billing and payment between large numbers of customers and suppliers can be expensive.

From our perspective, when firms elect to make rather than buy production inputs, they have chosen ownership as a co-ordination mechanism. That is, firms decide to invest in the necessary capital and human resources so that they do not have to risk being cheated by opportunistic suppliers. However, ownership as a co-ordination mechanism does not have to be an all or nothing affair. A number of researchers have argued that one failing of the original transaction cost theory is its focus only on markets versus hierarchies (i.e. in-house production), and not the many hybrid co-ordination mechanisms that are often found in practice (cf. Hennart, 1993; Perrow, 1986; Powell, 1987; Stinchcombe, 1990). One implication of this critique is that even when firms do have an in-house production capability, they may still acquire some proportion of the same type of input from external sources.

Williamson (1975; 1985) suggests a number of conditions that result in market failure, and lead organisations to choose hierarchy as their co-ordination mechanism. Firms have bounded rationality, and cannot know all contingencies that might influence an economic transaction. Hence when uncertainty and complexity are greater, firms face an information deficit and may opt out of the market. These conditions are further exacerbated in the case where there are small numbers of suppliers to satisfy a firm's input needs, and suppliers behave opportunistically. The small numbers problem is more likely to arise when acquiring firms need highly specific assets (or inputs), and as a result, do not have a large number of alternative suppliers with which to do business.

Interpersonal connections

Organisational contingency theory, as well as sociological literature on organisational relations suggests that much co-ordination occurs through the interpersonal linkages among trading partners. In the classic contingency theory formulation, under conditions of environmental uncertainty, firms that increase their information processing ability through lateral communications are more able to adapt (cf. Burns & Stalker, 1961; Lawrence & Lorsch, 1967). Use of interpersonal communication for co-ordination occurs between firms (Granovetter, 1985), as well as within them (Van de Ven , 1976; Tushman & Nadler, 1978).

Interpersonal relationships convey more than just information. Through social relationships, trust is developed between parties to an economic exchange (Granovetter, 1985; Zucker, 1986). As Granovetter notes, interpersonal relations can serve as a more powerful transmitter of the reliability of a potential trading partner than generalized reputation. He further argues that having personal experience with another is one of the most potent sources of information on their trustworthiness. Past experience provides better information because it is cheaper to get, one trusts one's own information best, when there is likely to be a continuing relation there is a motivation to be trustworthy, and the social content of relationships "carries strong expectations of trust and abstention from opportunism (Granovetter, 1985, p. 490)."

Proponents of a more relationship-governed co-ordination mechanism direct our attention to the mutuality of interest that exists between supplier and customer in many forms of economic exchange (Johanson & Mattson, 1987; Johnston & Lawrence, 1988; Lorenz, 1989; Powell, 1990). Mutuality of interest helps to develop trust, and occurs through social exchanges between the trading partners.

Johanson & Mattson in particular point out that mutual orientation emerges on the basis of the interpersonal interactions that occur among individuals in the firms. This mutual orientation permits adaptive behaviour, a sign of improved co-ordination. Hence, interpersonal relationships are a potentially important mechanism for co-ordination. Firms should rely more on interpersonal relationships as a co-ordination mode when they know more about their suppliers, and have more trust in them.

Electronic networks

In the information systems literature, it is now widely accepted that electronic networks can improve both internal co-ordination and co-ordination with the market, and that successful deployment of networks can enable firms to achieve a competitive advantage (Keen, 1988; Porter and Millar, 1985). The potential benefits to the firms include increased efficiency of order processing, reduced costs due to just-in-time inventory management, locking in trading partners because of the difficulties competitors faced once a network is in place, and greater ability to customize products and services based upon information arising from the transactions carried by the network (Cash & Konsynski, 1985; Johnson & Vitale, 1988). Although more recent works have questioned whether such electronic network use provides sustained competitive advantage, or is easily imitated by competitors, the basic premise -- that electronic networks can improve co-ordination -- is rarely doubted.

Information systems researchers have also directed their attention to inter-organisational electronic networks as a tool for improving co-ordination with external constituents (Cash & Konsynski, 1985; Johnson & Vitale, 1988). Malone et al., (1987) highlight three ways that inter-organisational electronic networks can improve co-ordination between firms. First, an *electronic communication* effect simply speeds up the flow of information between suppliers and customers, enhancing their ability to co-ordinate exchanges. This feature of electronic networks should become increasing by salient as firms remove the slack in their production processes and face greater time pressures (Davidow & Malone, 1994). The benefit comes in part from removing slow human-to-human communication from the co-ordination path.

Second, when networks are used to share detailed information that allows a producer and supplier to better co-ordinate their production activities, they have an *electronic integration* effect. An example would be an electronic data interchange system that connects a retailer's point of sale terminals to a supplier's delivery system, decreasing the likelihood of the retailer going out of stock on popular goods (Weber, 1995). Another example is the integration of CAD/CAM systems between a computer chip design firm and a silicon foundry, that allows the designers of a chip to monitor the manufacturing process and to have more flexibility in changing their designs (Hart & Estrin, 1991). This effect is manifested when technology is used not only to facilitate communication but also to tightly couple processes at the interface between stages of the value chain.

Third, by using electronic networks to reduce the costs of searching for appropriate goods and services, firms can achieve an *electronic brokerage* effect. Examples include airline reservations systems that allow travel agents and consumers to search for and buy tickets, and CommerceNet, which allows firms in Silicon valley to order computer supplies on the World Wide Web. These services all connect different buyers and sellers through a shared information resource (like a centrally maintained database or the decentralized World Wide Web) and provide some tools for searching the data. They help the buyers to quickly, conveniently and inexpensively evaluate the offerings of various suppliers. The electronic brokerage effect can increase the number of alternatives as well as the quality of the alternative

ultimately selected, while decreasing the cost of the selection process (Malone et al., 1987; Wildman & Guerin-Calvert, 1991).

The influence of using electronic networks on make-vs.-buy decisions

How does electronic network use influence make-buy decisions? In a widely cited article on co-ordination costs and electronic networks, Malone and colleagues (1987) argue that the use of electronic links between firms can reduce both the costs of co-ordinating economic transactions and the costs of co-ordinating production. To the extent that networks overcome the high co-ordination costs associated with markets, firms will be able to buy goods and services less expensively than to produce them in-house; hence there will be more outsourcing (Malone, 1987; Malone et al., 1987; Malone et al., 1989). In the apparel industry, for example, if a garment maker can easily identify and communicate with a high quality, efficient freelance dress designer, the transaction cost advantage of keeping designers on staff would disappear.

Malone and colleagues also posit that networks can lead to tighter coupling between producers and suppliers, as production activities become more integrated through electronic linkages. They term these integrated producer-supplier relationships electronic hierarchies. To the extent that firms deploy electronic networks for their electronic integration effect (i.e. to tightly couple with trading partners), they will tend to develop stable, hierarchical relationships with their trading partners.

In essence, Malone and colleagues suggest that reduced transaction costs come about because networks help to moderate the effects of specificity and complexity that normally lead to market failures. Through electronic brokerage effects, producers are able to efficiently search for and locate new suppliers, even when attempting to acquire highly specific assets. Tightly linking production activities across suppliers and producers also enables outsourcing for more highly specific assets. And, as networks become more capable, they can also transmit information that describes increasingly complex goods and services. Although they predict that both electronic markets and electronic hierarchies will emerge, they expect the former effect to be more significant than the latter, hypothesizing that "the result ... should be an increase in the proportion of economic activity co-ordinated by markets." (Malone et al., 1987, p. 489).

Empirical tests of the hypothesis that greater use of inter-organisational networks leads to greater outsourcing are only starting. Consistent with this hypothesis is evidence at the industry level that increases in investment in information technology were associated with a decline in average firm size and a rise in the number of firms (Brynjolffson, Malone, Gurbaxani, & Kambil, 1993). Kambil (1991) shows that industries investing more of their capital stock in information technology also contract out more of the value of the goods and services they produced to external suppliers (i.e. a higher buy/make ratio in production), with a two year lag. Limitations in the data, however, mean that the analyses are only suggestive. For example, analyses conducted at the industry level (2-digit SIC codes) do not necessarily speak to the way particular firms deploy information technology. The use of general information technology as the independent variable obscures the unique role that inter-organisational networks might play.

On the other hand, there are both case study and survey research findings that support the alternative view that inter-organisational networks are associated more with hierarchical relations than market structures (Brousseau, 1990; Keen, 1988; Malone & Rockart, 1993; Steinfield & Caby, 1993; Steinfield, Caby & Vialle, 1993). Brousseau (1990) studied 26 inter-organisational networks, finding that most were used to reduce production or distribution costs and served to reinforce already existing hierarchical relationships among firms. These networks were largely private networks, established prior

to the commercialisation of the Internet. However, quantitative research that encompassed a public data network infrastructure affording low cost linkages between buying and selling firms, the Teletel network in France, found that such network use was also associated with more stable trading partners (Streeter, Kraut, Lucas & Caby, 1996). Steinfield, Kraut & Plummer (1995) conclude that electronic hierarchies appear to be more common, and that networks are tools used to lock in trading partners and to increase switching costs associated with changing suppliers. In essence, the trading relationship is first established and becomes stable. Some degree of trust develops, which has been associated with inter-organisational network use (Hart & Estrin, 1991). Firms then are willing to open their networks to partners, and invest in equipment, software, or expertise necessary to gain benefit from electronic transactions. Because these investments can be costly, even when using public infrastructures, firms may be unwilling to make them unless they are guaranteed an important portion of trade (Bakos & Brynjolffson, 1992).

The influence of co-ordination modes on co-ordination success

Prior research on the value of new information technology in organisations has found it difficult to identify real impact of the technology in terms of economic productivity or firm performance (Landauer, 1996). One reason for this troubling and paradoxical result is that information technologies often have their greatest impact at an operational level and that consideration of performance impacts at the firm or industry level significantly obscure the consequences of information technology (Barua, Kriebel, and Mukhopadhyay, 1993). To counter this it is suggested that measurements of information technology impacts should focus on the intermediate outcomes in firms such as efficiency of operations and satisfaction with the execution of particular transactions.

Similar arguments apply when considering the impact of alternative contractual and interpersonal co-ordination mechanisms. Asking how these co-ordination mechanisms impact firm profits assumes that the execution of the transaction of interest is a significant direct component of firm performance. In most cases the execution of a particular transaction is not likely to have a direct impact on firm performance, and it should not be surprising that researchers have had difficulty finding such direct effect evidence. However by contributing to intermediate outcomes, such as increased quality of operations, process satisfaction, and reduced operational costs, the use of alternative co-ordination mechanisms may ultimately impact upon more direct measures of performance.

Empirical research on organisational use of electronic networks for transactions suggests that positive influences on such intermediate outcomes can occur, even for inter-organisational exchanges (Kekre & Mukhopadhyay, 1992; Streeter et al., 1996). How the use of interpersonal relationships, or in-house production in place of external suppliers, influences these intermediate outcomes is less clear. Reliance on interpersonal relationships might imply less efficiency, as measured by the degree of human intervention. On the other hand, if used as a proxy for trust, thus allowing firms to avoid the need for costly monitoring efforts, then greater use of interpersonal and ownership modes of co-ordination should result in better outcomes.

Research questions

We can summarize this review with the following research questions:

Under what conditions will firms elect to make rather than buy important inputs to their production processes? Our review suggests that when the inputs they seek are not highly complex and are therefore easy to describe and locate through search processes, firms should outsource more. In addition, when their relationship to suppliers is not subject to strong possibilities of opportunism, due to supplier market

dominance, or producer firms' needs for highly specific goods or services from suppliers, then outsourcing may also be more prominent.

Under what conditions will firms elect to co-ordinate with internal or external suppliers through electronic networks? First, reductions in labour costs through automation of transactions would motivate firms to employ electronic networks, but only if there were a sufficient number of transactions for this payoff to be meaningful given the costs associated with network implementation (Keen & Cummins, 1993). Second, the speed advantages of networks would also be more of an influence when organisations stood to benefit most from time savings. Hence under conditions of time pressures, or when firms cannot know well in advance when they will require inputs, electronic networks should be more desirable as a co-ordination mode. Third, networks are hard to use with products that are complex. Products whose essential features can be easily described, should be more amenable to trade over networks. Goods may be easier to describe than services, although not necessarily. Finally, we might expect that when the products or services may themselves be transportable over electronic networks (e.g. as in software or information), the cost advantages of using a network would be greater.

Under what conditions will firms elect to co-ordinate with internal or external suppliers through interpersonal contacts? Our review suggests that such factors as degree of trust, and the extent of knowledge producers and firms have about each other should influence the importance of interpersonal relationships as a mode of co-ordination. Complexity, uncertainty, and unpredictability may all lead to greater reliance on interpersonal connections.

What effects do electronic linkages have on make vs. buy decisions? The research reviewed here suggests that while use of electronic networks can facilitate co-ordination with both internal and external suppliers, information systems researchers believe in the long run it will lead to greater outsourcing. This should occur due to the moderating effect that electronic network usage is expected to have on factors such as complexity and specificity that are proposed causes of internalization.

What effects does the mode of co-ordination have on the outcomes of transactions with suppliers? Firms are motivated to use electronic networks for transactions because of the proposed gains in efficiency. Our review suggests that empirical evidence is limited on this front, but we should expect to find network usage effects on intermediate outcomes such as on the number of errors, the ease with which transactions are made, and general satisfaction with the transaction. To the extent use of in-house production improves co-ordination, it should have positive effects on these measures as well, even though the economic literature would argue that in-house production costs are likely to be higher than external suppliers' production costs. We do not have good empirical evidence guiding our expectations regarding the effects of interpersonal relationship-based co-ordination on outcomes.

Methods

Sample and interview

The empirical test was accomplished through a telephone survey of managers in a sample of 250 producer firms from four industries. The sample was drawn from all firms of at least 20 employees from the Dunn and Bradstreet data base in the advertising, magazine publishing, women's apparel, and pharmaceuticals industries[63]. Advertising and publishing were chosen as producers of information products. Apparel and pharmaceuticals were selected as examples of manufacturing industries, but contrasting large batch production with smaller scale, often customized, production. Firms were ranked

by number of employees, and a stratified sample of large, medium, and small firms (relative to each industry) from each third of the size distribution. Table 1 shows the average number of employees worldwide in each industry-size category and the number of firms sampled in each category.

Table 1. Sample Characteristics

Industry SIZE	*Pharmaceuticals*	*Advertising*	*Women's Apparel*	*Magazine Publishing*
Small (number of employees)	44.1	24.4	56.0	26.9
N	*18*	*22*	*24*	*20*
Medium	84.4	38.3	145.6	35.3
N	*21*	*21*	*14*	*23*
Large	13,262.0	507.5	261.0	759.0
N	*20*	*21*	*22*	*24*
N = 250	**59**	**64**	**60**	**67**

Note: Entries represent mean number of employees in the firms and the number of firms presented in industry-size category.

Source: Charles Steinfield, Alice Chan Plummer (Michigan State University), Robert Kraut, Brian Butler (Carnegie Mellon University), Anne Hoag (Pennsylvania State University)

The telephone survey focused on the way in which the producing firm acquired key inputs from suppliers. Respondents were asked to identify their company's principle product or service, and then were asked about a specific input needed to produce this product. Depending on the question, respondents were asked about the way they acquired this input in general or about the way they dealt with the "the most important supplier you've worked with in the past 12 months". We stressed that the suppler could be an employee or department in the respondent's firm or an outside individual or company.

We identified a set of key inputs for each industry, through a series of preliminary semi-structured interviews, in which key informants described the production of their firm's most important product or service. We conducted interviews in a total of 14 firms, primarily through face-to-face discussion. Interviews in a single firm typically lasted about three hours and involved two to four informants. Inputs were chosen to vary on whether they were products or services and whether they were tangible or intangible. The definitions of these terms are given below. Table 2 shows the four transactions for each industry, and their classification as a product or service and as tangible or intangible.

Respondents were questioned about one input randomly chosen from the list of four for each industry. If a particular company did not use this input or if the quota for the input had already been filled in the industry-size category, then the interviewer randomly selected another input.

The telephone survey was conducted by a professional survey firm. Interviews, typically lasting 30 minutes, took place in July and August 1996. In reaching the respondent, interviewers used a series of screening questions to identify "the person who is most responsible for arranging and acquiring" the specified input. Interviewees included both managers specializing in procurement (e.g. a VP of Purchasing) as well as those in operational area (e.g. the senior editor responsible for assigning stories to staffers and freelancers). The survey process produced 250 completed interviews on a survey instrument with about 50 items. The response rate was slightly over 50 per cent.

Measurement

To address the research questions described previously, we created multi-item scales to measure concepts related to uncertainty, opportunism, object specificity, and the co-ordination modes. Appendix A lists all the multi-item scales and their reliabilities.

The central variables in the analysis are the modes of co-ordination used by the producing firm in acquiring its key inputs: in-house production, electronic linkages, and interpersonal relationships. We are interested in how choice of co-ordination mode was predicted by attributes of the input (tangibility, product versus service, and complexity of product description) and other features of the production process (whether specifications for inputs and quantity needed were known far in advance and whether firms were under strong time pressures in production). We were also interested in how choice of co-ordination mode was predicted by features of the relationships with potential suppliers, including the specificity of the input (i.e. the extent to which its usefulness was limited to the producing firm), by specificity of knowledge (i.e. the extent to which the producing firm and its suppliers had invested in human capital, such as knowledge about each other, to accomplish ordering), the relative power of the supplier, the trust the producer firm had toward its supplier, and the order frequency. Finally, holding constant factors that may lead to the choice of a co-ordination mode, we were interested in whether different co-ordination modes were associated with different outcomes in the acquisition process: the respondent's satisfaction with the supplier, the efficiency of ordering, and the quality of the ordering process.

Co-ordination mode

In-house production is a composite index that estimates the extent to which a firm outsources the key input or produces it in-house. It is based on three items: (1) whether the major supplier for the input was external or in-house; (2) the nature of the relation between the major supplier and the producer firm, ranging from "departments within your firm" to "owned subsidiary" to "a joint venture firm" to an "outsider" firm; and (3) the percentage of the key input which was produced in house, ranging from 0 to 100. If the index is high, then the firm uses a more in-house procurement strategy. (Alpha=.86).

Electronic links. The survey asked about the importance of using electronic networks with a major supplier of the key input. This is the importance in the acquisitions process of using "any type of computer communication that allows you to exchange information with this supplier". We asked about the importance, on a 5-point scale, of using electronic links for each of six separable stages in acquisition (Johnston & Vitale, 1988; Kambil, 1993) including 1) searching for and selecting a supplier; 2) developing the specifications of the key input; 3) negotiating the terms of the acquisition such as price, delivery date, and so on; 4) ordering the input; 5) monitoring the quality of the good or service; and 6) fixing problems after the order. Respondents made their judgments on 5-point Likert scales, from not at all important to very important. The composite scale has high reliability (Alpha = .94).

Interpersonal relationships. We attempted to measure the importance of personal networks in acquiring the key input for each of the six stages of acquisition. According to the definition of the term for respondents, interpersonal relations includes "any type of personal connection or personal knowledge between people in your firm and people in the supplier's organisation." The composite scale has high reliability (Alpha = .85).

Product and production attributes

Products versus service. Products were objects acquired by the producing firm, (e.g. fabric or magazine articles), while services involved agreements by the producing firm to have the supplier complete one or more activities (e.g. cutting fabric or managing clinical trials). (See Table 2 for the classification.)

Tangibility. An input's tangibility refers to the ability to execute the transaction entirely through an electronic network with currently existing technology. If the completion of the transaction required the transfer of a physical object between two firms then the transaction was categorized as tangible. If, on the other hand, it was technologically feasible to completely eliminate the exchange of material objects and still complete the transaction, then the input was considered intangible, regardless of whether a pair of firms actually used electronic networks. (See Table 2 for the classification.)

Variability. Variability is the extent to which the item being ordered, its availability, and its price vary over time. (Two items; Alpha=.68).

Predictability. Predictability is the extent to which respondents knew far in advance the specific input they would need and its quantity (e.g. "How much does the unit price of the [product or service] change from order to order?") . (Alpha=.79).

Time pressures are the respondent's judgment of the extent to which production in the firm was rushed and subject to rigid deadlines (e.g. "To meet schedules related to this product or service, we need to use every available minute efficiently.") (Three items; Alpha = .68).

Order frequency is a single item measuring the ordering cycle for the key input, from monthly to yearly.

Ease of description. Complexity of product description was operationalised in terms of how difficult it would be to describe the input so that it could be ordered. Respondents were asked to rate how easily the key input could be described ("It is difficult to describe the [input] we routinely acquire (reversed)". They also rated how quickly an expert could construct a description sufficient for ordering purposes ("It would take a knowledgeable person only a few minutes to create a description of the [input] that would be complete enough for ordering."). Surprisingly, these two items did not correlate highly with each other (r=.15) and were entered as separate variables in the analyses.

Table 2. Key inputs studied in each of four industries

Industry	Product		Service	
	Tangible	Intangible	Tangible	Intangible
Women's Apparel	Fabric Trim (buttons, zippers, etc.)	Garment Design	Cutting Services	
Advertising		Artwork & Graphics Television Time Slots		Television Ad Distribution Services Market Research Services
Pharmaceuticals	Chemical Ingredients Packaging Materials		Packaging Assembly Services	Clinical Trial Management Services
Magazine Publishing	Paper Stock	Stories	Printing Services	Color Work Services

Source: Charles Steinfield, Alice Chan Plummer (Michigan State University), Robert Kraut, Brian Butler (Carnegie Mellon University), Anne Hoag (Pennsylvania State University)

Relationship with the supplier

Supplier power is the strength of the major supplier in the industry and is the average of the respondent's estimate of the number of employees the supplier has and its market share. (Alpha=.73).

Trust is a two-time scale measuring the extent to which the respondent believed the prime supplier would refrain from malfeasance (e.g. "If they thought they could get away with it, this supplier would cheat us") (Alpha=.43).

Object specificity is the degree to which the key input itself is usable only by the focal producer firm. It was measured by the extent to which respondents agreed on a 5-point Likert scale with four statements, (e.g. "My firm is the only one that uses the input ", "The [input] we get from this supplier is fairly standard for the industry" (reversed) (Alpha=.64).

Knowledge specificity was measured with four items reflecting the degree to which employees at both the focal firm and the supplier have developed skill and knowledge for dealing with each other and the industry as a whole (e.g. "The supplier's personnel who work with us have a great deal of specialized knowledge about our company") (Alpha = .65).

Control variables

In all analyses we included dummy variables for industry and size of firm. The firm size variable is the average of the number of employees in the firm and the firms annual sales, first

standardized and then logged (Alpha = .91). The data were taken from Dunn and Bradstreet's 1996 listing for the producing firm.

Outcome variables

Satisfaction with a supplier is an index in which respondents indicated their overall satisfaction with the supplier, their satisfaction with six aspects of the ordering process, and their satisfaction with the supplier's ability to handle exceptional orders (9 items; Alpah=.89).

Efficiency of ordering. This index indicates the average elapsed time between ordering and receiving a input, the number of different people who are involved in handling the order, and the number of communications with the supplier during a typical order cycle. The answers were reverse and standardized before averaging. (3 times; Alpha=.48).

Order quality is an index representing the absence of errors in a typical order, including late arrivals, failure to meet quality standards, and containing any other error. (3 items; Alpha = .62).

Missing data

Most variables had only a few missing values. (See Table 3.) In the regression models that follow, we imputed values by replacing missing values with the overall sample mean. When imputing firm size we replaced the missing value with the average number of employees in the other firms in the appropriate size-industry category. Since attributes of the suppliers varied with the input being acquired, we imputed supplier power from the average of the non-missing values from firms providing the same input (e.g. from other fabric suppliers).

Result

Predicting Co-ordination Mode

Significant positive correlations among the three modes of co-ordination demonstrate that these modes are complementary methods, rather than opposing ones (See Table 3). Firms that use an in-house production strategy are more likely to use both electronic networks ($r=.37$, $p<.001$) and interpersonal relationships ($r=.16$, $p<.05$) to co-ordinate the acquisition of important production inputs. The reduced costs of deploying electronic networks in-house and of supporting interpersonal communication through physical proximity may account for these associations. Firms that use interpersonal contacts more in co-ordination are also more likely to use electronic networks ($r=.20$, $p<.001$).

The literature review identified a number of variables that theory leads us to expect would be associated with the selection of a co-ordination mode for dealing with a supplier. Regression analyses predicting use of each mode of co-ordination show that these variables explain a substantial amount of the variance in co-ordination mode choice, over and above variations due to industry norms and practices. However, different variables were associated with the different co-ordination modes. In each regression, dummy variables representing industry as well as the organisation size index were first entered as control variables. Together they only accounted for 5 per cent, 1 per cent, and 2 per cent, respectively, of the variance in use of in-house production, interpersonal relations, and electronic network use as co-

ordination modes, using adjusted R^2. Once product and supplier-relationship variables are taken into account, adjusted R^2 measures increase to 34 per cent, 18 per cent and 24 per cent (Table 4). Below, we explore the pattern of associations for each of these three dependent measures.

Table 3. Descriptive statistics and correlations among independent and dependent variables

Variable	N	Mean	Std Dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 In-house production	250	-.01	.88		.37	.16	-.09	-.05	.06	.15	-.31	-.02	-.18	.11	-.28	.00	.03	.23	.21	.11	-.09	-.09
2 Electronic networks	248	2.21	1.39	.37		.20	.07	-.26	.17	.05	-.25	-.03	-.11	.10	-.09	.01	-.20	.22	.25	.11	-.09	-.12
3 Personal relationships	248	4.07	.87	.16	.20		.00	.02	.08	-.09	-.01	-.07	-.11	.09	-.09	.14	-.14	.38	.19	.29	.16	-.01
4 Firm size	210	.00	.96	-.09	.07	.00		-.11	-.05	.03	.01	.17	.13	-.10	.17	-.02	-.01	.03	-.08	-.05	-.31	-.03
5 Ease of input description	248	3.43	1.34	-.05	-.26	.02	-.11		.12	-.09	-.03	.00	.10	.10	-.08	.01	.08	.03	-.21	.02	.02	.11
6 Ease of description for expert	247	3.25	1.41	.06	.17	.08	-.05	.12		-.02	-.10	.07	-.17	.11	-.11	.02	-.09	.14	-.10	-.04	.04	.06
7 Service (0 = product; 1 = service)	250	.41	.49	.15	.05	-.09	.03	-.09	-.02		-.10	-.10	.01	-.02	-.01	-.10	.07	.01	-.06	.05	-.11	.00
8 Tangibility (0=intangible;1=tangible)	250	.51	.50	-.31	-.25	-.01	.01	-.03	-.10	-.10		-.14	.00	-.14	.28	.19	-.07	-.02	-.07	-.10	.07	-.09
9 Variability	248	2.81	1.06	-.02	-.03	-.07	.17	.00	.07	-.10	-.14		-.03	-.04	.08	-.06	-.03	-.04	-.09	.00	-.16	-.07
10 Predictability	247	2.48	1.12	-.18	-.11	-.11	.13	.10	-.17	.01	.00	-.03		-.11	.10	-.19	-.03	-.14	.05	-.10	-.32	.02
11 Time pressure	250	4.41	.89	.11	.10	.09	-.10	.10	.11	-.02	-.14	-.04	-.11		-.13	.11	-.06	.18	-.13	.11	.09	.23
12 Supplier power	236	-.05	.92	-.28	-.09	-.09	.17	-.08	-.11	-.01	.28	.08	.10	-.13		.10	.00	-.03	-.22	-.20	-.06	.09
13 Order frequency	247	4.49	.98	.00	.01	.14	-.02	.01	.02	-.10	.19	-.06	-.19	.11	.10		.06	.13	-.06	.15	.23	.12
14 Trust	247	3.68	1.04	.03	-.20	-.14	-.01	.08	-.09	.07	-.07	-.03	-.03	-.06	.00	.06		-.08	-.16	.09	.03	.10
15 Knowledge specificity	249	3.02	.73	.23	.22	.38	.03	.03	.14	.01	-.02	-.04	-.14	.18	-.03	.13	-.08		-.04	.37	.07	.08
16 Object specificity	246	1.88	.82	.21	.25	.19	-.08	-.21	-.10	-.06	-.07	-.09	.05	-.13	-.22	-.06	-.16	-.04		.04	-.07	-.27
17 Satisfaction with supplier	238	4.25	.63	.11	.11	.29	-.05	.02	-.04	.05	-.10	.00	-.10	.11	-.20	.15	.09	.37	.04		.25	.19
18 Efficiency of ordering	246	-.01	.74	-.09	-.09	.16	-.31	.02	.04	-.11	.07	-.16	-.32	.09	-.06	.23	.03	.07	-.07	.25		.25
19 Order quality n (% correct)	247	88.74	15.59	-.09	-.12	-.01	-.03	.11	.06	.00	-.09	-.07	.02	.23	.09	.12	.10	.08	-.27	.19	.25	

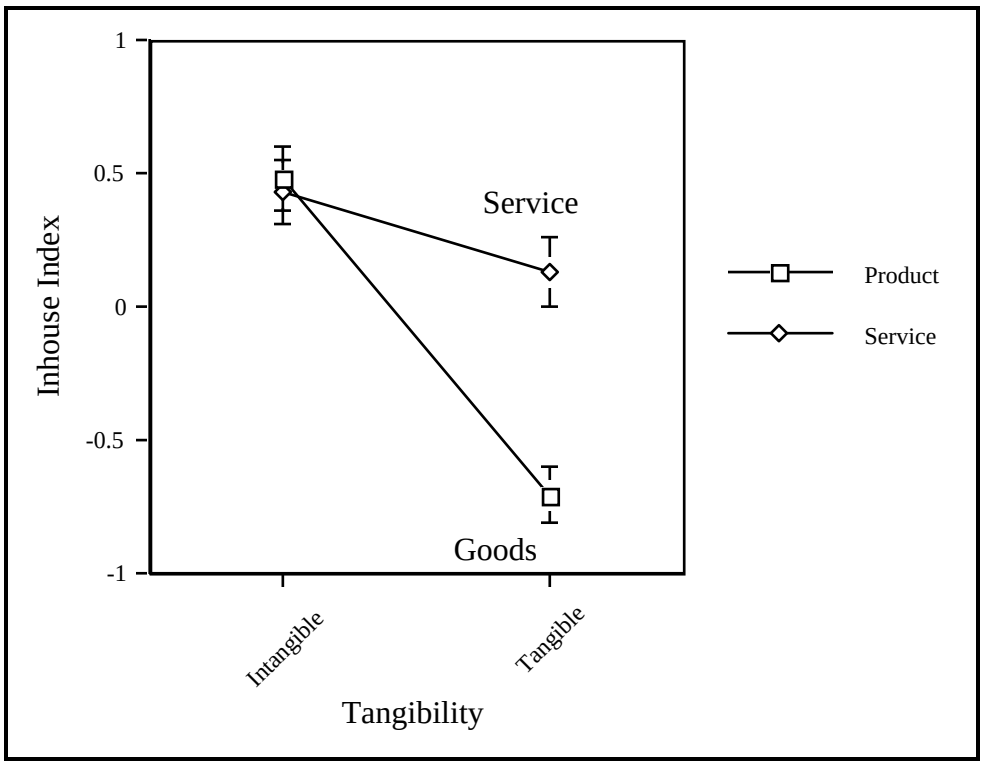
Note:
N=250.
For correlations, missing values have been replaced by imputed values.
$|r|>.124$, $P<.05$, 2-tailed
$|r|>.146$, $P<.01$, 2-tailed

Source: Charles Steinfield, Alice Chan Plummer (Michigan State University), Robert Kraut, Brian Butler (Carnegie Mellon University), Anne Hoag (Pennsylvania State University)

Make versus buy decisions

Model 1 in Table 4 shows the variables associated with a firm's decision to make an input in-house or outsource it. We expected that organisations would elect to internalize the production of needed inputs when inputs were more specific, complex, uncertain, and when suppliers were dominant. Results are basically supportive of these transaction cost theory expectations. We first looked at whether services rather than goods and intangible rather than tangible inputs were more likely to be made in-house. These expectations were confirmed. The interaction of these variables, shown in Figure 1, means that tangible products were more likely to be outsourced, while intangible products and both tangible and intangible services were all more likely to be produced in-house. Specifically, inputs such as fabric, trim, chemical raw materials, packaging materials, paper, and the time slots for advertisements[64], are more likely to be acquired externally. Garment designs, cutting services, artwork and graphics, stories, colourwork, television ad distribution, and packaging assembly are more likely to be accomplished in-house. The only services that are more likely to be acquired externally in our sample are printing services, which can be seen as commodity-like. Market research and clinical trial management services were intermediate in terms of in-house vs. external acquisition. The pattern of findings is consistent with transaction cost theory notions of specificity. That is, highly customizable types of inputs, where each input version is essentially unique to a producer, are more likely to be internalized. More commodity-like inputs, or those that can be supplied to multiple producers, enable the achievement of economies of scale and are more likely to be outsourced.

Figure 1. The Interaction Effect of Product vs. Service and Tangible vs. Intangible Input Characteristics on Make-Buy Decisions



Source: Charles Steinfield, Alice Chan Plummer (Michigan State University), Robert Kraut, Brian Butler (Carnegie Mellon University), Anne Hoag (Pennsylvania State University)

On the other hand, ease of product description and the amount of certainty about input features were unrelated to the degree of in-house production. The further firms knew in advance of their need for a particular input, the less likely they made it themselves, although this relationship was not strong (ß=-.10, p<.10). The ability to make orders well in advance of their need for inputs may make firms less vulnerable to poor supplier performance. On the other hand, the more frequent their need for an input, the more firms did use an in-house co-ordination mode (ß=.12, p<.05).

Table 4. Association of firm, product and production characteristics, and relationship with supplier on co-ordination mode.

Predictor	In-house Production		Personal Relationships		Electronic Networks	
Intercept	3.12		.09		1.13	
Publishing vs apparel	-.89	***	-.12		.18	
Pharmaceutical vs apparel	-.49	**	-.31		.30	†
Advertising vs apparel	-.79	***	-.28		.14	
Firm size	-.05		.06		.08	
Ease of input description	.01		.05		-.23	***
Ease of description for expert	-.02		.02		.15	**
Service	-.93	*	.14		-.36	
Tangibility	-2.06	***	.15		-.86	**
Service*Tangibility	.88	***	-.16		.25	
Variability	-.01		-.05		-.06	
Predictability	-.10	†	-.06		-.07	
Time pressure	.01		.03		.06	
Supplier power	-.12	*	-.02		.03	
Order frequency	.12	*	.09		.03	
Trust	.05		-.09		-.15	**
Knowledge specificity	.15	**	.35	***	.17	**
Object specificity	.17	**	.21	***	.18	**
N	250		250		250	
Df	17		17		17	
Rsq	.38		.23		.29	
Adjusted Rsq	.33		.17		.24	

Note. Entries are standardized beta coefficients from a multiple regression analysis.
† p < .10
* p < .05
** p < .01
*** p < .001

Source: Charles Steinfield, Alice Chan Plummer (Michigan State University), Robert Kraut, Brian Butler (Carnegie Mellon University), Anne Hoag (Pennsylvania State University)

Contrary to our expectations, the more dominant the supplier, the less a firm used in-house production (ß=-.12, p<.05). However, this seems to be an artifact created by the roughly one quarter of the sample for which an in-house division was the major supplier. Presumably, when a firm does in-house production of an input, the in-house unit is small relative to the industry as a whole and, given our measure of supplier power, appears to be weak relative to the buyer. The relationship between in-house production and supplier power disappears when we include in the analysis only the subset of the sample whose major supplier is an external organisation (see Table 5 in the following section).

Even after accounting for other product attributes, a central transaction cost expectation, that specificities will drive firms to internalize production capability, was supported. Both knowledge and object specificity were positively associated with an in-house co-ordination strategy (ß=.15, p<.01 and ß=.17, p<.01, respectively).

Interpersonal connections

Only two of our independent variables significantly predicted the use of interpersonal relationships as a co-ordination mode. In part, this may have been a result of the relatively high scores and limited variability on this variable. Mean scores on the items making up this scale suggest that in general, interpersonal relationships were very important in all aspects of a transaction (4.07 on a 5 point scale, s.d.=.87). Interpersonal relationships were likely to be more important for co-ordination, however, when specific knowledge is required to work with suppliers (ß=.35, p<.01) and when specific objects are required as inputs (ß=.21, p<.001). It is likely that greater interaction is needed here to ensure adequate co-ordination, given that inputs must have very particular attributes to be useful to the producing firm. Interestingly, trust was not significantly related to the use of interpersonal connections, although this failure to find a relationship may be due to low reliability of the trust measure.

Electronic networks

A different pattern of results is obtained when predicting the use of electronic networks for co-ordination. Respondents did not view that electronic networks were nearly as important as interpersonal linkages in co-ordinating transactions with suppliers (2.21 on a 5 point scale, s.d.=1.39). This difference is highly significant (t=19.62, p<.0001), with 207 firms reporting a higher interpersonal linkage score than an electronic linkage score. In fact, nearly half of the firms in the sample (117) reported that electronic linkages were not at all important in any part of the transactions associated with the acquisition of the input under question. This is contrasted with only 14 firms reporting that the use of electronic networks was very important in all aspects of the transaction in question.

Contrary to expectations derived from Malone and colleagues, firms used electronic networks more with inputs that were difficult to describe (Ease of description ß=-.23, p<.001). Paradoxically, our second measure of complexity -- the ability of experts to quickly provide a complete-enough description of the input for ordering -- had the opposite loading (ß=.15, p<.05); that is, when "knowledgeable" people could easily describe the input, electronic networks were used more in the procurement process. We believe that respondents interpreted the item to mean that an expert was needed for ordering, (i.e. inputs were complex). Assuming our interpretation is correct, both findings suggest that firms use networks more to acquire complex inputs rather than simple ones. However it may be that firms or industries have developed standardized ways of describing subtle variations in complex inputs. An order number may be sufficient to capture the otherwise infinite variation in fabric, for example. This is often done specifically for EDI use in particular industries. In this case, it may well be that an expert can quickly create a description complete enough for ordering, but nonetheless, the input itself could be quite difficult to describe to laypersons. Better measurement is needed to sort out these various explanations.

In keeping with our expectations, electronic network use was negatively associated with tangibility of acquired input (ß=-.74, p<.01), presumably because intangible inputs could be feasibly transmitted over a network. In our interviews, for example, magazine editors and art directors frequently described using electronic mail and shared file systems to exchange stories and artwork with their writers and artists.

Surprisingly, neither time pressure nor order frequency predicted electronic network use. Another somewhat surprising finding, given the findings from previous EDI research (Hart & Estrin, 1991), is that the lower the trust that producers had with suppliers, the more likely they used electronic networks (ß=-.15, p<.05). This may come about because firms are using electronic networks to monitor and control their transactions with untrusted suppliers.

Finally, greater knowledge specificity and object specificity were associated with increased use of electronic networks for co-ordination. It appears that networks were more likely to be used for more specific inputs, and when firms and suppliers had more specific knowledge about each other and their industry. It may be that electronic networks facilitated the sharing of complex data that permitted more specific, or custom inputs to be provided. This is consistent with Malone and colleagues (1987) notion of electronic hierarchies.

Markets versus hierarchy

Does the increased use of electronic networks with suppliers result in more market-like relationships with them? One test is to determine whether firms with heavier use of electronic networks are more likely to outsource. We examined this by adding use of electronic networks to the model shown in Table 4. As shown in Table 5, this results in an Adjusted R^2 of .39, which is significantly higher than the .34 from the model used in Table 4 ($p<.01$). The more firms use electronic networks, the more they acquire needed inputs from internal sources, however, rather than external (ß=.27, p<.001).

To determine whether this result came about just because internal networks are more common than external ones, and hence more likely to be used with internal suppliers, we examined the subset of the sample whose major supplier was an external organisation. Here again, network use was positively, associated (ß=.07, p<.01) with in-house production, albeit not as strongly. This finding again suggests that the more firms relied on electronic networks to co-ordinate the acquisition of important inputs, the more integrated they are with their suppliers. This is inconsistent with the view that network usage leads to greater outsourcing.

We also test to see if network usage had effects on make-buy decisions by moderating the effects of complexity, uncertainty and specificity. To do this, we examined the interaction of network use with each of the independent variables intended to measure these concepts included in the previous model. This analysis again focused on the subset of firms whose major supplier was external (although they still, of course, could have acquired some proportion of inputs from in-house sources). The set of interactions increases the variance explained in in-house production (Adjusted R^2 increases from .20 to .25, $F(13,154)=1.79$, $p=.05$). When firms have inputs that are difficult to describe and use electronic networks, they use in-house production more (ß=-.10, p<.01). In addition, when firms are under time pressure and use electronic networks, they use in-house production more (ß=.07, p<.01). Both findings are inconsistent with the hypothesis that use of networks eases restrictions on in-house production.

Effects of co-ordination mode on co-ordination success

Table 3 shows the correlations between using the three co-ordination modes and respondents' reports of their firms' co-ordination success in acquiring a key input. Respondents are more satisfied with their suppliers the more they used in-house suppliers ($p=.09$), the more they used electronic networks ($p=.08$), and the more they used interpersonal relationships as a basis for co-ordination ($p<.0001$). The association is reliably higher for interpersonal relationships than for the other mechanisms ($z=2.32$, $p<.05$ for use of networks and $z=2.21$, $p<05$ for in-house production).

Table 5. Predicting in-house production firm from electronic network use for the whole sample and for firms using external suppliers as their major supplier

Predictor	In-house Production All firms		In-house Production External suppliers		In-house Production External suppliers	
Intercept	2.82		.27		.14	
Publishing vs apparel	-.94	*	-.29	*	-.25	
Pharmaceutical vs apparel	-.57	*	-.22	*	-.20	
Advertising vs apparel	-.83	*	-.25	*	-.19	
Firm size	-.07		-.02		-.02	
Ease of input description	.07		-.01		-.03	
Ease of description for expert	-.06		-.04		-.06	
Service	-.83	†	-.19	†	-.15	
Tangibility	-1.83	***	-.54	**	-.50	**
Service*Tangibility	.81	***	.32	*	.29	**
Variability	.01		-.01		-.01	
Predictability	-.08		-.07	*	-.07	†
Time pressure	-.01		.03		.05	
Supplier power	-.13	**	-.01		-.02	
Order frequency	.11	*	.03		.02	
Trust	.09	†	.00		-.01	
Knowledge specificity	.10	†	.01		.02	
Object specificity	.12	*	.05		.06	
Electronic network use	.27	***	.10	**	.27	
Network use * Description ease					-.10	**
Network use * Expert description ease					-.02	
Network use * Service					-.04	
Network use * Tangibility					-.14	
Network use * Service*Tangibility					-.03	
Network use * Variability					.04	
Network use * Predictability					.04	
Network use * Time pressure					.07	*
Network use * Supplier power					.00	
Network use * Order frequency					.00	
Network use * Knowledge specificity					.02	
Network use * Object specificity					.02	
In-house production					-.01	
N	250		186		186	
Df	18		18		31	
Rsq	.43		.28		.38	
Adj Rsq	.39		.20		.25	

Note. Entries are standardized beta coefficients from a multiple regression analysis.
† p < .10
* p < .05
** p < .01
*** p < .001

Source: Charles Steinfield, Alice Chan Plummer (Michigan State University), Robert Kraut, Brian Butler (Carnegie Mellon University), Anne Hoag (Pennsylvania State University)

Respondents reported more efficient ordering when interpersonal relationships were the basis for co-ordination. Surprisingly they reported *less* efficient ordering when in-house production and electronic networks were the basis for co-ordination. Finally, they reported having *more* problems with order quality when electronic networks were used as a basis for co-ordination. Both results are inconsistent with the research literature on the effects of EDI on order processing, which has typically examined cases in which a single, relatively sophisticated firm, such as Chrysler, uses EDI with a variety of trading partners. These results may not generalize to the larger number of unsophisticated uses of electronic networks. The failure to replicate previous findings of improved outcomes with electronic network use may reflect the troubles that many firms have in mastering a complex technology.

Table 6. Association of co-ordination mode on co-ordination success

Predictor	Satisfaction with Supplier		Efficiency of Ordering		Order Quality	
Intercept	.12		-.36		.13	
Publishing vs apparel	.02		.30		.21	
Pharmaceutical vs apparel	-.05		-.03		.13	
Advertising vs apparel	-.02		.24		.38	
Firm size	-.05		-.24	***	-.03	
Ease of input description	.00		-.06		-.01	
Ease of description for expert	-.13	*	-.02		.05	
Service	.01		.14		-.13	
Tangibility	-.24		.39		-.26	
Service*Tangibility	.14		-.33		.07	
Variability	.07		-.12	*	-.12	†
Predictability	-.02		-.27	***	.06	
Time pressure	.02		.01		.17	**
Supplier power	-.20	**	-.04		.10	
Order frequency	.11	†	.10	†	.09	
Trust	.13	*	.00		.05	
Knowledge specificity	.32	***	.03		.07	
Object specificity	.00		-.08		-.19	*
In-house production	-.11		-.11		-.05	
Network use	.05		-.09		-.12	
Interpersonal relationships	.17	**	.14	*	.02	
N	250		250		250	
Df	20		20		20	
Rsq	.25		.29		.17	

Note. Entries are standardized beta coefficients from a multiple regression analysis.
† p < .10
* p < .05
** p < .01
*** p < .001

Source: Charles Steinfield, Alice Chan Plummer (Michigan State University), Robert Kraut, Brian Butler (Carnegie Mellon University), Anne Hoag (Pennsylvania State University)

Table 6 shows that co-ordination through interpersonal relationships continues to contribute unique variance in explaining the co-ordination outcomes, once product attributes, production attributes,

specificities, interfirm relationships, and use of the other co-ordination modes are entered into the model. Respondents are more satisfied with their suppliers and report more efficient ordering the more they use interpersonal relationships as the basis for co-ordination. In contrast, neither in-house production nor use of electronic networks reliably improves co-ordination success on any of the outcome measures, once other variables are entered into the model. Indeed, there is a suggestion that the use of electronic networks is associated with poorer order quality (i.e. more errors) ($p < .10$)

Discussion

Summary

Our findings about factors associated with a firm's make versus buy decisions are largely consistent with the transaction cost prediction that firms will make an input in-house when they are vulnerable to opportunism from a potential supplier. The results suggest that being one of a small number of firms who need the input can be a source of potential opportunism. In our sample, firms were more likely to outsource tangible products that they need as inputs; that is they outsourced commodities, such as trim, paper, chemicals and packaging materials, which are used by a wide range of firms. In contrast, they were relatively more likely to produce craft-like services or products in-house, such as garment designs, artwork, stories, or colour separation services. Even controlling for the tangibility and service nature of the input category, they were also likely to make in-house the inputs that the buyers perceived to be firm specific. For example, an advertising firm might have an employee create the graphics for a magazine advertisement for a particular model of an automobile, but use clip art to show the generic fruits and vegetables for a weekly newspaper ad for a grocery chain client. When the buying process required more knowledge of the industry, of the buying firm's requirements, or of a potential vendors' capability, they also were likely to make the input in-house rather than to outsource it. All three findings are consistent with the hypothesis that specificities lead to in-house production.

Firms can also avoid opportunism if they have more slack resources. Our finding that firms outsource more if they can predict what they need farther in advance is consistent with this hypothesis. Finally, firms will be less vulnerable to opportunism if their potential suppliers are not powerful (i.e. small and supplying only a fraction of the firms input). However, our finding that firms outsource more when they trade with a less powerful supplier may also have an alternative explanation. The association may come about because firms that make an input in-house may be small relative to the industry. We found no direct support in this study for Williamson's prediction that information impactedness, or in Malone's rephrasing, that difficulty of searching for or describing the input shapes the make versus buy decision. Neither of the items that asked about descriptions of the input were associated with the in-house index.

The use of interpersonal relationships and electronic networks are two mechanisms besides in-house production that help firms co-ordinate with suppliers of key inputs and lower the possibility of opportunism and other transaction costs. Firms in the four industries we studied used the three co-ordination modes in parallel. At odds with the implicit assumption of much discussion about EDI, the Internet, and other electronic networks, firms were not substituting electronic networks for interpersonal relationships. Those that heavily used electronic networks to co-ordinate transactions with suppliers were the same ones that heavily used interpersonal connections. Of these two co-ordination modes, interpersonal relationships were employed far more heavily than electronic networks.

As with the case of in-house production, firms were also likely to use both electronic networks and interpersonal connections more as co-ordination techniques when their inputs were firm-specific and

when the buying process required more firm and industry-specific knowledge. Perhaps because interpersonal connections were used so heavily in virtually all firms, few other attributes of the inputs, of the production process, or of the relationship between a buyer and a supplier were related to the use of interpersonal connections as a co-ordination technique. Electronic networks, as one might expect, were used more for transactions involving intangible services and products, presumably because the inputs themselves -- e.g. magazine stories, garment designs, or market research reports -- could be transmitted over the networks. Inconsistent with Malone's hypothesis that inputs that are easy to describe and search for would be exchanged electronically, we found the reverse. Electronic networks were used more when the inputs were difficult to describe and when it took expertise to create specifications complete enough for ordering purposes.

The data here allowed us to examine the hypothesis that increasing use of electronic networks as a co-ordination mechanism would lead to greater outsourcing of production. Our data are inconsistent with this hypothesis. Instead we find that the more firms use electronic networks with an external supplier the *more* they produce their key inputs in-house. That is, increased use of electronic networks is associated more with hierarchy than markets. This finding is consistent with the growing research literature showing that inter-organisational networks are associated more with hierarchical relations than market-based ones (Brousseau, 1990; Hart & Estrin, 1991; Keen, 1988; Malone & Rockart, 1993; Steinfield, Kraut & Plummer, 1995; Streeter, Kraut, Lucas & Caby, 1996).

We are making no claim here that use of networks leads to in-house production. Indeed, the most plausible interpretation is that the control and trust that results from ownership and from in-house production encourages firms to invest in greater network use. They may first do so for uses internal to their company and then as expertise and infrastructure are developed may extend this to outside suppliers as well. Indeed, the trade press reports that firms are using intranets rather than placing strategic company business on the public Internet; if this is indeed a common occurrence, then this use of electronic networks illustrates that firms desire a great degree of control and trust before they are willing to make such investments or share sensitive data. To tease apart causal direction will require longitudinal data.

The most counter intuitive finding from the research is that we did not find expected relationships between electronic modes of co-ordination and measures of the quality or efficiency of transactions. For two of the three outcome measures, greater use of interpersonal connections in support of the transaction was associated with better transactions. Inputs appeared to be relatively easier to order, as indexed by the amount of people and time involved, when firms relied on their interpersonal linkages for identifying and working with suppliers. Moreover, producer firms were more likely to be satisfied with their transactions to the extent they relied on interpersonal connections for co-ordinating with suppliers. Contrary to the expectations found in the information systems literature, greater use of electronic linkages was not associated with improved outcomes, and, indeed, we found a weak negative relationship between use of electronic networks with suppliers and the relative efficiency (percent of orders that arrive on time, without errors, or that meet quality standards) of transactions. Our findings thus add additional empirical evidence that productivity benefits of information technology investments are difficult to measure and observe in practice (Landauer, 1994; Roach, 1991). Product, transaction, and firm-supplier relationship attributes were more likely to influence outcomes than investment in electronic networks.

Caveats

Our conclusions must be tempered by several limitations constraining our ability to interpret these data. First, we are unable to offer any quantitative evidence for the direction of causation, given the

cross-sectional survey techniques used. This is a particular problem in trying to determine the extent to which electronic network usage influences firms' make-buy decisions. Our finding of a positive association between network usage and in-house production is generally inconsistent with an electronic markets hypothesis. Although we believe that the most plausible interpretation for this finding is that firms first develop an in-house capability for producing needed inputs, and then subsequently interconnect the related units with intra-company local and wide area networks, we cannot confirm this without historical and over-time data.

The same problem exists in interpreting the positive association between electronic network usage and interpersonal connections as co-ordination modes. It may be that the very act of putting in and working with electronic connections causes a greater need for complementary interpersonal co-ordination. Or, pre-existing relationships that lead to more interpersonal co-ordination may have lead firms to be more willing to attempt electronic support for transactions. Given that in-house co-ordination was also positively associated here, the most plausible explanation is that opportunities for interpersonal co-ordination are greater with in-house people, and the requisite control and trust is there for electronic connections. Again, our data are not sufficient for teasing apart these various interpretations.

The research reported here also suffered measurement limitations. For a few of our measures, scale reliabilities were low. In one case, for the measure of complexity (ease of product description), we were not able to construct a scale at all, and used only individual items. Our attempt to develop a trust scale also was not very successful, and we were forced to use a two item scale. In general, our dependent measures were reliable, although one outcome measure, ease of the ordering process, did have a relatively low reliability score (alpha=.48 for a three item scale). In those cases where we were unable to find significant relationships, we cannot rule out measurement problems as a potential reason.

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Appendix 1: Scale Items

Time Pressure (Alpha = 0.68)

To meet schedules related to this product or service, we need to use every available minute effectively.
In developing, producing, and distributing this product or service we have to meet tight deadlines.

Ease of Description Items

It is difficult to describe the [product or service] we routinely acquire. *
It would take a knowledgeable person only a few minutes to create a description of the [product or service] we use that would be complete enough for ordering.

Variability (Alpha = 0.68)

How much does the availability of the [product or service] change over the course of a year?
How much does the [product or service] your company needs change from order to order?
How much does the unit price of the [product or service] change from order to order?

Supplier Power Alpha = 0.73

Approximately how many employees does this supplier have? 1. Fewer than 20 2. Between 20 and 99 3. Between 100 and 499 4. 500 or more
Would you say that this supplier is one of the ten largest sources in the United States for [this product or service], in terms of volume, a major source but not in the top-ten sources, an average source, or a smaller than average source? (reversed) 1 Top ten 2. Major, but not top-ten 3. Average 4. Smaller than average 5. Not in this country

Predictability (Alpha = 0.79)

For a typical [product or service], how far in advance can you predict what [product or service] your company will need? 1. Within a week of when you'll need it 2. Within a month 3. Within three months 4. Within six months 5. More than six months from when you'll need it

How far in advance can you predict the quantity of [product or service] your company will need? 1. Within a week of when you'll need it 2. Within a month 3. Within three months 4. Within six months 5. More than six months from when you'll need it

Order Frequency

How often do you acquire [the product or service] from this supplier? 1. At least monthly 2. At least every three months 3. At least every six months 4. At least every 12 months 5. Less frequently than every 12 months

Trust (Alpha = 0.43)

To avoid problems with this supplier, it is necessary to specify all terms of the agreement in a formal, enforceable contract. *
If they thought they could get away with it, this supplier would cheat us. *

Knowledge Specificity (Alpha = 0.65)

The people in my company who work with this supplier have a great deal of knowledge about the supplier's products or services.
The knowledge that that we have gained through working with this supplier would apply equally well to other potential suppliers of [this product or service].
The supplier's personnel who work with us have a great deal of specialized knowledge about our company.
The knowledge that the supplier's personnel have about our company would apply equally well to other firms like us.

Object Specificity (Alpha = 0.65)

My firm is about the only one that uses [this particular product or service]. 1 : Strongly Agree - 5 : Strongly Disagree
The [product or service] we get from this supplier have certain features that are only useful to us. 1 : Strongly Agree - 5 : Strongly Disagree
Many other companies use the same types of [products or services] when they develop, make and distribute [their products or services]. 1 : Strongly Agree - 5 : Strongly Disagree
The [products or services] we get from this supplier are fairly standard for the industry. 1 : Strongly Agree - 5 : Strongly Disagree

In-house production (Alpha=.86)

The next set of questions asks about your company's dealings with one supplier of [good or service]. Think about the most important supplier you've worked with in the past 12 months. This supplier can be a person or department in your own firm or an outside individual or another company. Is this supplier: An individual or departments within your firm; A partly or fully owned subsidiary of your firm. Another firm which is your partner in a joint venture. Outsiders (individuals you don't employ or suppliers in which your firm has no ownership stake).
What percentage of [the input] does your firm get from in-house sources?

Electronic networks (Alpha = 0.93)

An electronic connection is one that connects your computers with each other and with computers from outside your company. When we refer to electronic connections here we mean any type of computer communication which allows you to exchange information with this supplier. We include modem connections, local area networks, online databases, electronic mail, electronic data interchange, Lotus Notes, or the Internet.
Using a five point scale where "1" is very important and "5" is not at all important, please tell me how important electronic connections are to the following items, or tell me if you don't use electronic connections at all for that purpose. How about...?
a. In selecting this supplier
b. Developing the specification of the [product or service] your company orders
c. The negotiation of agreements to acquire [the product or service]
d. Getting [the product or service]
e. Monitoring the quality of the [products and services] you receive
f. Fixing problems after you have ordered [the product or service]

Interpersonal co-ordination (Alpha = 0.85)

Now I'm going to ask you about the importance of interpersonal relationships in selecting and working with this supplier. When I refer to "interpersonal relationships" I am including any type of personal connection or personal knowledge between people in your firm and people in the supplier's organisation. Using a five-point scale where "1" is very important and "5" is not at all important, please tell me how important are interpersonal relationships in...?
a. Helping your company select this supplier
b. Developing the specification of the [product or service] your company order[s] from this supplier
c. The negotiation of agreements to acquire [the product or service]
d. Getting [the product or service]
e. Monitoring the quality of the [products and services] you receive
f. Fixing problems after you have ordered [the product or service]

Satisfaction with supplier Alpha = 0.89)

Using a five-point scale where "1" is extremely satisfied and "5" is not at all satisfied, how satisfied are you with the follow aspects?
a. The supplier's ability to handle a rush [order]
b. The supplier's ability to handle an out-of-the-ordinary [order]
c. That you have identified the best supplier
d. That your company can easily specify exactly what you want from your supplier
e. The terms your company is able to negotiate
f. The efficiency with which your company gets [the product or service]
g. Your company's ability to monitor and evaluate [the product or service] quality
h. Your company's ability to fix problems with this supplier
Using the same five-point scale, please tell me how satisfied are you with this supplier overall?

Order efficiency (Alpha = 0.48)

When you are processing a typical [order] for [this product or service], approximately how many different people in your firm would be involved with it, from the time it is placed to the time it is actually received?
During a typical cycle, from the time you think you need [the product or service] to the time the order is complete, how many times would someone in your firm communicate with the supplier?
Approximately how much time would elapse from when your company places a typical [order] for [this product or service] to when you would actually receive it?

Order quality (Alpha = 0.62)

Now I would like to ask you about the quality of the orders you have placed with this supplier over the past 12 months.
What percentage of these [orders] arrived after your targeted delivery date?
What percentage of these [orders] had an error of any sort?
What percentage of these [orders] did not meet your quality standards?

Note: For attitude statements, most items were represented as a 5-point Likert scale, where 5 meant strongly agree with the statement and 1 meant strongly disagree with the statement. Statements marked with a star "*" have been reverse.

The Telecommunications Act of 1996: Reducing Regulation to Spur Competition

R. Clark Wadlow, Sidley & Austin

On February 8 of last year, President Clinton signed into law the Telecommunications Act of 1996, the most comprehensive restatement of US Communications Policy in the more than 60 years since the adoption of the Federal Communications Act of 1934.

The 1934 Act had been adopted at a time when the world was a much simpler place. The existing communications technologies were comprised almost entirely of Wireline Telephone and Telegraph Service, and of AM Radio Broadcasting. The 1934 Act created a regulatory scheme based upon a rigid compartmentalisation of those services, which was designed to protect the consumer from monopolistic and oligopolistic service providers. It was classic utility regulation, based on the nineteenth century model of the interstate commerce commission.

Throughout the intervening years, the Federal Communications Commission adhered strictly to that compartmentalisation. As new technologies were developed, the FCC wrestled with how to fit them into the existing regulatory scheme. For example, the FCC struggled from the late 1950s until 1972 before deciding that it had the implied statutory authority to regulate cable television systems and that its authority to do so was "ancillary" to its power to regulate broadcasting.

The 1996 Act represents an entirely different approach. It attempts to address the realities of today's converging markets by eliminating regulatory barriers and encouraging competition in virtually every sector of the communications industry.

To understand the significance of the 1996 Act, and to appreciate why it took so long to achieve a new regulatory paradigm, one must understand that US Communications policy is not formulated by any monolithic agency with autocratic power and authority. Rather, such policy is determined through a process of negotiation and compromise involving a large number of players.

Within government, the FCC not only implements policy, it also has a strong voice in defining the issues and proposing solution. The administration generally is represented by the National Telecommunications and Information Administration, a component of the Department of Commerce, and the White House itself is often quite outspoken on communications issues.

In Congress, the powerful House and Senate Commerce Committees have jurisdiction over communications. There is often tension between those two committees, as well as between Democrats and Republicans. In Congress, there is also tension between communications policy, on the one hand, and, on the other hand, other policies, such as budgetary concerns, copyright policy, national defence, and other politically sensitive matters.

The states also have a role in the development of communications policy and the regulation of the communications industry. While communications is largely a part of interstate commerce, there are

uniquely local concerns that often come into play in such diverse areas as the use of local rights-of-way, the availability of spectrum for local police departments, and the definition of "Universal Service".

Additionally, the various industries, through their key members and through their trade associations, also play an important role in the process of policy development. Congress is often reluctant to adopt legislation affecting competing industries unless it reflects a compromise that has first been agreed to by those industries. That is not to suggest that the industries necessarily have an informal veto over legislation affecting them. Rather, it is politically easier for congress to adopt legislation that is perceived by all affected to strike a fair balance.

Finally, of course, the voice of the public itself is heard through public interest groups that speak for consumers and that are able to mobilise grass-roots campaigns to ensure that Congress does not ignore their views.

All these players had significant roles over the many years that were required to secure passage of the legislation that became the 1996 Act. Their input is reflected in the new Act in the various compromises struck and in the balance whereby each industry freed to enter new markets must in turn face new competition from new entrants into its primary market.

Perhaps the most significant feature of the 1996 Act is that it overturned the restrictions contained in the 1982 AT&T Antitrust Consent Decree and the Modified Final Judgement, or "MFJ". By its terms, the MFJ had mandated that AT&T divest itself of its subsidiary companies, which then provided monopoly local telephone service. As a result, the seven regional Bell operating companies, or "BOCS", were created. The BOCS were permitted only to provide local telephone service in their geographic regions. They were prohibited from providing long distance service and from manufacturing telephone equipment. In turn, AT&T was permitted to remain in the long distance and manufacturing businesses and prohibited from providing local exchange service.

As a result of the MFJ and of certain FCC actions in the area, the long distance market has evolved into a highly competitive one, with more than 500 service providers, or inter-exchange carriers ("IXCS"), including, most notably, AT&T, MCI and Sprint. In contrast, despite FCC efforts, the local telephone market has remained comparatively monopolistic in nature.

Under the new Act, the IXCS, including AT&T, are free to enter the local telephone market almost without regulatory restriction. The BOCS are required to open up their local markets to such competition. The terms of IXC and the local telephone company. If the parties are unable to reach agreement, there are procedures for arbitration and review. Those negotiations and arbitrations are now proceeding in markets all across the country.

In return, the BOCS are immediately permitted to provide long distance service outside their local service areas and to enter into manufacturing. However, the BOCS are not permitted immediately to provide long distance service within the most important areas, their own regions. In that regard, the Act reflects a continuing concern, the one upon which the antitrust case against AT&T had been based, that a provider of both local and long distance service could use its local monopoly to the disadvantage of its long distance competitors unless it faced competition in the provision of local service. Accordingly, the Act requires competition in its local market before a BOC can provide in-region long distance service. There are two devices used in the Act to achieve this goal. First, the Act requires that the BOCS demonstrate compliance on a state-by-state basis with a 14-point competitive checklist designed to ensure that other local service providers can obtain non-discriminatory interconnection and address to the local

facilities of the BOC. Second, the Act pre-empts all state and local regulations that restrict or prohibit competitors from providing local telephone service.

The ultimate objective of both the IXCS and the BOCS, as well as the other providers of local service, is apparent: they all intend to provide "one-stop-shopping" or integrated local and long distance service, with one bill for such telephone service to each customer each month.

By eliminating regulatory barriers and encouraging competition, the new Act also facilitates major consolidation among incumbents. For example, less than two months after the Act became law, two of the seven BOCS, Bell Atlantic and Nynex, announced a similar plan. Those agreements represent consolidations of BOCS in neighbouring regions. Those consolidations could have significant impact upon the development of local exchange competition within those expanded regions. They could also impact the long distance markets in those regions, whether they delay or hasten the entry of those BOCS into long distance. If those mergers are approved by the Justice Department and the FCC, the new entities will be the second and third largest telecommunications companies, behind only AT&T.

The 1996 Act also addresses competition in the video marketplace. The previous statutory ban on the provision of video services by telephone companies within their service areas has been eliminated. Telephone companies are now permitted to provide video service through any of three means. First, they can construct traditional cable television systems. Second, they can utilise frequencies available for "wireless cable" -- a form of multichannel video transmission in bands outside the broadcast band. Third, they can provide cable service through a new "open video service" which is largely free of the federal, state, and local regulation imposed on cable but which also requires that two-thirds of its capacity be made available to independent programmers on a common carrier basis. The sole remaining prohibition is that telephone companies cannot simply acquire control of existing cable systems within their service areas. The objective of that prohibition is to foster the competitive benefits of having two wires, one telephone and one cable, into the home wherever feasible. As in the case of local telephony, the Act is premised on the belief that cable competition will be most effective if it is facilities based.

In addition, the Act retained the programme access provisions of prior law. Those provisions mandate that those programmeming services that are owned and controlled by the cable industry, including many of the most popular programmeming services, such as HBO and CNN, must be made available to competing multichannel video programmers. Accordingly, such services cannot be denied to direct broadcast satellites, wireless cable, or the new telephone company entrants into the video distribution marketplace.

There are, however, also benefits to cable in the new act. While the cable industry now faces considerable potential competition, it is also freed from much of the restrictive regulation imposed upon it at the time of the adoption of the 1992 cable act. For example, the cable industry is freed of rate regulation, except basic broadcast service, upon the development of competition from the local telephone company or, in any event, three years after enactment.

Another major industry directly impacted by the new act is the broadcasting industry. In recent years, over the air the broadcasting industry has faced ever increasing competition from cable television and other multichannel video programmers. Those competitors enjoy the advantages not only of multiple channels, they also enjoy the benefits of dual revenue streams -- advertising revenues and subscriber fees.

The new act substantially liberalises the number of broadcast stations that one entity may own by eliminating all national radio ownership limits and by relaxing the national television audience reach limits. Moreover, the new law relaxes the restrictions on local radio station ownership, allowing a single

entity to own as many as eight radio stations in the larger radio markets. The local television ownership rules, and the newspaper/broadcast cross-ownership prohibition are left largely intact, pending further FCC action. The immediate reaction from the broadcasting industry has been a virtual snowstorm of mergers and acquisitions as groups consolidate and take advantage of new opportunities. Indeed, there is some concern that the creation of the radio super-groups may create a backlash and it appears that the justice department may take a more active and aggressive role with regard to broadcasting mergers.

The new act also permits television broadcasters to use their spectrum for certain non-broadcast services in the event the FCC grants them a second channel for transition to digital advanced television ("ATV"). This new flexibility could be an important step forward in that it could permit broadcasters to develop a second revenue stream from the use of their spectrum.

The FCC has been considering the transition to ATV for a number of years. The pending proposal would permit each television broadcaster to continue to broadcast in an analogue mode on its existing facilities while being issued a license for a second channel on which it would broadcast digitally. After a period of some years, during which consumers would have an opportunity to purchase and begin to utilise digital television sets, broadcasters would be required to turn in one of their two channels. The television band would then be auctioned off for other uses. There are obvious budgetary concerns that impact this process. Some in Congress have estimated that the auction could generate as much as 34 billion dollars. There are pressures to accelerate the process so that those monies can be used to achieve a balanced budget. The broadcast industry responds that acceleration could be disruptive of the transition, to the detriment of consumers.

There has also been an ongoing debate as to the standard to be adopted for digital television. Hollywood and the computer industry, as well as broadcasters and the consumer electronics industry, have divergent interests. On the one hand, there is concern that the lack of a strong standard agreed to by all industries could seriously compromise the prospects for ATV. On the other hand, there is a concern that a standard that is too restrictive could thwart innovation.

There is one area in which the act appears to depart from its general de-regulatory effort and to impose a new set of regulatory strictures. That is in the area of content regulation, a particularly troublesome area given the broad language of the first amendment to the US constitution.

First, the act requires that new television sets be equipped with a device, nicknamed the "V-Chip", which can be used by parents to block access to violent or sexually explicit television programmeming. The broadcasting industry is directed to establish a "voluntary" system for rating such programmeming, and the FCC is directed to intercede if the industry's efforts are not satisfactory. The system is defended as one that merely empowers parents to defend their children against offensive programmeming. It is attacked as a form of government-sponsored censorship.

Second, the act prohibits any person from sending patently offensive communications to a minor or from making such material generally available over the Internet. The American Civil Liberties Union has already received an injunction against enforcement of the Internet provision. Indeed, the US Supreme Court is scheduled to hear argument in that case, ACLU v Reno, on March 19. The ruling in that case may have far reaching implications.

As I stated at the outset, the primary goal of the 1996 act was to eliminate regulatory barriers that impede competition in the delivery of communications services. Ultimately, competition is intended to supplant regulation as the means by which the conduct of service providers will be checked. Toward

that end, the act jettisons many of the structural regulations that have for so many years compartmentalised the communications industry.

The problem is one of ensuring fairness in the interim, until the various markets become fully competitive. The consumer should not be disadvantaged during the transition. Moreover, new entrants are susceptible until such time as they have established themselves.

The solution offered by the act is one that might be called "managed entry". For example, if long distance carriers are not able to negotiate fair and reasonable terms of entry into the market for local exchange service, they are afforded the opportunity for arbitration and review. Furthermore, markets are opened to new entry on a reciprocal basis. Thus the monopolistic local telephone service provider is not permitted to offer long distance service to its customers until such time as it faces meaningful competition to its local telephone service.

Efforts are also made to foster competition to the other notable local monopoly, cable television. The telephone industry is permitted to enter that market and has been accorded the choice to do so free of most of the federal, state, and local regulatory burdens imposed on cable television. DBS has been given access to cable programmeming services in order to enable it to compete with cable on other terms, such as price and picture quality. Broadcasters are given opportunities to offer other services, to enter the digital age, and to achieve economies from consolidation.

On the anniversary of its passage, many observers questioned whether or not the 1996 Act has been a success. Senator McCain, the new chairman of the Senate commerce committee, has been highly critical of the act. His position is that the old regulatory scheme was succeeded, not by competition, but by "managed fair competition", which by its terms requires ongoing regulation.

Others have noted that both cable television subscription rates and local telephone bills have risen an average of 10 per cent in the past year. The mergers that have occurred at a frantic pace in the past year seem to have all been in-market consolidation, not reflective of any trend toward convergence. While DBS is growing, it still suffers from an inability to offer local signals. Furthermore, so far there is little evidence of cable television entry into telephony or telephone company provision of video services, by OVS or otherwise. Most damning, the pace of competition in each other’s market between the local and long distance telephone companies has been disappointingly slow.

However, it has been only little more than a year. The FCC has commenced more than 80 proceedings mandated by the act. Many are yet to be resolved. The negotiations and arbitrations leading to competition in the local exchange market, which in turn is a prerequisite to further competition in the long distance market, are moving along. Competition between cable and telephone in each other’s market will require massive amounts of capital and thus cannot be expected to happen quickly. In video, the digital revolution is about to explode and the remaining copyright issues affecting DBS are likely to be resolved soon. Perhaps unrelated, but also perhaps most significantly, the Internet continues to grow at exponential rates. In fairness, it is undoubtedly too early to judge whether or not the 1996 act will be successful in achieving its stated goals.

As a final thought, many believe that the pace of change is accelerating at rates beyond our present comprehension. If we look back the roughly 50 years to the end of World War II, and could quantify the technological changes from then to the present, we should anticipate the same quantity of change over the next 5 or 10 years. If that startling proposition is true, it will provide great challenges to policy makers and tremendous opportunities for the industries.

Interoperability - help or hindrance to the Information Society?

Peter Walker, OFTEL

Introduction

Ever since the world first heard of the 'Information Superhighway' and later the 'Information Society', the concept of interoperability has been mentioned as one of the many required components to achieve these long term goals. This immediately raises two questions. What do we mean by 'interoperability' and why are we so convinced it is a 'public good'?

This paper explores the concept of interoperability and whether it is always beneficial. In some cases it may promote competition and consumer welfare; in others it may restrict innovation. Very often the market will decide whether interoperability is desirable and agreements on interconnection and common standards will follow. Where this does not naturally arise, regulators are often called upon to impose interoperability. When should the regulator intervene and how?

What is interoperability?

The terms interconnection, interworking and interoperability are often used interchangeably. In this paper I use the term interconnection to mean the physical and logical connection of two networks, thereby allowing the customers of one to connect with customers on the other, or to access services provided from the second network. The term 'interworking' usually describes the protocols by which two networks or systems communicate when interconnected. I use the term 'interoperability' to mean the technical features of a group of interconnected networks or systems which ensure end-to-end provision of a given service in a consistent and predictable way. This may not be everyone's definition. In particular, it does not necessarily mean that all component parts of the systems conform to the same standards or protocols and are thus to a degree interchangeable. In other words, while interoperability costs may be minimised and flexibility maximised by adopting uniform standards throughout a set of systems, interoperability may nevertheless be achieved by protocol translation at interworking points with the same end result. This forms an important distinction for regulators. While voluntary adoption of common protocols may often occur in the market place, it is not usually the case that the internal arrangements of regulated entities should be subject to the regulator's discretion, only the end product of a given system.

Service interoperability

In a telecoms environment, interoperability may require appropriate conformance to particular protocols or interfaces between the originating customers' equipment at one end of a connection with the serving public network operator, between interconnected public operators and finally between the final public operator and the terminating customer's equipment. The situation may be complicated by the presence of quite complex customer networks or intervening service providers. Some services may require detailed conformance by all these players to achieve end-to-end interoperability, while in other cases, some services may, through the adoption of a layered approach, require little of the public network(s). In this latter case, interoperability is primarily achieved by compatible customer equipment.

For example, many advanced ISDN services require adherence to the relevant ISDN standards for the end-to-end teleservice to be delivered. In contrast, many quite advanced data services can be supported across the public network(s) by the use of modems and compatible data terminals. The public network(s) only have to provide a simple voice channel for the modems to communicate over.

In these circumstances, the interaction of market players will be impacted by which parts of the overall system they control, thus the role of the regulator, if any, needs to take account of this potentially wide scope of interoperability scenarios.

Interconnection and interoperability

From the earliest stages of the introduction of competition into telecommunication services, it has been recognised that interconnection between systems is essential to promote such competition. No customer would opt to move entirely to another Public Telecom Operator (PTO) if he or she could only dial those few customers that had chosen to move too. Interoperability of services between networks was implicit and caused few problems with the interconnection of simple voice telephony calls. The ability of every customer to be able to make calls to any other customer, irrespective of which network the other customer is connected to has often been called the 'any-to-any' principle, though it has never been formalised in a regulatory definition to date. Once this principle was recognised, the focus fell on how to arrange for the physical interconnection of networks and the price of services offered across such interconnect points. In the early days, the actual services provided were the simple origination and termination of telephone calls and interoperability was synonymous with interconnection, both being achieved through the provision of compatible signalling across the interface.

Since that time, a range of new services has emerged. Some, like ISDN, have been voluntarily offered as interconnect services, while some others, such as Virtual Private Networks, have not and have often become the subject of regulatory determinations. There are some arguments in favour of mandating service interoperability as it widens the addressable market for a service, but others suggest this would weaken the benefits of innovation. A clear framework is therefore needed to provide guidance on what services ought to be interconnectable and interoperable. Flowing from this is the issue of how the technical arrangements needed to ensure interoperability are also achieved in a way that promotes effective competition and provides incentives to innovation.

Voluntary adoption of interoperability

In many cases, interoperability will be voluntarily sought and agreed by the various involved parties. This is especially the case where no one party controls the entire end-to-end system. Service providers will want to maximise the addressable market for their service. Equipment suppliers will want to minimise technical variants to encourage a larger market and lower unit costs, which may help promote interoperability, though as mentioned above, this might not always be a necessary part of achieving this goal.

In other cases, *de facto* standards lead to interoperability being achieved by consent. In the face of delays from formal standards bodies and the desire to avoid the imposition of undesirable *de facto* standards, there has been a trend towards the emergence of consensus bodies which seek standards harmonization by the mutual recognition of common commercial interests. Examples include DVB, DAVIC and the ATM Forum.

Regulated interoperability

Some market players may not want interoperability. Indeed, the basis of much competition is the creation of an exclusive differentiated service from which the player can extract good financial returns at the expense of other market players. An adequate return is necessary to ensure that such innovation is worthwhile. If the player has not sought to widen the addressable market through interconnection, it might be assumed that the exclusive approach has been determined to be that which maximises profits. Hence, the regulator might well decide to leave well alone.

The general presumption is that regulation is only required where there is a market failure of some description; that is, left to itself the market would not provide the type and level of service wanted by customers at appropriate prices.

There are two potential sources of market failure in the area of network interoperability: the first concerns the externality associated with telecommunications networks which involve both the making and receiving of calls by different parties. This line or call externality which is commonly found in telecommunication networks suggests that normal market mechanisms might not take full account of the resulting benefits to customers of more widespread interoperability. Overall welfare might not be maximised by the independent choices of operators and service providers to maximise their own individual profits.

The second source is the existence of dominance in the provision of telecommunications services arising primarily from the unusual cost structures that provide very high levels of economies of scale (usually in the form of economies of density) and scope, and the previous operation of the sector as a statutory monopoly. This is usually associated with the existence of a network operator with significant market power (or dominance) in the major markets it operates in. Such an operator may not have the traditional commercial incentives to offer interoperability with other (much smaller) operators where there is actual or potential competition between them. The issue is one of asymmetry in that whilst the smaller operator needs access to the existing, ubiquitous network in order to compete, the dominant network does not significantly improve its commercial position by allowing access from a smaller operator.

A further aspect of this asymmetry is the ability of the dominant operator to decide on the standards or specifications to use for new services or interfaces. Through this there is a risk that an inappropriate standard might be imposed on the wider market, which creates extra costs or technical barriers to achieving interoperability. In extremis, the dominant operator might impose a standard with the express purpose of raising other operators' costs.

There is also an important issue of timing. On the one hand, innovatory operators will wish to maximise their profits through exclusivity. On the other hand, competitors will often follow the innovation with their own competing offering. After a time, the benefits flowing from the particular technical offering will contribute little benefit to either the customer or the operator and customers will call for interoperability with a wider market. Technical standards will then emerge to allow interworking between differing systems and interoperability between customers. Such standards have for obvious reasons been termed "exhaustion standards" (by Dr David Leakey) as they emerge only when benefits from technical differentiation have been exhausted.

In summary, the combination of the external benefit arising from wide network accessibility and the current market structure of a network operator with significant market power enjoying material economies of scale and scope, provides the rationale for regulation of interoperability.

How and when should the regulator intervene?

There are particular problems with regulatory intervention. By seeking to impose interoperability, the regulator may delay introduction of a given service and therefore slow down the benefits of innovation. Secondly, by seeking to impose a standard interoperable solution, a solution which better meets customers' needs may be suppressed, when it might otherwise have emerged as part of the competitive process. This is the main source of tension between seeking to achieve interoperability and promoting maximum innovation. There is a risk that regulatory intervention will lead to lower consumer welfare than if the market had been left to itself, notwithstanding that some anti-competitive effects might go without redress.

Thus for the regulator, the aim of any intervention must be to ensure that it bites only in cases where this risk is minimal and/or the potential gains are high. Therefore regulators should only enforce interoperability in cases where we are sure it will widen the addressable market for services and have the minimum impact on innovation. At the same time, in line with regulators' overarching objectives, they should seek to implement a policy which will promote, rather than restrict, effective competition between operators and service providers.

There is a critical distinction which can be drawn in this respect between services where the public operators have almost the exclusive ability to provide because of the close relationship to their ownership of the network infrastructure and those other services where market entry is as easy for independent service providers as it is for network operators. Even where there are high degrees of overlap in these distinctions, economic factors usually prevail which give one or another type of player an advantage for any given service. Advantages of economic scale and scope can often be outweighed by dynamic efficiencies of new market entrants.

In most advanced countries, regulators' scope to intervene has been restricted to public telecom operators. Services provided by independent service providers are almost always fully liberalised. It therefore seems self evident that regulators could not in practice intervene successfully in fully liberalised markets. The most governments will tend to do is to facilitate the ability of the market to come to a consensus on standards which promote interoperability.

It therefore seems sensible that for the range of enhanced services which we see provided by independent service providers, there should be no *ex ante* regulation, though competition authorities will wish to take action in cases where dominance appears to be an issue. Such has been the case in the "MSN/Windows 95" case and at the present time with conditional access services on digital broadcast systems.

Should all PTO services therefore be regulated in favour of interoperability? In order to explore this issue, it is first useful to analyse the types of service which tend to be the exclusive preserve of PTOs.

A service taxonomy

Firstly, there are the basic conveyance services, services which are often disparagingly described as 'bit transport': telephony, telex, ISDN and some other basic data services.

Secondly, there are the supplementary services associated with the basic conveyance services, such as Call Waiting, 3-Way Calling, Alarm Calls, Calling Line Identity Display and Ringback-when-free. These cannot technically be provided by another party; they can only technically be provided by the

operator who supplies the basic service. There are also a group of services where the economics of provision by the PTO who provides the basic service is such that market entry by others is virtually foreclosed. Examples include ISDN D channel delivered services, data over voice (for telemetry or alarms) and new techniques for delivering broadband services over conventional telephone lines such as ADSL. I have called these "line sharing services". While different in kind, new services like "No-Ring Calls" exhibit similar economic characteristics.

Thirdly, there are some more advanced conveyance services, such as Virtual Private Networks, 800 service and even Personal Numbering services, where market entry is possible by third party providers, but regulatory intervention to ensure a "level playing field" by insisting on comparable "arms length" operation (e.g. accounting or business separation) would not bring sufficient benefits to outweigh the disadvantages of denying the PTO the benefits of scope economies. Such conclusions may be reached when there is active competition from other non-dominant PTOs who would not normally be subject to such regulation in any event. In other words, the actions of other non-dominant PTOs will ensure not only effective competition on the vertically integrated service model but also effectively foreclose the market to third parties for anything other than niche opportunities.

All these three groups of services allow the PTOs to have some degree of advantage through their vertical integration. OFTEL has termed this group of three categories of services "Network Services". (Not very original, but the term "basic services" denies the evident complexity of some services now emerging in these latter two groups). Services where there are low barriers to market entry by independent service providers are termed Enhanced Services and include such services as Messaging Services, Transaction Services, Navigation & Directory Services and services delivering 'content', such as Audiotex and even 'Video-on-Demand'.

It might be thought that all Network Services might be the subject of regulatory intervention to promote a uniform interoperable approach. However, as I stated earlier, it should not be the regulators' aim to impose uniformity for its own sake. Rather the reverse. If competitive differentiation can be accommodated without major welfare loss, it should be allowed. In this respect, analysis of the range of services described above shows that some depend on interworking between network elements at either end of the call, while others are provided solely by the PTO to his own customer. To take two extremes: Alarm calls can be offered by PTOs without reference to interconnected networks, whereas complex services like "Ringback-when-free" require compatible software and protocol deployment across interconnected networks in order to deliver an end-to-end interoperable service. OFTEL has dubbed the distinction between these two types of service as being between 'co-operative' and 'non co-operative' services.

In a fully competitive market, with no dominant player, no single operator could launch a co-operative service without seeking the collaboration of other operators to offer the service to a wider market. There would be limited appeal for, say, "Ringback-when-free" if it only worked on a minority of occasions when a busy line was encountered. On the other hand, where a dominant operator exists, there would be a temptation to offer such a service on an exclusive basis as the limitation on use would be small. In contrast, a new market entrant, with a small market share, might be motivated to offer such a service to provide a richer service set than the incumbent, but would be denied the opportunity to launch until the dominant operator was also able to do so. All benefits of timing would be lost.

It is for these reasons that OFTEL has concluded that there should be regulatory intervention in favour of interoperability in cases where:

1. the operator has significant market power;

2. the service is a Network Service, and

3. the Network Service is a co-operative service.

Regulatory intervention should ensure that such services are available for interconnection at the same time as the launch of the retail service. While this might be seen to deny the incumbent operator any advantages of timing and returns on his innovation, such regulation provides a surrogate for an effectively competitive market where co-operative services could only be practically launched by collaboration between operators. Same day availability is the best substitute for the delays in innovation that the new operators otherwise suffer, from having to wait for the incumbent to offer the service.

Other supporting analysis

There are other arguments for separating the regulation of Network Services from Enhanced Services beyond the practical difficulties that regulators would have in attempting to regulate the wider liberalised service provision market.

With the larger number of potential market entrants in Enhanced Services, regulatory intervention is more likely to impose a sub-optimal solution on the industry. With Network Services, the regulatory intervention described above not only promotes competition between PTOs, but it also benefits the Enhanced Services market as well.

Almost all Enhanced Services depend on some underlying Network Services as inputs to the overall service. For example, Internet Service Providers depend on the provision of a range of dial-up telephone services to allow low traffic customers to access their systems.

Many new PTOs are able to provide such Network Services to Service Providers in ways which give them an advantage over the incumbent, be it price or features. Indeed, the regulatory imposition of non-discrimination rules on the dominant operator often restrains innovation in this type of case, offering an opportunity for the new entrant. However, if the Service Provider takes service from the new PTO, he needs to take into account the fact that most callers will still be on the network of the incumbent operator. Unless the Network Service he is using is interoperable, he cannot realistically take service from the new PTO. A double loss of welfare results. For the new PTO, denied a good source of valuable custom, he is less strong to compete with the incumbent. At the same time, the Service Provider is denied the benefits of price and features he had hoped to gain.

This strengthens the argument that co-operative Network Services should be interoperable.

The role of technical standards

Because of the arguments set out above, a dominant PTO will often be the ‘first mover’ in launching co-operative services. Regulatory intervention can mitigate this by insisting on the availability of ‘same day’ interconnection. However, there are other areas where the effect of the dominant operator can be felt.

Many new services might not be the subject of existing standards. This leads to the possibility that the dominant operator will launch the service with technical standards determined by it alone. Such standards may be competitively neutral in effect. But it is also possible that they can favour the launching

operator over those who seek to interconnect. In particular, a standard determined by one party may raise the costs of entry to others, whether or not this is a deliberate tactic. In the UK, this is particularly noticeable because the standards implemented by BT are those it has agreed with its main switch suppliers. As it happens, many new entrant PTOs use different suppliers who would not have been party to the agreement on standards and a more costly solution for them might therefore occur. Furthermore, the fact that they were not involved in the decision-making means that their own development of the necessary protocols and interfaces cannot start until the these have been put in the public domain.

This points to two conclusions:

1. Where a new co-operative Network Service is to be launched, the industry should decide the standards in an open forum, such as a formal standards body or consensus forum. A proprietary standard with IPR ownership by one party is unlikely to be suitable if fair competition is to result.

2. Any such standard must be publicly declared in sufficient time for other efficient parties to make appropriate arrangements to meet the agreed launch date.

Again, this may seem over-regulatory, especially as the timing issue seems to require the incumbent to share all his innovation with others so they can copy him. However, as mentioned above, in an effectively competitive market, this is exactly what one would expect to do in order to ensure widespread interoperability to result. The work in forums like the ATM Forum would seem to support this notion. Competition in the provision of ATM services is likely to result from different marketing, pricing, customer service and product packaging, rather than attempting to exploit exclusive technical standards, whose benefit is, as discussed above, likely to be transitory at best.

The interface with the customer

The analysis above has almost wholly concentrated on the relationship between interconnected, regulated PTOs. But as I described at the start, interoperability may well require compatible arrangements with the interfaces between the PTOs and their customers. For this reason, ISDN customer interfaces are highly standardised.

The issue came to prominence in the UK when in 1994 two separate interfaces arose for the delivery of Calling Line Identity Display. (A similar situation has more recently emerged across the EU). It was widely thought that this was not in the public interest. It would inhibit the portability of terminals across networks and therefore become a barrier to customers switching to other operators.

There are some strong arguments both for and against. As long as “CLI transport” as a co-operative Network Service is delivered, there are arguments that CLI display is a non co-operative supplementary service and different solutions do not in principle affect others. New entrant PTOs are only likely to adopt alternative solutions if there is a ready supply of existing customer equipment for their chosen interface -- in the CLI case this was true.

On balance we have concluded that since many features which operate across the customer interface can be different, while still delivering end-to-end interoperability, we should not attempt regulation in this area.

However, in the CLI case, much of the problem stemmed from the new standard not being produced in an open forum, where the whole debate could have been worked through. Is there a case for at least mandating the use of open standards? Again, after lengthy analysis, we conclude that if common customer interface standards are desirable, they would need to be backed up by powers to insist on the use of a given standard not only by the dominant operator but by all others too. This seems an unattractive policy in the light of the general presumption of light regulation for new market entrants.

Indeed, the new EU Directives in the form of the Interconnection Directive and the (Amending) Voice Telephony Directive support this view. In the former, the regulator is empowered to insist, as seen necessary, on interoperability conditions in PTO interconnection agreements, while the latter specifically preclude anyone from adding extra interoperability requirements beyond those included in equipment attachment approval requirements. Even the latter requirements may not contain interworking requirements beyond those for the setting up of basic conveyance services, which means that optional supplementary service interoperability cannot be mandated.

Publication of interfaces

However, there is one important regulatory action in favour of interoperability that can be performed in respect of the customer interface. As the customer interface forms the barrier between the regulated PTO market and the liberalised customer equipment market, it is important that the PTOs should publically declare the interfaces they use so that apparatus manufacturers can adopt compatible interfaces.

Without this, the apparatus might become the monopoly of the equipment arm of the incumbent PTO and competing PTOs would be denied the opportunity to launch compatible service interfaces which would have the benefit of terminal portability.

This policy has long been promulgated by various EU Directives and the new Amending Voice Telephony Directive makes it an obligation on the regulator to require all PTOs to publish their Network Services interfaces.

Conclusion

Interoperability is not always beneficial to a competitive market. However, in the face of market failure there is a case for regulatory intervention in favour of interoperability for PTO Network Services which are co-operative in nature. Launch opportunities for new entrants must be protected in respect of timing and standards to be adopted.

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John H. Barton is George E. Osborne professor of Law at Stanford Law School, where he concentrates on international law (including international competition law) and on high technology law. He is also co-director of the Law School's Center for Law and Technology Policy. His publications and his research and consulting include technology transfer, intellectual property, and licensing issues, in both the software and the biotechnology sectors. He is also co-author of a casebook on international trade law and has served on international NAFTA dispute settlement panels involving antidumping issues. He is a fellow of the American Association for the Advancement of Science.

Timothy F. Bresnahan

Timothy F. Bresnahan is Professor of Economics and, by courtesy, of Business, at Stanford University. He also serves as Co-Director of the Stanford Computer Industry project and Co-Director of the Technology and Economic Growth Programme in CEPR. A 1975 graduate of Haverford College, he received the Ph.D. in Economics from Princeton in 1980. Bresnahan's research interests lie in Industrial Organisation Economics and in the Economics of Technology. In the industrial organisation area, he has

been concerned with econometric measurement of market power and testing of models of imperfect competition. Publications in this area include a chapter in the Handbook of Industrial Organisation. In the economics of technology area, he studies the economic process by which raw technology generates value in use. Publications in this area include "General Purpose Technologies," "Large Firm's Demand for Computers," and "The Competitive Crash in Large-Scale Commercial Computing." In both research areas, most of his work is detailed industry studies. A winner of the Dean's award for Excellence in Teaching, he nonetheless enjoys coaching Matthew and Claire Bresnahan in soccer more than indoor instruction.

Dick Butler

After graduating in Physics in 1946 Dick Butler joined the Army, was commissioned into REME and served in a variety of appointments concerned with weapon system development, in R&D establishments and in the MoD. He retired from the Army in 1970 and joined Vickers plc, spending several years in small operating units before becoming Engineering Director for capital projects. It was at this stage that he became involved with the exploitation of IT for engineering applications, particularly for design, analysis and project management. Dick left Vickers in 1986 and has since been a director of a small, specialised management consultancy, advising a group of small, high-technology businesses as well as working on the dissemination of information about new technology for the Department of Trade and Industry. Dick is active in the IEE, where he has been involved in trying to widen the Institution's appeal to IT professionals who were not trained as engineers, and he is also active in promoting a wider understanding of Science through interactive exhibitions.

Martin Cave

Martin Cave is Professor of Economics and Vice-Principal of Brunel University. He has worked for a number of years in the regulation of telecommunications and broadcasting industries, in which field he has written a number of books and articles. He is also Consultant to OFTEL and the Office of Fair Trading, and has undertaken projects for DGIV and the OECD.

Richard Cawley

Richard Cawley (rca@dg13.cec.be) is principal official at the General Directorate for Telecommunications and the Information Market (http://www.ispo.cec.be) of the European Commission. He has worked at the Commission since 1983, firstly in DG II Economics and since 1989 in DG XIII in the department responsible for telecommunications policy and regulation. In 1995-96 he was on leave as EU-USA Fulbright Fellow, based at Tufts University in Boston.

Inuk Chung

Dr Inuk Chung is Senior Research Fellow of the Korea Information Society Development Institute (KISDI) in charge of the international telecommunications and trade policy team. Dr Chung has been a member of the Korean Delegation in Korea-US bilateral telecommunication trade consultations

since 1994 and has attended many other bilateral and multilateral negotiation meetings in telecommunication sectors. He is currently a member of the Korean Government Advisory Group on International Economic Affairs.

He has participated in the OECD's Information, Computer and Communication Policy (ICCP) Committee meetings and its Working Party on Telecommunications and Information Services Policies (TISP) meetings as the head or deputy head of the Korean delegation from the beginning of Korea's application for observership in the Committee right through to full membership of Korea in the OECD. He was the organiser of two international conferences, organised jointly with the OECD and KISDI. The first was in 1995 "Information Infrastructure: The Vision for the New World Order" and the second in 1995, the Fifth OECD Workshop on the Economics of the Information Society "Government Responses to the Emerging Information Society". Dr Chung's recent research interests include the analysis of competition and co-operation strategy in global and regional information infrastructure initiatives and in-depth study of dispute settlement procedures in the telecommunications markets.

Brian Collins

Professor Collins is a specialist Information Management consultant and External Professor in Information Systems at The University of Glamorgan. He has carried out consultancy engagements, in the UK and Europe, concerned with information security policy and architectures, security in electronic messaging systems, policy issues for information services carried on information and telecommunications systems, strategic infrastructure design, information systems security audits, in particular of a major clearing bank, and policy reviews.

As Head of Information Systems at the Welcome Trust he was responsible and accountable for the specification, development, procurement and operation of the information systems in the Trust, the largest charity in asset terms in the UK and the principle private funder of medical research.

At GCHQ he held the appointment of Director of Science and Technology and was financially and programmematically accountable for the strategic direction, development and procurement of all information and communication systems.

He is a Freeman of the Worshipful Company of Information Technologists, a City Livery Company. He is a Fellow of the Institution of Electrical Engineers (IEE), Chairman of the Information Engineering Committee of the IEE Public Affairs Board and an elected member of the Computer and Control Board of IEE.

Natasha Constantelou

Natasha Constantelou is currently a DPhil Candidate at SPRU. She holds a BSc in Informatics majoring in telecommunication engineering and an MSc in Technology and Innovation Management. Her previous experience includes work as an account executive in a Greek telecommunication company, and in SPRU working for the Centre for Information and Communication Technologies on European infrastructures in telecommunications and telematic services. She has also worked as a consultant to the OECD on telecommunication numbering issues. She is the author of various articles and reports on European telecommunication policy with special reference to development issues in the less-favoured European regions and economies in transition.

Peter Crowther

Peter Crowther holds degrees in law and economics. Formerly a lecturer in the Law Department, Brunel University, he is currently Research Fellow in the Law Department, Copenhagen Business School. His principal research interests include European law, telecommunications law and competition law.

Paul A. David

Paul A. David is Professor of Economics at Stanford University, and (since 1994) is a Senior Research Fellow of All Souls College, Oxford. He is Programme Leader for the High Technology Impact Programme in the Center for Economic Policy Research at Stanford University, and currently is Professorial Fellow in the Economics of Science and Technology at the Maastricht Economic Research Institute on Innovation and Technology (MERIT).

David is known internationally for his contributions in a number of fields, including economic history, economic and historical demography, and the economics of science and technology. He was among the pioneering practitioners of the "new economic history," using the theoretical and statistical tools of modern economics to reconstruct and analyse economic life in the past, and studying its bearing on present policy issues. Posing the question "When does history really matter in economic processes?", much of David's research has sought to characterise the conditions under which micro-level and macro-level phenomena will follow a "path-dependent" course of evolution. The development of "the new economics of science," and studies of the role of compatibility standards and standardisation strategies in the growth and evolution of networks -- with special reference to information technology networks -- have been focal points of his most recent research and writings.

David has authored more than 100 articles and a number of books, including Technical Choice, Innovation and Economic Growth (1975), Reckoning with Slavery (1976), with several other volumes scheduled to appear in 1996-97: The Economics of Qwerty and Tomorrow's Technology; Standards, Markets and Network Evolution, and Behind the Diffusion Curve -- Contributions to the Microeconomics of Technology Adoption. He is a founding editor of the international journal Economics of Innovation and New Technology, and serves on the editiorial boards of numerous other journals.

Elected a Fellow of the International Econometrics Society (1975), the American Academy of Arts and Sciences (1979), and the British Academy (1995), David is a past Vice-President and President of the Economic History Association, and is an elected Member of the Council of the Royal Economics Society. He has served as a consultant to the US National Academy of Sciences, the United Nations Commission on Trade and Development, the United Nations University Institute on New Technologies, the World Bank, the Organisation for Economic Co-operation and Development, the National Science Foundation, the Economic and Social Research Council of the UK, and other public organisations.

Born in New York City, he was educated at the High School of Music and Art, then studied economics at Harvard College (BA 1956), economics and economic history at Cambridge University as a Fulbright Scholar, and returned for further graduate study in economics at Harvard University, from which he received the Ph.D. in 1973. Joining Stanford's Economics faculty in 1961, promoted to associate professor in 1967 and to full professor in 1970, David held the William Robertson Coe Professorship in American Economic History at Stanford University during the years 1977-1994. He has been a Visiting Professor of Economics at Harvard University, the Pitt Professor of American History and Institutions at

the University of Cambridge, Extraordinary Research Professor in the Economics of Science and Technology at the Rijksuniversiteit Limburg, and Visiting Professor in the Economics of Science and Technology at the University of Paris-Dauphine.

Rowan Douglas

Rowan Douglas is 27 and managing director of the World-wide Intellectual Resources Exchange, based in the UK and Bermuda. He took a degree in geography at Durham and Bristol Universities and is currently a Visiting Fellow at the Science Policy Research Unit, University of Sussex and sits on the Editorial Board of the *Financial Times* Virtual Finance Newsletter.

In 1992 he became a reinsurance underwriter with Syndicate 1095 at Lloyd's of London underwriting international catastrophe liability business in over 30 territories.

In 1994 he formed the World-wide Intellectual Resources Exchange (WIRE). WIRE's interest is trading and broking in an emerging market in the world's most powerful and valuable commodity: intellectual capital. The company interconnects parties across traditional boundaries in banking, reinsurance, energy, law and other sectors.

As more forms of intellectual capital can be stored and switched digitally, the deployment of emerging technologies, especially the Internet within this agenda is a key area of focus for WIRE. For example the company is developing an Internet-based interface for the world reinsurance market and fusing these organisations with alternative risk transfer mechanisms developed by banks and derivative exchanges.

WIRE is also involved with governments in offshore jurisdictions to develop the most appropriate electronic domiciles, to exchange and base intellectual capital.

John Dryden

Since January 1993, John Dryden has been the Head of the Information, Computer and Communications Policy Division of the OECD Directorate for Science, Technology and Industry. He joined the Directorate in 1987, and has held a number of other senior positions, including Head of the Science, Technology and Communications Policy Division, Head of the Economic Analysis and Statistics Division, and Head of the Scientific, Technological and Industrial Indicators Division. Between 1980 and 1987, Mr. Dryden worked in the Economics and Statistics Department of the OECD. Before joining the OECD, he worked in the Cabinet Office of the UK government. A United Kingdom citizen, Mr Dryden was educated at Oxford University and the University of Wales.

Detlef Eckert

Dr Detlef Eckert was born on October 1953. He did his first degree in Economics at the University of Siegen in 1979 after having one year of practical studies with an industrial company. From 1979 to 1985 he was Assistant Professor at the University of Siegen and completed his Doctorate in Economics with a dissertation entitled "Risk Structures of Industrial Research and Development" published by Erich Schmidt Verlag, Berlin in 1985. From 1985 to 1988 Dr Eckert was a Civil Servant, being head of Unit in the Bremen Ministry for Economic Affairs, Technology and Foreign Trade.

From 1988 to the present he has been with the European Commission and is currently Advisor to the Director General of DG XIII (Telecommunications, Information Market, Exploitation of Research).

Christopher Freeman

Christopher Freeman was the founder of the Science Policy Research Unit (SPRU) at the University of Sussex in 1965 and its first Director until 1983. He is now an Emeritus Professor at SPRU. He was educated at the London School of Economics and was a Platoon Commander in the Manchester Regiment during the Second World War. After experience in market research and as a salesman in the 1950s, he became a researcher at the National Institute of Economic and Social Research, leading European projects on technical change in the world electronics industry, the chemical industry and industrial research and development. His work at SPRU involved leading a group of natural and social scientists and engineers in researching and teaching on the social and economic consequences of technical change. In his work on technical change and employment he has collaborated closely with Professor Luc Soete, Director of MERIT, University of Limburg, Maastricht, The Netherlands. Recently, they completed a study of "Information Technology and Employment" for IBM Europe and a book entitled *Work for All or Mass Unemployment: Computerised Technical Change into the 21st Century*", (Pinter, 1994) and are about to publish the third edition of Freeman's textbook *Economics of Industrial Innovation* (Pinter, 1997 forthcoming) He is author of various papers and books on technical change and economic policy. He has five children.

Jens-L. Gaster

Born in 1955 in Oberwesel, Germany	
Studies in Law and International Relations	1976 - 1981
First state examination in Law	1981
Postgraduate Studies in European integration	1982 - 1983
Certificate in advanced European studies (Saarbrücken)	1983
Doctor at Law degree (Dr. iur), (Thesis on law of the sea issues)	1985
Second state examination in Law	1985
Assistant, then Attorney, in law firm specialising in Public Law	1983 - 1987
Principal assistant to State Constitutional Court Judge	1985 - 1987
Professor W.K. Geck (public law, public international law)	
Commission of the European Communities, DG VI (Agriculture)	1987 - 1990
Legal Directorate (infringements, complaints)	
DG VI (Agriculture), Division "Legislation relating to crop products and animal nutrition"	1990 - 1993
DG XV (Internal Market & Financial Services), Unit "Copyright and Neighbouring Rights, including international aspects"	1993 - present

Principal Administrator, responsible, inter alia, for IPR issues related to computer software, databases and multimedia products, artists' resale right, distribution right and parallel imports.

Commission delegate in the respective Council working parties and European Parliament committees. Delegate to the OECD Committee for Information, Computer and Communications Policy.

Mr Gaster is author of numerous publications in particular on copyright issues.

Shane Greenstein

Shane Greenstein is Associate Professor in the Department of Economics and the Institute of Government and Public Affairs at the University of Illinois in Urbana/Champaign. He teaches courses on micro-economics, the economics of technology and the economics of regulation. He is also a Research Associate with the productivity group at the National Bureau of Economic Research in Cambridge Massachusetts. He is a regular columnist on computer industry economics for *Micro*, published by the Institute of Electronic and Electrical Engineers. For the 1994-95 academic year he was Visiting Scholar with the Computer Industry Project at Stanford University and a Research Associate with the Institute for Management, Innovation and Organisations in the Haas School of Business at the University of California, Berkeley. He has received several grants from the National Science Foundation. His research examines the economics of high technology, covering issues of interest to academics, business and policy. Recent research examines the diffusion of networked computing, benefits from advances in information technology in telecommunications and computing, structural change in information technology markets, standardisation in electronics markets, investment in digital infrastructure, and government procedures for acquiring computers. He received his BA from the University of California at Berkeley in 1983, and his PhD from Stanford University in 1989.

Ken Guy

Ken Guy is British and was born on 31 January 1950. He holds an MA degree in Natural Sciences from the University of Cambridge and an M.Sc. in Science and Technology Policy from the University of Manchester. After leaving Manchester in 1974, Ken Guy held a SCOPE Research Fellowship at Clark University, Massachusetts, prior to appointments at the SCOPE/UNEP Monitoring and Assessment Research Centre in London and the Department of Geography, Leicester University. His work focused on evaluations of government policy in fields as diverse as drug safety, nuclear power and environmental protection, and on industrial strategies in a wide range of economic sectors. In 1982 he joined the Science Policy Research Unit at Sussex University where he founded and led the EGIST (Evaluation of Government and Industry Strategies for Technology) group. Currently, Ken Guy is a Director of Technopolis Ltd, an innovation policy consultancy which he founded in 1989. Over the last 15 years much of his work has focused on Information Society issues and policies.

Richard Hawkins

Richard Hawkins, BA, MA (Simon Fraser), DPhil (Sussex) is Fellow in the Centre for Information and Communication Technologies, Science Policy Research Unit, University of Sussex. His research focuses on the development of technical and policy infrastructures for global networks. He has undertaken research and consultancy for the Government of Canada, the British Standards Institution, the London Metropolitan Police Service, the European Commission, the UK Department of Trade and Industry, and the OECD.

Gary Hewitt

Gary Hewitt works in the Competition and Consumer Policy Division of the Organisation for Economic Co-operation and Development's (OECD) Directorate for Financial, Fiscal and Enterprise Affairs. Over the six years he has been with the OECD, Mr Hewitt has specialised in technical assistance to competition policy makers in the formerly centrally planned economies of Eastern and Central Europe

and ex-Soviet Union (i.e. "transition economics"). This included organising and participating in two conferences in 1994 and 1995 dealing with competition and regulatory issues in network infrastructure industries (including telecommunications) in transition economies. Mr Hewitt has recently been extensively involved in the OECD's regulatory reform initiative.

Before joining the OECD, Mr Hewitt worked for two years at the Canadian Competition Bureau and prior to that he taught business administration and economics in several Canadian universities.

Staffan Hultén

Born 22 June 1954. Doctor in business economics in 1988. He became assistant professor at Stockholm School of Economics in the same year and was appointed associate professor in 1994. He is currently visiting professor at the Ecole Centrale, Paris. His principal research area is the structure and evolution of the telecommunications and transportation industries. Some of the most important recent publications are: *High Speed Trains: Fast Tracks to the Future* (1993), Leading Edge Publishers, (editors Torbjörn Flink, Staffan Hultén and John Whitelegg), Hultén, S and Mölleryd, B. (1995), "Mobile Telecommunications in Sweden" in Müller, J.et al (eds), *Mobile Telecommunications in Western and Central-Eastern Europe: Integrative and Institutional Dimensions,* Artech House; Helgesson, C-F. Hultén, S. and Puffert, D. (1995), "Standards as Institutions - Problems with Creating All-European Standards for Terminal Equipment", in Groenewegen, J. et al (eds.), *On Economic Institutions - Theory and Applications,* Edward Elgar Publishers., Aldershot; Hultén, S. and Mölleryd, B (1996), "Esprit d'entreprise et collaboration interentreprises dans les télécommunications mobiles', in Brousseau, E., Petit, P. and Phan, D. (eds), *Mutations des Télécommunications, des Industries et des Marchés*, ENSPTT Economica, Paris; and Cowan, R. and Hultén, S., 'Escaping Lock-in: The Case of the Electric Vehicle", *Technology Forecasting and social Change,* 1996.

Brian Kahin

Brian Kahin is Director of the Information Infrastructure Project and Adjunct Lecturer in Public Policy at Harvard's John F. Kennedy School of Government. Launched in 1989, the Project is supported by a mix of federal, corporate, and foundation funding. Current work encompasses Internet co-ordination and administration, the economics of digital information, the Global Information Infrastructure, and the future of intellectual property.

Mr Kahin has developed Kennedy School courses on Information Technology, Law and Policy, Information Infrastructure, and, most recently, Information Technology, Business Strategy and Public Policy. The last was offered jointly with Harvard Business School, and a new version will be taught in Spring 1997 with both the Business School and Harvard Law School.

Mr Kahin is also General Counsel for the Interactive Multimedia Association, a 400-member trade association based in Annapolis, which he helped found in 1988. He directs the Association's intellectual property activities, which currently focus on technology-based management of proprietary rights in the multimedia environment.

Mr Kahin is the author of numerous articles on information infrastructure policy issues. He is the editor of *Building Information Infrastructure* (McGraw-Hill, 1992), and the *Information Infrastructure Sourcebook* (1993-1995), and co-editor of *Public Access to the Internet*, (with James Keller; MIT Press, 1995), and *Standards Policy for Information Infrastructure* (with Janet Abbate; MIT Press, 1995). He is

co-editor of the forthcoming volumes, *National Information Infrastructure Initiatives* (with Ernest Wilson; MIT Press, 1996), *Borders in Cyberspace* (with Charles Nesson; MIT Press, 1996), and *Co-ordination and Administration of the Internet* (with James Keller; MIT Press, 1997).

Mr Kahin serves on the US Advisory Committee on International Communications and Information Policy and chairs the Committee's Working Group on Intellectual Property, Interoperability and Standards. He serves on the board of Telecommunications Policy Research Conference, the editorial advisory boards of the Boston University *Journal of Science & Technology Law* and the practitioner newsletters *Multimedia Law Strategist* and *Cyberspace Lawyer*, and on the advisory board of the *Center for Electronic Texts in the Humanities*. He was on the original steering committee for the Software Patent Institute (1990-91) and has served on the advisory board since 1992.

Mr Kahin was a member of the 1992-94 Task Force on a National Strategy for Managing Scientific and Technological Information. He was co-editor of the journal *Information Infrastructure and Policy* (IOS Press) from 1994 to 1996. As a consultant, Mr Kahin's clients have included EDUCOM, the Council on Library Resources and the US Congress Office of Technology Assessment. He has also served as principal counsel to FARNET (Federation of American Research Networks), and the International Interactive Communications Society, the society for professionals in multimedia. Prior to his affiliation with Harvard, Mr Kahin worked with the Research Programme on Communications Policy at MIT, where he served in various capacities for the Research Programme, the MIT Communications Forum, and Project Athena.

Mr Kahin received his BA from Harvard College in 1969 and his J.D. from Harvard Law School in 1976. He has been a member of the Wyoming State Bar since 1976.

Jiro Kokuryo

Jiro Kokuryo is Associate Professor, Graduate School of Business Administration, Keio University. He took his BA from the University of Tokyo and MBA and DBA from Harvard University.

From 1982 to 1988 he worked at Nippon Telegraph and Telephone Corporation and then went as a Research Associate to Harvard University and completed his MBA and DBA in the period 1988 to 1992 when he returned to NTTC. He joined the Graduate School of Business Administration at Keio University in 1993.

Primary publications:

-- Kokuryo, J (1994) "The impact of EDI-based quick response systems on logistics systems" in G. Pogorel (ed) *Global Telecommunications Strategies and Technological Changes*, Amsterdam: Elsevier Science Publishers BV.
-- Kokoryu, J (1994) *Infocom Research Inc.* (in Japanese).
-- Kokoryu, J (1995) "Open Network Keiei" *Japan Economic Journal* (in Japanese).
-- Kokoryu, J (1995) "The role of intermediaries in electronic commerce", paper presented at the OECD Workshop No. 2 on the Economics of the Information Society, Istanbul, Turkey, 14-15 December 1995.

Anne Leeming Bsc, Msc. FBCS, C Eng, FRSA

Senior Lecturer in Information Management, Director MBA Information Technology & Management, City University Business School, London.

A Chemistry graduate from University College London, Anne Leeming started her career in research with BP and worked in Work Study with ICI before joining IBM UK.

While raising her three sons she worked as a freelance consultant and programmer before joining Deloitte, Haskins and Sells in Computer Audit. She joined City University Business School in 1981 where she teaches mid-career managers in the use of IT as a business enabler.

Consultancy and research interests are in the area of organisational impact of Information Systems, specialising on skills to manage with IT, women and management education. She is a livery member of the Worshipful Company of Information Technologists.

Franco Malerba

1983	Doctor of Philosophy in Economics - Yale University
from 1988 to 91	Associate Professor of Industrial Economics - University of Brescia
since 1991	at Bocconi University Milan

Editor of the Journal *Industrial and Corporate Change*
Advisory Editor of *Research Policy*
Associate Editor of the *Journal of Evolutionary Economics*
Deputy Director of CESPRI (Research Center on Internationalisation) - Bocconi University
Member of the Scientific Committee of CISE - Italy
Member of the "National Technology and Science Board" - Italian Ministry of University and Scientific and Technology Research since 1994
Research and collaboration with the European Commission, OECD, EUREKA, American National Science Foundation, ENEA (Italian Energy Agency), Italian Ministry of Science and Technology, Italian Ministry of Industry, Confindustria, Assolombarda, Lombardy Region, American Enterprise Institute.

The Most recent publications include:

-- **"**Learning and Incremental Technical Change", *Economic Journal*, July, 1992.
-- "The Organisation of the Innovative process and the Commercialisation of new Technologies in Europe" in N. Rosenberg, R. Landau, D. Mowery, (ed) *Technology and the Wealth of Nations,* Stanford University press, 1992.
-- "Internal capabilities and external networks in innovative activities" (with S. Torrisi) *Economics of Innovation and New Technologies*, Vol. 2, 1992.
-- "Italy" in *National innovation Systems: A Comparative Analysis*, R. Nelson (ed), Oxford University Press 1993.
-- "Technological regimes and firm behaviour"(with L. Orsenigo), *Industrial and Corporate Change*, Vol. 2, n.1, 1993.
-- *Evolutionary Approaches to Economics*, L. Magnusson (ed), Kluwer, London, 1993.
-- "Competence, innovative activities and economic performance in Italian high-technology firms", (with L. Marengo), *International Journal of Technology Management*, 1994.
-- "Schumpeterian Patterns of Innovation" (with L. Orsenigo) *Cambridge Journal of Economics* 1994.

-- **"**Schumpeterian Patters of Innovation are Technology Specific" (with L. Orsenigo) *Research Policy*, forthcoming.
-- "The Dynamics of Market Structure and Innovation in the Western European Software Industry" in D. Mowery (ed), *The International Computer Software Industry: A Comparative Study of Industry Evolution and Structure*, Oxford University Press, Oxford, forthcoming.
-- "Organisation and Strategy in the Evolution of the Enterprise**"** (with G. Dosi), MacMillan, London, forthcoming.

Robin Mansell

Robin Mansell is Professor of Information and Communication Technology Policy and Head of the Science Policy Research Unit's Centre for Information and Communication Technologies at the University of Sussex. She is currently Director of Graduate Studies. She has degrees in social psychology (BA, MSc) and in economics of communication policy (MA, PhD). Since joining SPRU in 1988 her research has focused on the economic and social impact of advanced information and communication technologies with a particular emphasis on innovations in telecommunication as well as policy and regulatory issues.

She has particular expertise in matters concerning industrial policy, competitiveness and trade in information and communication services. She worked as an Administrator with the OECD Information, Computer and Communication Policy Division (1986/87) and as an academic and consultant in Canada, the United States and Europe on issues of European and international communication policy. Professor Mansell is the author of many scholarly articles and reports on issues of technical and institutional change in advanced information and communication technologies including: *Communication by Design: The Politics of Information and Communication Technologies*. Oxford: Oxford University Press, forthcoming 1996 (editor and contributor with Roger Silverstone); "Strategic Issues in Telecommunications: Unbundling the Information Infrastructure", *Telecommunications Policy* 18(8), pp. 588-600, 1994; *The Management of Information and Communication Technologies: Changing patterns of control*. London: ASLIB, 1994 (editor and contributor); *The New Telecommunications: A political economy of network evolution*, London: Sage, 1993.

Christian Micas

Christian Micas was born in 1964 in Paris. In 1990, he completed his postgraduate studies in Economic Sciences at the Paris-Nord University. In 1991 he joined the Industrial Analyses Department of IDATE (Institut de l'Audiovisuel et des Télécommunications en Europe) as a research consultant. In 1993 he obtained an expert position at the European Commission DGXIII (Telecommunications and Information Market). Since 1996 he has been working as an independent consultant in Brussels.

Horace Mitchell

Horace Mitchell was educated at Merchant Taylors' School, Crosby, the Royal Military Academy, Sandhurst, and Christ's College, Cambridge and had a first career as a Regular Officer in the Royal Artillery before joining IBM in 1970. During 13 years with IBM he specialised in sales and marketing and was responsible for introducing marketing and market development techniques that are now in universal use across the IT and telecommunications sectors. He gained first-hand experience of small firms as chief executive of a start-up software house before becoming an independent consultant and

adviser to governments and industry on innovative uses of technology and the impacts of technology change. He is currently programme director of a three-year European information society initiative supported by the European Commission.

Tsuruhiko Nambu

Professor of Economics, Gakushuin University, Faculty of Economics, 1-5-1, Mejiro, Toshima-ku, Tokyo, 171, Japan. Born in 1942.

Education:

BA - 1966, University of Tokyo, Economics;
MA - 1970, University of Tokyo, Economics

Academic Positions:

Assistant Professor of Economics, Musashi University, 1970-73
Associate Professor of Economics, Musashi University, 1973-76
Associate Professor of Economics, Gakushuin University, 1976-79
Professor of Economics, Gakushuin University, 1979-present
Visiting Professor, Catholic University of Louvain, Institute of Economic Science, 1978-79
Visiting Professor, European Institute for Advanced Studies in Management, 1979-80

Professional Activities:

Associate Editor, *Journal of Industrial Economics*, 1978-83
Associate Editor, *International Journal of Industrial Organisation*, 1983-88
Associate Editor, *Managerial and Decision Economics*, 1990-present
Associate Editor, *Economics of Innovation and New Technology*, 1990-present
Director, The Tokyo Center for Economics Research, 1984-1992
Director, The Research Institute for Energy and Information Technology, 1990-present
Research Fellow of the Institute of Fiscal and Monetary Policy within the Ministry of Finance, 1990-95
Research Fellow of the Institute of Posts and Telecommunications Policy within the Ministry of Posts and Telecommunications, 1990-93

Recent Publications:

(Recent Articles available in English)

-- "Deregulation in Japan", Robert W Crandall and Kenneth Famm eds. *Changing the Rules*, (The Brookings Institution, 1989).
-- "The Optimum Access Charge under Competition" Dieter Elixmann and Karl-Heinz Neuman eds. *Communications Policy in Europe* (Springer Verlang, 1990).
-- "A Model-Oriented Approach to the Information Service Industry", Y.Oishi and M.Komai eds *Networks and Society* (Institute for Posts and Telecommunications, University of Tokyo Press, 1991).
-- "The cost Structure of International Telecommunications Industry of Japan", (with Y.Nakajima and K.Yoshioka) *Review of Economics Studies Quarterly*, vol. 44, No. 1, March, 1993.
-- "A Comparison of Deregulation Policies", Eli Noam and Seisuke Komatsuzaki eds. *Telecommunications in the Pacific Basin*. Oxford University Press, 1994.

-- "Competition and Regulation of Japanese Telecommunications Industry", *The Keizai Bunseki*, (The Economic Planning Agency) No. 141, December, 1995. (forth coming in a book from the Oxford University Press).
-- "Is 'Bottleneck' a viable concept for NTT breakup?" the ITS conference paper, Seville, June 1996.

(Books in Japanese)

-- *The Theory of Industrial Organisation and Public Policy*, Nihon Keizai Shinbunsha, 1982.
-- *Telecommunications Economics*, Nihon Keizai Shinbunsha, 1986.
-- *The Structural Change of the Japanese Industries and the Industrial Organisation* (with H. Nüda and A.Goto) Toyokeizai Shinposha, 1987.
-- *Telecommunications Industry in Japan* (with M.Okuno and K.Suzumura) Nibon Keizai Shinbunsya, 1993.

Michael Oborne

Michael Oborne is the Deputy Director for Science, Technology and Industry at the Organisation of Economic Co-operation and Development in Paris. His responsibilities include work on science policy, innovation and biotechnology, megascience and information technologies. Mr Oborne was educated at the University of California at Berkeley (PhD), Cambridge University and the Ecole Normale Supérieure in Paris. He held academic appointments at universities in the United States, France and Italy before coming to the OECD, where he successively worked on technology and investment issues in Asia-Pacific/China, science and technology policy and innovation policy.

Sam Paltridge

Dr Sam Paltridge has degrees from the Universities of Adelaide and Wollongong in Australia. After completing university studies Dr Paltridge worked for the Centre for International Research on Communication and Information Technologies (CIRCIT) based in Melbourne. In the summer of 1992, he was visiting fellow at the Centre for Communications and Information and Communications Technology (CICT) in the Science Policy Research Unit, University of Sussex.

In 1993 Dr Paltridge joined the OECD as a telecommunication analyst in the Information, Computer and Communications Policy (ICCP) Division. His recent work in telecommunication has been on infrastructure competition, mobile communication, performance indicators, telecommunication employment and Internet pricing and regulatory issues. OECD reports written by Dr Paltridge on these subjects, including the Internet report, are freely available at the OECD world wide web site: http://www.oecd.org/dsti/sti_ict.html

He is a principal author of the biennial OECD Communications Outlook -- the latest edition was published on 5 April 1997.

Lord Renwick

Lord Renwick is an active member of the House of Lords and has been a member of the House of Lords Select Committees, first, on the European Communities and their Sub-Committee "B", (Energy, Transport & Technology) and latterly, on Science and Technology. He is Chairman of the European Informatics Market (EURIM), Honorary Secretary of the Parliamentary Information Technology Committee (PITCOM), Honorary Treasurer of the Parliamentary Space Committee (PSC) and a Member of other groups including the Parliamentary and Scientific Committee, the Foundation for Science and Technology and the All-Party Disablement Group.

Since the late ‘70s, he has concerned himself with the problem of Dyslexia and Special Educational needs, being a one-time chairman and current Vice-President of the British Dyslexia Association, chairman of the Dyslexia Educational Trust and a Member of Council of the National Council for Educational Technology. All this brings him into close contact with universities, government departments and other agencies at home and abroad.

For 16 years until 1980, he was a Partner in W. Greenwell & Co., one of London's leading firms of Stockbrokers, where he gained experience of financial institutions, general investment practice and corporate finance.

From 1975-93, he was a director of General Technology Systems Ltd, involved in technology consultancy, the promotion of innovation and the development of new technologies.

He currently has active interests in a range of companies in the field of technology, media, application software and education.

Current Activities

Chairman, EURIM (European Informatics Market)
Hon-Secretary, PITCOM (Parliamentary Information Technology Committee)
Hon-Treasurer, Parliamentary Space Committee
Member of Council, National Council for Educational Technology
Chairman, Steering Committee, Project Connect
Member, Parliamentary & Scientific Committee
Member, all-party Disablement Group, and other permanent and ad hoc committees
Former Member, House of Lords Select Committee on Science & Technology and on European Communities and Sub-Committee "B" (Energy, Transport & Technology)

Directorships

European Informatics Market (EURIM), Chairman
Virtual Precincts Limited, Chairman
The Dyslexia Educational Trust, Chairman
SAP (UK) Ltd, Adviser

Societies, Trust and Associations

Vice-President, (Chairman, 1977-82), British Dyslexia Association (1982-..)
Chairman, The Dyslexia Educational Trust (1986-..)

Vice-President, Combustion Engineering Association
Member, Foundation for Science and Technology
Fellow, Royal Geographical Society
Fellow, Royal Society of Arts
Life Fellow (Ordinary), Zoological Society of London

Interests

Processes of Innovation and Change
Applications of Informatics and Telematics Technology
Commercial Use of Space
Special Educational Needs

Employment History

Morgan Grenfell & Co, Merchant Bankers (1957-59)
W. Greenwell & Co, Stockbrokers (1959-80, Partner: 1964-80)
General Technology Systems Ltd, Technology Consultants (Director: 1975-93)

Pasi Rutanen

Ambassador Pasi Rutanen, who took up his post as permanent Representative of Finland to the OECD in July 1991, is also the Dean of the OECD Council.

Born in 1936, Mr. Rutanen graduated from Helsinki University. He worked as a journalist from 1960 to 1970, serving notably as chief correspondent for the Finnish Broadcasting Corporation in the United States from 1964 to 1970.

He joined the Finnish foreign service in 1970, serving both in the Ministry and abroad. 1989-1991 he served as Foreign Policy Adviser to the Prime Minister.

Mr. Rutanen is the author of numerous articles and five books dealing with international political and economic questions, the latest -- on the economic dynamism of the Pacific Basin -- having been published in 1987.

Charles Steinfield

Dr Charles Steinfield is a Professor in the Department of Telecommunication at Michigan State University. He holds a master's degree and doctorate in Communications Theory and Research from the Annenberg School for Communication at the University of Southern California. In 1991, he was awarded MSU's Teacher-Scholar Award for excellence in teaching and research and was nominated for a University Distinguished Faculty Award in 1996. In addition to numerous articles and book chapters, he has published three books: *Organisations and Communication Technology,* which received the Research Book of the Year Award in 1990 from the Organisational Communication Division of the Speech Communication Association; *Telecommunications in Transition: Policies, Services, and Technologies in the European Community;* and *Convergence: Integrating Media, Information and Communication.*

Dr Steinfield's recent research, funded by the National Science Foundation, focuses on the use of electronic data networks between firms and their external constituents -- including both end-customers as well as other organisations who are suppliers or distributors. He recently served as guest editor of a special issue on electronic commerce of the Internet publication, Journal of Computer Mediated Communication. In 1991-92, he received a nine-month Fulbright research award to study information services usage in France where he was a visiting professor at the Institut National des Télécommunications. In 1992-93, Dr Steinfield worked in Bellcore's Applied Research Laboratory as a full time member of technical staff. His research at Bellcore focused on better understanding residential needs for telecommunications and information services in light of the changing social and economic structure of American households. Since 1995, Dr. Steinfield has been a visiting faculty member in the annual summer Interactive Telecommunications Programme at the Helsinki School of Economics. He has also been as a visiting researcher in CNET, the national telecommunications research laboratory of France. Finally, since 1990, Dr Steinfield has organised and directed the Telecommunications in Europe Overseas Study Programme, held every July in Paris, France.

W. Edward Steinmueller

W. Edward Steinmueller is Professorial Fellow of the Economics of Technical Change at the Science Policy Research Unit, University of Sussex and former Professor at MERIT, Maastricht University, the Netherlands. He received his Ph.D. from Stanford University where he was previously employed as Senior Research Associate and Deputy Director at the Center for Economic Policy Research.

Professor Steinmueller has also been professionally involved in the study of industrial economics for 20 years, with a focus on the economic implications of technological change for industrial structure and organisation. He has also been a consultant in the area of antitrust economics and competition policy for over 15 years and has been involved in cases in the telecommunications, computer, and newspaper industries where his work has most often been devoted to the analysis of markets and business costs.

His research interests include the influence of technological change on industrial structure and the relationships among social, organisational, and technological factors in the production and adoption of new technologies.

He participated in research related to judicial proceedings in US vs. AT&T, Fairchild vs. Data General, Poloroid vs. Kodak, and Intel vs. AMD and served as a consultant to OFTEL, the European Parliament, the European Commission and the US Congressional Budget Office, US Office of Technology Assessment, National Advisory Committee on Semiconductors, and National Academies of Science and Engineering, as well as numerous private clients. His work on integrated circuits, telecommunications, software, computers, and basic research is internationally recognised for its synthesis of economic, institutional, and technological approaches.

Selected Publications:

-- "Demand for Computer Products and Services by Large European Organisations" (and Garth Saloner, Stanford University), Maastricht: MERIT, 16 January , 1996.
-- "The US Software Industry: An Interpretative History" in David C. Mowery (ed.), *The International Software Industry*, Oxford University Press, 1995.
-- "The Economics of Compatibility Standards and Competition in Telecommunication Networks', *Information Economics and Policy* 6(3,4), 1994, pp. 217-242.

-- "The Economics of Alternative Integrated Circuit Manufacturing Technology: A Framework and Appraisal", *Review of Industrial Organisation*, 7, 1992, pp. 327-349.
-- "The ISDN Bandwagon is Coming--Who Will be There to Climb Aboard?: Quandaries in the Economics of Data Communications Networks", with Paul A. David, *Economics of Innovation and New Technology* 1 (1-2), 1990, pp. 43-62.

R. Clark Wadlow

R Clark Wadlow received his AB degree in 1968 from Dartmouth College and his JD in 1971 from Harvard Law School. From 1971 to 1972, Mr Wadlow served as law clerk to the Honourable George F Boney, Chief Justice of the Supreme Court of Alaska. He has practised communications law in Washington, DC since 1972. Mr Wadlow joined Sidley & Austin as a partner in 1990. He taught communications law at the Columbus School of Law, Catholic University of America, from 1983 to 1987. From 1985 to 1990, Mr Wadlow served as a member of the Board of Trustees of Greater Washington Educational Telecommunications Association, licensee of WETA-TV/FM, Washington, DC. Mr Wadlow is a member of the Alaska and District of Columbia bars, the American Bar Association, the Federal Communications Bar Association, and the American Judicature Society. He has chaired numerous committees of the American Bar Association, including the Governing Committee of the Forum Committee on Communications Law, which he chaired from 1987 to 1989, and was a Member-at-Large on the Association's Board of Governors from 1978 to 1981. He currently chairs the ABA Standing Committee on Continuing Education of the Bar. Mr Wadlow served as a member of the Executive Committee of the Federal Communications Bar Association from 1989 to 1992, and was recently elected to serve as President-Elect of the FCBA. He frequently speaks before industry groups and on continuing legal education panels on communications law topics. He has also published articles on a wide array of communications law subjects.

Peter J. Walker

Peter Walker has been Technical Director at OFTEL, the UK telecoms regulatory body, since 1993. After graduating from Queens' College, Cambridge he was at BT for 22 years in a range of roles involved in network engineering, notably as Planning Manager for BT's London network and Director of Planning at BT International. He maintains wide contacts throughout the telecoms industry, including through OFTEL'S Network Interoperability Consultative Committee. He is a member of the Government's Foresight ITEC panel and the Universities' Advisory Committee on Networking. He is a Fellow of the IEI and a member of their Professional Group on Telecoms Networks & Services.

Qing Wang

BSc in Electrical Engineering (Xian, China, 1982), Postgraduate Dipl. in Management (Tianjin, China, 1986) and PhD in Marketing and Strategic Management (Warwick, 1993).

Dr Qing Wang worked for several years in China, first as a control systems design engineer in Kunming Machine Tools Co., and later as a lecturer in Yunnan University of Technology. She subsequently came to Britain for her PhD study and has been appointed as Lecturer in Technology and Innovation Management since she finished her PhD four years ago.

She is currently Lecturer, and Associate Director for M.Sc. Technology and Innovation Management Programme at Science Policy Research Unit, University of Sussex. Her main research areas and interests include (1) cross-functional interface in product innovation, (2) organisational learning and the process of a firm's core competence-building, and (3) the affect of FDI (Foreign Direct Investment) on the capabilities of Chinese partners and domestic suppliers.

She is a member of the British Academy of Management and the R&D Society. She is also involved in management consultancy activities for technology-based firms in the UK, Eastern Europe and China.

Relevant publications include:

-- "The Exploitation of A Multidisciplinary Approach in Studying the R&D/marketing Interface with Some Empirical Evidence", *International Journal of Technology Management,* 1996, 11(3), pp.369-379.
-- "R&D/marketing Interface in A firm's Capability-building Process: Evidence from Pharmaceutical Firms", *International Journal of Innovation Management,* 1997, 1(1).
-- "The R&D and Strategic Marketing in Drug Innovation - A case of the UK Pharmaceutical Industry". *Warwick Business School Research Paper Series*, Nov. 1992. No. 56, ISSN 0265-5976.
-- "A Feasibility Study into the Provision of Direct Flight Support Services for the Aeronautical Market", Bennett and Steward (eds.) *Technological Innovation and Global Challenges,* 1995, Aston University, Birmingham, United Kingdom. pp. 596-601.
-- "The Interlink Between Science-based Innovation and Engineering-based Innovation and their Impact upon R&D Strategy". *Proceedings of the British Academy of Management Annual Conference.* Lancaster, England, September 1994.
-- "A Critical Review of the R&D/marketing Interface and the Exploitation of A Multi-disciplinary Approach with Some Empirical Evidence", *Proceedings of the 5th International Forum on technology Management,* Finland, June 1995.
-- "The Interrelationship Between Government Policy and Firm Strategy in a High Technology Environment", The 2nd National Science and Technology Congress, 1995, Beijing.
-- "Creating and Enhancing A Firm's Core Competence Through Innovation Projects", *International Journal of Technology Management,* 1997, Forthcoming.

John C. Williams OBE FENG FIEE

Dr Williams was born at High Wycombe in Buckinghamshire in 1938. He was educated at the High Wycombe Royal Grammar School and Queen Mary College, London where he gained his first class honours degree BSc(Eng) in 1960 and his PhD in 1964. His thesis was on the subject of all dielectric bandpass microwave filters and his principal engineering interests since then have been in the fields of microwave techniques, antennae, radar, satellite communications and satellite remote sensing. Dr Williams has recently been honoured by the award of Honorary Fellow of Queen Mary & Westfield College, London.

He joined the Mullard Research Laboratories (later renamed Philips Research Laboratories) in 1964 and his early work was on Maser and parametric amplifiers. He developed a novel method for broadbanding parametric amplifiers and was a member of the team that installed the first operational parametric amplifiers onto British Telecom's Earth Station at Goonhilly Down in 1968. He subsequently undertook research into microwave integrated circuits, lumped element Gunn oscillators, and Doppler

Radar modules. In 1977 he jointly developed an early low power solid state f.m.c.w. radar and invented a new class of printed antennae for use in industrial and commercial applications.

In 1978 he joined GEC at the Marconi Space and Defence Systems establishment at Stanmore and was both Project Manager and Engineer Manager of a major ship-borne satellite communication development programme. In 1980 the company asked him to set up a new research team within the Central Research laboratories of GEC at Wembley, Middlesex. In 1982 he was appointed Director of the Marconi Research Centre at Great Baddow in Essex and was subsequently Managing Director of GEC Research and Director of the GEC-Marconi Research Centre. For six months in 1989 he was managing director of an innovation company based on the campus of the Cranfield Institute of Technology. Since 31 May 1989 he has been employed by the Institution of Electrical Engineers (IEE) as Secretary and Chief Executive.

John Williams is a Chartered Electrical Engineer and was elected a Fellow of the IEE in 1985 and a Fellow of the Royal Academy of Engineering in 1990. John Williams was elected to the Fellowship of Queen Mary & Westfield College in 1995. He is also a member of the Royal Institution, a member of the Livery of the Company of Engineers and a Freeman of the City of London. He has served on the Electronic Devices and Materials Committee of the Department of Trade and Industry, the Research Advisory Committee of the Electronic Engineering Association and numerous other government committees and advisory bodies to government Research Establishments.

John Williams has maintained his links with Queen Mary College, London by serving on the Industrial Advisory Committee to the Electrical Engineering Department. He is also on the Court of Brunel University and is a Board member of the Artificial Intelligence Applications Institute, University of Edinburgh. He also maintains close links with the Electronic Engineering School in the University College of Wales - Bangor.

He is a former-President of the Chelmsford Engineering Society and a former Director of the Chelmsford Festival Committee.

Dr. Williams is married to Susan (a musician) and has two children, a daughter Rachel and a son, Matthew. He lives near Chelmsford in Essex and his main hobbies are listening to his family play classical music, traditional jazz, contract bridge, walking his dog and gardening.

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NOTES

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2. In fact this stability has led to the occasional case where social and economic progress has necessitated moving backwards technologically. (See Bullitt, R., 1990)

3. There are other corollaries of these changes such as the need to rethink the nature of time in R&D which cannot detain us here. This latter has severe implications for Corporate strategies such as that promulgated by Boston Consulting Group (Stalk et al, 1990) which emphasise time-based competition.

4. It is a moot point how far any R&D group can in this day and age afford not to be commercially driven. However, for the most part I have in mind Corporate R&D functions and contract research organisations.

5. There is a line of reasoning to be pursued here that seems to put a limit on the extent to which internal R&D can be outsourced.

6. This work has been summarised in numerous places. See Button, G. & Sharrock, W. *The Production of Order and the Order of Production* and *Social Boundaries and Network Technologies* submitted to CSCW'97

7. It is important not to see these as "problems to be resolved" or "defects". They are characteristics, that's all.

8. E.g. Directive 96/9 of the European Parliament and of the Council, of 11 March 1996? on the legal protection of databases, OJ No. L 77/20, 27.3.96.

9. E.g. exclusive access to *digitized* nautical charts, *DeLorme Publishing Co. v. National Oceanic and Atmospheric Administration of the U.S. Dept. Of Commerce.* 917 F.Supp. 67 (D. Me. 1996).

   Although they constitute an extremely important form of intellectual property right, and are used extensively in the computer/software sector, I do not include trademarks in this list, because they raise economic questions very different from those raised by the forms listed.

10. E.g. J. Barton, "Patents and antitrust; A rethinking in light of patent breadth and sequential innovation," *Antitrust L.J.* (Forthcoming); R. Merges & R. Nelson, "Market structure and technical advance: The role of patent scope decisions," in T. Jorde & D. Teece (eds), *Antitrust, Innovation, and Competitiveness* 185 (1992); S. Scotchmer, "Standing on the shoulders of giants; Cumulative research and the patent law," 5 *J. Of Econ. Perspectives* 29 (1991).

11. 648 F.2d 642 (9th Cir. 1981).

12. ECJ 258/78 (1982).

13. See, e.g. *United States v. Imperial Chemical Industries*, 1954 Trade Cas ¶ 67,739 (S.D.N.Y., 1954) (U.S. court allowing restrictions on ICI imports into U.S., following unsuccessful effort to free U.S. competitor's exports to U.K.).

14. Uruguay Round Agreement on Trade Related Aspects of Intellectual Property Rights (1994).

15. *Supra.*

16. U.S. Constitution, Art 1, § 8.

17. 17 U.S.C. § 302.

18. See, e.g. European Directive 91/250 on the legal protection of computer programmes, OJ 1991 L122/42, 14 May 1991) (software directive permitting decompilation under certain circumstances); and *Sega Enterprises v. Accolade, Inc.*, 977 F.2d 1510 (9th Cir. 1992), *amended* 1993 U.S. App. LEXIS 78 (1993) (dicta interpreting copyright law to permit decompilation as part of reverse engineering).

19. 49 F.3d 807 (1st Cir. 1995) *aff'd by an equally divided Court* 116 S.Ct. 804 (1996).

20. For a proposal for context-dependent protection to respond to this concern, see L. Burgunder & C. Heckman, "An emerging theory of computer software genericism," 2 *High Tech. L.J.* 229 (1988).

21. Federal Trade Commission, Consent Decree, 60 *Fed. Reg.* 57870, Nov. 22, 1995.

22. *Re: The European Telecommunications Standards Institute (ETSI) Interim Intellectual Property Rights Policy*, [1995] 5 C.M.L.R. 352 (E.C. Comm. 1994).

23. 1997 U.S. App. LEXIS 1527 (2d. Cir. 1997).

24. *International News Service v. Associated Press*, 248 U.S. 215 (1918).

25. 86 F.3d 1447 (7th Cir. 1996).

26. Directive, *supra* Art. 8(1).

27. E.g. *Digidyne v. Data General Corp.*, 734 F.2d 1336 (9th Cir. 1984), *cert denied* 473 U.S. 908 (1985); 35 U.S.C. § 271(d)(5).

28. See, e.g. M. Lemley, "Antitrust and the internet standardication problem," 28 *Conn. L. Rev.* 1041 (1996).

29. For valuable insights, see G. Lunney, "Atari Games v. Nintendo: Does a closed system violate the antitrust laws?" 5 *High Technology L. J.* 29 (1990).

30. *Alaska Airlines, Inc. v. United Airlines, Inc.*, 948 F.2d 536 (9th Cir. 1991).

31. *Radio Telefis Eiranne v. Commission*, C241/91 & 242/91, 6 April 1995.

32. *United States v. American Telephone and Telegraph Co.*, 552 F.Supp 131 (D.D.C. 1982), *aff'd mem. Sub nom., Maryland v. United States*, 460 U.S. 1001 (1983).

33. Telecommunications Act of 1996, P.L. 104-104, Feb. 8, 1996.

34. *Re British Telecommunications plc and MCI*, [1995] 5 C.M.L.R. 285 (E.C. Comm 1994).

35. *United States v. MCI Communications Corp.*, 1994-2 Trad.Cas ¶ 70,730 (D.C.D.C. 1994) (consent decree).

36. U.S. Patent 4 567 359, considered in *Lockwood v. American Airlines*, 1997 U.S. Appl LEXIS 3830 (Fed. Cir. 1997).

37. U.S. Patent 5 521 815, May 28, 1996. See generally M. Lubbock, "Intellectual property protection for financial and other service industry products," [1996] E.I.P.R. 249 (May 1996).

38. See *United States v. Automobile Mfrs. Ass'n*, 1969 Trad.Cas. ¶ 72,907 (C.D. Cal. 1969; 1982-83 Trade Cas ¶ 65,008 (C.D. Cal 1982) (automotive emissions control technology).

39. E.g. *Intel Corp. v. ULSI System Technology, Inc.*, 995 F.2d 1566 (Fed. Cir. 1993); *Intel. Corp. v. U.S. Int'l Trade Comm.*, 946 F.2d 821 (Fed. Cir. 1991). The exception is Texas Instruments which broke with the pattern and brought suit against established competitors, e.g. *Texas Instruments v. U.S. Int'l Trade Comm.*, 988 F.2da 1165 (Fed. Cir. 1993).

40. For examples of the difficult analysis here, see, e.g. *United States v. Singer Mfg. Co.*, 374 U.S. 174 (1963); *Carpet Seaming Tape Licensing Corp. v. Best Seam, Inc*., 616 F.2d 1133 (9th Cir. 1980).

41. I would like to thank workshop participants for comments and thank Tim Bresnahan for many helpful discussion over the years. This paper follows largely from Bresnahan and Greenstein (1997b). I bear sole responsibility for any errors or omissions in this work.

42. See, for example, Inmon (1985) or Friedman and Cornford (1989) or Steinmueller (1996) for descriptions and analysis of the wide variety of computing platforms in use. Recent analyses of the current shift in platforms include Bresnahan and Saloner (1997) and Bresnahan and Greenstein (1997a, 1997b).

43. See Bresnahan and Greenstein (1996, 1997a) and the citations therein for further references.

44. For a much more careful statement of these and the following results, see Sutton (1991).

45. For more thorough summaries, e.g. see Besen and Saloner (1989), David and Greenstein (1990), David and Steinmueller (1994).

46. For example, when IBM introduced the AS/400 it arranged well ahead of time for the development of thousands of application programmes. When Sun first virtually gave away the specifications for its workstations, it was with the express purpose of encouraging third party applications development.

47. IBM's management of the migration from the System/360 to the 370 can be interpreted two ways. It either results from barriers to entry erected by IBM or it reflects the efficient preservation of users' investments in the platform (Fisher et al, 1983a, 1983b, Brock, 1975a, 1975b). The debate over the social efficiency of the technological lock-in to standards, such as the QWERTY keyboard, has a similar dichotomy. QWERTY can either be interpreted as myopic socially inefficient lock-in or rational preservation of durable investments with little foregone opportunity costs (David, 1985, Liebowitz and Margolis, 1995). Interestingly, these normative issues also arose in the discussion of Microsoft's behaviour. Microsoft either integrates technology for the good of all customers or it sabotages innovation from competitive software firms through its control of an essential facility (Reback et al. [1994] or FTC [1996]).

48. See Packard (1995), chapter 7. HP canceled the development of new products that required more elaborate servicing and marketing than they already had in place (pp. 103-104).

49. With one notable exception prior to client/server, the entry of the IBM PC. See below.

50. This gap was widely recognized and might have been filled in other ways. Extending an existing mainframe line would have permitted compatibility and growth, as before. Alternatively, a whole new platform, unconstrained by design history, could be designed to be optimal for a new customer body.

The latter strategy was attempted, with limited success, by IBM, Wang, and others in the early 1970s. Their "small business systems" were much more expensive than a standard (dedicated application) minicomputer because they included commercial features such as a standard servicing, training, and maintenance arrangement.

51. The hardware for a supermini such as the VAX-11/780 was not really much different from its technical ancestors (i.e. the PDP-11). The advances were well within normal platform growth: enlarged capacity (for multiple users), superior peripherals and air-cooled technology (Bell and Mudge [1978]). Though DEC also sold computers under the VAX name for technical uses, we focus on the commercial segment.

52. After an initial period of marketing VAX systems in the traditional technical manner, DEC added software tools and applications, simple servicing and maintenance contracts, and peripherals. DEC also began to add processors from a range of sizes and retained compatibility across the whole product line for much of the 1980s (Pearson [1992]). Wider general purpose use in business arrived with each addition of third-party application software (Friedman and Cornford [1989]). Multi-user capability suited the minicomputer to text-editing and printing, and other small data-based tasks such as multi-cash-register monitoring and report-writing or simple accounts receivables (Inmon [1985], Cortada [1996]). Software firms such as Oracle (databases) grew up to serve this segment. Users began to design the VAX platform into commercial applications.

53. See Davidow (1986), Teece (1986) on theories of "niche creation."

54. On the AS/400, see the account in Bauer, Collar, and Tang (1992) for an insider's view of the project management and product launch. See Andrews, Martin, Elms, and Simeone (1989) or West (1992) for analyses of technical capabilities and product design goals.

55. For a general theory of these roles, see Ferguson and Morris (1993).

56. The managers in IBM's PC division in Boca Raton aimed to introduce their product within a year. They saw no other way to achieve a fast introduction unless they used outside suppliers. See, e.g. Chopsky and Leonsis (1988), Fergosen and Morris (1993), Freiberger and Swaine (1984), Langlois and Robertson (1995), Steffens (1994) or Cringely (1994).

57. This is the standard theory of IBM the "strong second" succeeding commercially where others innovated. See, e.g. Davidow (1986) or Teece (1986) for similar summaries.

58. See Bresnahan and Greenstein (1997a).

59. This point has been emphasized by many authors. In the context of policy making in computing, see e.g. Flamm (1987, 1988) and Luzio (1996).

60. Since 1 April 1997 Christian Micas is working at the European Commission, DG XIII.

61. Wall Street Journal, 26/2/97.

62. Source: Standard & Poor's Bloomberg Financial Market, in *Business Week*, 07/02/96.

63. Women's apparel manufacturers came from the following SIC codes: 2331, 2335, 2337, 2339, 2342, 2384 and 2389). Magazine publishers SIC code was 2721. Pharmaceutical manufacturers SIC code was 2833

and 2834. Advertising agencies were from SIC code 1591.

64. In retrospect, the selection of broadcast time slots as an input was a poor choice. While airtime is a key input into a broadcast advertising campaign, since no advertising agencies own radio or TV stations, they must by necessity buy this input from an external organisation.