EVOLUTION OF THE TELECOMMUNICATIONS INDUSTRY INTO THE INTERNET AGE[1]

Martin Fransman
Professor of Economics and Founder Director
Institute for Japanese-European Technology Studies
University of Edinburgh

m.fransman@ed.ac.uk

A version of this paper will appear in *The International Handbook on Telecommunications Economics*: Edward Elgar Publishing, forthcoming.

---

[1] The author would like to acknowledge with gratitude his numerous discussions on telecommunications with Professor Sadahiko Kano with whom the layer model of the Infocommunications Industry, shown here as Exhibit 7, was constructed. Professor Kano has also been closely involved in the construction of TelecomVisions.Com (see below).

This paper has benefited from funding provided by the Targeted Socio-Economic Research (TSER) Programme of the European Commission (DGXII) under the Fourth Framework Programme, European Commission (Contract no.:SOE1-CT98-1114; Project no: 053), coordinated by W. Lazonick and M. O'Sullivan at the European Institute of Business Administration (INSEAD).

CONTENTS

EVOLUTION OF THE TELECOMMUNICATIONS INDUSTRY INTO THE INTERNET AGE[2]

Martin Fransman
Professor of Economics and Founder Director
Institute for Japanese-European Technology Studies
University of Edinburgh

m.fransman@ed.ac.uk

INTRODUCTION

How has the Telecommunications (hereafter Telecoms) Industry changed since the mid-1980s when liberalisation began in Japan, the UK and the US and what are the causes of this change? How has the Internet affected the Telecoms Industry? This chapter deals with these two questions.

In this chapter the interrelated causes of change are analysed that led, in the first place, to the transformation of the Old Telecoms Industry into the New Telecoms Industry and then, almost simultaneously, to the latter's metamorphosis into the Info-communications Industry. The demise of the Old Telecoms Industry began in the mid-1980s when, due to different combinations of political-economic circumstances, the monopoly of telecoms was ended in Japan, the UK and the US. By the late-1990s, with the agreement of the European Union to fully liberalise its telecoms markets and the similar agreement of the WTO, there was a widespread consensus that the liberalisation of telecoms is essential. The roots of change that gave birth to the New Telecoms Industry in the early-1990s, however, as this chapter will show, were far more fundamental than the political and regulatory decisions that finally legitimised the changes. In the 1990s a new set of influences, that had begun thirty years earlier in an initially unrelated set of activities, brought about fundamental forces that further transformed the Telecoms Industry into the Infocommunications Industry. These influences came from the Internet based on its triad of core technologies: packet-switching, Internet Protocol (IP), and the World Wide Web.

The Telecoms Industry and the Economics of Industrial Change

Despite important contributions made by earlier economists, such as Alfred Marshall and Joseph Schumpeter, it is reasonable to conclude that we do not yet have a comprehensive theory of the dynamics of industry capable of explaining the process of change in specific

---

[2] The author would like to acknowledge with gratitude his numerous discussions on telecommunications with Professor Sadahiko Kano with whom the layer model of the Infocommunications Industry, shown here as Exhibit 7, was constructed. Professor Kano has also been closely involved in the construction of TelecomVisions.Com (see below).

industries, even though an increasingly rich body of knowledge is emerging in this area.[3] Indeed, it could even be conjectured that the search for such a comprehensive theory would inevitably be wrecked on the rocks of complexity and diversity. Under these circumstances a valuable purpose is served by detailed accounts of the evolution of particular industries which focus specifically on what Schumpeter called the 'engine'[4] of change.[5] What this engine consists of then becomes a key problem in the analysis. In the concluding section several observations are made regarding the relevance of the Telecoms Industry for the economic analysis of the dynamics of industrial change.

TelecomVisions.Com

This chapter has been written in conjunction with the preparation of a Web site dedicated to one key question: What will happen to the Telecoms Industry and its companies over the next five years? The information and analysis provided on the Web site, TelecomVisions.Com, complements that contained in this chapter. (TelecomVisions.Com will be activated around August 2000.)

THE TECHNOLOGICAL AND LEARNING REGIMES

A key part (though not the only part – see below) of the 'engine' driving change in the Telecoms Industry is the technological regime that exists in this industry.[6] The

---

[3] For example, an important recent survey of economics literature on industrial dynamics by Dosi, Malerba, and Orsenigo (1997) concludes that "Certainly the gap between the richness of the histories [of the evolution of specific industries] and of their 'appreciative' interpretations on the one hand and the theoretical models that are used to 'explain' them on the other still appears quite large." (p.20) Dosi. G., Malerba, F., and Orsenigo, L., 1997, 'Industrial Structures and Dynamics: Evidence, Interpretations and Puzzles', *Industrial and Corporate Change*, Vol. 6, No.1, p 3-24.

[4] "The fundamental impulse that sets and keeps the capitalist *engine* in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates." Schumpeter (1943), p.83 (emphasis added). As will be seen, it is proposed in this chapter that there are several engines driving the evolutionary process, in addition to those proposed by Schumpeter.

[5] Such studies, of course, cannot be dismissed as inductive and descriptive for the simple reason that it is not possible to induce or describe the causes of industrial change. These causes do not emerge automatically or unambiguously from the huge mass of information that exists on the complex process of industrial change. Rather it is necessary to use, and constantly test, frameworks of interpretation in the attempt to come to grips with the tangle of causes that bring about industrial change. That alternative frameworks and conclusions are often possible, and accordingly have to be tested against the evidence, is part and parcel of the process of knowledge creation in this area.

[6] The concept of technological regime used here is similar to that used in Nelson and Winter (1974, 1978 and 1982) and in Winter (1984), although it is broader. For example, Winter (1984) distinguishes between two kinds of technological regimes: an entrepreneurial and a routinised technological regime. "An entrepreneurial regime is one that is favorable to innovative entry and unfavorable to innovative activity by established firms; a routinized regime is one in which the conditions are the other way round." (p.297) Audretsch (1997) uses the concept in the same way as Nelson and Winter. Malerba and Orsenigo (1990 and 1993) and Dosi, Malerba, Marsili and Orsenigo (1997) provide a further elaboration of the concept of technological regime. More specifically, in the latter reference it is stated that "a technological regime is a particular combination of some fundamental properties of technologies: opportunity and appropriability

technological regime is defined by the conditions under which technological knowledge is created - which determine the rate of technical change and the kinds of technologies that are created - and the opportunities and constraints that exist in the use of that knowledge. The technological regime, in turn, defines the *learning regime* that determines the kinds of learning paths and patterns in which the firms and other organisations involved in the industry will engage.

In order to understand the evolution of the Telecoms Industry - from the Old Telecoms Industry that existed until the mid-1980s, through the New Telecoms Industry, to the Infocommunications Industry – it is necessary to analyse the changing technological and learning regimes.

THE OLD TELECOMS INDUSTRY TO THE MID-1980s

Mapping The Old Telecoms Industry

A simplified map of the Old Telecoms Industry is provided in Exhibit 1 in the form of a layer model.[7]

Exhibit 1. Layers Of The Old Telecoms Industry

LAYER 3: SERVICES LAYER (voice, fax, 0800 services)
LAYER 2: NETWORK LAYER (circuit-switched network)
LAYER 1: EQUIPMENT LAYER (switches, transmission systems, customer premises equipment)

The Layers Of The Old Telecoms Industry

Layer 1 of the Old Telecoms Industry is the equipment layer where the network elements – such as switches and transmission systems - and customer premises equipment are produced that are combined to form and use telecoms networks. Until the 1970s these networks, shown in Exhibit 1 in Layer 2, were primarily circuit-switched networks where a dedicated circuit connects the sender and the recipient of information. In the 1970s, as will be seen later, the first commercial packet-switched data networks made their appearance although it was only in the 1980s, and even more so in the 1990s when the Internet became widely adopted, that data communications that data services became economically important. As shown in Layer 3, the main services in the latter stages of

---

conditions; degrees of cumulativeness of technological knowledge; and characteristics of the relevant knowledge base.” (p.94)

[7] Further details on the layer structure of the Telecoms Industry are to be found in TelecomVisions.Com).

the Old Telecoms Industry were voice, fax, and enhanced services such as toll-free 0800 services. Later in this chapter we shall return to the layer model in order to examine the impact of the Internet on the Infocommunications Industry.

Monopoly, Vertical Integration and Quasi-Vertical Integration

In the days of the Old Telecoms Industry the conventional wisdom was that telecoms was an example of 'natural monopoly', that is due to increasing returns to scale telecoms services could only be provided efficiently by a monopoly provider. Accordingly, in most industrialised countries (Finland being a notable exception) Layer 2, the network layer, was dominated by a monopoly network operator.

The natural monopoly hypothesis, however, was not, by and large, extended to Layer 1, the equipment layer. In different countries the production of telecoms equipment was organised in different ways. At the one extreme was the US where a pattern of vertical integration emerged almost from the birth of the Telecoms Industry.

In the U.S. "from the time that Alexander Graham Bell co-operated with instrument-maker Thomas Watson in producing the first telephone sets, it was the same organisation that both developed the telecommunications network and developed and manufactured the equipment that it required. This pattern was firmly established in 1880, when the American Bell Telephone Company purchased Western Union's telephone supplying subsidiary, the Western Electric Company of Chicago. According to an 1882 agreement, American Bell restricted itself to purchasing all its telephone equipment from Western Electric, while the latter agreed to limit its activities to supplying American Bell and its licensees."[8] This vertical integration of network operation and equipment production in AT&T continued until the company's voluntary trivestiture in September 1995 into one company providing telecoms services - the new AT&T - one providing equipment, Lucent, and one providing computers and computer services, essentially the former NCR that had been acquired in a hostile take-over by AT&T in 1993.

At the other extreme were the smaller industrialised countries (Sweden with Ericsson being a notable exception) and most of the developing countries where the national monopoly telecoms carriers procured their telecoms equipment from the handful of specialist telecoms equipment suppliers who competed in world markets. While being profitably locked into long-term relationships with the monopoly network operators in their home country, these specialist technology suppliers competed vigorously in the rest of the world where telecoms equipment markets were not similarly locked up by competing suppliers with privileged supply relationships with the national operator.

In the middle were the large industrialised countries with domestic markets that were sufficiently large to support domestic telecoms equipment production. In this category of countries, however, the economic organisation of Layers 1 and 2 – the equipment and network layers – differed significantly.

---

[8] See Fransman (1995), p.24.

In Japan, for example, from the late Nineteenth Century, when the Ministry of Communications took responsibility for the development of the new telecoms infrastructure, the decision was made for several competing companies to produce the telecoms equipment required for the Japanese telecoms network. In this way a family of four specialist telecoms equipment suppliers emerged to supply the Ministry under a form of economic organisation that has been referred to as 'controlled competition'.[9] The lead company was NEC, founded in 1899 as a majority-owned subsidiary of Western Electric, the equipment supplying subsidiary of AT&T. The other three members of the family were Fujitsu – which had an ownership link with Siemens – Hitachi, the only independent Japanese telecoms equipment supplier, and Oki. This family of suppliers continued to supply NTT, the national monopoly operator, after it was separated from the Ministry in 1952 as an independent state-owned company.

In Britain the Post Office which had responsibility for telecoms (later separated as BT) also co-operated closely with national telecoms suppliers that included GEC, Plessey, and STC (a subsidiary of the US firm ITT). However, the British experience with a long-term obligational co-operative relationship between network operator and equipment supplier was not nearly as happy as in the Japanese case. By the time BT was privatised in 1984 and liberalisation began in the British telecoms market the relationship between BT and its privileged national suppliers had already started to crumble.[10]

In France and Germany the monopoly network operator – to become France Telecom and Deutsche Telecom respectively – also co-operated closely with national equipment suppliers. In France a complex process of government-inspired re-organisations and mergers, largely between the subsidiaries of the American company ITT and French electronics companies, resulted in the birth of the major French specialist telecoms equipment company, Alcatel.[11] In Germany it was the electrical and electronics company, Siemens, that immediately became the major national equipment supplier although the Deutsche Bundespost (which would become Deutsche Telecom) also procured equipment from non-German suppliers like SEL, also a subsidiary of ITT.

To conclude, in Japan, Britain, France and Germany a pattern of close, long-term, obligational co-operation emerged as the dominant form of economic organisation between the monopoly operator in Layer 2 and the specialist technology suppliers in Layer 1. Although the degree of competition between the national suppliers in their national market differed – with Japan insisting on the strongest degree of competition – it is reasonable to characterise the dominant form of economic organisation in these countries as one of quasi-vertical integration.

---

[9] For a detailed account of the origins of the Japanese system of 'controlled competition' in telecoms, see Fransman (1995), pp.27-41.

[10] For a detailed account of the less-than-happy British attempt at co-operative research and development in the case of telecoms switches, involving the monopoly operator and its family of suppliers, see Fransman (1995), pp.89-97.

[11] For a detailed account of the birth of Alcatel, see Fransman (1995), pp.87-89.

The Technological Regime in the Old Telecoms Industry

Earlier we stated that the technological regime is defined by the conditions under which technological knowledge is created and the opportunities and constraints that exist in the use of that knowledge. What were the conditions under which technological knowledge was created in the Old Telecoms Industry? To answer this question it is necessary to understand the *innovation system* that existed in the Old Telecoms Industry.

Essentially, in the Old Telecoms Industry the 'engine of innovation' was located in the central research laboratories of the monopoly telecoms operators, such as AT&T's Bell Laboratories, BT's Martlesham Laboratories, France Telecoms's CNET Laboratories, or NTT's Electrical Engineering Laboratories. It was in these laboratories that the research was done that would lead eventually to the next generations of switches, transmissions systems and other telecoms equipment that would improve telecoms services. Many of the key technologies still driving the Infocommunications Industry began life in these central research laboratories - such as the transistor, the laser, the design of cellular mobile systems, and the software language C, that all emanated from Bell Laboratories.

Typically, after the central research laboratory did the initial research and developed and tested the initial prototypes the task of further development and mass manufacture was handed on to the specialist equipment suppliers – such as Western Electric in AT&T's case or NEC, Fujitsu, Hitachi and Oki for NTT. Over time, however, these specialist equipment suppliers increased their own R&D capabilities with the result that they eventually took over many of the innovative tasks that in the Old Telecoms Industry were performed by the central research laboratories of the monopoly telecoms operators. As we shall see, this created a fundamental change in the technological and learning regimes that was to profoundly change the entire structure of the Telecoms Industry.

How efficient was the innovation system of the Old Telecoms Industry? In answering this question it has to be said that, despite the national monopoly position enjoyed by the telecoms operator and the small number of privileged specialist suppliers who created the equipment for the telecoms network, the innovation system system worked remarkably well. Evidence for this conclusion comes from the impressive stream of both radical and incremental innovations that emerged from the central research laboratories of the monopoly operators. One performance benchmark comes from the fact that in the US the price of a local phone call remained constant in money terms for about one hundred years.

The paradox of a rapid rate of radical and incremental innovation from a system dominated by a monopolist supplied by no more than four privileged suppliers is to be explained in terms of the non-market incentives for innovation that nevertheless existed in the Old Telecoms Industry. The first of these non-market incentives came in the form of the 'co-operative competition' that existed between national systems to be the first to introduce the next generation of technologies and services. One example is the races that took place to develop the next generation of telecoms switches, races that were nonetheless punctuated by the formal and informal sharing of information through institutions such as regular international switching conferences that brought together the world's best.[12] The second major non-market incentive came in the form of political incentives and pressures to improve telecoms services for both residential and business users who together constituted the bulk of the population and therefore wielded political muscle.

However, despite the impressive innovative performance of the Old Telecoms Industry, there were several characteristics of the innovation system in this industry that constituted important constraints on the innovation process, constraints that were to be highlighted by a comparative analysis of the new innovation process in the New Telecoms Industry that replaced it (which is examined in more detail below).

The characteristics of the innovation system in the Old Telecoms Industry are summarised in Exhibit 2.

Exhibit 2. Characteristics of the Innovation System in the Old Telecoms Industry

Closed innovation system **High entry barriers**
Few innovators
Fragmented knowledge base
Medium-powered incentives
Slow, sequential, innovation process: **Research – prototype –** **trials - cutover**

To begin with, the innovation system in the Old Telecoms Industry was closed in the sense that only the monopoly telecoms operator and its chosen circle of specialist equipment suppliers were given access to the telecoms network and were able to make innovations for it. This implied that there were extremely high, even prohibitive, barriers to entry into this innovation system. Accordingly, there were very few innovators. Furthermore, the knowledge base underpinning global telecoms was fragmented. Each national telecoms network had its own specific designs and technologies. For example, central office switches designed for the Japanese market could not, without the cost of considerable modification, be immediately deployed in Europe or the US. The same was true for switches designed for the European or US markets. Under this regime incentives

---

[12] For a detailed study of the development of telecoms switches in the US, Japan, and Europe and for the development of optical fibre in the US, Japan and the UK, see Fransman (1995).

were medium-powered since the market size for products designed for specific markets was relatively small.

Finally, the innovation process itself was slow and sequential. In the circuit-switched network it was necessary that switching and transmission equipment worked with extremely high degrees of reliability. Equipment failure could lead to entire networks being shut down. Typically, the innovation process began with research being done in the central research laboratories of the leading monopoly operators. This research eventually resulted, in the second stage, in a prototype being developed. In the third stage the prototype was exhaustively tested, first in the laboratory and then, after its further development and manufacture by the specialist equipment supplier/s, in field trials. Finally, after the reliability of the prototype had been adequately demonstrated, the equipment was 'cutover' into the network. Although this innovation process 'worked' in the Old Telecoms Industry, its drawbacks became apparent, as we shall see below, in the light of the fundamentally different process that replaced it in the New Telecoms Industry.

The Learning Regime in the Old Telecoms Industry

The technological regime structures the learning regime. Essentially, the learning process involved the monopoly network operator (located in Layer 2) learning how to run and improve its telecoms network which provided the platform for the services that it offered. Being a monopolist, the 'selection environment' of the network operator excluded pressures and incentives to compete in telecoms services markets. However, as noted in the previous section, there were pressures and incentives to improve both the network and services emanating from domestic political processes as well as rivalry between national systems to rapidly introduce new technologies and services. The latter pressures and incentives shaped the learning process.

In the Old Telecoms Industry the monopoly network operator was both a user and an innovator of telecoms technologies and equipment. However, there was a division of labour with the network operator concentrating on research (including fundamental and long term research) and design while its selected equipment supplier/s (located in Layer 1) specialised in development and mass manufacture of equipment. As a sophisticated user and innovator of telecoms technologies and equipment the monopoly network operator was well-placed to learn-by-using and by experiencing opportunities for further improvements through running the network. However, in developing telecoms technologies and equipment for mass manufacture the specialist equipment suppliers also underwent a learning process that enabled them over time to move into the upstream parts of the innovation process, namely into increasingly research- and design-intensive activities. Moreover, while they may have enjoyed sheltered access to the procurement book of the monopoly network operator in their own domestic market, in order grow they were forced to enter and compete in foreign markets, particularly third-country markets where there were not similarly sheltered equipment suppliers producing for the domestic monopoly network operator. Competitive pressures and incentives in these markets were an important stimulus for learning by the specialist equipment suppliers.

The learning process was also structured by technological paradigms and trajectories. For example, the transition to each new generation of central office switch – from electro-mechanical to space-division electronic to digital time-division to asynchronous transfer mode (ATM) switches – was accompanied by considerable controversy over the question of whether improvements in the old paradigm would make the new paradigm irrelevant.[13] Overall, however, it was the circuit-switched paradigm that shaped thinking and learning about how to achieve improvements. The deeply-ingrained influence of the circuit-switched paradigm on the part of telecoms researchers and engineers is apparent in the reception that Vinton Cerf and his colleagues (who were amongst the original founders of the Internet) encountered from Bell Labs researchers when details about the packet-switching that they were developing became known. In Cerf's words:

> "The packet-switching network was so counter-culture that a lot of people thought it was really stupid. The AT&T guys thought we were all beside ourselves; they didn't think that interactive computing was a move forward at all."[14]

Coming from a computer culture, the developers of the ARPANET, the forerunner of the Internet, were not inclined, as were their telecoms counterparts, to see the problem of communications through the paradigmatic prism of circuit-switching (as will be seen in more detail later).

THE TRANSITION TELECOMS INDUSTRY

In the mid-1980s, for different political-economic reasons, Japan, the UK and US decided to end the monopolies of their monopoly network operators. The result was the birth of the original new entrants.

The Birth of the Original New Entrants

The introduction of liberalisation and competition in these three countries, however, was at first cautious and tentative. In Japan three long-distance competitors were given regulatory permission to compete with NTT, namely DDI, Japan Telecom, and Teleway Japan. NTT was only partially-privatised, with the Japanese Government continuing to own approximately two-thirds of the company. The UK government, on the other hand, soon sold off the majority of BT's shares but began the process of liberalisation with a period of duopoly with Mercury, a subsidiary of Cable and Wireless, as the sole competitor to BT. In the US, AT&T was divested with the new AT&T inheriting the former company's long-lines business (i.e. long-distance) while seven regional

---

[13] See Fransman (1995), Chapter 3, for further details.

[14] *Internet*, 'Is there a future for the Net? David Pitchford finds out from the man who invented it, Vinton Cerf', June 19th, 1996, p.75.

companies – the Baby Bells – retained the de facto monopoly of local telecoms services in their regions. MCI and Sprint were the two long-distance companies allowed to compete with AT&T.

Original New Entrants and Specialist Technology Suppliers

Although liberalising regulatory regimes provided a necessary condition for rapid and successful entry by the original new entrants, they were not sufficient. Equally important were low technological barriers to entry into the telecoms services markets (in Layer 2) created by the existence of specialist telecoms equipment suppliers. These specialist technology suppliers provided the 'black-boxed' technologies that the Original New Entrants needed to contruct and run their own networks. Unlike their counterparts in other industries such as pharmaceuticals or semiconductors, where substantial in-house technological capabilities were necessary in order to enter and compete, the Original New Entrants in the Telecoms Industry were able to turn to specialist technology suppliers for most of their technology requirements. Without the knowledge-acquisition and learning processes that the specialist technology suppliers underwent in the Old Telecoms Industry, would-be original new entrants would have faced formidable technological barriers to entry.

From the point of view of the specialist technology suppliers, liberalisation created new markets for their accumulating knowledge and competencies. An important example is Nortel that seized the new opportunities presented by liberalisation with both hands. Nortel was originally established in 1895 as the subsidiary of Bell Canada. From 1906 to 1962 AT&T's equipment subsidiary, Western Electric, held a minority stake in Nortel, a stake that was gradually sold to Bell Canada. In 1971 Bell Canada, that bought most of its equipment from Nortel, established a joint R&D subsidiary with Nortel called BNR. However, in order to grow, Nortel from the late 1970s made strenuous efforts to enter export markets. In these attempts the company was considerably aided by its pioneering success in developing one of the first small digital central office switches, the DMS 10. Beating AT&T into this segment of the switching market Nortel was able to gain a foothold in the US, its first major breakthrough outside Canada.[15]

In MCI, the main long-distance competitor to AT&T, Nortel found an important ally. As a competitor to AT&T, MCI, like many of its original new entrant counterparts in other parts of the world[16], did not want to depend on the same specialist equipment suppliers that supplied the incumbent. This provided Nortel with the opening it was seeking. Furthermore, able to rely on Nortel and other specialist technology suppliers for the technology and equipment it needed, MCI also decided that it did not need to replicate similar R&D capabilities that AT&T had in its Bell Laboratories.[17] With further stages

---

[15] Further details of Nortel's success are to be found in Fransman (1995), pp. 55-61, including an explanation of why Nortel managed to beat AT&T in this switch market segment.

[16] DDI, the main competitor to NTT, similarly refused to procure its equipment from NTT's family of specialist equipment suppliers, NEC, Fujitsu, Hitachi, and Oki.

[17] Indeed, MCI took particular pride in the fact that, with access to specialist technology suppliers, it did not need to make the same expenditures on R&D as AT&T. While AT&T was spending more than seven

of liberalisation in the US and Europe, Nortel quickly became the main technology supplier to the 'new new entrants' as will be shown below.

The Conservatism of the Original New Entrants

Perhaps because the selection environment into which they were born was characterised by only partial competition, the original new entrants in the US and UK were conservative rather than radical in their competition with their incumbent, tending largely to imitate them while only slightly underpricing them. Soon, however, the orginal new entrants would be overshadowed by the new breed of 'new new entrants' whose entry signaled the emergence of the New Telecoms Industry.

THE NEW TELECOMS INDUSTRY FROM THE EARLY-1990s

Enter the New New Entrants

In retrospect, from the vantage point of the late-1990s, it was clear that a qualitative change had occurred in the Telecoms Industry in the early-1990s, signifying the birth of the New Telecoms Industry. The most evident sign of qualitative change was the rise of the new new entrants who quickly eclipsed the original new entrants and went on to pose the most significant threat to the incumbents.

Most dramatic was the rise of WorldCom, a company that was born in 1984 in the inauspicious location of Hattiesburg, Mississippi, and began life as a reseller of the newly-divested AT&T's capacity before making the key strategic decision to become a facilities-based operator. By the end of the millenium not only had WorldCom capped a string of mergers and acquisitions with the takeover of MCI and Sprint, the two main long-distance competitors to AT&T, it also boasted the world's best global telecoms network making this company the most serious threat to the Big Five Incumbents – AT&T, BT, Deutsche Telecom, France Telecom, and NTT. Although they emerged later than WorldCom and were not as large in terms of revenue and market capitalisation, several other new new entrants replicated essentially the same growth process. These companies included Qwest, Level 3, Global Crossing, Williams, and Viatel.

In Europe new new entrants made a similar, though somewhat later, dramatic entry. These new players in Europe included telecoms operators such as COLT (City of London Telecommunications), Energis (the English telecoms subsidiary of the regional electricity supplier), and Mannesmann (the German industrial engineering company that transformed itself into both a fixed-line and mobile operator).

---

percent of its sales on R&D, MCI's expenditures were so negligible that they were not even reported. (Author's interviews with Serge Wernikoff, Senior Vice President and Board Member of MCI, 1993 and 1994.)

Unlike the original new entrants, the new new entrants were far more aggressive in their competition. This was seen both in their activities in the market for corporate control as well as in global telecoms markets. In the late 1990s, for example, WorldCom acquired MCI and Sprint (as already noted), Qwest acquired US West (the smallest Baby Bell), and Global Crossing acquired Frontier. Furthermore, all the major US new new entrants began to construct their own global networks even before their US networks were fully completed, typically beginning in the UK, the most liberalised of the European markets, and then moving on to construct pan-European networks. (This raises an important puzzle about the characteristics of the US telecoms system that explain why the most aggressive telecoms operators, in terms of the global expansion, are American.[18]) It was only in Japan that by the end of the millenium new new entrants had not displaced the original new entrants.[19]

Why were the new new entrants able to make such a dramatic entry and why were they able to be so successful so rapidly? A large part of the answer to this important question lies in the changes that occurred in the technological regime, changes that began already in the late stages of the Old Telecoms Industry.

The Technological Regime in the New Telecoms Industry

By the mid-1990s a decisive process of vertical specialisation had occurred between Layers 1 and 2 (see Exhibit 1 above) in the Telecoms Industry. As noted earlier, in the Old Telecoms Industry the R&D engine was largely located in the central research laboratories of the monopoly network operators such as AT&T, BT, and NTT, with the specialist equipment suppliers being largely relegated to playing the role of dependent developers and manufacturers. By the end of 1995, however, this situation had changed dramatically with the now incumbent network operators making the decision to leave more and more of the R&D related to the network and its elements to the specialist equipment suppliers. At the same time the incumbents decided to open their procurement, agreeing to buy from new suppliers in addition to their traditional suppliers.

A snapshot of the technological regime in transition, as it moved from the Old to the New Telecoms Industry, is provided in an article published in 1994 that compared AT&T, BT and NTT in terms of their visions, strategies, competencies, and R&D.[20] This article, amongst other things, showed that these three companies had made fundamentally different organisational decisions regarding their technological competencies and their procurement of telecoms equipment. While AT&T resorted to vertical integration, procuring the bulk of its equipment from its own equipment business, BT, at the other extreme, had decided increasingly to resort to the market for its equipment needs. In the middle, NTT relied on its own home-grown form of organisation, namely controlled

---

[18] As will be made clear later, this generalisation, while true for the fixed-line operators is untrue for the mobile operators. It the mobile field, for reasons that will be analysed below, it was European and to a lesser extent Japanese companies that dominated globally.

[19] This is a further puzzle that also requires explanation in terms of the characteristics of the Japanese telecoms system. Unfortunately, however, there is insufficient space here to explore this puzzle.

[20] See Fransman (1994), reprinted in Fransman (1999).

competition involving a closed family of four suppliers, for its equipment supplies. The different choices made by these three companies were reflected in their markedly different R&D-intensities. While AT&T spent about 7 percent of its sales on R&D, the figure was around 4.5 percent for NTT and about 1.9 percent for BT.

By the end of 1995, however, a decisive process of convergence began to take place between these three companies. AT&T underwent the biggest change when, in September 1995, the company voluntarily trivested itself, spinning off its equipment business in the form of Lucent, and NCR, the computer company that it had acquired in a hostile takeover in 1993. BT continued along the path that it had charted from the early 1990s, after its unhappy experiences in jointly developing its own System X digital switch, and left more and more of its network needs to the market. NTT, to begin with under trade-related pressure from the US but later increasingly responding to the new opportunities provided by vertical specialisation, also began to procure a greater proportion of its equipment from outside its traditional family of suppliers and to shift its R&D away from network-related areas and more towards service-related innovation.

The Changing Location of R&D in the New Telecoms Industry

One of the best indicators of change in technological regime as the Old Telecoms Industry gave way to the New Telecoms Industry is provided by data on the changing location of R&D. This data is summarised in Exhibit 3

Exhibit 3. The Location of R&D in the New Telecoms Industry, 1999

FIRM/INDUSTRY	R&D % SALES
NTT	3.7%
BT	1.9%
AT&T	1.6%
Cisco	18.7%
Ericsson	14.5%
Nortel	13.9%
Lucent	11.5%
Nokia	10.4%
WorldCom	~ 0%
Qwest	~ 0%
Level 3	~ 0%
Global Crossing	~ 0%
Roche	15.5%
Glaxo Welcome	14.4%
Smithkline Beecham	10.8%
Vehicle Industry	4.2%
Leisure & Hotel Industry	3.2%
Building Materials Industry	3.0%
Brewery Industry	2.3%

Source: *Financial Times*, R&D Scoreboard, 1999,
and author's calculations from company reports.

Several characteristics of the technological regime in the New Telecoms Industry are evident from Exhibit 3. The first characteristic is that the incumbent network operators – represented in Exhibit 3 by NTT, BT and AT&T – are not particularly R&D-intensive. Indeed, the bottom cell in Exhibit 3 shows that the incumbents are less R&D-intensive than the average intensity in industries that are not normally thought of as 'high-tech' industries, namely the vehicle, leisure and hotel, building materials, and brewery industries.

The second characteristic is that the new new entrants – represented here by WorldCom, Qwest, Level 3, and Global Crossing – are even less R&D-intensive than the incumbents, doing virtually no in-house R&D. The reason, as already mentioned in this chapter, is that the new new entrants have made the strategic decision to outsource almost all of their R&D requirements to the specialist technology suppliers. The reasoning given by Energis, one of the major new new entrant rivals to BT in the UK, for not doing its own R&D is typical for all the new new entrants:

> "Energis' policy is not to undertake significant research and development, but to utilise technology developed by its suppliers and, as a result, Energis has spent an immaterial amount on research and development…"[21]

As a substitute for its own internal R&D Energis has forged a highly satisfactory relationship with Nortel as its main technology supplier, a relationship that has also involved the subcontracting of specific R&D projects.[22] Similarly, Qwest, the US new new entrant that in 1999 acquired the smallest of the Baby Bells, US West, also undertakes virtually no internal R&D. In its 1998 Annual Report Qwest states that its "R&D costs incurred in the normal course of business are …$27.7 million…in 1998." This compares with the company's total revenue for 1998 of $2,242.7 million, which makes Qwest's R&D expenditure a mere 0.012 percent of total revenue.[23] As Qwest freely admits,

> "We built our network with state-of-the-art technology and through alliances with companies like Cisco, Nortel and Ascend. In 1998 we continued to join with the best in the business to take the power of network applications to more markets in new ways with advanced products."[24]

The third characteristic is that R&D-intensive activities, mainly relating to the elements that go into networks, have moved decisively into the specialist technology suppliers, represented in Exhibit 3 by Cisco, Ericsson, Nortel, Lucent and Nokia. These specialist

---

[21] Energis, *Global Offering*, Form 20-F, p.6.
[22] Author's interview with Mike Grabiner, CEO of Energis, 1999.
[23] Qwest, *Annual Report*, p.33 and 28 respectively.
[24] Qwest, *Annual Report 1998*, p.11.

technology suppliers are some six times as R&D-intensive as the incumbents, AT&T, BT and NTT. Furthermore, their R&D-intensity is comparable to that of the pharmaceutical companies, acknowledged to be amongst the most R&D-intensive of all sectors. This is evident from the figures provided in Exhibit 3 for the pharmaceutical companies Roche, Glaxo Welcome, and Smithkline Beecham. And the five specialist technology suppliers represented in Exhibit 3 represent just the tip of the iceberg. In addition to the other large telecoms equipment suppliers - such as Alcatel, Siemens, NEC, and Fujitsu - are the huge number of R&D-intensive medium sized companies that are supplying advanced telecoms technologies in numerous niches.

It may be concluded, therefore, that while in the Old Telecoms Industry the 'innovative engine' was located largely in the central research laboratories of the monopoly network operators, in the New Telecoms Industry the 'R&D engine' has moved decisively into the specialist technology suppliers. This provides one key indicator of the extent of the process of vertical specialisation between Layers 1 and 2 (see Exhibit 1) in the New Telecoms Industry.

A significant word of caution, however, is necessary regarding this conclusion. This arises because it is important not to confuse R&D with innovation. Firms with low R&D-intensity may nevertheless be highly innovative, and their innovativeness may lead to competitiveness and high profitability. One example is MCI's Family and Friends billing innovation that allowed the company to offer preferential tariffs on several frequently called numbers and gave the company for a while a significant advantage over its rival, AT&T. Although not falling under the conventional classification of R&D, this innovation is indicative of the kinds of advances that may be made that do not involve R&D. We shall return later to the importance of innovation in discussion of the learning regime in the New Telecoms Industry.

Specialist Technology Suppliers and Low Technological Barriers to Entry

One part of the answer to the puzzle of why the new new entrants were able to enter the Telecoms Industry so rapidly and so successfully is now, in the light of the analysis of the changing technological regime, apparent. Being able to rely on highly competitive markets for technology supplied by a host of rivalrous specialist technology suppliers, the new new entrant operators have faced extremely low technological barriers to entry.

This also explains the apparent paradox of firms that to begin with knew virtually nothing about telecommunications becoming telecoms operators. Examples include Bernard Ebbers who was one of the founders of WorldCom but had a background as a football coach and motel operator; COLT (City of London Telecommunications), one of the main challengers to BT in the UK, which was established by Fidelity, the largest mutual fund in the US (that earlier had established Teleport, a competitive local exchange carrier in New York and Boston that was later sold to AT&T); Qwest, established by Philip Anschutz, a billionaire with a background in ranching, oil, and railroads; and

Mannesmann, Olivetti, and Energis that came from backgrounds in industrial engineering, electronics, and electricity respectively.

With such low technological barriers to entry, the result has been a highly competitive market for network services (in Layer 2, see Exhibit 1).[25] However, the contribution of specialist technology suppliers was not confined to the supply of technology. Also important are the human resources that these suppliers provided, through the operations of the labour market, to both the original new entrants and the new new entrants. An examination of the backgrounds of the leading executives in the major original new entrant and new new entrant telecoms companies readily reveals the importance of recruitment from specialist technology suppliers (as well as from the incumbents). Furthermore, there are key examples where specialist technology suppliers, like Nortel and Ericsson, have also provided their new new entrant customers with finance that in some cases has played a major role in facilitating the growth of these companies.

Also central has been the role played by capital markets. In some cases capital markets have interacted with labour markets to support the entry and growth of new entrants, for example where share option schemes, with the expectation of significant future increases in share values, have provided an important incentive for people possessing key knowledge to move from specialist technology suppliers, or incumbents, to new entrants. The role of capital markets is analysed in more detail in a separate section below.

The Learning Regime in the New Telecoms Industry

As noted earlier, the technological regime structures the learning regime. What are the main learning processes that occur in the New Telecoms Industry?

Learning by Network Operators[26]

Exhibit 3 above suggests that it is necessary, in examining the learning process in the New Telecoms Industry, to distinguish between the R&D-performing incumbent network operators – such as AT&T, BT, Deutsche Telecom, France Telecom, and NTT – and the R&D-less new new entrants such as WorldCom, Qwest, COLT, and Engergis. In the former companies the learning process includes activities undertaken in organisationally-

---

[25] A further important contributor to competition in Layer 2 has been the proliferation of competing network technologies, a topic that is take up later in the section dealing with different forms of competition in the New Telecoms Industry.

[26] Attention in this section is confined to those telecoms companies that own and operate their own networks, that is to the larger companies in Layer 2 (see Exhibit 1). In a very different position are facilities-less telecoms service providers – such as call-back providers, resellers, or facilities-less Internet Service Providers. Since these kinds of telecoms companies buy-in the services of network operators their learning processes are fundamentally different from those of facilities-based telecoms companies. We shall return to facilities-less telecoms service providers in our discussion below of the layer model for the Infocommunications Industry shown in Exhibit 7. See TelecomVisions.Com for further details on the facilities-less service providers.

distinct R&D laboratories, whether they are attached to business units (where the bulk of the incumbents' R&D resources are located) or situated in central research facilities. In the latter companies, as we have seen, R&D learning is entirely outsourced to specialist technology suppliers and the fruits of this learning bought-in in the form of tangible assets such as telecoms equipment or intangible knowledge such as occurs when technological advice is given.

However, all network operators participate in the division of labour that follows from the process of vertical specialisation between Layers 1 and 2 (see Exhibit 1). In particular, all network operators are heavily dependent on purchases from specialist technology suppliers in the form of network-related equipment and associated systems such as billing and IT management software. This dependence is even greater in the case of the new new entrants who, as we have seen, do not undertake their own R&D. Nevertheless, since all of the network operators are very dependent on specialist technology suppliers, much of their learning takes the form of learning to *use*, rather than learning to *produce*, technology.

New New Operators as F4 Firms

A further distinguishing feature of the new operators, in contrast to the incumbents, is their ability to focus on a subset of market segments. This ability has resulted largely from the absence of universal service obligations (even though regulatory regimes usually require new operators to contribute financially to universal service). This has meant that new operators have been able to choose particular market segments – such as multinational business, large domestic business, small and medium-sized business, or residential customers – and focus their learning processes on the chosen segments. In turn, their focus on particular customer segments and their absence of universal service obligations has allowed the new operators to be smaller than their incumbent competitors. Smaller employment size, correspondingly, has allowed new operators to create three other organisational 'F-characteristics': flatness, fastness, and flexibility. Compared with the incumbents, the new operators have been able to avoid hierarchical, bureaucratic organisations in favour of flat organisations; they have been able to establish streamlined decision-making procedures facilitating fast decisions; and this has given them the ability to change direction or establish new directions more quickly than their incumbent competitors. Together with focus, in short, they have been able to become 'F4 Firms'.

An example is provided by Energis, the telecoms subsidiary of the National Grid, the main electricity provider in England and Wales. Exhibit 4 shows the functional employment of Energis, that has become one of the main long-distance competitors to BT and more recently has moved into metropolitan area networks and has begun operations on the European continent.

Exhibit 4. Employment by Function in Energis

DEPARTMENT/FUNCTION	NUMBER	PERCENT
Customer Service	138	17%
Executive	6	0.8%
Finance, Property & Legal	123	15%
Human Resources	11	1.4%
Information Systems	84	11%
Marketing	48	6%
Network Operations & Engineering	256	32%
Sales	129	16%
Strategy and Business Development	3	0.4%
Total	**798**	**100%**

Source: HSBC, *Global Offering of 60,000,000 Ordinary Shares At A Price of £16.50 Each In Energis plc*, January 22nd, 1999, p.19.

At this stage Energis, which started operations only in 1993, had sales of around £400 million, had built a network of 6,500 km covering all the principal business centres in England, Wales and Northern Ireland, and had already joined the FTSE 100 (Financial Times stock exhange index) list of the most valuable companies.[27] Leading stock market analysts estimated that Energis would win 11 percent of the UK market for advanced telecoms services by 2006. In 1998 Energis already carried 60 percent of the UK's total Internet traffic.

The Differentiation Dilemma

Although the network operators have benefited greatly from the technology supplied by the specialist technology suppliers, they have also had to confront the downside of this transaction. By depending on the specialist technology suppliers, who supply their state-of-the-art technology to anyone with the ability to pay for it, the network operators have foregone a possible source of differentiation from their competitors, namely improved products, services and processes brought about by internally produced technical change. This may be referred to as the differentiation dilemma. In short, network operators are unable to enjoy the benefits of better technologies than their rivals. All have access to essentially the same technologies.[28]

The differentiation dilemma is particularly acute for the new operators who, as we have seen, do virtually none of their own R&D.[29] The R&D-performing incumbents, on the

---

[27] Energis plc, *Interim Report 1999/2000, p.2.*

[28] Of course, different network operators may choose different technologies. For example, operators competing in the local access market have the choice of optical fibre, XDSL/copper cable, coaxial cable, fixed wireless access, cellular mobile, and even satellite. However, other operators have access to exactly the same technologies.

[29] In theory, new operators do have the option of outsourcing R&D to specialist technology suppliers. In my interviews I have come across cases where the new operator has negotiated temporary privileged access to the output resulting from outsourced R&D. After the temporary period has ended, however – usually a short period of around six months – the specialist technology supplier tends to assume full control over the

other hand, have a potential advantage stemming from their in-house R&D capabilities. However, as we have also seen, the vast bulk of R&D in the New Telecoms Industry is done by the specialist technology suppliers and this accordingly limits the ability of the incumbents to achieve significant technological advantages from their in-house R&D. Nevertheless, this issue raises the important question of whether, over time, the new entrants will find that they too should be doing their own internal R&D in order to keep up in the competitive race.

The differentiation dilemma is a dilemma precisely because, in the absence of differentiation, and with substantial new entry facilitated by low entry barriers, firms are unable to earn scarcity rents. Accordingly, profit margins will be low. This raises two key questions: How do network operators compete in the New Telecoms Industry? What characteristics drive competitiveness?

In some cases a partial solution to the differentiation dilemma is available to a few network operators. For example, Qwest, as a result of Philip Anschutz's railway property rights, was able to acquire important rights-of-way that allowed the company to secure its optical fibre conduits by burying them alongside railway lines. In turn, the scarcity of these property rights allowed Qwest to earn substantial economic rents. More specifically, Qwest has been able to earn significant revenues by selling some of the capacity on its optical fibre networks to competitors Frontier, WorldCom, and GTE in the form of dark fibre[30] Indeed, Qwest has stated that "the sale of dark fiber [primarily to these three competitors] has financed more than two-thirds of our overall [network] construction costs."[31] Similarly, cellular mobile and fixed wireless access companies have benefited from the natural scarcity of spectrum (to some extent paid for by the auction price of spectrum). Some competitive local exchange carriers have also argued that permission to dig up the streets and lay cables, and the sheer difficulties involved in so doing, constitute important entry barriers and, faced with competitive service tariffs, make entry relatively unattractive for late-comers.[32]

However, even after these entry barriers are taken into account, the problem for an operator attempting to differentiate its products and services remains. So, how do network operators compete in the New Telecoms Industry?

In competing with the incumbents the new new operators enjoy a particular competitive advantage (that has to be set against the disadvantages of the new entrant vis-à-vis the established incumbent). This advantage stems from the so-called legacy networks of the incumbent, that is the older-generation technologies that are, inevitably, incorporated in parts of the incumbent's network. The new new operator, on the other hand, can start with a clean slate, deploying only the latest, state-of-the-art technology. Reading through the evaluations of the new new operators made by the leading stock market analysts it is

---

technology. In practice, however, there seem to be very few examples where this has given the new operator a significant technology-based competitive advantage.

[30] That is, unused, or unlit, optical fibre.

[31] Qwest, *Annual Report 1998,* p.13.

[32] Authors interviews.

clear that considerable weight has been placed on the technological advantage of the new entrant relative to the incumbent in calculating expected future market share and earnings.[33] The problem facing the new new operator, however, is that while the latest technology may provide a competitive advantage against the incumbent, the window of opportunity thereby provided is inevitably short-lived: in due course, even newer entrants will be able to enjoy the benefits of even more recent technologies.

Furthermore, in competing with other new new entrants that have entered at the same time an operator is unable to rely on technological superiority. In these cases competition revolves around the attempt to provide superior quality of service – such as quicker provisioning time and quicker restoration of disrupted service – and superior customer care, such as better understanding of customer needs and a greater ability to provide solutions, on the basis of the same common technology, to customer problems. This competitive process is similar to other industries where service providers are supplied by common specialist technology suppliers, such as the airline business where airlines, supplied by the same providers of airframes, aero-engines, and in-flight entertainment systems, struggle to persuade customers that they are somehow different.

This analysis of the differentiation dilemma, however, raises the puzzle of why stock markets have valued the shares of new new entrant operators so highly. In turn this poses the broader question of the role that financial markets have played in the New Telecoms Industry.

The Role of Financial Markets

In this paper significant weight has been put on the technological and learning regimes as an 'engine' of evolution in the Telecoms Industry. However, it is not the only engine. Another important engine of change has been financial markets.

Financial markets have influenced the evolution of the Telecoms Industries in two major ways. First, they have facilitated the entry and initial growth of new entrants, in particular the new new entrants. Secondly, they have facilitated the 're-shuffling of the capital stock'[34] that has taken place as both network operators and specialist technology suppliers with highly valued shares have used their valuable 'paper' (shares) to acquire the complementary knowledge and tangible assets of other companies. By so doing, financial markets have facilitated the process of consolidation in the Telecoms Industry

---

[33] For example, in the valuations of Qwest considerable weight has been attached to the company's competitive advantage that has followed from its more effective use than AT&T of technologies such as self-healing SONET (an optical protocol facilitating broadband capacity transmission) ring architectures, that allow traffic to be routed in two directions thus facilitating a continuity of service in the event of a break in the optical fibre cable; advanced optical fibre and transmissions technologies that allow for OC-192 level bandwidth which operates at 10 gigabits providing the highest speeds currently available; and a 2.4 gigabit (OC-48) Internet Protocol architecture that supports the most advanced data communications services.

[34] This is a concept that comes from the Austrian economist, Luwig Lachmann (1978).

that, in turn, has enabled dynamic increasing returns, economies of scale, and economies of scope to be realised.

Financial markets have facilitated the entry and initial growth of new entrants as investible resources have been made available to the owners of these companies, primarily through bond and equity markets. But financial markets have also aided entry and initial growth through the equity valuation process. Those new entrants that have been able to convince financial analysts and investors that they have relatively attractive future prospects have been rewarded with appreciating share values. In turn, appreciating values have enabled these new entrants to further tap bond and equity markets on reasonable terms. Furthermore, as already noted, by making employee incentive schemes such as stock options lucrative, financial markets have reinforced the operation of labour markets, enabling new entrants to attract necessary human resources.

Acquisitions have also been facilitated by the stock market valuation process.[35] For example, WorldCom's acquisition of MCI and Sprint, Vodafone's acquisition of Airtouch and Mannesmann, Qwest's acquisition of US West, and Global Crossing's acquisition of Frontier were paid for largely with shares of the acquiring company. In this way these companies used their shares, highly valued by stock markets, as a 'currency' with which to finance their acquisitions.

In Exhibit 5 the market capitalisation of the main US new new entrants is examined and compared to the incumbents and some of the major specialist technology suppliers.

Exhibit 5. Market Capitalisation of Some New New Entrants and Other Selected Companies.

NAME	RANK	MKT VALUE ($bn)	COUNTRY
Microsoft	1	407	**US**
AT&T	7	186	US
Cisco	9	174	US
NTT	13	157	Japan
MCI-WORLDCOM	**14**	**152**	**US**
Lucent	16	150	US
Deutsche Telecom	23	115	Germany
BT	26	107	Britain
NTT Docomo	27	106	Japan
SBC Communications	31	100	US
France Telecom	43	80	France

---

[35] The high-yield bond market has also played an important role in providing the finance for expanding telecoms operating companies to extend their networks. One advantage of resorting to bonds rather than equity in funding expansion is that the dilution of ownership and control can be limited. The bonds, however, are high-yielding as a result of the high risk attached to loans to new entrant telecoms operators.

Telecom Italia	58	67	Italy
Nortel Networks	84	50	Canada
QWEST	**146**	**30**	**US**
LEVEL 3	**172**	**27**	**US**
WILLIAMS	**204**	**22**	**US**
GLOBAL CROSSING	**244**	**20**	**US**
NTT Data	255	19	Japan
GLOBAL TELESYSTEMS	**716**	**6**	**US**

SOURCE: *Business Week*, July 12, 1999.

Exhibit 5 shows the remarkable market capitalisation of the US new new entrants, shown in bold, who were only established in the late 1980s and early 1990s. These figures are for mid-1999 and at this time the new new entrants were together worth approximately the same as BT.[36]

It is clear, therefore, that the process of stock market valuation of companies has played a key role in the Telecoms Industry, justifying the inclusion of financial markets as one of the 'engines' driving the evolution of the industry. However, since stock market valuation has played such an important role it is necessary to inquire further into how these 'values' are determined.[37]

Inventing the Value of Telecoms Company Shares

In principle, the value of a company's shares is determined by the present discounted value of that company's future earnings. Accordingly, the would-be valuer of a company's shares must decide on what discount rate to use and on how to determine the company's future earnings. Ignoring the discount rate, attention will focus here on future earnings and in particular on the future earnings of the new new entrant network operators.[38]

---

[36] These figures are changing almost weekly. For example, they do not reflect WorldCom's acquisition of Sprint, Vodafone's acquisition of Airtouch and Mannesman, Qwest's acquisition of US West, Global Crossing's acquisition of Frontier. In March 2000 the market capitalisation of Cisco briefly exceeded that of Microsoft, hitherto the world's most valuable company. The figures in Exhibit 5, however, suffice to make the main point emphasised here, namely the stock market valuation process that has significantly increased the value of the shares of the new new entrant fixed network operators.

[37] The theory of value has played a key role in economic thought from the Greeks through the classical political economists such as Adam Smith, David Ricardo and Karl Marx to the neoclassical economists from the late Nineteenth Century. It may well be argued that the 'valuation' of telecoms and Internet shares at the turn of the Twenty First Century adds further relevant material for the debate about the determinants of 'value'.

[38] The same issues regarding valuation, however, also apply to new Internet companies and other companies that have little relevant track record.

The problem that immediately arises in attempting to calculate the future earnings of the new new network operators is one of *uncertainty.*[39] For example, uncertainty arises regarding the ability of the new company to organise and manage its entry and initial expansion; regarding future market demand and the proportion of the market that the new company will be able to address and win; regarding the number and strength of future competitors; regarding the extent of the threat posed by alternative technologies; regarding the importance of future substitutable services; etc. Furthermore, to make matters worse, the new new entrants, by definition, begin without any track record on which analysts and investors may base judgments and, in addition, typically make significant losses in their set-up period as a result of the substantial fixed costs involved in constructing their networks, costs that are incurred in advance of compensating revenue being generated.

Grappling with the problem of valuing the shares of a new new operator, the financial analyst might well be forgiven for a feeling of bewilderment at the concept of the 'efficient markets hypothesis'. This hypothesis holds that a capital market is efficient if "it fully and correctly reflects all relevant information in determining security prices. Formally, the market is said to be efficient with respect to some information set, x, if security prices would be unaffected by revealing that information."[40]

The first problem the financial analyst may have with this concept is that 'information', by definition, refers to the past; it is not possible to have information about the future. Yet the problem arising in valuing a new new operator's shares relates essentially to future magnitudes. Secondly, the current information set often yields contradictory inferences regarding many of the key variables with which the financial analyst is concerned. For example, Chris Gent, CEO of the largest global mobile company, Vodafone, is adamant in his belief that mobile communications will seize a significant part of the market from fixed communications. Bernard Ebbers, CEO of WorldCom, however, was equally vehement in his rejection of this belief.[41]

In short, decision-makers in the Telecoms Industry often confront what has been termed 'interpretive ambiguity' in attempting to calculate the implications of the current information set. Interpretive ambiguity may be defined as existing when the information set is capable of yielding contradictory inferences regarding what will happen.[42] Under

---

[39] Many years ago Frank Knight (1921) drew a crucial distinction between risk and uncertainty. In the case of risk, probability distributions can be calculated on the basis of present data that can reasonably be expected to be valid for the future. These probability distributions, for example, provide the basis for the operations of the insurance industry. In the case of uncertainty, however, such probability distributions cannot be derived. This distinction, unfortunately, is often neglected. As Knight (1921) put it, "a *measurable* uncertainty, or 'risk' proper…is so far different from an *unmeasurable* one that it is not in effect an uncertainty at all. We shall accordingly restrict the term 'uncertainty' to cases of the non-quantitative type." P.20.

[40] Malkiel (1987), p.120.

[41] Although there was some evidence of a shift in belief when Ebbers acquired Sprint, largely as a result of the attraction of that company's mobile network.

[42] See Fransman (1999). As Knight (1921) noted, "we do not react to the past stimulus, but to the 'image' of a future state of affairs…. We *perceive* the world before we react to it, and we react, not to what we perceive, but always to what we *infer*." p. 201.

such circumstances the decision-maker simply has no alternative but to construct his or her own 'vision' of what will happen in the future, based on personal beliefs and expectations. Rather than being able to bask in the sunshine provided by the notion that the markets (of which she or he is an organic part) are 'fully and correctly reflecting all information', however, the financial analyst will also be uncomfortably aware of the possibility of 'vision failure', that is of being wrong.

So how does the financial analyst proceed in the light of this incomplete information and interpretive ambiguity?[43] The answer, as a reading of the company reports of the leading telecoms financial analysts readily shows, is that the analyst 'invents' the key assumptions that drive the calculations of future cash flows and earnings. There is little pretence in these reports that the 'inventions' that the analyst makes 'fully and correctly reflect all information'. Rather the language of the analyst usually disarmingly betrays the discomfort that all decision-makers feel under conditions of interpretive ambiguity.[44]

But it must be said that the strength of this whole valuation processes lies, not in its objectivity, but in the fact that the 'visions' that guide this invention process, and the beliefs and expectations that underlie these visions, are made explicit and therefore are subject to the possibility of disagreement on the part of those with different visions. In

---

[43] Note that the problem here is not Herbert Simon's problem of 'bounded rationality' resulting from excessive information which is greater than the ability of the human mind to process that information. Simon (1957) defines bounded rationality in the following way: "the capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problems whose solution is required for objectively rational behavior in the real world – or even for a reasonable approximation to such objective rationality." (p.198) The problem being dealt with here is not that the 'capacity' of the human mind is 'very small' relative to the large amount of information that must be processed. Rather, the problem stems from the fact that the information set yields interpretive ambiguity in the sense that it yields contradictory inferences. Under these circumstances, different 'rational' people may well arrive at contradictory conclusions regarding what to infer and therefore how to act.

[44] The following quotations are typical. They come from financial analysts in the research department of one of the best-known financial companies in a valuation of one of Europe's best-performing new new entrants:

- "We are using a five-year DCF [discounted cash flow] model…in order to value [X]. Quite obviously, given [X's] relative immaturity, it is impossible to value the company using conventional earnings ratios such as price/earnings, price/earnings relative, EPS [earnings per share] growth and even firm value (market capitalisation plus net debt)/EBITDA [earnings before interest, tax, depreciation, and amortisation]."
- "We are using a discount rate of 14%….At present we have assumed that further finance is provided through debt. It is entirely possible that the company could choose to issue equity, but we have more confidence in our ability to predict future interest rates than to predict at what price future equity could be sold. This does, of course, mean that interest expense could be overstated."
- "We are using a terminal EBITDA multiple of 10 [in order to calculate the final share price as a multiple of the EBITDA]. Such a multiple suggests substantial growth in EBITDA and EPS even after 2003. We believe (to the best of our ability to predict what will happen in 2004 and beyond) that [X] will be increasing EBITDA at 12%-15% and EPS at 15%-20% post-2003. We believe that 10x terminal multiple is reasonable relative to growth profiles, the size of [X's] opportunity, its network/technology advantages (fibre, SDH) and [X's] EPS/EBITDA growth post-2003."
- Nonetheless, we realise the inherent volatility and uncertainty in attempting such a valuation and we have tried to perform several cross-checks in order to validate our assumptions and methodology, including sensitivity analysis of multiple and discount rates."

this way the conditions are created for ‘a thousand flowers blooming, a thousand thoughts contending’ – all in all a reasonable way of dealing with conditions of interpretive ambiguity.

Stock market valuation, however, involves more than the attempted prediction of future earnings. It also involves the attempted calculation of how other investors will react to the same ambiguous set of information. In effect, therefore, there are two evaluation questions that are being tackled. First, what do we, the decision-makers, expect the future earnings of the company will be? Secondly, what do we think other decision-makers (e.g. financial analysts and investors) will say and do regarding the company?

Given interpretive ambiguity/incomplete information, these two questions are independent of each other. For example, I may believe that a company does not have good relative prospects but still buy its shares because I believe that sufficient others will disagree and will buy the shares in the future. In this way ‘circular expectations’, that is expectations of other peoples’ expectations, may enter into the valuation process even when the link between the expectations and the supporting information is tenuous. Under these conditions ‘fashion’, rather than ‘information’, may drive share prices. It is this kind of valuation process that has driven the market value of many Internet start-ups aound the world. However, tenuous as these stock market values may at times be, they have had a significant impact on ‘real’ variables and therefore on the evolution of the Telecoms Industry.

An important further factor that has influenced the rapid appreciation in the share values of many telecoms companies has been the ‘explosion in demand for data communications’ as a result of the global adoption of the Internet. However, here too the invention of beliefs and visions has played a role. This is most apparent in the paucity of accounts that couple the explosion in demand with the accompanying explosion in supply[45] and analyse the combined effects. A further key variable is the price elasticity of demand since a fall in the price of data carrying capacity as a result of the combined effects of the demand and supply of capacity may nonetheless, if the price elasticity is high enough, be accompanied by an increase in the total revenue of all the sellers of capacity. An additional issue, crucial in the valuation of individual company shares, is how successful a company will be in winning its share of the increased total market revenue. These factors, however, are seldom introduced explicitly into the valuations.

---

[45] For example, in a public talk in 1999 a representative of WorldCom stated that “the lack of available bandwidth is one of the key factors driving WorldCom’s business strategy”. However, at the same conference it was stated by another speaker that the carrying-capacity of optical fiber is doubling each 12 months and the carrying-capacity of wireless channels doubling every 9 months. (Moore’s Law, established by Gordon Moore of Intel in 1965, states that the transistor density on a manufactured die will double each year.) By 1999 Lucent’s Bell Labs had succeeded in sending 1.6 trillion bits, or terabits, of information through a single fiber by using the dense wavelength division multiplexing technique. This is enough for 25 million conversations or 200,000 video signals simultaneously and one cable may contain a dozen or more such fibres. Of course, significant uncertainty attaches to the future demand and supply of communications carrying capacity and to the future price elasticity of demand. Interpretive ambiguity is, therefore, a significant problem in this area.

THE INTERNET AS A NEW PARADIGM AND THE BIRTH OF THE INFOCOMMUNICATIONS INDUSTRY

In the early 1990s the Internet emerged as a commercial force, creating an alternative way of delivering the same or similar services to those provided over the conventional circuit-switched telecoms networks and, in addition, a host of new services. But the Internet was far more than just an alternative platform; it was nothing less than a radically new paradigm in the area of both information and communications, changing fundamentally the way in which people would think of problems and solutions in this field. Furthermore, by inserting itself into the very fabric of the Telecoms Industry, the Internet brought about the metamorphosis of this industry into what will be termed here the Infocommunications Industry. In this section the emergence of the Internet and its impact on the Telecoms Industry will be examined.

The Emergence of the Internet[46]

In Exhibit 6 the main landmarks of the Internet are shown.

Exhibit 6. Landmarks in the Evolution Of the Internet

DATE	EVENT
1950s	**1958** – ARPA founded in response to Sputnik.
1960s	**Early 1960s** – Packet-switching invented independently by Paul Baran, Rand Corporation in the US, and Donald Davies, National Physical Laboratory, UK, based on the notion of 'message switching' that went back to the postal and telegraph systems. **1962** – ARPA's Information Processing Techniques Office (IPTO) founded. **1967** – ARPANET project started.
1970s	**1972** – ARPANET demonstrated at the First International Conference on Computer Communications (ICCC). - First commercial packet-switching network introduced. - E-mail starts to be widely adopted. **1973** – Robert Kahn approaches Vinton Cerf to develop a system for Internetworking and they outline the basic Internet architecture. **1974** – Initial version of TCP (Transmission Control Protocol) specified. - AT&T declines to take over operation of ARPANET. **1975** – Ethernet created by Robert Metcalfe. **1977** – ARPANET demonstrates its first multinetwork connection, connecting the networks ARPANET, PRNET, and SATNET. **1978** – IP (Internet Protocol) established.
1990s	**1990** – First incarnation of the World Wide Web, created by Tim Berners Lee,

---

[46] This section draws heavily on the account of the evolution of packet switching given by Lawrence Roberts, who joined ARPA in January 1967 and managed its computer research programmes - see Roberts (1978) - and on Janet Abbate's (1999) excellent *Inventing the Internet*. See also Norberg and O'Neill (1996).

	Robert Cailliau and others at CERN, Switzerland. **1993** – Marc Andreesen and team develop improved Web browser, Mosaic. **1994** – Andreesen and team set up commercial version of Mosaic, Netscape. **1995** – On May 26, 1995 Bill Gates issues memo, 'The Internet Tidal Wave', that acknowledges that Microsoft will have to adapt all its systems to the Internet.

ARPA and Time-Shared Computing

The institution that gave birth to the network that was eventually to evolve into the Internet was ARPA (the Advanced Research Projects Agency) that was established in 1958 in the US in reponse to the Russian launch of Sputnik. From 1962 to 1964 ARPA, under J.C.R. Licklider, encouraged through its funding the development of time-sharing computer systems at leading universities and government-funded research laboratories in the US. "One of Licklider's strong interests was to link these time-shared computers together through a widespread computer network."[47] This interest was motivated by the high cost of time-share computers and the desire to make more efficient use of this resource. Licklider's interest and the considerable research funding controlled by ARPA and its Information Processing Techniques Office (IPTO), established in 1962 to further advanced research in computing, served to stimulate discussion and debate around the question of how to construct computer networks to facilitate interactive computing between time-shared computers.

Clearly, if time-shared computers were to be linked, a communications system would be needed in order to facilitate the flows of data between the mainframe computers.[48] This, in turn, raised the question of what kind of communications system would be suitable.

Circuit-Switching Versus Packet-Switching

The obvious way to link distant time-shared computers was through leased telephone lines. However, the cost of using these leased lines was high. Apart from AT&T's monopoly over leased lines, a major determinant of the high cost was the technology that was used, namely a *pre-allocation* technique called *circuit-switching* according to which a fixed bandwidth is pre-allocated for the duration of the connection. While this technique was fairly well-suited for the transmission of voice calls, it was not particularly well-adapted for the transmission of interactive data traffic that occurs in short bursts and that can result in as much as 90 percent of the pre-allocated bandwidth being wasted. This, in turn, raised the question of whether there were any more cost-effective alternatives.

It had long been realised that an alternative to pre-allocation existed in the *dynamic-allocation* of transmission bandwidth. This method had traditionally been used in postal

---

[47] Roberts (1978), p.1308.

[48] As Roberts put it, "the interest in creating a new communications system grew out of the development of time-sharing and Licklider's special interest in the 1964-65 period." (p.1308)

mail systems and the telegraph. The method involved collecting and storing messages at a node in the network and then, when sufficient messages had been accumulated, sending the messages in bulk on to the next node in the network. This made better use of transmission capacity compared to the pre-allocation technique that was wasteful since it allocated capacity even when no messages were being transmitted. The problem with dynamic allocation, however, was that many sorting and routing decisions had to be made by human operators and this entailed a high cost in using this technique.

The advent of relatively inexpensive computers, however, created the possibility of removing this obstacle to dynamic allocation. It is here that the computer revolution, and the linked revolutions in computer storage and processing, enters the story of the evolution of the Internet. In 1965, the time when discussions were being held regarding an appropriate communications system for linking time-shared computers, DEC introduced its PDP-8 minicomputer that would drastically reduce computing costs compared to the mainframes that then dominated. This computer revolution gave a new breath of life to dynamic allocation. In the words of Roberts: The "economic tradeoff [between pre-allocation/circuit switching and dynamic allocation/packet switching] is simple: if lines are cheap, use circuit switching; if computing is cheap, use packet-switching." (p.1307) However, Roberts also noted that this trade-off, recognisable with hindsight, was by no means acknowledged at the time: "Although today this seems obvious, before packet switching had been demonstrated technically and proven economical, the tradeoff was never recognized, let alone analyzed." (p.1307)

The alternative of dynamic allocation/packet-switching as an appropriate technology for the communications system linking time-shared computers, however, did not emerge only as a theoretical possibility, based on old postal and telegraph systems. Coincidentally, research in this area had been undertaken independently by two researchers, one in the US and one in the UK. It was their research, and the feasibilities that it demonstrated, rather than the purely theoretical superiority of dynamic allocation, that paved the way for the adoption of packet-switching as the basis for the communications system chosen for ARPANET, the network that would be constructed to link the time-shared computers in ARPA's computer research programmes.

At the Rand Corporation, Paul Baran in the early 1960s did research for the US Air Force on a military communications system for data and voice. "The Air Force's primary goal was to produce a totally survivable system that contained no critical central components."[49] The injunction against centralised control of the system followed from the desire to make the system less vulnerable (i.e. 'survivable') to Russian attack. Baran's research, published in August 1964, proposed a fully decentralised (i.e. distributed) communications system based on packet switching/dynamic allocation. However, his "report sat largely ignored for many years until packet switching was re-discovered and applied by others."[50]

---

[49] Roberts (1978), p.1308.

[50] Roberts (1978), p.1308.

In the UK in the early 1960s, at the government-funded National Physical Laboratory, Donald Davies was also developing a communications system based on packet-switching/dynamic allocation designed for interactive computing.[51] In autumn 1965 Davies sponsored a conference reporting on his results that was attended by Lawrence Roberts (who would join ARPA in January 1967 and assume management of its computer research programmes) and others from MIT. It was at this conference that Roberts and his colleagues decided that dynamic allocation should be used in the ARPANET. "Almost immediately after the 1965 meeting, Donald Davies conceived of the details of a store-and-forward packet switching system, and in a June 1966 description of his proposal coined the term 'packet' to describe the 128-byte blocks being moved around inside the network. Davies circulated his proposed network design throughout the UK in late 1965 and 1966. It was only after this distribution that he discovered Paul Baran's 1964 report."[52]

Communications Engineers Versus Computer Professionals

However, what was obvious to some of the key computer scientists in the National Physical Laboratory and the ARPA computer research programme was by no means obvious to those in the telecoms industry whose 'visions', and the beliefs and interpretations they embodied, had little room for a reversion to what they disparagingly saw as outdated dynamic allocation techniques. In the words of Lawrence Roberts:

> "In the early 1960s, preallocation [i.e. circuit-switching] was so clearly the proven and accepted technique that no communications engineer ever seriously considered reverting to what was considered an obsolete technique, dynamic allocation. Such techniques had been proven both uneconomic and unresponsive 20-80 years previously, so why reconsider them? The very fact that no great technological breakthrough was required to implement packet switching was another factor weighing against its acceptance by the engineering community."

It was only from a group of outsiders, with a fundamentally different starting point, set of problems, and set of beliefs and interpretations, that a new alternative technology, based on dynamic allocation, could emerge:

> "What was required was the total re-evaluation of the performance and economics of dynamic-allocation systems, and their application to an entirely different task. Thus, it remained for outsiders to the communications industry, computer professionals, to develop packet switching in response to a problem for which they needed a better answer: communicating data to and from computers."[53]

---

[51] Abbate (1999), p.23.

[52] Roberts (1978), p.1308. According to Abbate (1999) it was in March, 1966 that Davies first presented his ideal publicly to an audience of computing, telecoms, and military people and a man from the British Ministry of Defence gave him the surprising news about Baran's 1964 report (p.27).

[53] Roberts (1978), p. 1307.

In evaluating Roberts's evaluation of the respective role played by 'computer professionals' and 'communications engineers' it is worth being reminded of the research agenda that existed at the time in the field of telecoms switching. In the mid-1950s the first electronic space-division switching research programme incorporating stored progam control (SPC) was introduced by Bell Laboratories. This resulted in the first trial electronic SPC switch in 1960 and the first commercial switch, AT&T's No.1 ESS, in 1965.

But no sooner were the first electronic space-division switches being introduced than they were in the process of being displaced by the next generation of central office switches, namely by time-division digital switches. Although the first research on time-division switching went back to the work of Reeves in 1938 and Deloraine in 1945, it was only in 1959 that the Essex Project in Bell Labs demonstrated the feasibility of time-division switching. This was followed by the development of pulse-code modulation (PCM) transmission systems in the early 1960s and the beginning of research in Bell Labs on AT&T's first digital switch, the No.4 ESS, the first laboratory model of which was introduced in November 1972. In 1976 Northern Telecom (now Nortel) began development of its first relatively small digital switch, the DMS, which was commissioned in 1977, about four years earlier than AT&T's equivalent switch, the No.5 ESS, that was introduced in 1982. As this brief account makes clear, therefore, the telecoms engineering community were very much focused on the development of electronic space-division switching, and then time-division digital switching, both within the broader context of circuit-switching, at the time that the debates were occurring in the ARPA community about the feasibility of packet-switching for the communications system that would connect time-shared computers.[54]

In October 1972, the first packet switched network was publicly demonstrated at the first meeting of the International Conference on Computer Communications (ICCC) in Washington, DC when a complete ARPANET node was installed in the conference hotel with about 40 active terminals permitting access to dozens of computers in various parts of the US. This provided proof that packet switching could really work and managed to convince many working in the networking field. However, some still remained to be persuaded. According to Roberts, in an article published in 1978,

> "AT&T evidenced even less interest in packet switching than many of the PTT's in other countries. AT&T and its research organization, Bell Laboratories, have never to my knowledge published any research on packet switching. ARPA approached AT&T in the early 1970s to see if AT&T would be interested in taking over the ARPANET and offering a public packet switched services, but AT&T declined."[55]

---

[54] This discussion on telecoms switching comes from Fransman (1995), Chapter 3, specifically from Fig. 3.1, p.47, and Fig. 3.3, p.50. See also Chapuis and Joel (1990).

[55] Roberts (1978), p.1310. See Abbate (1999), p.137 for further discussion.

The Internet Protocol

It was in this way that a new communications paradigm was born based on packet-switching and offering a radically new approach to the communication of both data and voice[56]. In 1968 virtually all interactive data communication networks were circuit-switched. By 1978, however, virtually all new data networks being built throughout the world were based on packet-switching, a remarkable rate of diffusion for a radically new technology.[57]

In the spring of 1973 ARPA researchers Robert Kahn and Vinton Cerf got together to consider how to interconnect *dissimilar* networks.[58] This led eventually to TCP/IP. As shown in Exhibit 7, in 1974 the initial version of TCP (Transmission Control Protocol) was specified. In 1978, "They proposed splitting the TCP protocol into two separate parts: a host-to-host protocol (TCP) and an internetwork protocol (IP)….IP would simply pass individual packets between machines (from host to packet switch, or between packet switches); TCP would be responsible for ordering these packets into reliable connections between hosts."[59] In this way, the transfer of packets across different networks, using different technologies, was facilitated.

The Proliferation of the Internet

When did the realisation first dawn that the Internet has become a Schumpeterian tidal wave of creation-destruction? One way to tackle this question is to examine the reactions of Vinton Cerf, often referred to as one of the fathers of the Internet, who, as noted earlier, co-wrote the Internet Protocol (IP) with Robert Kahn and made major contributions to the Transmission Control Protocol (TCP). Cerf has said that in 1977 he "Assumed that [ARPANET] was a research project that would probably never get bigger than 128 networks."[60] By 1996 the Internet was a network of some 50,000 networks.

When did Cerf first realise that the innovations that he and his co-workers made would form the basis for a fundamental shift in the way in which we think of information and communications? The answer is between 1989 and 1991 as Cerf makes clear:

---

[56] Roberts's prediction in 1978 regarding voice communications by packet-switching are apropos: "The economic advantage of dynamic-allocation over pre-allocation will soon become so fundamental and clear in all areas of communications, including voice, that it is not hard to project (predict?) the same radical transition of technology will occur in voice communications as has occurred in data communications….the obvious solution would be an integrated packet switching network that provides both voice and data services….Given the huge fixed investment in voice equipment in place today, the transition to voice [packet] switching may be considerably slower and more difficult. There is no way, however, to stop it from happening." (p.1312) In 1995, an Israeli-owned startup, based in Silicon Valley, Vocaltech, introduced the first software allowing for voice over the Internet.

[57] Roberts (1978), p.1307.

[58] See Abbate (1999), Chapter 4, From ARPANET to Internet.

[59] Abbate (1999), p.130.

[60] This and the following quotations from Vinton Cerf come from Cerf (1996).

> "We now know that the lift-off point for exponential growth [in the Internet] came around 1988, though it wasn't obvious at the time. I certainly didn't sense it in the early days of research, 22 years ago. But I remember vividly walking into a trade show in 1989, one of the InerOp shows in San Jose, and looking at the booths, and this was the first time that I had seen really expensive booths being put up. It was obvious that the vendors were spending very significant dollars and that there was something serious going on. And then the second epiphany, if you can call it that, came a couple of years later when the first commercial service companies started to show up. This really confirmed my increasing expectation that this was turning into a serious business."

And how did he feel when he realised what was happening? "My first reaction was something like, 'Holy Shit'."

In 1990, as shown in Exhibit 7, the first incarnation of the World Wide Web emerged, created by Tim Berners Lee, Robert Cailliau and others at CERN, the particle-physics research establishment in Switzerland. In January 1993 Mosaic was introduced, the first World Wide Web browser, based on research done at the University of Illinois. In April 1994 Mosaic Communications was established, a firm that soon became Netscape Communications Corp. that was floated on the stock exchange on August 8, 1995 (the shares increasing in value on the first day from $28 to $58).

There is evidence that Bill Gates began to understand the implications of the Internet only in 1995. Although Gates and Microsoft were immersed in the development and shipping date of Windows 95 (eventually released on August 24, 1995) and until mid-1995 did not pay too much attention to the Internet, Gates' vision of the future of computing and Microsoft had come to encompass the importance of networked computing. On October 6, 1994 Gates wrote a memorandum titled "Sea Change" that spelled out plans for networked computing by Microsoft. Earlier, in May 1993, Gates had approved work on Marvel, an online service that would be offered by Microsoft (and later became MSN). Marvel, however, was not intended to be Internet-compatible.

Until early to mid-1995, however, it is clear that Gates saw Microsoft as the dog of networked computing and the Internet, at best, as a rather insignificant tail. In Gates' own words:

> "I wouldn't say it was clear [at this time] that [the Internet] was going to explode over the next couple of years. If you'd asked me then if most TV ads will have URLs [Web addresses] in them, I would have laughed."[61]

By the automn of 1995, however, some 20 million people were accessing the Internet without using Microsoft's software and on May 23, 1995 Sun's Java software language was officially released which, being platform-independent, further threatened to by-pass Microsoft's systems. By the latter date, however, the alarm bells that had for some time been ringing inside Microsoft (in the form of several younger staff, more in touch with

---

[61] *Business Week,* July 15, 1996, pp 38-44.

the rapidly growing adoption of Internet technologies, particularly on American campuses) were heard by Gates and the rest of the leadership. On May 26, 1995 Gates issued a memorandum, "The Internet Tidal Wave", that finally confirmed his conversion to the view that the Internet had become the dog, with Microsoft, after all, only its tail.

The Birth of the Infocommunications Industry

How has the Internet changed the Telecoms Industry and transformed it into the Infocommunications Industry? The Internet has had four major effects on the Telecoms Industry that together have fundamentally changed this industry. Exhibit 7 shows in the form of a layer model the main features of the Infocommunications Industry (which may be contrasted with the features of the Old Telecoms Industry, shown in Exhibit 1).

Exhibit 7. The Infocommunications Industry:
A Layer Model

LAYER	ACTIVITY	EXAMPLE COMPANIES
VI	*Customers*	-
V	*Applications Layer, including contents packaging* (e.g. Web design, on-line information services, broadcasting services, etc)	Bloombergs, Reuters, AOL-Time Warner, MSN, Newscorp, etc
IV	*Navigation & Middleware Layer* (e.g. browsers, portals, search engines, directory assistance, security, electronic payment, etc)	Yahoo, Netscape, etc
III	*Connectivity Layer* (e.g. Internet access, Web hosting)	IAPs and ISPs
IP INTERFACE		
II	*Network Layer* (e.g. optical fiber network, DSL local network, radio access network, Ethernet, frame relay, ISDN, ATM, etc)	AT&T, BT, NTT, WorldCom, Qwest, Colt, Energis, etc
I	*Equipment & Software Layer* (e.g. switches, transmission equipment, routers, servers, CPE, billing software etc)	Nortel, Lucent, Cisco, Nokia, etc

First, the Internet has established that packet-switching and the IP (Internet Protocol) networks in which it is embodied constitute a superior technology compared with circuit switched technologies, not only for data but also, as Lawrence Roberts correctly foresaw at least by 1978 (see above), for voice. Indeed, to go even further, the Internet has created a fundamentally new paradigm for the understanding of information and communications problems and solutions.

Secondly, as shown in Exhibit 7, TCP/IP has created a bridge, facilitating easy and cheap interoperability across radically different networks using radically different technologies. Kavassalis, Lee and Bailey (199xx) have explained the importance of the TCP/IP interface using the analogy of containerisation in the Transport Industry. Pre-containerisation, high costs were involved in moving goods between different transport networks such as road, rail, ship, and air. The advent of containerisation, however, facilitated a smooth interface between these networks, increasing the degree of interoperability between them and significantly lowering the cost of interoperability. Likewise, TCP/IP has facilitated the transfer of bits across the different networks, embodying significantly different technologies, of the Network Layer (Layer II).

TCP/IP has produced several important consequences:

- Easy and cheap communications is possible globally across a huge number of interconnected networks
- …which has given greater effect to global standardisation based around the Internet protocols and practices
- …which has created a global knowledge-base, facilitating the creation of further knowledge (as will be discussed in more detail below)
- and competition between networks, technologies and services has been greatly increased.

Thirdly, TCP/IP has provided a platform for three largely new layers of services, as shown in Exhibit 7. Not only this, it has created the possibility for the emergence of a new industrial category of *facilities-less service providers*, specialised in one or more of the service layers, who are able to provide services using this platform while ignoring what else goes on in the network layer, Layer 2. In turn, this has created new potential for the Infocommunications Industry to become *vertically-specialised* like the computer industry did from the 1980s.[62] For example, in Layer 3 the function of connectivity is provided and with it new services, such as Internet access and Web hosting. In Layer 4 the function of navigation is provided and navigational systems such as browsers, portals, and search engines. Layer 4 also contains the 'middleware' that, sitting on top of Layers 1 to 3, provides the software that facilitates the applications in Layer 5, for example software systems that provide security (such as fire walls) and facilitate electronic payment.

The fourth way in which the Internet has changed the Telecoms Industry is through the integration of the Computer Industry that it has facilitated, hence justifying the nomenclature, the Infocommunications Industry. As shown in Exhibit 7, computer hardware and software and computer networks fit into the Infocommunications Industry in all the layers. For example, Layer 1 contains computers such as routers and servers

---

[62] Whether the Infocommunications Industry will become more vertically specialised, to what extent and when, and what the implications are for incumbents, new operators and specialist facilities-less service providers, are key questions the causes and implications of which are addressed in TelecomVisions.Com.

and software systems such as billing software. The Internet, as a 'network of networks', is an integral part of the Network Layer, Layer 2. All the services, provided in the service layers, Layers 3 to 5, depend on computer hardware and software. At the same time, elements of both the Old and the New Telecoms Industry have also been integrated into the layers of the Infocommunications Industry, particularly in Layers 1 and 2. From the perspective of the layer model of the Infocommunications Industry, therefore, it is possible to give a specific meaning to the widely used (perhaps over-used) concept of 'convergence' between computing and telecommunications.

To conclude, the Internet that emerged from the attempts to link time-shared computers, an event that initially was remote to the Telecoms Industry, has fundamentally transformed this industry, turning it into the Infocommunications Industry. How the Infocommunications Industry itself will evolve in the future is the key question that is tackled in TelecomVisions.Com.

The Technological and Learning Regimes in the Infocommunications Industry

The innovation system in the Infocommunications Industry has also undergone a fundamental transformation. Some of the important changes are shown in Exhibit 8 that contrasts the innovation systems in the Old Telecoms Industry, shown earlier in Exhibit 2, and the Infocommunications Industry.

Exhibit 8. The Innovation Systems in the Infocommunications Industry and the Old Telecoms Industry

INFO'COMS INDUSTRY	OLD TELECOMS INDUSTRY
Open innovation system	Closed innovation system
Low entry barriers	High entry barriers
Many innovators	Few innovators
Common knowledge base	Fragmented knowledge base
High-powered incentives	Medium-powered incentives
Rapid, concurrent, innovation; New forms of innovation (e.g. concurrent co-operative innovation by remote innovators)	Slow, sequential, innovation: Research – prototype – trials - cutover

As is apparent from Exhibit 8, the innovation system in the Infocommunications Industry differs fundamentally from that which existed in the Old Telecoms Industry. To begin with, in the Infocommunications Industry the innovation system is open in the sense that virtually anyone can create innovations within the industry. In marked contrast, in the Old Telecoms Industry the innovation process was open only to the monopoly network operator and its favoured suppliers. The barriers to entry into the innovation system (i.e. the barriers constraining individuals or firms from becoming innovators) in the Infocommunications Industry are low. Entry is greatly facilitated by the fact that there is widespread common knowledge of the main operating systems, software languages and protocols that are used in the various layers of the industry. This common knowledge is largely the result of globalised de facto standardisation (e.g. TCP/IP, html [hypertext markup language], or WAP [wireless application protocol]). In the Old Telecoms Industry, as noted earlier, many standards and practices differed markedly from country to country, resulting in a fragmented knowledge base. The increasing importance of software, together with the common knowledge base, and the relatively low cost of producing many software applications has meant that there are a large number of software innovators in the Infocommunications Industry.[63]

Furthermore, in this industry there are high-powered incentives to innovate. Internet-related innovations have a particularly large potential global market and successful innovations may be extremely richly rewarded. With so many innovators competing with each other the rate of innovation is much faster than it was in the Old Telecoms Industry. In addition, the very nature of packet-switched networks has facilitated concurrent, rather than sequential, innovation. In the Old Telecoms Industry a laborious process of trials was necessary *before* new equipment could be introduced into the network. If equipment in a circuit-switched network fails, the service on that network is disrupted. It was for this reason that exceptionally high reliability was a necessary requirement in the Old Telecoms Industry and, accordingly, equipment had to be exhaustively tested. However, in a packet-switched network the fact that packets can be routed in many alternative ways adds greater robustness to the network and means that many kinds of equipment and software can be tested on-line at a far earlier stage in the development process than was possible in the Old Telecoms Industry. This too has speeded up the innovation process.

In the Infocommunications Industry new forms of innovation have been created using the Internet as a ubiquitous platform for innovation. One significant example is the concurrent co-operative development of the UNIX-based operating system, Linux, by a large number of remotely located co-innovators who do not even know each other and have no visible hand of co-ordination. The main features of this remarkable new process of innovation are summarised in Exhibit 9.

---

[63] For the example of innovators in the field of live video over the Internet, see Fransman (2000).

Exhibit 9. Co-operative Innovation by Remotely Located Innovators: The Case of Linux

PRODUCT	UNIX-based operating system
FOUNDER	Linus Torvalds, Finnish, began as university project in 1991
COMPETITORS	Microsoft's Windows NT
PRICE	Linux: Free on Internet; $50 on CD Windows NT: $800
DISTRIBUTION	Given away on Internet i.e. a Public Good, therefore cannot be bought by Microsoft. Many users of Linux make their own additions to the operating system which they also put, free, into the public domain.
FORMAT	Linux: Source code – open, expandable by user Windows NT: Binary code – unintelligible to user
APPLICATIONS	Mainly servers
CUSTOMERS	Linux: 7 million, including Netscape, Intel, IBM Microsoft: 300 million
PERFORMANCE	Linux in 1998 the fourth most often installed version of UNIX

MOBILE COMMUNICATIONS

In the late-1990s civilian cellular mobile communications took off around the world, becoming the most rapidly-growing telecommunications service. The UK company, Vodafone, acquired Airtouch of the US in 1999 and Mannesman of Germany in 2000, becoming the largest global mobile operator. NTT's majority-owned mobile subsidiary, NTT DoCoMo, introduced the first mobile Internet access service, i-mode, in February, 1999. By March 2000 the company had attracted 5 million customers in Japan. Shortly thereafter, NTT DoCoMo became the most valuable company on the Tokyo Stock Exchange and one of the most valuable telecoms companies in the world, even more valuable than its parent, NTT. In the late 1990s efforts began to develop a global standard for so-called Third Generation mobile, capable of providing Internet access at speeds of 2 megabit per second compared to the 9.6 kilobit offered by Second Generation systems.

Interpretive Ambiguity and Mobile Communications

At the turn of the millenium it seemed obvious that consumers in many circumstances had a strong preference for mobile communications. Predictions of future penetration rates – that reached as much as 50 percent in the most advanced countries – became commonplace. A decade and a half earlier, however, considerable interpretive ambiguity reigned regarding consumer preferences in this area, as is clear from Exhibit 10.

Exhibit 10. Interpretive Ambiguity and Mobile Communications

1970s-1980s	Despite inventing the cellular mobile system, Bell Labs downgrades research on radio communications that it deems to be an inferior transmission technology.
1984	At the time of its divestiture a Senior Executive of AT&T expresses the company's view that there is little future in mobile communications (1). "When I joined Ericsson in 1984 Radio Communications was something odd happening on the outskirts of Stockholm", Kurt Hellstrom, President, Ericsson (2).
Early 1980s	AT&T asks consultancy company McKinsey how many cellular phones there will be in the world in 2000. McKinsey's answer: total global market = 900,000. In 2000 there are about 400 million mobile phones globally (and about 180 million PCs) (3).
1992	GSM standard agreed by European standards bodies and firms.
1994	Sam Ginn quits as CEO of Baby Bell Pacific Telesis to head the company's spun-off mobile operations renamed AirTouch. But AirTouch's share price languishes.
1997	Demand for mobile telephony explodes globally.
1999	British Vodafone acquires AirTouch forming the largest global mobile telecoms operator (and acquires Mannesmann in 2000). Players talk of possibility of mobile replacing fixed communications.
1999	UMTS third generation mobile standard agreed by Europe, Japan & US, making high-speed Internet on mobile phones possible.

(1) *Financial Times*, February 22, 1999.

(2) *Financial Times*, July 26, 1999.

(3) *The Economist*, October 9th, 1999.

Co-evolving Consumer Demand

As Exhibit 10 makes clear, it is inappropriate to see consumer tastes and preferences as always fully formed, with firms responding to the consumer demand thus generated. Instead, there exists a process of co-evolution, frequently involving substantial interpretive ambiguity, with consumer tastes and preferences, products and services, technology (and sometimes science), firms, and related institutions, interacting and co-evolving within the context of the various selection environments that select and reinforce some of them while rejecting others. In some cases, indeed, products and services are developed before consumer demand for them exists, with the intention of creating the very demand that the product or service is intended to satisfy. Some times these efforts succeed, other times they fail. Exhibit 11 depicts four possible evolutionary paths, with examples from the field of infocommunications.

Exhibit 11. Evolutionary Paths for Co-evolving Consumer Demand

		OUTCOME	
		Successful	**Unsuccessful**
DEVELOPMENT OF PRODUCT/ TECHNOLOGY	**Before large demand**	• Mobile cellular communications • E-mail	• Video-phone
	After large demand	• Many	• Video-on-demand

Mobile cellular communications, shown in the top left-hand cell, are an example of a set of services/products/technologies that were developed well in advance of the huge global mass demand that would much later emerge. The concept of cellular communications was invented in Bell Laboratories. The first proposal to use cellular systems in the field of mobile communications in order to make most efficient use of the limited spectrum was put forward in 1947 "and discussed subsequently in a number of internal Bell Laboratories memoranda. These ideas formed the basis for worldwide cellular radio. The first publication was by H.J. Shulte, Jr., and W.A. Cornell [of Bell Labs] in 1960."[64]

Only a decade later, in 1970, the first civilian standard for modern cellular telephony began to be specified in Scandinavia, leading to the Nordic Mobile Telephony (NMT) standard that was introduced in 1981. However, although demand for cellular mobile telephony in Scandinavia exceeded initial expectations, the general feeling, as indicated by the statement from Kurt Hellstrom, President of Ericsson, in Exhibit 10, was that

---

[64] Millman (1984), p.235.

mobile communications were not particularly economically significant. Indeed, Ericsson's mobile division was very much the 'ugly sister' to the company's other division, based on the company's digital central office switch, the AXE, used at that time for fixed communications. The small market for Ericsson's equipment in mobile communications was insufficient to deflect the company from its vision for the 1980s of a merging of telecommunications and the paperless office, a vision that turned out to be incorrect. It was only in 1990 that Ericsson's new CEO, Lars Ramqvist, made mobile communications the main priority and reorganised the company accordingly.[65]

E-mail is a similar example of a service being developed will in advance of a large market demand. More accurately, e-mail was an unintended by-product of the ARPANET project and only emerged initially as a convenient way for the researchers working on this project to communicate. Once the service was available its usefulness quickly became apparent and rapidly diffused, first amongst the ARPANET researchers, then amongst their other colleagues at their universities and research institutes, and, finally, amongst a broader community. Indeed, "Email [introduced in 1972] quickly became the network's most popular and influential service, surpassing all expectations."[66]

A very different co-evolutionary path for consumer tastes, preferences, services, products and technologies is represented by the top right-hand cell. An example is the video-phone. The details of this example are summarised in Exhibit 12.

Exhibit 12. Vision of the Video-Phone

ASSUMPTION	People who can hear each other will also want to see each other
1950s	Bell Labs begins work on video-telephony
1964 – WORLD FAIR, NEW YORK	AT&T demonstrates the video-phone
1960s – AT&T's BUSINESS PLAN	By 1980s video-phone market = 1% of residential, 3% of business market
1973	AT&T withdraws video-phone after spending up to $0.5 billion
1992	AT&T reintroduces video-phone with limited success

---

[65] "In 1990 Ericsson got a new CEO, namely Lars Ramqvist, who came from Ericsson Radio Systems. As he came from radio communication and not switches, choosing him to be top manager was in many ways a recognition of the growing importance of wireless telecommunications to the concern as a whole, and indeed Ramqvist immediately focused Ericsson on that." McKelvey (1999), p.17. See also McKelvey and Texier (1999).

[66] Abbate (1999), p.107. "The popularity of email was not foreseen by the ARPANET's planners. Roberts had not included electronic mail in the original blueprint for the network. In fact, in 1967 he had called the ability to send messages between users 'not an important motivation for a network of scientific computers'….Why then was the popularity of email such a surprise? One answer is that it represented a radical shift in the ARPANET's identity and purpose. The rationale for building the network had focused on providing access to computers rather than to people." Abbate (1999), pp108-109.

M. Katz, FORMER FCC CHIEF ECONOMIST, 1996	**"Many at 1964 World Fair touted video-phone as next big thing. I think they were right, just a bit premature."**
INTERPRETIVE AMBIGUITY	**'The price is too high and people are not used to it' versus 'People often feel uncomfortable under close visual scrutiny and don't want it'**

By contrast, video-on-demand (VOD) represents an example of a service developed after the emergence of a large market demand for video recordings (using the VHS format). For many VOD was the much sought-after 'killer application' for the 'multi-media' objectives that were very popular in the Telecoms Industry of the late-1980s, before the widespread adoption of the Internet. It was VOD that stimulated numerous trials around the world, and indeed the local access technology, XDSL (digital subscriber loop), designed to carry broadband signals over local copper wires, owes its origin to VOD-related research and trials. However, like the video-phone, by the dawn of the new millenium there was significant ambiguity regarding demand for VOD.

As these different evolutionary paths and examples suggest, it is necessary to analyse consumer tastes and preferences, and therefore market demand, as an endogenous part of the co-evolutionary process, a process that seldom settles down 'in equilibrium' for very long but which, on the contrary, is usually in a process of flux.

Scandinavia Leads

As noted earlier, work on the first standard for civilian cellular mobile communications began in Scandinavia in 1970, involving the PTTs (national network operators) and specialist equipment suppliers of Denmark, Finland, Norway and Sweden. Although a fair amount of research was undertaken in telecoms laboratories around the world at this time, it was Scandinavia that took the lead in developing and using mobile communications. Precisely why this commitment first occurred in Scandinavia is still unclear. Explanatory hypotheses include the large, weather-prone countries of Finland, Norway and Sweden; the widely distributed population of these countries; and the far-sighted and pro-active nature of the PTTs, particularly Televerket of Sweden with its own sophisticated radio research laboratories; and the co-operation of the PTTs that resulted in the first international mobile standard, NMT, which, in turn, allowed Scandinavians to use their mobile phones in any of the participating countries.

However, it is clear that whatever the explanation for Scandinavia's early entry, there were regional dynamic increasing returns that allowed Scandinavia to maintain its lead in several important areas into the new millenium. One of these areas is penetration rates where Scandinavian countries still have the highest rates in the world. Another is the Scandinavian companies, notably Ericsson and Nokia, that have come to dominate not only European but also global mobile equipment markets, overcoming the opposition of powerful rival companies such as Motorola and NEC. These dynamic increasing returns at the level of the firm have been traced by McKelvey and Texier (1999) for the case of Ericsson and for Ericsson and Nokia by McKelvey (1999).[67] The strength of these companies resulting from dynamic increasing returns has allowed them to play a highly influential role in shaping the W-CDMA (code division multiple access) standard for Third Generation mobile communications adopted by Europe and Japan and by a few operators in the US.[68]

Europe and Japan Rule - The US Lags[69]

Exhibit 13 shows the diffusion of second generation mobile systems in Europe, Japan and the US.

Exhibit 13. Diffusion of Second Generation Mobile Systems
In Europe, Japan and North America

REGION	POPULATION (mn)	NO. OF SUBSCRIBERS 1997		NO. OF SUBSCRIBERS 1998	
		Absolute No. (mn)	Per 1000	Absolute No. (mn)	Per 1000
Western Europe	387	46.3	12.0	93.5	24.2
Japan	126	36.2	28.7	47.3	37.5
North America	300	5.5	1.8	27.2	9.1

Source: Kano (2000)

As can be seen from Exhibit 13, in mobile communications Europe and Japan rule while the US lags. Several qualifications, however, must be made regarding the data in Exhibit 13. First, Western Europe includes countries with the highest penetration rates in the world, such as the Scandinavian countries, as well as countries with much lower rates, such as Greece and Portugal, and therefore is not strictly comparable with Japan and North America, which is largely the US. Secondly, one of the reasons for the low penetration rates in the US is that the data is limited to second generation mobile. One cause of low penetration of second generation mobile in the US is the relatively high penetration rate of first generation mobile in this country. At the end of 1998 there were 50.7 million first generation subscribers in the US and Canada (using the analogue AMPS

---

[67] Ericsson was founded in 1876 to produce telephones using technologies developed by Alexander Graham Bell but not patented in Sweden. McKelvey and Texier (1999).

[68] See Kano (2000).

[69] This section draws heavily on Kano (2000). The data in Exhibit 13 comes from Kano (2000), Table 2 and Figure 2. The author is grateful to Professor Kano for access to this information and for numerous discussions on telecommunications in general and mobile communications in particular.

standard – Advanced Mobile Phone Service). This implies a penetration of 16.9 people per 100 in North America.[70] As Kano (2000) notes, one of the reasons for the relatively low penetration rate of second generation mobile in the US was the fairly high rate of penetration of first generation.

The figures for North America (mainly the US) pose an interesting puzzle since there are not many parts of the Infocommunications Industry where the US is behind[71]: Why does the US lag in mobile communications?

Kano (2000) suggests several answers to this puzzle. The first is the lack of a single dominant standard in the US, unlike in Europe and Japan where one standard dominated. In Europe the dominant standard for second generation digital cellular mobile systems is GSM (Global System for Mobile Communications), which has more subscribers than any other standard in the world.[72] In Japan the dominant second generation standard is PDC (Personal Digital Cellular). In the US on the other hand, where the principle was accepted that the adoption of standards should be left to the market, there were three incompatible second generation standards: ANSI-136 and ANSI-95 (American National Standard Institute) and cdmaOne (Code Division Multiple Access). Kano suggests that the lack of a single dominant standard in the US had several other undesirable knock-on effects: some operators and users adopted a wait-and-see attitude to see which standard would dominate; there was poor geographical coverage since the standards adopted by different operators were incompatible and did not provide interoperability, in turn leading to slower user adoption of mobile services; and large-scale production of equipment and phones was frustrated by the lack of a single standard, leading to high costs.

However, Kano suggests that the US lag was not only due to the failure to provide a single dominant standard. There were several other reasons for the relatively slow diffusion of mobile communications in the US. To begin with, as already noted, the relatively rapid diffusion of first generation analogue mobile services in the US served to frustrate the take-up of second generation digital services. Furthermore, the specific characteristics of fixed telecoms services in the US also slowed the diffusion of mobile services. These included the arrangement that the called party, rather than the caller, paid for the call; the fact that a flat rate is paid for fixed local calls, making pay-per-call mobile calls relatively expensive; and the high cost of spectrum, sold by the US authorities by auction, that depleted investment resources for operators. To the extent

---

[70] Kano (2000), p.12.

[71] For an analysis of the causes of US global leadership in the computer, software, and microprocessor semiconductor industries, see Mowery and Nelson (1999).

[72] In it interesting to note, apropos the point made earlier about dynamic increasing returns in mobile communications in Scandinavia, that the Conference on European Postal and Telecommunication Administrations (CEPT), that began work on specifying a pan-European digital standard in the early 1980s, decided in 1987/88 that GSM would become the European standard. This happened formally in 1992. GSM, however, incorporated a later version of the original Scandinavian mobile standard, NMT (Nordic Mobile Telephony) rather than continental European alternatives that were also proposed. This occurred even though the Scandinavian standard was narrow band while the continental alternatives were broadband. “This decision on the GSM standard was very important to the Scandinavian firms Ericsson and Nokia because GSM is based on technical solutions they had already been pursuing. With this decision, they were leading the technical race, not close followers or imitators.” McKelvey and Texier (1999), p.16.

that the flat rate for local calls was an inhibitor of the diffusion of mobile services in the US, it is ironical that the same tariffing system provided a significant boost for the diffusion of the Internet and that attempts are currently being made in Europe and Japan to imitate this system (even if at the cost of Internet congestion as a result of the low price of a scarce resource, namely Internet access.) Even more ironical is the contrast between the US's failure to generate a single dominant standard in mobile communications and the same country's superb success in generating not only US but also global standards for the Internet, partially documented earlier in this paper.

THE FOUR FORCES OF COMPETITION

Earlier in this chapter it was stated that the technological regime and the associated learning regime constituted one of the 'engines' driving the evolution of the Telecoms Industry. The technological regime was defined in terms of the conditions surrounding the creation of knowledge and the opportunities and constraints regarding the use of that knowledge. The learning regime refers to the patterns and paths of learning that occur under the technological regime. One of the conditions 'surrounding' the creation of knowledge, which therefore is part of the technological regime, that has not been emphasised until now is the forces of competition. It is these forces that Schumpeter had in mind when he referred to the "fundamental impulse that sets and keeps the capitalist engine in motion", quoted at the beginning of this chapter, such as new consumer goods and new methods of production.

In the Infocommunications Industry it is necessary to distinguish between four forces of competition: between products/services; between networks; between technologies; and between firms. Examples of competition in each of these four areas are, respectively, competition between telex, phone (mobile and fixed), fax, and e-mail; competition between copper cable/XDSL, optical fibre, and fixed wireless for local access; competition between TDMA and CDMA in second and third generation digital mobile; and competition between AT&T, WorldCom, and Qwest. Competition in each of these areas may occur independently of competition in the other areas although sometimes there will be interdependencies between some or all of the areas.

One area where both network and technological competition is strongest is in the local access market (including Internet access). Exhibit 14 shows the main competing networks and technologies providing local excess.

Exhibit 14. Competing Networks and Technologies
in the Local Access Market

NETWORK/TECHNOLOGY	DESCRIPTION
Copper cable/XDSL	Broadband over twisted-pair copper cable.
Optical fibre	Glass optical fibre cable
Cable	Coaxial cable
Cellular mobile	Radio network, user mobile
Fixed wireless access	Radio network, user not mobile
Satellite	Communication satellites
Power Line[73]	Radio signals sent through regular electricity cables received through electricity sockets
Laser access[74]	Uses low-powered laser beams

The creators of the knowledge embodied in networks and technologies in any of these areas have to constantly do battle to keep up with parameters defined by the alternative competing networks and technologies. For example, second generation digital mobile transmits data at 9.6 kilobits per second. Third generation digital mobile sends data at 2 megabits per second, a similar speed to ADSL. However, TeraBeam claims that its laser access technology will send data at 2 gigabits per second. This competitive environment provides a powerful context, permeated by pressures and incentives, within which knowledge creation takes place. And a changing knowledge base provides an important engine of change. Moreover, as Schumpeter also pointed out, "competition acts not only

---

[73] Power Line involves the provision of data communications, including voice over the Internet and Internet access, through the electric power cables that are already connected to firms and homes, thus avoiding the need to dig up streets (as with optical fibre cables) or establish radio base stations (as with mobile or fixed radio access connections). Power Line works through radio frequencies being transmitted through electric power cables. Relatively cheap enabling technology is required at the electricity substation (serving 250 homes) and at the customer's electricity meter. The original innovation was made by an engineer working with Norweb, the electricity company that supplies the Manchester and Yorkshire areas of Britain. In the event, Norweb obtained the commanding patents for Power Line. However, Norweb, lacking the technological competencies, entered into a strategic alliance with Nortel which went on to develop the necessary technology. Although it is too soon to tell whether this new technology will be a serious substitute for other alternative local access technologies, Norweb and Nortel claim that it is significantly cheaper than the other alternatives.

[74] Laser access is a technology that was announced in March, 2000 by a Seattle-based startup called TeraBeam Networks. "The heart of TeraBeam's technology is a transmitter/receiver that is about the size of a small satellite dish and can be made for $150. Mounted near the window inside an ordinary office, it send and receives data, as light, at speeds of up to two gigabits a second. TeraBeam does not require bulky outdoor aerials or long drawn-out negotiations with building owners to gain rooftop access, unlike similar microwave technologies. And because it does not operate in the radio spectrum auctioned by the Federal Communications Commission, it can operate without licences. [The company claims that its] optical transmission gear passes all legislated safety tests: no danger of lasers frying the eyes of the unwary." *The Economist*, March 25th, 2000, p.89.

when in being but also when it is merely an ever-present threat. It disciplines before it attacks."[75]

CONCLUSION

This chapter has focused on two questions: How has the Telecoms Industry changed since the mid-1980s, when liberalisation began in Japan, the UK, and the US, and what are the causes of this change? How has the Internet affected the Telecoms Industry?

In analysing the causes of change, particular emphasis was placed on the changing technological and learning regimes, that refer essentially to the processes of knowledge creation and use in the industry. However, while these regimes play the role of a Schumpeterian 'engine', powering the process of change, it was shown that financial markets and co-evolving consumer tastes and preferences also constitute important engines of change in the Telecoms Industry. Furthermore, through the analysis of the Internet, it was seen how a paradigmatic transformation of the industry was brought about by a set of ideas, and associated technologies and services, that originally emerged from outside the Telecoms Industry, ideas that at first were vehemently rejected by the industry's technological representatives.

A latent theme in this chapter, that has thread its way through the analysis of the evolution of this industry, relates to the ability of the industry's participants to understand what is happening in the industry, and, in the light of their understanding, to adapt and act in what they believe is an appropriate way. At numerous junctures in the industry's evolution it was seen that the participants have confronted what was termed 'interpretive ambiguity', when currently available information left significant ambiguity regarding what should inferred. Rather than 'rational' and smooth adjustment to 'given facts' we saw a mixture of responses. These ranged from decisive actions based on strong convictions, that subsequently turned out to be wrong (such as the original views of telecoms engineers regarding packet switching), to more hesitant and tentative conclusions (such as those of some financial analysts). The importance of interpretive ambiguity, and the role that it has played at key turning points in the evolution of the Telecoms Industry, suggests that it might be necessary for us as economists to review the way in which we understand the decision-making processes that are, together with selection environments, the ultimate drivers of evolutionary economic processes.

---

[75] Schumpeter (1943), p.85.

BIBLIOGRAPHY

Abbate, J. 1999. *Inventing the Internet*. Cambridge, MA: MIT Press.

Aksoy, A. 1992. "Mapping the Information Business: Integration for Flexibility". In *Understanding Information Business, Technology and Geography,* ed. K. Robins. London: Belhaven Press, 43-62.

Antonelli, C. 1999. *The Microdynamics of Technological Change*. London: Routledge.

Armstrong, M. 1997. "Competition in Telecommunications". *Oxford Review of Economic Policy* 13 (1): 64-82.

Armstrong, M., S. Cowan and J. Vickers. 1994. *Regulatory Reform, Economic Analysis and British Experience.* Cambridge, MA: MIT Press.

Audretsch, D.B. 1977. "Technological Regimes, Industrial Demography and the Evolution of Industrial Structures". *Industrial and Corporate Change* 6 (1):49-82.

Bailey, J., et al. 1995. "The Economics of Advanced Services in an Open Communications Infrastructure: Transaction Costs, Production Costs, and Network Externalities". *Information Infrastructure and Policy* 4: 255-278.

Berners-Lee, T., R. Cailliau, A. Luotonen, H. Frystyk Nielsen and A. Secret. 1994. "The World-Wide Web". *Communications of the ACM* 37 (8): 76-82.

Brock, G.W. 1994. *Telecommunication Policy for the Information Age: From Monopoly to Competition*. Cambridge, MA: Harvard University Press.

Campbell-Kelly, M. 1988. "Data Communications at the National Physical Laboratory (1965-1975)". *Annals of the History of Computing* 9(3/4): 221-247.

Cave, M. 1997. "The Evolution of Telecommunications Regulation in the UK". *European Economic Review* 41: 691-699.

Cerf, V. 1993. "How the Internet Came to Be". In *The Online User's Encyclopedia,* ed. B. Aboba. Addison-Wesley.

Cerf, V. 1996. "Is there a future for the Net? David Pitchford finds out from the man who invented it, Vinton Cerf". *Internet* June 19th: 75.

Chapuis, R.J. and A.E. Joel.1990. *100 Years of Telephone Switching, ii. Electronics, Computers and Telephone Switching: A Book of Technological History, 1960-1985*. Amsterdam: North Holland.

David, P.A. and W.E. Steinmueller. 1994. "Economics of Compatibility Standards and Competition in Telecommunication Networks". *Information Economics and Policy* 6: 217-242.

Dosi, G., F. Malerba, O. Marsili, and L. Orsenigo. 1997. "Industrial Structures and Dynamics: Evidence, Interpretations and Puzzles". *Industrial and Corporate Change* 6 (1): 3-24.

Fransman, M. 1994. "AT&T, BT and NTT: A Comparison of Vision, Strategy and Competence." *Telecommunications Policy* 18 (2): 137-153.

Fransman, M. 1994. "AT&T, BT and NTT: The Role of R&D." *Telecommunications Policy* 18 (4): 295-305.

Fransman, M. 1995. *Japan's Computer and Communications Industry: The Evolution of Industrial Giants and Global Competitiveness*. Oxford: Oxford University Press.

Fransman, M. 1998. "Information, Knowledge, Vision and Theories of the Firm." In *Technology, Organization, and Competitiveness: Perspectives on Industrial and Corporate Change*, eds. G. Dosi, D.J. Teece, & J. Chytry, J. New York: Oxford University Press.

Fransman, M. 1999. "Where Are the Japanese? Japanese Information and Communications Firms in an Internetworked World". *Telecommunications Policy* 23: 317-333.

Fransman, M.1999. *Visions of Innovation: The Firm and Japan*. Oxford: Oxford University Press.

Gong, J. and P. Srinagesh. 1996. "Network Competition and Industry Structure". *Industrial and Corporate Change* 5 (4): 1231-1241.

Hawkins, R.W., R.E. Mansell and W.E. Steinmueller. 1997. *Green Paper: Mapping and Measuring the Information, Technology, Electronics and Communications Sector in the United Kingdom.* Prepared for the Office of Science and Technology, Technology Foresight Panel on Information Technology, Communications and Electronics, Department of Trade and Industry, London.

Houghton, J.W. 1999. "Mapping Information Industries and Markets". *Telecommunications Policy* 23 (10/11): 689-699.

Huber, P.W. 1987. *The Geodesic Network: Report on Competition in the Telephone Industry.* Washington, DC: US Department of Justice.

Kano, S. 2000. "Technical Innovations, Standardization and Regional Comparison - A Case Study in Mobile Communications". *Telecommunications Policy* (in press).

Katz, M.L. 1996. "Remarks on the Economic Implications of Convergence". *Industrial and Corporate Change* 5 (4): 1079-1095.

Kavassalis, P., et al. 1996. "The Internet: A Paradigmatic Rupture in Cumulative Telecom Evolution". *Industrial and Corporate Change* 5: 1097-1126.

Kavassalis, P., T. Lee and J. Bailey. 1998. "Sustaining a Vertically Disintegrated Network Through a Bearer Service Market". In *Telecommunications Transformation, Technology, Strategy and Policy*, eds. E. Bohlin and S. Levin. Amsterdam: IOS Press.

Kavassalis, P. and W. Lehr. 1998. "Forces for Integration and Disintegration in the Internet. *Communications and Strategies* 30.

Kavassalis, P. and R. Solomon. 1997. "Mr. Schumpeter on the Telephone: Patterns of Technical Change in the Telecommunications Industry Before and After the Internet". *Communications and Strategies* 26: 371-408.

Klepper, S. 1997. "Industry Life Cycles". *Industrial and Corporate Change* 6: 145-183.

Klepper, S. and K.L. Simons. 1997. "Technological Extinctions of Industrial Firms: An Inquiry into Their Nature and Causes". *Industrial and Corporate Change* 6: 379-460.

Knight, F. 1921. *Risk, Uncertainty and Profit*. Boston: Houghton Mifflin.

Lachmann, L. 1978. *Capital and its Structure*. Kansas City: Sheed Andrews and McMeel.

Laffont, J.-J., P. Rey and J. Tirole. 1997. "Competition Between Telecommunications Operators". *European Economic Review* 41: 701-711.

Malerba, F. and L. Orsenigo. 1990. “Technological Regimes and Patterns of Innovation: A Theoretical and Empirical Investigation of the Italian Case”. In *Evolving Industries and Market Structures*, ed. A Heertje. Ann Arbor: University of Michigan Press.

Malerba, F. and L. Orsenigo. 1993. “Technological Regimes and Firm Behaviour”. *Industrial and Corporate Change* 2: 45-71.

Malkiel, B. 1987. "Efficient Market Hypothesis". In *The New Palgrave: A Dictionary of Edonomics*, eds. J. Eatwell, M. Milgate and P. Newman. London: Macmillan, 120-123.

Mansell, R. 1994. *The New Telecommunications: A Political Economy of Network Evolution*. London: Sage Publications.

McKelvey, M. 1999. "Global Firms, Small Countries: Ericsson, Nokia and Wireless Telecommunications". *International Journal of Technology Management* (in press).

McKelvey, M., F. Texier and H. Alm. 1998. The Dynamics of High Tech Industry: Swedish Firms Developing Mobile Telecommunication Systems. Mimeo.

Meurling, J. and R. Jeans. 1994. *The Mobile Phone Book: The Invention of the Mobile Phone Industry*. London: Communications Week International.

Millman, S. ed. 1984. *A History of Engineering and Science in the Bell System: Communications Sciences (1925-1980).* Murray Hill, NJ: AT&T Bell Laboratories.

Mowery, D. and R.R. Nelson, eds. 1999. *The Sources of Industrial Leadership*. Cambridge: Cambridge University Press.

Nelson, R.R. 1998. "The Co-evolution of Technology Industrial Structure and Supporting Institutions". In *Technology Organization and Competitiveness: Perspectives on Industrial and Corporate Change*, eds. G. Dosi, D.J. Teece and J. Chytry. Oxford: Oxford University Press.

Noam, E.M. 1994. "Beyond Liberalization: From the Network of Networks to the System of Systems". *Telecommunications Policy* 18: 286-294.

Norberg, A.L. and J.E. O'Neill. 1996. *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986*. Johns Hopkins University Press.

Nelson, R.R. and S.G. Winter. 1974. "Neoclassical vs Evolutionary Theories of Economic Growth: Critique and Prospectus". *Economic Journal* 84: 886-905.

Nelson, R.R and S.G. Winter. 1978. "Forces Generating, and Limiting Concentration under Schumpeterian Competition". *Bell Journal of Economics* 9: 524-548.

Nelson, R.R. and S.G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Rao, P.M. 1996. "R&D and Innovation in US Telecommunications: Recent Structural Changes and Their Implications". In *Proceedings of the International Telecommunications Society Eleventh Biennial Conference*.

Rao, P.M. 1998. The Changing Structure of Corporate R&D in US Telecommunications: Is Software Taking the Helm? International Telecommunications Society Twelfth Biennial Conference: Mimeo.

Richardson, G.B. 1972. "The Organisation of Industry". *The Economic Journal* 82 (327): 883-896.

Roberts, L.G. 1978. "The Evolution of Packet Switching". *Proceedings of the IEEE 66* 11: 1307-1313.

Schumpeter, J.A. 1943. *Capitalism, Socialism and Democracy*. London: Unwin.

Simon, H. 1957. *Models of Man*. New York: John Wiley & Sons.

Teece, D.J. 1995. "Telecommunications in Transition: Unbundling, Reintegration and Competition". *Michigan Telecommunications and Technology Law Review* 4.

Temin, P. and L. Galambos. 1987. *The Fall of the Bell System: A Study in Prices and Politics*. Cambridge: Cambridge University Press.

Winter, S.G. 1984. “Schumpeterian Competition in Alternative Technological Regimes”. *Journal of Economic Behavior and Organization* 5: 287-320.