Technological Convergence: a Strategic Perspective[*]

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Abstract

The information and communication technologies (ICT) sectors are in a process of technological convergence. Determinant factors in this process are the liberalisation of the telecommunications markets and technological change. Many firms are engaged in a process of mergers and alliances to position themselves in this new framework. Technological and demand uncertainties are very important. Our objective in this paper is to study the economic determinants of the strategies of the firms. With this aim, we review some key technological and demand aspects. We shed some light on the strategic motivations of the firms by establishing a parallel with the evolution of the retailing sector.

Keywords: Technological Convergence, Demand Uncertainty, technological Uncertainty, Technology Life Cycle, Internet, Multimedia, Strategy

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1. Introduction

Economists think about reality in terms of markets[1]. In practice, a market is just an abstraction, and drawing the limits of markets out of actual information is a difficult task, that has different answers depending on the objectives of the analysis we want to perform (strategy formulation, competition policy, industrial organization). It is not very common to have the opportunity of studying a process by which some well differentiated markets are transformed into new ones, because of changes in the technology and the demand that cause the products or services of the original markets to end up by serving identical needs to the same customers. In such a situation, firms are faced with big opportunities and big potential drawbacks. Those that are able to correctly foresee the future developments can gain an important headstart and position themselves so as to obtain an important competitive advantage. On the other hand, making irreversible investments in the wrong technology can seriously threaten the competitive position of a firm.

In this paper, we study the so-called technological convergence, a process by which the telecommunications, broadcasting, information technologies and entertainment sectors (collectively known as ICT–Information and Communications Technologies) may be converging towards a unified market. Actually, one of the first questions we consider is how accurate this convergence forecast is. But, whether or not a unique market results in the end, it is clear that those sectors are involved in the kind of process we described above, by which old markets change to give rise to new ones.

Our aim is to study the determinants of the firms' strategies. Many interesting phenomena are taking place within the domain we consider. For instance, we could analyze many interesting case studies to consider the old strategic controversy about the conditions under which firms should vertically integrate or consider some alternative like joint ventures or strategic alliances. Actually, the process of mergers and alliances is so fast that any attempt we made at describing it would necessarily be outdated by the time this paper is read. What we do in this paper is to describe the underlying technological and economic factors that influence the firms' choice of strategies. Technological convergence is possible because of a confluence of technological and economic factors. On the technological side, the key factor is the evolution of communications and information technologies. On the economic side, the most important factor is the worldwide liberalization of the telecommunications markets.

When making strategic decisions, firms take into account the environment, but when the uncertainty associated is very high, making accurate expectations becomes very difficult. Some firms try to influence the future developments. For instance, the investments of Microsoft in the cable industry may be interpreted as an intention to

[1] See, for instance, the guideline of the Office of Fair Trade of the UK about market definition. http://www.oft.gov.uk/html/comp-act/technical_guidelines/oft403.html (10/05/01)

position its Windows CE software as a key element in the set-top-boxes for digital television. The establishment of alliances which is taking place in the ICT illustrates very well how the participants are trying to position themselves in the market. There are many reasons behind the changing nature of competition in the ICT. These are: the need to cope with technological uncertainty (trying to impose a standard), market uncertainty (create demand with the supply of content and get the rents where margins are higher) and huge investments (the need of complementary resources).

Before making a more accurate analysis, it is important to point out which have been the driving forces of the big changes in the industry. In the first place, the possibility of digitizing all type of signals has given rise to technological convergence, which has implications both for the supply (merging of different sectors that were previously separated) and the demand. In the second place, the costs of voice and data transmission have experienced a remarkable decrease. This reduction has been made possible thanks to an improvement in compression techniques, and the reduction in the costs of infrastructures. The increased efficiency of data delivery was one of the factors that influenced the decision by governments to change the monopolistic structure of the old Public Telecommunications Operators (PTOs, nowadays just TOs), engaging in a worlwide process of liberalization that started in 1998. Market dominance and high fixed costs have caused TOs to engage in a process of mergers, acquisitions and alliances. The arguments behind this agreements can be explained by two main reasons: to get the economies of scale needed to maintain profitability (horizontal co-operation); or looking for those steps in the value chain which can offer bigger profit margins (vertical co-operation).

By technological convergence is meant that any type of terminal can access any type of data, which in turn is able to be transmitted through any kind of pipe. Internet has been the catalyst of this process. The technology that has been responsible for platform-independence in the Internet is the IP protocol, which is the basis of a set of protocols that allow routing and transmitting any kind of data (text, image, and voice). Convergence has implications both for demand and supply. First, businesses and home users may have access to a lot of information in an interactive way using any type of terminal. Second, information that is transmitted is platform-independent. This means that there are several alternatives to transmit a given content. For instance, it is possible (or will be in the near future) to obtain local phone connection through the traditional copper wire, wireless, cable or television antennae. It is expected that in a few years just digital data will circulate through the pipes. Some of these data will be telephony voice (which requires low bandwidth), but other content, like digital films, will require more transmission capacity. But many problems must be solved; for instance, the current copper networks, which are the main asset of the TOs, are not wide enough to carry the bulk of information that is needed to broadcast a film. Hence, a telecommunications operator that wants to compete with, say, a cable company, must make the necessary infrastructure upgrades to provide broadband services. But problems may arise because neither the new technology nor the market may be mature enough. When will the demand size allow the firm to recoup the money? Besides, how will this demand be? If the services provided are close to a competitor's offer, consumers will choose the

solution that fits their budgets best. So, it is difficult to bet on a concrete technology when the most popular uses of that technology are not clear yet. Leaving the demand aside, who can tell that the investment that is made today will not be obsolete tomorrow because a more cost-effective technology has appeared? In the next sections we will elaborate all of these aspects.

All the changes mentioned above have shaped the landscape in the transmission activities. On the one hand, there are a lot of opportunities for all the agents involved because the markets are growing. But on the other hand, the competition has widened because there are more technological alternatives to satisfy the same demand. The technological changes provide opportunities for firms, but also imply big risks. In order to understand the opportunities and risks that have arisen in the ICT sectors, in section 2 we make a brief survey of what is technological convergence and which are its consequences, for both the supply and demand sides. In section 2.1, we provide a small description of infrastructures capable of supplying information. In section 3, we take into consideration the factors that must be carefully weighed when launching a product to the market, and use some examples to illustrate them. In section 4, we focus on the demand side of the technological convergence. Are the users ready for technological convergence? As an early indicator we use some data published by the ISPO on the Information Society. Essentially, the question we pose is whether there is a real convergence between television and Internet consumers. In section 5, we analyze the determinants of the firms' strategies. In section 6, we present some conclusions and avenues for further research.

2. Technological convergence today

Technological convergence has both a technical and a functional side. The technical side refers to the ability of any infrastructure to transport any type of data, while functional side means the consumers may be able to integrate in a seamless way the functions of computation, entertainment, and voice in a unique device able to execute a multiplicity of tasks. The European Commission, in its Green Paper on Technological Convergence (1997), illustrates this idea and defines technological convergence as:

> "The ability of different network platforms to carry essentially similar kinds of services, or
>
> The coming together of consumer devices such as the telephone, television and personal computer."

The convergence affects those industries that are concerned with the delivery of data and content, as well as those that take care their displaying, and will affect their market power because, as already noted, it implies the merging of different markets. We show our idea in Table 1.

According to Table 1, technological convergence means that consumers have the capacity to access any kind of contents using any type of terminal (be it the PC, the mobile telephone or the television, for instance). This could imply that any telephone operator would have the ability to provide video services to its clients, or that a broadcasting company could give access to the Internet using the TV –without the need to use the telephone to send data outside. Taking another focus, this could mean that anyone could shop in the World Wide Web through a television set or on the other way around, watch a TV program using its PC. Let us assume that the market is ready for this technological convergence: does this imply that the firms technologically ready?

Many sources of infrastructure provision	Many Services	Many Terminals
·Over the air: — Terrestrial — Satellite — Mobile communications (WAP, GPRS, UMTS…)	·Telephone service: — Local — Long Distance ·Data provisioning — Dedicated lines (LANs, WANs) — Internet access	·TV Receiver: — Conventional — Home Theatre ·Set-Top Box: — CATV converter — DBS decoder
·Wired: – Telecommunications — Coaxial Cable (CATV)	·Content provisioning — VOD — NVOD – Information Services	·Player/Recorder: — VCR — Disk Player ·Personal Computer
·Physically-Delivered: — Tape (VCR) — Laser Disk – Digital Video Disk (DVD)		

Table 1: The implications of convergence
Source: Adapted from Noll (1999) and Towndsed (1997)

A Business Week article (Wildstrom, 2000) discusses to what extent can nowadays the convergence between television and Internet be considered a superior option to the conventional television. Its author tried a satellite TV with access to the Internet, and he thinks that, from a technological standpoint, the convergence has still a long way to go. Even though the quality of satellite TV was higher than any current cable system, the Internet navigation system was clumsy, as compared to the navigators usually used on PCs. The mail system was also found defective. The results of his experience can be summarized in the following quote:

> **"Deadly wait.** A big handicap for interactive TV and other WebTV Internet services is that they rely on dial-up connections. By the time I waited a couple of minutes to establish a connection, I often forgot what I wanted to interact with. Similarly, waiting several minutes for a response to a click on a movie's Web link is painful. This would work a lot better if WebTV were paired with a two-way cable system rather than the inherently one-way satellite TV. Unfortunately, that's not an option now."

In summary, there are various issues that should be considered in this process of convergence. The Digital TV (DTV) will imply the coming together of several devices such as television, PCs or telephones[2], but as of now the technological convergence has yet to arrive. On the supply side, neither the terminal equipment nor the transmission infrastructures are still well prepared to provide broadband video and switched data service (Owen, 1999). Besides, the present television sets are not able to deal with the storage and processing capabilities of the computer world, nor have they the functionality of a PC navigation tool. And, if TV sets were ready to get the user into the World Wide Web, would their static appearance appeal to consumers compared to the more dynamic TV advertisements?. And, on the demand side, consumers do not seem very aware of what technological convergence means –except for some segments. Noll (1999) studies the failure introduction of the High Definition Television (HDTV). He discusses the fact that yet in the early eighties HDTV seemed to be the television of the nineties, but at the beginning of the new millennium the future of the HDTV remains uncertain. He uses some examples to illustrate that the market was not ready for the interactive television yet; we use some of this material in the next section.

2.1. Considering alternatives for data transmission

The final effect that the technological convergence will have on the different firms will be conditioned by market, technological and regulatory issues. It has been pointed out (Townsend, 1997; EC, 1997) that the ultimate outcome will be strongly influenced by whether the governments and international institutions are able to set up a regulatory framework that establishes *neutral* conditions intended to promote *fair* competition. In this subsection, we concentrate on the technological alternatives to provide *broadband interactivity* to the homes. Even though we recognize that technology itself may not be the deciding factor, regulatory aspects are not treated in this section.

Traditionally, TOs have enjoyed the monopoly of voice telephony. The digital revolution and the liberalization of markets have lowered barriers to entry, allowing new players to enter the market. As a natural consequence, TOs have to fight price competition in their traditional core markets from others–basically foreign TOs seeking

[2] Although it could be said that the great advantage of the DTV lies in its better display quality, it has been said often that its great appeal is the interactivity it can offer (Noll, 1999).

to broaden their market, and also cable operators. Although voice telephony still enjoys a good health, sooner or later these markets will become mature. This fact is pushing these antique *gods* to enter the *entertainment* market as a good prospect to maintaining their profitability in the long-term. Cable operators represent the new competition for TOs, especially in those countries where these operators are allowed to provide voice telephony. They are experiencing a situation similar to the one just described for the TOS, in the sense that they are facing competition from satellite broadcasters vying for consumers' attention, with a market that is becoming increasingly saturated. To challenge their competitors, cable companies are trying to offer more options to their subscribers (high-speed Internet access, telephony and conventional TV[3]), but cable operators can't embody all these offerings in their actual pipes for free.

There are various generic media for transmitting signals under development, as noted in Table 1, which are grappling to provide *television*. In this section, we only make a description of wired infrastructures in order to elucidate the risks faced by telecommunications and cable firms, and discuss some intermediate solutions adopted by them. Each delivery system has advantages and suffers handicaps, and it is not clear, especially because issues about demand are still so confusing, that any of them is dominating the others. Traditionally, the broadcasting of radio or television signals (wired or wireless) was in essence a broadband, one-way communication. On the other hand, telephone (be it wired or wireless) is a two-way narrowband communication. The meaning of this is that if some interactivity is to be permitted (in the case of the TV broadcasters) or wider bandwidth is to be provided, then some network enhancements must be made.

Wired infrastructures are the twisted-pair copper wires, which are the main telecommunications operators' asset, and the coaxial cables owned by the cable operators (CATV[4]). The similarities between these two transmission media are basically that both of them have a tree and branch structure[5], but a CATV resembles more a wireless broadcasting medium in the sense that the information is one way (with the difference that the CATV is able to provide multiple channels). Because the use of the main lines -trunk technologies- is spread across a lot of users, they used to be broadband—coaxial cable, radio towers that transmit microwave signals, communication satellites or fibre optic. These broadband infrastructures are expensive, and since the liberalization of the telecommunications markets the necessary investment has increased substantially. Although these trunk technologies could be used in the local loop, it doesn't seem that it would be economically profitable, given the current levels of demand. It is plausible that in the long-term the demand will shift from conventional to interactive television but, at the moment, guessing the momentum is just a

[3] This bundle is what is generally acknowledged as the *one-stop-shopping*

[4] The acronym CATV corresponds to Collective Antennae Television used in the fifties in the U.S.A. to enhance the TV broadcasting in the farthest rural areas.

[5] A tree and branch structure is like a highway (the main or trunk lines) that supports the big bulk of traffic and the local roads (the local loop) that delivers the traffic to the particular homes. The computers which are in charge of driving this traffic are the switches in the case of the telecommunications operators and the headends in the case of the CATV operators.

speculation. This is the chief argument that explains the intermediate solutions adopted by firms, which are spelt out in the next paragraphs.

Telephone lines, which were initially designed to transmit voice, are inadequate to transmit the great quantity of information that high-speed data or multimedia services need. For this reason, telephone engineers have been working on software solutions that offer the possibility to use the traditional copper wires as high-speed lines. This is the DSL technology (Digital subscriber Line). The DSL technology comprises a set of modems at both ends of the pipe, which compress the data. There are various types of DSL modems, being the most popular currently the ADSL (Asymmetric Digital Subscriber Line). The term Asymmetric means that the speeds of the downstream data (going to the user) are higher than the upstream (going out) data. As a result, the ADSL technology may be a good solution for some functions that can support this asymmetry, like surfing across the World Wide Web or sending an e-mail, but is not so convenient for telephone calls or videoconferencing.

Telephone companies hold a good position to compete with other alternatives: firstly, they have the advantage of accessing a larger customer base than cable companies, and secondly, they are cash-rich companies. On the other hand, in order to install ADSL the switching station must be located near the consumer if the latter wants to reliably operate with an ADSL line. This implies the need of higher investments by the telephone companies, because fibre-optic links must be lengthened to the local loops. Nevertheless, it is better to invest on equipment than on the network itself, since the investment can be easily shared with the consumers (Owen, 1999).

Cable television operators come from a broadcasting tradition, in the sense that their pipes are one-way broadband transmission. The challenge for them is not to enlarge their capacity but to provide interactivity. To overcome this, there are two proposed solutions. The first one is to install a one-way cable modem. In this case, the system relies on a cable modem that uses the cable network for downstream data and the telephone network to send data outside; the customer must get an extra phone line, an analogue modem and a cable modem as well. Although this alternative is clearly inferior to the DSL proposed by telephone operators, it allows cable operators to reduce costs and risks, because the customer must undertake most of the investment.

Another choice for cable operators is the installation of two-way cable modems. This alternative uses the coaxial cable both for upstream and downstream data. This is a more expensive solution, because the same pipe must sustain more traffic. In consequence, the cable operators should reduce the number of subscribers at each node, add equipment or upgrade the system as a whole. Any of these possibilities increase the break-even point.

To examine the different alternatives that are available nowadays, a comparison has been made among the time it would take for a user to send or receive 650 Mbytes (the information contained in a CD-ROM). In order to establish similar criteria to judge the differences, congestion problems have been disregarded, so it must be understood that the used transmission speeds are theoretical in each case. We have not taken into account, either, whether the different connections guarantee a minimum bandwidth,

although this is a requirement to allow the PC confirm that packets have arrived to their destination. Also, the possible "hang-ups" have been ignored.

From Table 2 it is easy to see that a universal network for managing the variable bandwidth transfers in real time needed for the new applications does not exist yet. The different choices are more suitable for receiving than for sending information. The consequence is that some services that require high downstream transmission speed, like the reception of software, films or music, are clearly benefited. Instead, having a videoconference, which requires a high bandwidth both for the delivery and the reception of data, is more problematic. The two-way 27 Mbps cable modem connections are the ones that perform best but, at the moment, their availability in the markets is limited. Nevertheless, in spite of the fact that cable seems a better alternative than the DSL in offering high-speed, there are other points that should be considered in weighting the advantages and disadvantages of the different technologies. While the coaxial cable permits higher Internet speeds, the DSL is more consistent and safer to hackers' attacks. This is because the DSL is a dedicated telephone line, while the coaxial cable is a shared platform, which suffers from congestion at peak hours.

The most ambitious view of the technological convergence promises to provide full interactivity to the homes (VOD, NVOD, telephony and so on). There are different alternatives competing for the prize, and the winner will not necessarily be the one that performs best, but the one more favoured by the customers. There are some warnings about how regulatory aspects should adapt in order to prevent market failures (Blackman, 1998; Parker, 1999; Townsed, 1997). A desirable outcome in the technological war would be the coexistence of the different alternatives to allow home access. The choice would depend on the intended usage and the costs of the competing alternatives. But there are more pessimistic views that argue that allowing the joint provision of voice telephony and data by telecommunications and cable operators could reinforce the incumbents' power and hinder innovation. The reason is that TOs are much larger than their cable competitors and, as a consequence, so is their borrowing capacity.

In the next section, we present a framework that identifies the factors underlying the risks in the ICT markets. The framework should be useful to understand the volatility of the technological firms' shares. Uncertainties about policies and regulation interact with uncertainty about demand and technology. In Parker's (1999) words, "technological invention is the precondition, but by no means the guarantee, of the market's embrace".

		Transmission Speed		Transmission Time	
		Downstream	Upstream	Downstream	Upstream
POTS (analogue Voice telephony)	1997	28,8 Kbps 33,6 Kbps 56 Kbps	28,8 Kbps 33,6 Kbps 56 Kbps	50h 9m 15s 42h 59m 21s 25h 47m 37s	50h 9m 15s 42h 59m 21s 25h 47m 37s
ISDN		64 Kbps 128 Kbps	64 Kbps 128 Kbps	22h 34m 11s 11h 17m 4s	22h 34m 11s 11h 17m 4s
xDSL	(SDSL) (HDSL) (ADSL) (ADSL)	384 Kbps 768 Kbps 1,5 Mbps 8 Mbps	384 Kbps 768 Kbps 12 Kbps 500 Kbps	3h 45m 41s 1h 52m 50s 57m 46s 10m 49s	3h 45m 41s 1h 52m 50s 120h 22m 13s 2h 53m 19s
Cable modems		1,2 Mbps 27 Mbps	128 Kbps 10 Mbps POTS line used for upstream	1h 12m 13s 3m 12s	11h 17m 4s 8m 39s 25h 47m 37s
Wireless	(900 Mhz) (LMDS) (MMDS)	28,8 Kbps 1,5 Mbps 1,5 Mbps	28,8 Kbps 1,5 Mbps 1,5 Mbps	50h 9m 15s 57m 46s 57m 46s	50h 9m 15s 57m 46s 57m 46s
Satellite	(Direct PC)	400 Kbps	POTS line used for sending outside	3h 36m 39s	25h 47m 37s

Table 2: Waiting time for sending or receiving a CD using the different alternatives that provide access to the Internet[6].
Source: Elaborated with data from Owen (1999), pg. 194.

[6] It must be said here that the speeds in the table are only potential. In Catalonia, for instance, ADSL goes from 256 Kbps to a maximum of 2-4 Mbps.

3. Potential sources of uncertainty

After ten years of risky and expensive investments, in 23 September 1998, the Iridium[7] consortium launched its first low-orbit satellite, with the aim of allowing connection by users on any part of the planet. Although forecasts were very optimistic, and the project counted with the advantage of being the kind running[8], about two years later the firm went into bankruptcy. The failure[9] of the project is related to wrong market forecasts and problems in commercialization because, according to experts, the idea was *fantastic* in the technological sense. Supposedly, the bulk of its potential clients were business people who travel all over the world (besides other small groups like adventurers, mountain climbers or scientists who travel to remote places), but Iridium found that, by the time the product appeared in the market, these potential clients already had more convenient alternatives, which gave coverage in their more frequent destinations. No doubt the initial market studies showed that the project was profitable, but the problem lies in the fact that those studies did not take into account the developments in mobile telephony that took place while the project was being developed.

This case reflects the technological and market uncertainties marketing people must cope with when making forecasts. Besides, in emergent and technology-intensive sectors, the right moment of entering the market is a critical decision. When they were launched, the Iridium devices had been displaced (entered the market late), because the GSM mobile systems were already satisfying the demand at a much lower cost and with more adequate (smaller) devices. The adoption of GSM as a standard by the European Union in 1992 is behind the explosion of the mobile phone market in Europe. It diminished technological uncertainty both for users and suppliers. Competition in the GSM phone market led to enhancements in the technology that resulted in cheaper, lighter and smaller devices, and besides, in a wider coverage.

On the contrary, the size of the terminals provided by Iridum and the cost users must bear, both for the acquisition of the terminal and for each call, were too high compared to the alternatives. The cost of the Iridum terminals was much larger than the cost of a mobile phone, and they weighed half a kilo. Also, the price of each call was way above the price for mobile phones. The market size of Iridium has not gone further than 55,000 clients for all the world, which proved insufficient to recoup an investment of between 5,000 and 7,000 million US dollars, the annual costs of maintenance and the financial expenditures derived from the huge debts contracted.

According to Shanklin and Ryans (1988), high technology markets can be *technology-driven* (radical innovations) or *demand-driven* (incremental innovations). In the first case, the product is based on *presumed* rather than identified needs. For instance, the changes occurred in the ICT markets are a consequence of the emergence

[7] Backed by Motorola.

[8] Other global satellite network projects like Globalstar, backed by Loral Space Systems or Teledesic, among whose main shareholders is Bill Gates, promised to compete fiercely for a total market that experts estimated to reach the $8,5 billion in 2002.

[9] "El pesimismo invade la telefonía por satélite". Ciberp@ís, march 30th 2000.

of new ways to transmit the information, which is finally the outcome of technological innovation. A secondary factor in the development of these markets is the demand, which is later developed. Finally, the change in the regulatory framework is only an intention to give answer to all of these transformations. It is clear that in these emergent sectors the role of the technology is fundamental and it is a key element in the strategy of the firms (Foster, 1988; Grant, 1995, Chapters 9 and 10). Though the potential benefits in the emergent sectors are enormous, they are very hazardous as well. An explanation of the volatility of these markets can be found in Grant (1995), who makes a decomposition of the risks associated with technology-intensive products. First, the lack of knowledge about the likely size of the market; second, the evolution of the technology itself; and, finally, the difficulty of making predictions about the nature of the demand–for instance, what will be the more conventional uses of the product.

In the following paragraphs, we describe the risks associated to technological products that derive from discontinuous innovations. As noted in the section before, there is a variety of infrastructures that provide broadband-interactive access. Guessing which is the most cost-effective technological solution is difficult when consumer demand is not clear; firms have uncertainties regarding both the size and the characteristics of the demand.

3.1. Market uncertainty

In a changing environment, firms must reconsider their product mix continuously. This entails abandoning old products, modifying existing ones, and making new launchings. The last two actions involve innovations. The risks associated with new or improved products originate in technological or market uncertainties. We are concerned in this section with market uncertainties. In the launching of any new product (be it a radical or an incremental innovation) there is never certainty about the consumers' reaction to it. The problem is more acute when the product is *too* novel and requires a high level of effort to induce consumers to switch to it. Firms try to reduce this risk by conducting systematic studies before entrusting large sums of money to new product releases. These are, typically, concept testing, product testing, and market testing. The chief objective of concept testing is to render more precise earlier ideas before devoting the firm's wealth to any prototype. Moore (1988) points out that, in general, concept testings are more suitable for modifications of products (incremental innovations) than for radical new products. The reason is that the consumers' lack of familiarity with radical innovations, and the absence of other external factors, like social influences, that affect consumers' behaviour, make concept testing fruitless in predicting market success. For this reason, it has been said before that radical innovations are based upon presumed needs, because in fact consumers are not the best judges in evaluating new products (Foster, 1988; Moore, 1988). According to this argument, when consumers lack information and education about the product, they have a marked tendency to reject it.

Once the product concept has been developed, and the firm has decided to commit funds into the new venture, it is time to organize the whole process and make predictions. This requires a degree of forecasting and projection into the future to turn R&D programmes into profit. The first problem appears in trying to forecast the level of sales. "When" and "how many users" will adopt a particular product weigh heavily in determining the moment in which the profit objectives will be reached. However, the future development of the demand is difficult to predict with a radical new product (Moore, 1988; Foster, 1988), basically because no historical data is available and, as mentioned earlier, consumers lack familiarity with the product. We quote some examples that illustrate those problems.

The I.T.U. (1995) explains how Bell Atlantic failed in his expectations to supply interactive television in 1995[10]. The company expected to have 1,2 million homes subscribed at the beginning of that year, but at the end of the year the number of subscribers was zero.

Noll (1999) reports two examples more, one from the telecommunications industry and the other from the computer industry. The author explains how in the mid eighties, AT&T made some trials in order to grant its customers interaction with their televisions via Videotext. Videotext allowed users to access information through the television using a telephone line. The project failed because its users complained that the system interfered with their watching TV programmes.

Microsoft made a new attempt in that direction in the nineties. With a 40% PC home market penetration, Microsoft spent $1 billion in the acquisition and promotion of WebTV with the intention of integrating the TV and the PC. After spending about $50 million in advertising during the 1996 winter holidays, WebTV and its allies –Sony and Philips Electronics– only reached 50,000 subscriptions, much below forecasts. According to Judge (1998), Microsoft would have found useful to wonder why 60% of homes did not have a PC yet. This author suggests that behind those failures there is marketing myopia by the firms, who have not been able to understand the differences between TV fanatics and Web fanatics.

Those three examples serve us to draw some preliminary conclusions. Consumer habits are not easy to change, and the market needs time to be *educated*. Following this idea, some analysts discuss the fact that a menu-driven television can substitute, at least in the short term, the conventional television (be it free or not), and as of now it seems more appropriate to bet on a monolithic television, although with more channels. As with any radical innovation, it does not seem that this transition may take place overnight.

We end this subsection with a quotation that illustrates the phenomenon of market uncertainty for new products:

> "The newer and more innovative a product is, the more likely it is that the public might not appreciate it at the beginning. In 1952, our company marketed a tape recorder. Despite the fact that it was a great achievement and a technological

[10] WTR, Footnote No 9 Chap. 2

innovation for us, at the time it looked like a toy to the general public. Nobody thought about recording speeches or using a tape recorder to learn languages…. In the case of an entirely new product, a market must be created"[11]

3.2. Technological uncertainty

In section 2.1 we have made a revision of wired infrastructures that are competing for the home market. It is quite likely that, by the time this paper appears in print, that information will be outdated. This is nothing more than a manifestation of technological uncertainty, which is characteristic of any disruptive innovation.

The Product Life Cycle (PLC) has been a useful tool for economists in explaining the evolution of markets and how firms' strategies adapt (Grant, 1995; Moore and Koprince, 1999; Teece, 1988). Four phases are distinguished in the PLC: an introductory phase, growth, maturity and decline. PLC analysis can be applied in many instances (from a particular trademark to a brand new market). Our starting point here is a disruptive innovation, which gives rise to a different technological paradigm, but we also consider incremental innovations that are based on established technologies. The introductory phase is the most uncertain, because of the technology itself, and also because many issues about compatibility with current consumer habits are only based on presumptions, as we commented in section 3.1.

From the standpoint of the supply, a big source of uncertainty is related with the issue of standardization. Sometimes, one among all competing products will end up becoming a *de facto* standard. In other (rarer) instances, a *de iure* standard (imposed by governments or public institutions) will appear. Strongly related with standardization is the issue of compatibility among different products.

In the introductory phase of the product, there are many technological alternatives and configurations available vying to emerge as a dominant design. The growth of the market may be favoured by the emergence of a *paradigm* design that allows the better quality/price performing ratios. When such designs become *de facto* standards, the market will be dominated by a small handful of companies who have control over the products' architecture, so other vendors and suppliers are submitted to their requirements. Similar patterns of behaviour are found in markets for network products, like the VCR market (Cusumano, 1992) and the PC industry (Langlois, 1992). In both cases, firms entrenched their leadership in the industry by establishing their own designs as the successful ones taking advantage of *indirect network externalities*.

There is a vast literature on this type of emergent markets and the role played by the standards[12] when network externalities are present[13]. There are different sources of

[11] Morita, Akio (1981). "Creativity in Modern Industry", Komn, K March 1981, p. 6. Cited in Shanklin, William; Ryans, Johnk K. Jr. (1988)

[12] We refer here to the interface standards or compatibility standards.

[13] On this regard, one can consult David and Greenstein (1990).

network externalities (Katz and Shapiro, 1985). First, direct network externalities, in which the utility function of a user increases when there are more people using that product (communication technologies are a typical example). In this sense, standards play a critical role in the expansion of the market because they affect positively the *quality* of the product. Second, the so-called indirect network externalities, which have their origin in the variety and quantity of complementary products (the well known case of software and add-ons for PCs). Finally, the expanse of the installed base of customers has a positive effect on the quality and availability of after-sale services. There are several case studies that analyze standardization processes under a strategic perspective[14]. An example is the well-known battle of standards in the video recorders market. Cusumano (1992) explains the failure of Sony in the launching of its Betamax. The author argues that Sony, who had too much confidence in its reputation and relied excessively on the superior quality of its product, was reluctant to share its technology. On the contrary, JVC licensed the technology to other manufacturers, and this encouraged the suppliers of contents to use JVC's standard. The creation of complementary resources (for instance, more availability of films in VHS than in Beta format) and direct network externalities played a crucial role in favour of the VHS system, which in the end almost completely displaced Sony's Betamax.

In technology-intensive sectors in which network externalities are present, the imposition of a technology as a *de facto* standard may displace the technologies that are not dominant. In the World Telecommunications Development Report (WTDR) of 1995[15], the I.T.U. (International Telecommunications Union) explains how the lack of co-ordination was the origin of some inconveniences for the users, because of several reasons. First, the lack of a standard in the transmission means of multimedia content (CD-ROM, CD-i, Photo CD); second, the diversity of incompatible standards (IBM PC–compatibles, Apple Macintosh, multimedia Kiosks); and third, the different codification alternatives (MPC1, MPC2 and MPEG-1). According to the report, these incompatibilities were the cause that four out of ten products were returned (according to a study backed by CD-ROM producers), because the users found that their product did not work. Even though competition among different alternatives can increase the rate of technological progress in the industry, it must be pointed out that the presence of many options may provoke delays in the development of the market—consumers prefer to wait rather than betting on the wrong horse. The following example is an application of the previous considerations to the ICT sectors.

Compatibility issues do matter in the case of the ICT because each part of the system must dovetail with the other. Nolan (1997) discusses the bottlenecks that appeared in the development of digital television in Europe, and compares the situation with the USA. In order to understand the importance of compatibility, he gives a clear explanation of the different elements involved in the functioning of pay television. Among these elements, he cites the Electronic Programme Guides (EPG), which are "the video cousins of the Web browsers such as Netscape and Microsoft Explorer", and

[14] Besen and Farrel (1994) have done a very clarifying analysis of compatibility decisions under a strategic context.
[15] Chapter 5, pg. 27.

the Applications Programming Interface (API) which is the TV counterpart of the computer operating system. Firms are interested in controlling the API as a way of establishing barriers to entry. The existence of incompatible receivers and proprietary APIs is inconvenient for hardware vendors, service providers and consumers, and has limited the competition in European markets. Moreover, the multiplicity of incompatible systems has brought about diseconomies of scale, and higher costs have limited the market acceptance of the products. To illustrate this, he explains how in Germany all of these factors have had unfortunate consequences (insignificant penetration levels).

Microsoft, a computer operating systems and software developer, has benefited from the ubiquity of the Windows operating system in the PC market. The firm is trying to get the same dominance with the operating system Windows CE in the set-top-box market. The reason: control the gate to the nascent digital world. In a pay-TV model, viewers need a set-top-box to unscramble the signals sent by the broadcasters. These set-top-boxes have the potential of giving access to a set of sophisticated services, such as video-on-demand, interactive banking, and so on. Moore and Koprince (1999) explain Microsoft's proposal to the cable industry in 1997, and how this firm's proposal was finally beaten by TCI's[16]. The plan consisted of building a constellation between the cable and software industries. Microsoft proposed to design a unique set-top-box for all firms in the constellation, so this became the industry standard and, as a consequence, the costs of the set-top-boxes would be lower. In this way, Microsoft would have access to the local loop, and thus to a wide captive market. At the end, the cable industry did not accept Microsoft's proposal because of their fear of becoming too dependent on Microsoft. Instead, they adopted TCI's alternative plan under which the cable firms would rely on an open system model. CableLabs, the joint R&D body of cable companies, formulated a series of specifications for an operating system (API) that would allow interactivity among different service providers.

We summarize with two lessons that apply to ICT markets. The first one is the role played by compatibility standards as a response to the initial chaos that rules the nascent industries; this is the idea of the "ecosystems" discussed in the Moore and Koprince (1999) paper. The second one is that the technological superiority of an alternative is not a guarantee that it will become the *paradigm* of the market.

3.3. Huge up-front costs and complementary resources

Some innovations require huge investments before the market starts to generate profits. Because of this, the risk is very high. The initial investment implies a commitment to a particular technology, and the danger of making the wrong bet is enormous, as there is no way to go back without sustaining huge costs. The Iridium history is a clarifying example. Although the project promised a lot, it finally resulted a fiasco because, during

[16] Tele-Communications Inc (TCI) is the biggest American cable-TV firm

its development, a competing technology that had a wider acceptance appeared. Another example comes from the ADSL versus cable battle. There is no way to tell whether one or the other will end up as a *de facto* standard and, of course, there is also the possibility that a third competing technology will emerge and take that role. Discontinuous innovations can change the leadership in an industry (Foster, 1988); that is, former followers or even start-ups become leaders and the other way round. Foster (1988) gives some examples, and concentrates on what he calls the technological myopia– overinvesting in an obsolete technology. We think this risk is very important in the ICT sectors.

In providing broadband (with full interactivity) to home consumers, cable companies and TOs must invest large amounts in infrastructures. This large investments give rise to economies of scale, an will be finally profitable only if the market is big enough. In Table 3 we present an estimate of the cost that cable and telephone operators would have to face if they had to provide broadband to the home market without being able to use any previous infrastructures.

Medium: terrestrial wired	**Fixed Cost of the system**	**Variable Cost per household**
Copper pairs (telephone)		
Analogue Modems (to 56 kilobits per second)	0	‹$200
Digital Subscriber Line (xDSL)	$1,000+	$600
Cable Television	0	Negligible
Conventional	60	Negligible
Digital modem	$500-$1000 +	$500

Table 3:Estimated cost to serve serve 100 million household subscribers, each
Source: Owen (1999)

Imagine that both, a TO and a cable operator upgraded their infrastructures installing DSL and digital modems respectively, and they had to spend about the same amount ($1000 per house). In this case, the lower average fixed cost would be for a 100 percent of the market (100 million households), but if the penetration rate declines to the 50 percent the average fixed cost is doubled. Note that, depending on the size of the market, the costs vary notably.

In the next section, we present a framework that identifies the factors underlying the risks in the ICT markets. The framework should be useful to understand the volatility of the technological firms' shares. Uncertainties about policies and regulation interact with uncertainty about demand and technology. In Parker's (1999) words, "technological invention is the precondition, but by no means the guarantee, of the market's embrace".

The economic impact of an innovation depends on its diffusion. The diffusion of a product can be understood as the process of its market adoption. The market adoption is favoured by the improvement of the product itself (amending problems related to its functioning) and the creation of a set of complementary products, which may originate bandwagon effects and accelerate the diffusion process. An instance in the automobile industry of complementary products (the so-called indirect consumption externalities) would be the existence of a repair and maintenance network as well as a gasoline station network. In the home provision of broadband services, the shortage of contents has been viewed as a bottleneck for the development of some markets (pay television[17]).

Shurner (1997) studies pay TV services in the UK. In his opinion, there are some drivers that should be taken into account when making considerations about the encouragement of the pay TV UK market[18], namely:

(a) The enlargement of the programming choice, which would give rise to more niche-content seeking.

(b) The development of the video-on-demand (VOD) or near video-on-demand (NOVD) services.

(c) Enabling new interactive television services, such as home-shopping, home-banking and other narrowband interactive services through the television set.

The development of those services requires the engagement of important sums by those who have to adapt the equipment in order to digitalize the information (contents). But many problems must yet be solved. Relating to the first driver commented above, the European Commission highlights the importance of the fragmentation of the languages and cultures in the European Union. This is a big problem, since the critical mass needed in order to recoup costs may be more difficult to reach than in a more homogeneous market like the USA. Considering the expansion of digital contents, the European Commission observes, in his Green Paper of 1997, that the Intellectual Property Rights are not protected enough, essentially in the off-line delivery format. If

[17] The pay TV can be analog and digital.

[18] The HDTV is seen as the broadcasters as their ace to combat the telecommunications and cable industry. It is widely argued, the reader can find some notes in Shurner's article as well as in Nollan's, that the great advantage of HDTV for consumers would be the interactivity (not the increase in quality of pictures). It is for this reason that the drivers of HDTV are included here.

in the TV world content providers were worried about illegal copies made on tape, nowadays this fear has extended to the online world (the case of Napster is an example). In spite of that fact, content providers view the "digital" world as a way to resell their old films in digital format (as happened with music and Compact Discs). But they are not likely to unleash their productions without adequate copyright protections. Regarding the development of VOD or NOVD services in order to encourage demand, it is not immediate to conclude that upgrading the pipes will boost the market; it could happen that storage facilities (the DVD, for instance) became the "natural" delivery method for VOD. And relating to the third driver considered by Shurner (1997), we think that remote online services (shopping, banking, learning) are still in their infancy. There are a lot of inhibitors still, about which we comment on the next section. Even so, it is clear that the convergence must be a supply driven phenomenon.

4. Users' attitudes versus the Information Society: ready for convergence?

In this section, we briefly consider technological convergence from the point of view of its adoption by the end users. We want to stress two main facts: on the one hand, the current percentage of home Internet users is still quite low; on the other hand, most people who do not use the Internet are *not* interested in doing so.

Traditionally, conventional television has occupied the central place in the sitting room of peoples' homes. The consumption experience of the traditional television consists of passively absorbing a set of pre-selected packages of programmes. The technological convergence implies that viewers change their appreciation of the television and become more active. The challenge for telecommunications and cable firms is to have the ability to change consumers' attitudes. This seems easy to achieve with teenagers used to PC or console video games, but it is not so for older generations. Interactive television, for instance, could be compared to browsing on the World Wide Web, because the consumer must choose from thousands of web pages instead of absorbing whatever happens to be available on the screen. For this reason, it would be clarifying to understand the demand drivers of the Internet, understood as a preliminary indicator of *interactivity acceptance* by end-consumers.

Technological convergence can be viewed as the application of the Internet philosophy to the current TV markets. Though some studies view the Internet as a direct competitor of the TV in the broadcasting of video, in this paper we consider the Internet a precursor of what the TV might become in the future. For this reason, in this section we comment on some studies about the Internet. One of our conclusions is that some reports about the Information Society are overly optimistic. For instance, according to research conducted by NUA in 2000,[19] 62% of the US Internet users would rather browse the Internet during part of the time they spend watching TV. This seems to

[19] http://www.nua.ie

indicate that it will not be long before the Internet becomes dominant in the home markets. But we should bear in mind that the percentage of Internet home users is still low, mostly in countries other than the US. For instance, in Europe the percentage of homes with a connection to the Internet in 2000 was only 18% (INRA, 2000). Furthermore, the Internet is mainly used to send mails, chat, and get information, in addition to playing online games; the latter application is closer to technological convergence, while the former ones are more traditional.

1	No need to do such tasks within the home	55
2	Too expensive	24.2
3	No need to do such tasks within job	22.7
4	Insufficient equipment	21.5
5	Too complicated	18.2
6	Lack of knowledge about the subject area	13.7
7	Lack of interest in new technologies	13
8	Lack of time to use	9.7
9	Fear of security when conducting financial Transactions over the Internet make me feel uneasy	9.1
10	Other reasons	8
11	Lack of time to learn how to use	7.2
12	No prior knowledge about service / product	6.5
13	Service did not exist in country	2.5
14	Partner uninterested in services	2.1
15	N.S.P./does not know	6.6

Table 4 : Reasons for the lack of interest in services over the Internet throughout the European Union

Source: Eurobarometer 50.1 Report.

Most studies on the Information Society warn about some critical issues: the availability of contents, the reliability of the payment systems, the simplicity of the users' interface, and the broadband infrastructures. But it is worth pointing that these factors can do little by themselves. But the potential consumers' attitudes are also very important for the creation of the new markets: marketing actions by the firms should help in transforming needs into wants, and the different offerings must fit into the interests and goals of the consumers. Table 4 describes the responses got from a sample of EU citizens when asked about their lack of interest in services over the Internet. The responses show those consumers felt little need of Internet services, viewed their prices as too high, and did not own the necessary equipment. These findings might be interpreted as discouraging, if prior needs are viewed as a necessary requirement to motivate consumers.

5. Key determinants of the firms' strategies

To understand the main motivations behind the strategies of the firms in the ICT markets, it will be convenient to establish a parallel with the retailing markets. A look at the evolution of retailing in the twentieth century reveals a pattern of increasing market dominance by big firms that are located at the last step in the vertical chain, that is, those directly serving the consumers. Actually, there has been a shift in market power from producers to big retailers, who nowadays can impose stringent conditions even on large producers. This process can shed light on what is happening in the ICT markets. We can better understand the strategic moves of the firms from this perspective: if direct access to the markets is so important in the retailing industry, why should it not be so in the ICT sectors?

Securing access to the market can be a way of protecting the distribution of content. For instance, let us consider the merger between Time Warner and AOL[20]. AOL contributed twenty-three million *paying* Internet subscribers, and Time-Warner 13 million cable subscribers. The newly created company has a diversified portfolio of distribution assets and thus a wide variety of delivery options in the local loop. The merger can be better understood if we make a very simple scenario approach. The first scenario consists of one particular technology (cable, for instance) ending up by being clearly superior to any alternative; in this case, those who have stakes in the predominant technology will find themselves in a much better competitive position. For this reason, companies are trying to diversify their asset portfolio. The second scenario, which is, according to some, the most plausible in the long term, is that several of the delivery technologies end up by being close substitutes. In this case, owning the rights to content may prove decisive, because the delivery sectors would be more competitive. To forestall such a situation, firms would like to have stakes in the sectors that own the contents.

The discussion of the last case is interesting, because it helps us understand the limits of the parallel with the retailing markets. If several of the delivery technologies end up by being close substitutes, then it will be the firms that own the content those that will be in a better competitive position. It is for this reason that, in addition to having direct access to the consumers, firms are also interested in having access to the content creation sectors.

Let us discuss a further case, in which a firm is trying to establish a strong position starting from its dominance in the content markets. Bertelsmann is nowadays the biggest English-language publisher—its core strength lies in books and magazines (Spencer et al, 2000). That is, Bertelsmann's traditional focus has been content rather than distribution. Via a series of mergers and acquisitions of Internet-related firms, it is trying to consolidate its access to the distribution markets. It established joint ventures

[20] The portfolio of the new corporation includes: content (print content, movies, music, television and digital films), pipes (deals with regional Bells for DSL service and Time Warner Cable), satellite (AOL shares in DirecTV), and Internet service.

with the Internet portals AOL and Lycos to sell its contents. In order to have a foothold in the on-line book retailing industry, it bought stakes in Barnes & Noble (to compete with Amazon in the US), and launched BOL (Bertelsmann On Line) in Europe and Asia. Its last acquisition, Napster[21], has given Bertelsmann access to the thirty eight million users of the portal and its technology, with the idea of converting it into a subscription-based download service for any kind of good that can be digitzed.

But the Internet is not the only focus in Bertelsmann's strategy. The firm announced in April 2000 the creation of a joint venture with Pearson and Frère with the intention of becoming the biggest TV conglomerate in Europe, capable of disputing the world markets to their US rivals, such as Time Warner, Walt Disney, and Seagram. The new consortium was publicized as a way to link complementary assets and get advantage of synergies in content production (Pearson's lowbrow production) and television (CLT-UFA) and radio broadcasting (Stanley, 2000).

There is a wide diversity of firms that intervene in the ICT sectors, from telephone operators to cable companies or Internet portals. The parallel we have established with the retailing markets can help us understand a basic motivation of how these firms prepare for the future competitive situation: all of them try to be the last link in the chain that gets to the consumers. More precisely, they try to be the window through which the consumers access the networking services. An Internet portal like Yahoo[22] provides a wide variety of services, like e-mail, messagerie, auctions, and access to online shopping. But a similar intention and interface is supplied by a telephone operator giving access to the net, though Yahoo and a telephone operator are so different in every respect. Concluding, firms try to establish themselves not only as the last link to the consumers, but also as the window through which the consumers will access all the other services—this is what can ultimately give them a decisive competitive advantage.

Let us now consider economic factors behind the process of mergers and alliances that is taking place, resulting in an important move towards vertical integration. On the one hand, technological uncertainty favours less integrated forms of co-operation, because then the risks are spread among more firms; in this case, it is important to agree upon standards, so as to decrease the market risks. An instance of this is the agreement about the GSM and WAP standards. On the other hand, market uncertainty favours more integrated organizational forms, because the difficulty in foreseeing all relevant contingencies originates high transaction costs. The merger between AOL and Time Warner illustrates this case. Obviously, the existence of economies of scale is another factor which favours integration.

[21] Originally, an Internet portal that allowed the exchange of music among its users.
[22] Which started off as an Internet search engine.

6. Conclusions

For the analysis of firms behaviour we have examined the process of technological convergence that is taking place in the Information and Communication Technologies (ICT) sectors. This process implies that some markets will disappear to give rise to new ones. We have taken in consideration in some details the technological and economic factors that play a role in the process. In the first place, we make a revision of the different alternatives coming from different sectors —at least until the convergence was possible— that are grappling for getting the market. At the moment, neither of the transmission media nor terminal is completely capable of displaying all kind of data in a "convenient" way, and that means to commit large sums of money to enhance infrastructures. In such a situation, predictions about the likely size of the market and its momentum becomes crucial in order to evaluate the potential gains or losses of the project, but when the product is so novel it is difficult to judge consumer's reaction to it.

Developing a competitive advantage implies to anticipate an unarticulated market, select core capabilities and bet on a particular technology. In a context where it is difficult to asses whether there will be a "winner" technology or all of them will become perfect substitutes it is difficult to predict whether contents or delivery will prove more decisive. The examples we have surveyed suggest that firms diversify their portfolio assets defensively and integrate backwards to avoid the foreclosure of some content.

Much of the thrust of this paper has been concerned with suggesting how these technological and market uncertainties is shaping firms' strategies. One of our main conclusions is that a key element in the firms' strategies is to be the window through which the consumers access the market. We have briefly discussed the process of mergers and alliances that is taking place. An interesting question that deserves further research is the establishment of a taxonomy of the different organizational forms that have appeared, together with an evaluation of the transaction costs involved in each case.

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