Telecommunications : understanding the dynamics of the organization of the industry

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This paper focuses on the evolution of the telecommunications industry. Within the economic literature, different analytical assumptions are proposed, from a global sustainability of competition to the re-emergence of a stable oligopoly generated by a process of shakeout through mergers and acquisitions. In a nutshell, then, the understanding of the dynamics of the organization of the industry is still an open question with a multiplicity of answers. The main purpose of this paper is to clarify this timely debate, and to sustain that the organization of the industry is progressively evolving towards an oligopoly structure. The specificities of the argument developed in this paper are the following. Firstly, the paper confronts different analytical frameworks, namely mainstream and evolutionary-based, on key questions such as the successful entry and long term sustainability of new telecommunications carriers, as well as new actors such as Internet-related companies. Secondly, the paper analyses the industry as a broad system called 'info-communications' and composed of 'vertically-related' subsystems such as equipment suppliers, telecommunications carriers, Internet access and service providers, broadcasting and middleware groups. Thirdly, the paper analyzes past and current restructurings observed within this industry over the last twenty years, in order to infer reliable conclusions on the future evolution of this industry. Fourthly, the paper advocates that the evolution of the organization of the industry is highly connected to the characteristics of the innovative process and to the conditions of its implementation.

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Key words:
Innovation, competition, shakeout, telecommunications and Internet, info-communications.

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1. Introduction

The historically-based analysis of the telecommunications industry is not in coherence with the general teachings of industry life cycle models in which market structures are intrinsically connected to the stages of evolution of a new product (Fransman, 1998). Within the life cycle framework, a stable oligopoly is supposed to characterize the market structure in the maturity stage as soon as a standard or a dominant design emerges, implying that product innovations are progressively replaced by process innovations (Klepper, 1997). The telecommunications industry, which could have been considered as an industry reaching its phase of maturity and consequently as a specific domain of application of life cycle models, is now faced with new entries, and more generally with a critical process of restructuring driven by a redefinition and an increasing diversification of the uses and products. As a matter of fact, the recent history of the telecommunications industry thus sheds a new light on how processes of innovation and processes of competition are articulated over time.

Different analytical assumptions can be elaborated on this puzzling situation which profoundly questions the theory of industry life cycles. The first (extreme) assumption is a global refutation based on the evidence collected from this industry of the statistical life cycle models. The second one is a major technological discontinuity occurring within the telecommunications life cycle, and related to the emergence of a new technological trajectory driven by the Internet. The third one refers to a transitory turbulence in the organization of the industry, with a subsequent predominance of a stable oligopoly at the end of a (rather) conventional process of shakeout. The purpose of this article is to give content to this third assumption, and to analyze the nature and determinants of shakeout in this context.

We present in a first step the concrete features of the telecommunications industry, as well as major analytical characterizations available in the economic literature of both firms' strategies and organization of the industry. From this selective rather than exhaustive survey, we emphasize the divergent conclusions that can be derived from mainstream and evolutionary approaches on the key question of the evolution of the telecommunications industry (section 2). To proceed the argument further, and to analyze whether the industry evolves towards a competitive or an oligopoly structure, we stress that the industry has to be conceived as a broad system composed of 'vertically-related' subsystems such as equipment suppliers, telecommunications carriers, Internet access and service providers, broadcasting and

middleware groups. This new definition of the industry is useful to analyze the transition from the old telecommunications industry to the new info-communications industry in which activities such as the Internet, computing, software, middleware and broadcasting activities are crucial. Clearly, what occurs within a subsystem is highly dependent on what happens among other (upstream or downstream) subsystems. But, more importantly, this new definition clarifies the challenges related to innovation which is a recurrent phenomenon in this industry. In our perspective, the organization of the industry must be considered as a means of making viable innovation processes, essentially by providing appropriate incentives and adaptability conditions. Firstly, the organization of the industry has to favor the entry of new firms into the different subsystems on behalf of an expected consistency of investments implemented by each firm. Secondly, some competitive adjustments mechanisms have to appear over time in order to reduce the impact of unexpected disequilibria, e.g. disequilibria which occur despite the desired consistency of investments (section 3). We build on this basis an analysis of the current evolution of the info-communications at the age of high speed Internet and 3G mobile phones. We conclude that the latest evolutions observed within the info-communications industry seem to validate the assumption of shakeout – obtained either through a massive process of mergers and acquisitions or by the exit of some firms – is likely to prevail and leads to the emergence of a new oligopoly structure (section 4).

2. Characteristics of the telecommunications industry: facts and theories

An increasing number of publications is dedicated to the characterization of major technological and institutional changes that occurred within the telecommunications industry (Fransman, 2000, 1998; Laffont and Tirole, 2000; Armstrong, 1998; Katz, 1996; Tannenbaum, 1996; Armstrong, Cowan and Vickers, 1994; Baumol and Sidak, 1994; Ungerer, 1988; Temin, 1987; Brock, 1986[1]). Some of these contributions provide an in-depth analysis of the implications on the industry structure over the 1980's and 1990's, using different analytical frameworks – namely mainstream or evolutionary. Nevertheless, the conclusions derived from these analytical frameworks regarding the evolution of the industry are divergent, and this involves further investigations.

2.1. From monopoly to competition

Until the 1980's, the industry of telecommunications is characterized by the following elements. The industry is composed of telecommunications carriers which are monopolies (generally, state-owned monopolies), and have a full control over the infrastructures and services in their respective countries. The technologies are based on circuit-switched systems – which means that a leased line is pre-allocated by the telecommunications carrier to the end-users for all the duration of the connection – and provides a well-defined and closed set of applications, namely the transmission of voice calls (local, long distance and international) and the fax[2]. These monopolies can either be vertically-integrated with their equipment providers (this is the case of ATT in the US), or connected with a group of both competitive and cooperative equipment suppliers (this is the case of NTT with a group of four different equipment suppliers), or intrinsically linked with them through a bilateral monopoly structure (this is the case of Deutsche Telekom with Siemens, and France Telecom with Alcatel)[3]. The industry is considered as globally efficient in the sense that cost decreases were echoed on the final market by decreases in prices[4]. The industry is highly innovative, mainly on the specific domain of telecommunications networks, and these innovations are the product of an intensive technological competition between research laboratories, directly linked with telecommunications operators[5]. The industry is highly involved in cooperative research projects at the international level[6].

In the recent years, and mainly over the 1990's, the telecommunications industry has incurred many changes, and can thus be characterized by the following elements. The incumbent monopoly firms are privatized, and markets are deregulated in the US or legally liberalized in Europe by a series of EC directives. At that time, the telecommunications industry cannot be reduced to telecommunications carriers and equipment suppliers anymore. Telecommunications has now more intimate connections with connected activities such as computing, software, semiconductors, the Internet and e-commerce, and the media. Consequently, firms which undertake these activities are now closely involved in the evolution of the telecommunications industry. A massive process of entry occurs then with widely different firms arriving in the industry: from small new start-ups to subsidiaries of large incumbent firms previously installed in other industries or countries. Most of them successfully enter the market with no specific competence in telecommunications. In fact, they elaborate some joint-ventures agreements with incumbent telecommunications operators, develop capabilities linked to marketing and retailing activities that progressively become

strategic in the telecommunications industry, or even acquire over time telecommunications firms through stock-for-stock transactions.

On the technology side, the industry is faced with recurrent and major technological innovations, the most drastic one being the packet-switched technology which implies that messages, decomposed in packets, are sent all over the Internet network and further reassembled at termination. The development of high capacity and intelligent networks has involved a multiplication as well as a qualitative diversity of applications (either effective, such as toll-free numbers, name or number identification, voice messaging, routing of calls, data transfer, home banking, video on demand, videoconferencing, online services; or in development, such as telephony over the Internet, m-commerce)[7]. The increasing number of networks supporting these technological innovations are then induced to develop a global inter-compatibility to connect end-users: public switched telecommunications networks for local, long distance and international calls operated by incumbent firms require to be interconnected with new entrants' networks, namely mobile networks, cable TV networks, digital technologies for local area network and wide area network – LAN and WAN – and more generally IP technologies for the Internet. Moreover, entrants build and extend their networks progressively and are generally obliged – at least for a certain period of time – to lease the existing networks operated by incumbents. The specificity here is that the equipment suppliers are the main technology providers. Incumbent telecommunications carriers massively disengage from R&D activities to focus on the operation and management of the network and on the provision of associated services.

On the market side, the industry has to deal with an explosion of new uses that refer to an increasing diversification and differentiation of demand (real or potential) for products and services in the global domain of information and communication. One can cite, for instance, the development of the multimedia which implies the management and end-to-end transfer of an open set of communications applications such as voice, texts, graphs, sounds, fixed images or videos; the emergence of communications between groups of users based on new patterns of infrastructures and services; the need for end-users friendliness, reliability and safety relying on high performance networks; the choice for mobility of the equipment premise, of the end-user, of the services, of the different elements within the network. The specificity here is that these new market opportunities are not captured initially by existing firms but by new entrants. New firms are then able to analyze customers' attempts in terms of technologies and

associated services generally better than what incumbents use to do. Finally, significant decreases in price are registered in most countries.

2.2. Structure and evolution of the industry

What are then the implications of these new specificities on the strategies of firms and further on the whole organization of the industry? Within the economic literature, two main different interpretations are available. The first one focuses on the structure of the industry, especially on its impact on prices and further on the whole efficiency of a network industry. The second one aims at characterizing the main driving forces of the evolution of the industry.

2.2.1. Structure of the industry and pricing issues

Mainstream industrial organization focuses on the pricing rules required in a context of transition from a monopoly structure to a competitive structure, and especially in network industries. Laffont and Tirole (2000), for instance, analyze the different pricing regimes imposed by regulators mainly in the US telecommunications industry. The authors examine in turn the respective characteristics of a *performance-based pricing system* in which the regulator makes the incumbent telecommunications carriers accountable for a higher fraction of their costs, a more *business-oriented pricing structure* in which the regulator fixes an average level price called 'price cap', and the *current flexible pricing regime*[8]. They focus on the new competitive game between incumbents who own or control the facilities-based infrastructure through the development of proprietary networks, and entrants who do not own nor control such a complete network. In this context, three main strategies can be implemented by entrants. Firstly, they can choose to *build their own network*. This duplication of the infrastructure requires a high level of investment, and may imply at the same time important losses in economies of scale and scope[9]. In most cases, however, this strategy which is capital and time-consuming is complemented by other solutions dedicated to connect the entrants' customers through the incumbents' existing infrastructures. The second and third strategies – resale and unbundling – are possible complements in this context. *Resale* implies that the entrant buys the incumbent's services (mainly the local loop services) at a discount rate and resells these services to its own end-users customers. Finally, *unbundling* corresponds to a situation in which the entrant can lease only some elements of the incumbent's infrastructures and services[10]. These different strategies require the implementation of specific pricing rules, namely cost-based pricing (such as *total element long run incremental cost*) or opportunity costs pricing (such as *efficient component pricing*

rule). In any case, however, the main problem is the elaboration of pricing agreements between incumbents and entrants, and this requires an in-depth analysis of the incentives of the different players involved in the competitive game. The specificity here is that, in most cases, the traditional marginal cost pricing does not involve sufficient incentives for firms involved in long term investments or in business segments requiring large joint and common costs. In this context, some price discrimination implemented either at the retail level or at the wholesale level (access pricing) tend to reduce pricing distortions.

The main implication for the organization of the industry is then the multiplication of agreements between incumbents and entrants in order to favor a global interconnection between networks. These agreements can generate in turn a more concentrated organization of the industry if pricing strategies occur in a context of conflicting incentives, implying processes of merger and acquisition between incumbents and entrants. Mergers and acquisitions can be considered as optimal strategies to endogeneize a (negative) externality such as double marginalization, price distorsion, opportunism or asymmetry of information. The increasing involvement of regulation authorities in the specific domain of interconnection shows that the relationship between incumbents and entrants is certainly a conflicting one. Moreover, the fact that mergers and acquisitions are increasingly observed in practice gives evidence that this kind of strategies can solve conflicts of interest between incumbents and entrants, and sometimes bypasses the role of the regulator.

2.2.2. Evolution of the industry and sources of change

More evolutionary-based analyses of the changing nature of the telecommunications industry are also available. Within this framework, the strategies of firms, and further the evolution of the telecommunications industry, cannot be reduced to pricing issues. According to Fransman (1998, 2000), the problem is to define "the main driving forces of the evolution of the industry" (Fransman, 1998, p. 5)[11]. More specifically, instead of considering that the new competition between incumbents and entrants is a basic given fact, the author focuses on the different processes by which new firms successfully entered the industry. Four major drivers are then listed and analyzed by the author (ibid, p. 11-35). The first one refers to *the quasi-vertical specialization between telecommunications carriers and equipment suppliers*. Over the recent years, equipment suppliers significantly increased their expenses in R&D in order to satisfy new emerging demands from new telecommunications carriers. This implied that the traditionally high barriers to entry involved by the need to elaborate a productive capacity

were significantly lowered: new entrants could enter the industry without any R&D expenses. This quantitative change in the strategy of equipment suppliers was also complemented by a significant qualitative change involved by the necessity to acquire new capabilities related to the development of Internet and software equipment dedicated to the new entrants in telecommunications (see Annex 1). Secondly, *the process of competition occurring between incumbents and entrants is a complex phenomenon in which the assets, technologies, networks and services offered and used by each specific actor play a crucial role*. Incumbents already operate an existing infrastructure (circuit-switched / copper cable) and control an existing set of consumers, and their strategy over the recent years mainly concerned the upgrading of their network (by developing, for instance, data compression techniques such as DSL technologies), associated with a more efficient use of this network through price competition. New entrants were then induced to use new technologies (packet-switched / IP or cable technologies) supported by alternative networks (optical fiber or cable TV) and dedicated to provide high quality services[12] (see Annex 2). Thirdly, *high performances on stock markets – and, more generally, privileged relationships with financial institutions - favored the emergence and the competitiveness of new firms within the telecommunications industry*. This, in turn, had a decisive impact over the characteristics and mechanisms of the labor market: new entrants could acquire competences and labor force from stock-for-stock transactions (see Annex 3). Fourthly, *the increasing segmentation of consumer demand and rapid change in the communications services created market niches for new firms*. The strategies of these new firms is not to be confined to specialized market segments. Over time, they tend to offer a larger set of services (see Annex 4).

These four major forces give a specific profile of evolution to the telecommunications industry, characterized by the following elements. Firstly, the telecommunications industry does not necessarily evolve towards an oligopoly structure. Both the existence of a vertical specialization between carriers and equipment suppliers and the increasing diversification of demand imply that entry is profitable, and that a long-term sustainability of latecomers is possible. Exits at the moment are quasi-inexistent and, as such, the end of the story can be different from a traditional shakeout. Secondly, evidence shows that incumbents and original new entrants do not necessarily enjoy a "first movers' competitive advantage", related to the fact that they own or control the essential facilities or enjoy a larger consumer base than latecomers. Especially in the US, latecomers such as Worldcom tended to perform better than established firms, and eventually had the opportunity to acquire original new entrants such as

MCI. Thirdly, product innovation coexists with process innovation. An extended set of radically new products and services is proposed to end-users over the recent years. At the same time, recurrent process innovations are provided to improve the quality, rapidity and reliability of transmission over the network. Fourthly, because markets are in constant evolution, we cannot observe a perfect stabilization in market shares. Fifthly, no dominant design is emerging, rather a competition between different standards is observed.

2.2.3. Summing up

The following table summarizes the main problems and results from both mainstream or evolutionary-based analyses of the telecommunications industry.

	Key questions	Strategies of firms	Implications for the organization of the industry
Mainstream	Definition of (optimal) pricing regimes in a context of the emergence of competition in a network industry	Bilateral level (incumbent and entrant): • Building essential facilities • Resale • Unbundling	Emergence of a globally interconnected network: • Pricing agreements in case of converging incentives • Integration/emergence of oligopoly in case of conflicting incentives
Evolutionary -based	Definition of the drivers of the evolution of the industry: from the 'old' to the 'new' organization of the industry in telecommunications	Multilevel, including: equipment suppliers, telecommunications carriers, Internet access and service providers, broadcasting and middleware groups • Vertical specialization of equipment suppliers • Competition for technologies, networks, services • High performances on stock markets • Increasing diversity of demand	Sustainability of competition: • No shakeout/no oligopoly • Multiplication of products and services • Volatility of market shares • Coexistence of products and process innovations • Shared leadership between incumbents, entrants and latecomers • No dominant design or standardization

Table 1: Synthesis of mainstream and evolutionary-based analysis of the telecommunications industry

These contributions stress the crucial issue of the stability of the current organization of the industry. On the one hand (mainstream), the industry tends to be transformed into a global interconnected network, with a potential domination of an oligopoly composed of firms owning or controlling the essential facilities (i.e. incumbents and original new entrants). On the other hand (evolutionary-based), the evolution of the industry is driven by different forces, and the competitive structure obtained through processes of liberalization and technological

innovation can be sustained over time. In both cases, then, the question does not involve a definite answer. In fact, the assumption that oligopoly will be the dominant structure is not less nor more probable than the reverse assumption of the sustainability of competition.

The divergent conclusions of these contributions are quite natural, especially if we look at the key questions they address respectively. In one case, the problem is the definition of an optimal pricing regime in a context of the emergence of competition in a network industry. In the other case, the key issue is the definition of the drivers of the evolution of the industry, that is the underlying economic forces that transformed the telecommunications industry over the recent years. This involves radically different visions of both the strategies of firms and the organization of the industry, and the opposition between these different visions can generate further teachings about what needs to be investigated.

Firstly, the level of analysis is different. The first approach focuses on bilateral relationships (incumbent and entrant), or trilateral relationships (incumbent, entrant and regulator). The interaction between these different entities is given and, in any case, the question of how a new entrant with no specific competence in telecommunications (being initially a software company, an information service provider, a media group, or an infrastructure owner such as electricity, gas, water, railroad companies) could enter the industry and compete with the incumbents is completely neglected. In the second approach, this question is central and involves the analysis of multilateral relationships. Depending on their technological background, their structure, their date of entry, their competences, their strategies, their specific relationships with upstream and downstream firms, some new entrants did better than their competitors, better than established firms. Moreover, key variables are different. In conventional analyses, variables such as the increasing diversity of demand, or the role of high performances in stock markets, are neglected, or at least taken as 'external' (given) features. In evolutionary-based approaches, these variables are key elements in the analysis of the long-term viability of entrants. Especially, helped by a rapidly rising share price, latecomers could successfully enter the market because they could buy the technology to the equipment suppliers, and develop new commercial practices adapted to the increasing diversification of demand.

This first point shows that the evolution of the telecommunications industry cannot be reduced to the sole interaction between telecommunications carriers, namely incumbents and

entrants. The analytical framework within which this evolution has to be studied has to include other sets of activities. Especially, this framework has to include upstream and downstream firms who play a direct role on the current competition between incumbents and entrants at the network operator level.

Secondly, assumptions on cost and demand functions are different. Conventional approaches generally focus on problems of price competition in a stable environment, e.g. in a context where cost and demand functions are observable by firms, though not perfectly observable by third parties (the regulator). Evolutionary-based analyses sustain however that this price competition appears as a specific facet of a more complex rivalry in which disequilibria prevail. These disequilibria are generated by a constant discovery of new technology and market opportunities which implies that cost and demand functions are subject to radical and persistent change.

From this second point, what needs to be investigated is precisely how these disequilibria are generated and what is their impact not only over time, but also at each moment in time. Clearly, any engagement in an innovative process has an impact over the long term market structure, but also over the current market structure as reflected in variations of prices and wages or in the implementation of specific organizational arrangements and restructurings. The feasibility of an innovation, seen as an endogenous change, depends first on the coordinated engagement of the firm with its suppliers and customers, and second on the competitive adjustment mechanisms implemented either endogenously (by firms within the industry) or exogenously (by regulation and competition authorities) to prevent or reduce the effect of unexpected disequilibria at each stage of development of the innovation.

These two points will structure the analytical framework we propose in the next section.

3. Innovation and competition in the info-communications industry

Apparently, the literature does not provide a clear answer to the question of the stability of the organization of the telecommunications industry. Part of the problem is that the outcome is highly uncertain, and that the attempt to understanding a reality which is evolving every day is necessarily a complex issue. But, on the other hand, we can also advocate that what is

needed to clarify this timely debate is a better characterization of what the telecommunications industry really is, and how innovation proceeds within this industry and affects competition. In what follows, the telecommunications industry now called info-communications will be characterized as a broad system composed of vertically-related subsystems. This definition of the industry allows us to stress that what is occurring within a specific subsystem is highly dependent on what happens within and between other subsystems. Innovation requires the coordinated engagement of different types of firms, generally involved in different subsystems. Despite the desired consistency of investments of the different firms, this ex-ante coordination does not prevent nevertheless the occurrence of disequilibria. This requires the step by step implementation of competitive adjustments from price and wage variation, to restructurings, mergers and acquisitions and exits of firms. We provide an illustration of this argument on the basis of a reinterpretation of the 1980's and 1990's waves of liberalization.

3.1. Definition of the industry in terms of vertically-related subsystems

In the literature, some contributors decompose the telecommunications industry into different layers (Noam, 1983; Kavassalis, Lee, Bailey, 1998). However, what these authors mainly emphasize in the definition of the different layers is their technological characteristics. Here, following Fransman (2000)[13], we will stress that the different layers or subsystems refer more importantly to different domains of economic activities. As such, a subsystem regroups firms undertaking some activities which require the same pool of competence in their implementation. If the activities undertaken by firms do not require similar capabilities, but rather complementary (e.g. vertically-related) ones, different vertically-related subsystems can be defined[14].

We propose a decomposition of the telecommunications industry into the following different subsystems (Fransman, 2000 ; Fransman and Krafft, 2001):

Subsystems	Activities	Firms
S1	Equipment provision	Equipment suppliers
S2	Network operation/management and associated services provision	Telecommunications carriers
S3	Internet connectivity and associated service provision	IAPs and ISPs
S4	Navigation and middleware provision	Browsers, data protection companies
S5	Content provision	Broadcasting and information companies

Table 2: The info-communications industry decomposed into vertically-related subsystems

The 'equipment provision subsystem' (S1) regroups firms (equipment suppliers) specialized in the development of switches, transmission equipment, routers, servers, billing software. Within this subsystem, firms share the same type of competences to undertake a specific activity, namely the conception and development of equipment (essentially network equipment and customer premises). This pool of competence, however, is distinct from the one developed by firms located in subsystems S2, S3, S4, and S5. The 'network operation/management and associated services subsystem' (S2) regroups network operators (telecommunications carriers) involved in the provision of fixed and mobile telephony services. The 'Internet connectivity and associated services subsystem' (S3) regroups firms (Internet access providers and Internet service providers) involved in Internet backbone provision, and Internet services provision (e-mail, web hosting). The 'navigation and middleware subsystem' (S4) regroups firms involved in search engines, browsers, security electronic payment, firewalls and data protection services. The 'content subsystem' (S5) regroups firms involved in web design, online services, information services and broadcasting services.

The link between these different subsystems is obviously a technical one: to operate a network, network and customer promise equipments are needed. In turn, Internet access and services, and further content and security, are provided on the basis of a network infrastructure. Nevertheless and more importantly, these different subsystems are also linked from an economic point of view. Subsystem 1 provides most of the R&D on products and processes, Subsystem 2 essentially products telecommunications services, Subsystem 3 commercializes Internet services, Subsystem 4 provides additional services concerning selection and security of information, and Subsystem 5 provides end-users with a larger set of applications and content. The whole system, decomposed into five subsystems, corresponds to

an 'extended production process' in which activities of conception, production, commercialization and marketing are present[15].

Subsystems	Extended production process
S1	Conception/development
S2	Production/Commercialization
S3	Commercialization/Marketing
S4	Commercialization/Marketing
S5	Commercialization/Marketing

Table 3: The info-communications systems as an extended production process

Because firms constantly develop their competences over time, in order to undertake new activities, this framework should not be considered as a static one. Our main problem is to understand how a given firm can be present in different subsystems, and what is the opportunity for that firm to move from one subsystem to the other. Because economic activities are generally separable, though related, and evolving, firms can enter in some of these activities, and outsource others through market or cooperation agreements in order to evolve and progressively adapt themselves to economic changes. This framework emphasizes then the great heterogeneity of firms and their ability to change over time, but also regularities which may exist in the organization of the industry for some periods of time. Especially, firms in S1 seem constitute a rather independent subsystem: firms from other subsystems do not extend their competences and activities towards the ones undertaken in S1, firms from S1 do not penetrate other subsystems by the extension of their competences towards 'downstream' activities. However, combinations exist between S2, S3, S4 and S5 in the sense that firms which are present in S2 tend to be also present in S3 and, similarly, some firms combine competences and activities related to S4 and S5.

3.2. Coordination, competitive adjustments and incentives: the nature of an innovative choice

The characteristics of the telecommunications industry is to be recurrently faced with major changes due to innovative choices. Innovation has two main specificities (Amendola and Gaffard, 1988). Firstly, the process of innovation is at the same time the development of a new technology and the transformation of the productive structure of the economy. As such, the organization of the industry itself changes together with the technology as the process of innovation goes on. Secondly, the process of innovation is not linear. It is characterized by

permanent feedbacks occurring within the different (vertically-related) subsystems, each of which plays a specific role in the different phases of development of the innovation (from the R&D stage to the marketing stage). In this context, an innovative choice implies the breaking up of the existing industrial structure and a modification of market conditions, followed by a gradual reshaping which reflects changes in cost conditions, in profitability and in relative prices, modifications in consumers' preference system, and all other elements that mark the actual profile of the process of innovation. Innovation thus appears as a process of research and learning which results in the appearance of new productive (technological) options, and further in the modification of the environment itself, namely the organization of the industry, costs prices, wages and major characteristics of demand. Technology is then the result of the process of innovation, and not a pre-condition of it; the process of innovation is a process of 'creation of technology' which, when successfully brought about, makes it possible to obtain increasing returns. Thus defined, innovation is essentially a sequential process which takes (and can change) form, content and direction at each successive step. The problem of technological change does not consists so much in the choice between given alternatives (whether based on complete or incomplete information), rather it is a search for coordinating as well as possible the innovation process. Accordingly the economic aspect of this problem is no longer represented by the 'rationality' of the choice between known alternatives, but by the 'viability' of the process through which a different alternative is brought about. This viability depends on how coordination problems are dealt with step by step, that is, on how the process of competition takes place.

For a process of change to take place investments must be decided and actually undertaken in a coordinated way. After a phase of construction, these investments will result into a new productive capacity to be matched by a corresponding demand for final output during the phase of utilization. As Richardson (1990) puts it, the profitability of any investment project depends on the setting up of a satisfactory amount of both complementary and competitive investments along the way. The volume of competitive investment must not exceed a critical limit set by the demand available, and the volume of complementary investment has to go beyond a minimal threshold for the investment project considered to be feasible. This means that the innovative firm has to control and coordinate the further implementation of complementary investments engaged by clients, suppliers or partners in order to sustain the in-process investments, but also to limit the engagement of competitive investments by rivals. Clearly, at any point in time, the cost and demand functions of the innovative firm and thus

the feasibility of the innovative choice are highly dependent on what other firms do, either within the same subsystem or in upstream and downstream subsystems. A coordination within and between subsystems sustains the innovative process. Of course if firms immediately had a complete information on all existing investment projects no coordination problem would arise, and eventually there would be no imbalance between supply and demand on the market for final output. However "it seems more reasonable to assume that entrepreneurs will generally learn of the investment commitments of others only after a certain period of time which, for convenience, will be called the transmission interval" (ibid. p.51). A specific coordination problem emerges, a problem that becomes effective if we also take into account another delay, the delay of construction, which characterizes the production process. The problem of coordination arises then at the junction of these two lags of time: the delay of construction of productive capacity - which entails sunk costs - and the delay of transmission of information - which implies uncertainty[16].

The coordination problem, however, is a recurrent one. It re-emerges at each step of the sequence of the innovative process and cannot be solved once for all by an appropriate incentive scheme. Even if an ex-ante coordination of the investment decisions were achieved, we cannot neglect that any technological change results in unexpected disequilibria. One reason is that human and financial resources constraints necessary emerge, and this generates distortions in the balance of the production process between construction and utilization phases. Another reason is that production and information delays necessarily generate market imbalances. These distortions and imbalances induce discrepancies between costs and proceeds. According to Alchian, costs depend not only on the current output, but also on the total volume of output, the moment at which the first unit of output is to be completed, and the length of the interval over which the output is made available (Alchian 1959, p. 24). In this perspective, it is no longer possible to separate the phase of construction from the phase of utilization of production processes. For instance, sunk costs which are nothing but adjustment costs interfere along the way with price and output decisions. The problem is how to deal with these distorsions between costs and proceeds, in fact how to prevent them from being cumulative.

These considerations lead to reconsider what incentives really are. In the literature, incentives issues are linked with efficiency and productivity in the following sense. Incentives are basically evaluated with respect to market imperfections: market imperfections can weaken

the incentives to innovate but, on the other hand, incentives schemes may compensate the effects of market imperfections (among them asymmetries of information) and further improve the efficiency of the organization of the industry. However, incentives can be analyzed in a different perspective, especially if we consider the conditions by which innovation processes actually take place. In this perspective, the efficiency level does not pre-exist; rather it is the result of an economic process, i.e. the way in which coordination problems are dealt with *along the way*. Incentives are intrinsically linked to the *time profile* of production costs. This means that for making viable innovation processes and for creating appropriate incentives, a consistency between the nature of technological change (identified by the frequency of innovations, the costs and the duration of construction and utilisation of new productive capacities), and the current organisational arrangements (restructurings, exits, mergers and acquisitions) have to be maintained either by firms or by specific authorities. In this context, the problem is to build an appropriate innovation system, which is a blend of market and organisation elements (Amendola and Gaffard 1992, 1994, Amendola, Gaffard and Musso 2000 a, b, c; Krafft, 2000).

3.3. The impact of the incentive reform: a revised interpretation of liberalization

A focus on the different waves of liberalization in the 1980's and 1990's is useful to illustrate how firms and regulation or competition authorities interacted in the development of new activities on behalf of an expected relative consistency of investments, and also in the implementation of competitive adjustment mechanisms to reduce the impact of unexpected disequilibria. Moreover, this illustration shows that although the first wave of liberalization was mainly elaborated in order to correct market imperfections in a given technological context, the second wave of liberalization produced incentives to develop viable innovation processes sustained by specific organizational arrangements.

The official rationale of liberalization was the introduction of price competition and the achievement of an increased customers surplus in a context which was characterized, in a former analysis, by a relative stability of the structure of the industry, if not of the technology[17]. Liberalization was introduced by different decisions by regulators: the divestiture of ATT, but also the entry of a limited number of original new entrants, such as MCI and Sprint in the United States or Mercury in the UK. The underlying argument of these decisions was that, in the case of contestable markets, a natural structure of the industry would emerge with a double effect: the predominance of a technological efficiency (e.g. the

minimization of the costs of the industry), and the implementation of optimal prices. Within the regulators' vision of the telecommunications industry, the nature of end-users' requirements was to some extent pre-established (exogenous), and liberalization was intended to favor the emergence of a less concentrated industrial structure to sustain technological efficiency. To illustrate that point, we should mention the role of price caps, one of the major tool implemented within this first wave of liberalization. Telecommunications carriers, namely incumbents such as ATT in the US and original new entrants such as MCI and Sprint, were induced to adjust their price below a certain average level determined by the regulator, the individual prices being intended to reflect costs and demand elasticities. This pricing regime was implemented to encourage companies to (1) improve their efficiency by developing profit-making incentives to decrease costs, (2) invest efficiently in new plants and facilities, and (3) develop and deploy innovative service offerings.

Nevertheless and over time, US regulators recognize that if points (1) and (2) were achieved, price caps did not provide firms with sufficient incentives to achieve point (3). Recent decisions by the FCC were intended to significantly change the former orientation towards price caps: "The Commission found that (…) the rate structure imposed a costly, time-consuming, and unnecessary burden on incumbent LECs and significantly impeded the introduction of new services". Moreover, "As the market becomes more competitive, such constraints can be counter-productive. We recognize that the variety of access services available on a competitive basis has increased significantly since the adoption of our price cap rules. Therefore, in response to changing market conditions, we grant price cap LECs immediate flexibility to deaverage services in the trunking basket and to introduce new services on a streamline basis"[18].

The second wave of liberalization was more closely oriented towards that aim. Regulators sustained a new organization of the industry in which new entrants were given incentives to implement viable innovative processes.

For these new entrants such as Worldcom, a competitive advantage could not be obtained by replicating the competitive model of established firms (incumbents and original new entrants from the first wave of liberalization), based on technological efficiency under pricing constraints. New entrants were then induced to create their own competitive model to enter the market and further ensure a long term leadership. Their strategy was the exploration of

new market opportunities, especially by considering that customers' demand was not standardized but rather diversified and evolving. Specific 'downstream' complementary investments concerning new marketing practices appeared within the telecommunications industry, such as billing systems, management data systems, calling centers, etc. The sunk costs related to these investments were supported by new entrants but also by firms specialized in the Internet, computing and middleware (Subsystem 3 and 4). The development of these new activities required the implementation of mergers and acquisitions to ensure the consistency of investments. Eventually, these mergers and acquisitions were authorized by competition authorities when they were intended to consolidate complementary investments (see for instance Worldcom-UUNet, Worldcom-MCI[19]). Nevertheless, on some occasions, mergers and acquisitions were prohibited (see Worldcom-Sprint): although Worldcom's attempt was to consolidate its end-to-end connectivity network, this acquisition would bring dramatic disequilibria in the mobile market, Sprint's second core activity.

New entrants' strategy was also the utilization of new technologies such as IP or cable modems, namely alternative technologies to those that established firms used to employ, and this required the engagement of adequate 'upstream' complementary investments. Especially, new equipment suppliers (Subsystem 1) specialized in IP or cable modems technologies, coming from the computer industry, entered the telecommunications industry and supported the R&D sunk costs (Cisco, Ascend, BayNetworks[20]). In this case, vertical specialization between Subsystem 1 and 2 seems to provide an adapted organizational arrangement sustaining processes of innovation and competition. However, we should note that this vertical specialization, in which equipment suppliers and telecommunications carriers remain legally independent, is sustained by competitive adjustment mechanisms implemented by firms. Clearly, the fact that equipment suppliers send their labor force to operate and manage the networks within the telecommunications carriers structures (see for instance Cisco-Worldcom), or plan some financial contributions in the case of UMTS licenses (see for instance Alcatel, Ericsson and Nokia's recent declarations) is not neutral to the viability of the innovation process, and further to the competitiveness of the current organization of the industry.

In conclusion, what appears then is that the main effect of deregulation was not so much the adaptation of the industrial structure to the new characteristics of the technology than the creation of new market opportunities which were corresponding to the evolving end-users

needs for telecommunications networks and services. From an analytical point of view, an essential dimension of liberalization was the exhibition, or even the creation of a market information (on demand and on market behaviors of the different actors involved in the telecommunications industry) in order to ensure a suitable coordination of complementary and competitive investment and, further, the implementation of these investments to provide firms with the adequate incentives to innovate. Liberalization allowed the entry of new firms which had a profound impact on the evolution of the telecommunications industry, now highly dependent on activities such as Internet, computing, software, and broadcasting. Overtime, competitive adjustment phenomena will proceed in the form of mergers and acquisitions, restructurings, and even exits of some firms. In the next section, we study how these phenomena operate in the domain of high speed Internet and 3G mobile phones.

4. Stability in the organization of the info-communications industry

The different waves of liberalization, combined with the recurrent trends of technological innovation, have produced a new organization of the industry in which a large number of new entrants were registered, as well as the development of new activities such as the Internet, computing, software, middleware and broadcasting. This new organization of the industry, now called info-communications, was represented in a framework composed of different vertically-related subsystems. In this section, we analyze the stability of this new organization of the industry with respect to subsequent competitive adjustments. In other words, we investigate what kind of disequilibria may appear over time, and especially what type of solution will be implemented to limit the impact of these in-process disequilibria. We focus especially on two cases. The first one is the domain of the end-to-end connectivity, in which the emergence of the high speed Internet involves a transition from narrowband access and service provision to broadband set of activities, and further causes the predominance of some firms and eventually the exit of others. The second one is the domain of the 3G mobiles in which the UMTS auction system may generate turbulence in the organization of the industry[21].

4.1. The economics of the Internet

4.1.1. Origins and evolution

In the 1980's, the Internet was primarily used to connect universities and research groups[22]. Within this period, 'packet switched' technologies, together with the generalization of URL addresses and Hypertext links, led to concrete applications, especially the real-time transfer of documents and e-mails between dispersed groups of scientific users. At this stage, however, Internet applications were not yet market-driven. Even if private telcos provided Internet backbone, the global operation and management of the Internet was undertaken by a public Internet service provider. In the US, with the administrative and technical assistance of ANS (a joint venture of IBM and MCI), the National Science Foundation created NSFNet, a network connecting research groups at a local, regional and national level.

In the 1990's, the development of the World Wide Web allowed a multiplicity of new services such as data transmission, e-commerce and the development of web sites which are now profitable commercial opportunities. With the viability of the Internet having been established, and with the traffic increasing, the NSF decided in 1995 to leave the management and operation of the Internet to private firms. This was the opportunity for telcos, already present in the 1980's as Internet backbone providers, to expand their markets through the extension and upgrading of their network and to provide a large spectrum of Internet services. This also favored the entry of a large number of new firms which are often referred as Internet Access Providers (IAP) and Internet Service Providers (ISP). The IAPs carry the Internet packets as facilities-based companies; the ISPs are facilities-less companies which offer value-added services to customers.

For the 2000's, the use of the Internet is now widespread, with constant technological innovations (e.g. high capacity and intelligent networks) and open-ended applications more and more related to content and middleware activities (e.g. videoconferencing, e-commerce, IP telephony, web design, broadcasting services). For IAPs and ISPs, new challenges appear to sustain their long term viability.

4.1.2. Innovation and coordination

Initially, the entry of new firms in Subsystem 3 was possible because they simply had to lease the infrastructure of a network operator (Subsystem 2), or develop on it some POPs to connect their customers end-to-end. But soon, these firms increasingly extand their activities, and

penetrate other subsystems. For instance, large facilities-based IAPs are more and more affiliated to telecommunications carriers (Subsystem 2) looking for a diversification into a value-added activity to recover the sunk costs involved by the development of their backbone network. Large ISPs are also increasingly linked with firms operating in middleware and content activities (Subsystem 4 and 5). Nevertheless, smaller IAPs/ISPs remain exclusively specialized in Subsystem 3. Different strategies can thus be defined, supporting different scenarios at the age of the high speed Internet.

The first scenario is integration between Subsystem 2 and Subsystem 3. This first scenario is well documented in both academic papers (Srinagesh, 1997; Gong and Srinagesh, 1996, 1997; Kavassalis et alii., 1998) and practice (acquisition by Worldcom of UUNet, MCI, and eventually Sprint before being thwarted by the US regulator). This scenario essentially expresses a global integration/consolidation process from telecommunications carriers to IAPs/ISPs, i.e. big telcos extend their competitive advantage on Internet activities[23]. These telcos develop and upgrade their networks to meet the demand for high speed Internet and associated applications, and appear then as major Internet backbone providers. By the integration of ISPs, telcos can accumulate a larger consumer base in order to provide new high speed Internet services at reasonable price.

The second scenario is integration between Subsystem 3, Subsystem 4 and Subsystem 5. This scenario is an integration/consolidation from IAPs/ISPs to the related content and middleware activities (a typical example is AOL's acquisition of Time Warner and the browser Netscape). This means that big IAPs/ISPs progressively extend their competitive leadership on related activities such as software, middleware, broadcasting. By the integration of firms located in Subsystem 4 and 5, big IAPs/ISPs accept to bear high sunk costs in the perspective of high marginal revenues from the determinant role they will have the opportunity to play in the new uses of high speed Internet.

The third scenario is an exclusive specialization in Subsystem 3. This third scenario is a specialization of firms as IAPs/ISPs (Kavassalis et alii., 1998). In fact, despite the consolidation and integration moves previously described, there still are a large numbers of small IAPs/ISPs who specialize in end-to-end connectivity and associated services. Nevertheless, there is a good deal of debate regarding their long term viability.

4.1.3. The process of competition in the Internet

The future economics of the Internet apparently will be driven by two consolidated blocs which are, on the one hand, the global integration between Subsystems 2 and 3 and, on the other hand, the consolidation between Subsystem 4 and 5. Presumably, small ISPs exclusively specialized in Subsystem 3 will not play a dominant role. Clearly, the viability of these small-narrowband Internet companies is highly questioned at the age of high speed Internet. Part of the problem is that Internet access and many Internet services (such as e-mails and web hosting) is becoming a commodity business driven by economies of scale and scope, mainly captured by Subsystem 2 companies. Another problem is that free Internet is robbing ISPs of much of their revenues, making it increasingly difficult to differentiate themselves. While content may be a key differentiator, the cost of differentiated high demand content corresponding to the high speed Internet premises is prohibitively high for many small ISPs. The end-result, very likely is significant shakeout through exit, merger and acquisition, and falling new entry. These IAPs/ISPs have played a key role in the development of the Internet, especially in its commercial uses, as well as in pushing the trend towards free Internet charges. As such, they highly contributed to the radical innovation of the Internet. Nevertheless, for those who did not anticipate the new challenges of high speed Internet, and further did not coordinate complementary and competitive investments, important disequilibria are expected, and this may lead to non-viability.

4.2. The economics of 3G mobiles

4.2.1. Origins and evolution

In the 1980's, mobile telecommunications were essentially used by a limited number of end-users, on a very restricted market area. 1G mobile phones were based on analogue systems which provided low quality transmission services at a very high price. Different standards were offered, depending on the different regions or countries in which mobile telecommunications were developed: NMT and TACS in Europe, NTT system in Japan, AMPS in the US. At that time, only few firms were competing.

In the 1990's, the traffic suddenly explodes and this explosion corresponds to significant cost reduction as well as improved security and voice quality made available by the development of digital 2G mobile systems. Two different types of 2G systems emerged, and each of them generated a set of competing standards. The first system, the cellular mobile system, gave birth to different standards: GSM in Europe, PDC in Japan, and ANSI-136 or ANSI-95 in the

US. The second system, the personal communications system, generated DECT in Europe, PHS in Japan, as well as seven different standards in the US. Many new firms were now competing, and the role of Nordic equipment suppliers such as Nokia and Ericsson was boosting the industry.

In the 2000's, a new step is achieved by the development of 3G mobile systems. This new system provides a higher data speed for Internet and multimedia applications. Moreover, this system is intended to favor a world compatibility which was inexistent before, on the basis of a unique standard, the IMT-2000 or UMTS. Different issues are driving the future evolution of mobile telecommunications. First, firms already present in 2G have to decide how to organize the transition towards 3G. Second, because 3G combines highly evolving technologies, the Internet and the mobile, each of them providing an open set of applications, the end-result of this combination is highly uncertain. Clearly, the viability of 3G requires a coordination between firms involved in Subsystem 2, 3, 4 and 5. Finally, while 1G and 2G licenses were allocated according to a beauty contest procedure, many countries – not all – decided that the allocation procedure for 3G would be based on a license auction system. Very high sunk costs are thus involved, and this may produce unpredictable effects on the viability of firms, as well as a large heterogeneity between them.

4.2.2. Innovation and coordination

3G mobile operators are thus concerned with an innovative choice which depends on at least two requirements:

1) to engage the (sunk) costs of the investment in a UMTS license. This primarily requires financial plans such as bank loans, or stock market capitalization. Some equipment suppliers such as Ericsson, Nokia and Alcatel (Subsystem 1) have already announced that the price of the license will be too high for mobile operators and that they certainly will have to elaborate some arrangements with them, and eventually finance in part the investment.

2) to deal with these sunk costs. This means that:

a. mobile operators have to develop 3G mobiles from a technical point of view (especially the transition 2G-3G), and this involves the active participation of the equipment suppliers (Subsystem 1), especially for R&D expenses.

b. mobile operators have to create market opportunities for 3G mobiles, and this involves directly Internet access and service providers (Subsystem 3) and content and middleware groups (Subsystem 4), especially for the provision of an extended set of applications and services at a reasonable price.
c. mobile operators have to face the competition from direct competitors, especially lower costs competitors coming from countries in which a beauty contest was preferred for the allocation of licenses.

In fact the problem of mobile operators is to control the level of complementary and competitive investments, and to elaborate a coordination between these different investments. Points 1), 2)a and 2)b refer to the coordination of complementary investments: mobile operators enter the new 3G domain if a relative consistency of action between suppliers, clients and partners is achieved. This consistency can be obtained by the continuation of specific relationships with equipment suppliers, and also by the development of portals in collaboration with firms in Subsystem 3, 4 and 5 (see for instance 'i-mode' in Japan, or 'vizzavi' in Europe). Here also, different scenarios can be proposed (see Kano, 2000): from vertical integration into Subsystem 2, 3, 4 and 5, to an exclusive specialization in Subsystem 2 complemented by a geographical expansion. Point 2)c essentially refer to the potential limits that mobile operators can impose on competitors. This latter issue which deals with the process of competition in 3G mobiles is not obvious however and requires a deeper investigation.

4.2.3. The process of competition in 3G mobiles

We would like to tackle this question by analyzing some of the key points that are much debated right now.

The first point is the impact of auctions on the price consumers will have to pay for 3G services. For some economists (see for instance Klemperer, 2000; Cave and Valetti, 2000), the sunk costs involved by the auction system is just 'water under the bridge'. This means that the final price to the consumer will never reflect the sunk costs involved by the price of the license. Namely, a rational firm only takes account of its own forward looking costs and revenues and the likely behavior of firms and, in this context, the license fee which is a sunk cost for all firms does not affect price. Clearly, this statement is in contradiction with the

different declarations of top executives of major mobile operators. More importantly, this statement can only be sustained on the basis of specific assumptions. Firstly, all firms in the world are supposed to support similar license fee. This is untrue: the level of licenses were generally high, but not similar among countries; moreover, a number of countries decided not to implement an auction system and preferred a beauty contest. As a consequence, competition will eventually proceed among firms with widely different characteristics and this fact may question this first assumption. Secondly, firms in a rational setting are supposed to constantly behave as if productive choices did not affect market choices not only over time but also at each moment in time. This second assumption is contested by authors such as Richardson and Alchian we mentioned earlier. As a consequence, different firms will presumably bear different sunk costs, and this will constantly interfere along the way with price and output decisions. To us, the major problem for these firms will be to deal with the gap between costs and proceeds, and to prevent these gaps from being cumulative.

The second point is the impact of the auction system on the rolling out of 3G mobile phones. On the one hand, operators have shelled out for licensing billions of euros, which have the status of sunk costs. These costs can only be carried if 3G services quickly start contributing a significant amount of revenues. This means new equipments will have to be delivered as soon as possible. Nokia and Ericsson, which are the main suppliers of the 2G, clearly have difficulties for meeting demand. Nevertheless, equipment suppliers that lost out the GSM (the 2G challenge), such as Lucent, Nortel, Siemens or Alcatel, have already acquired the required competencies in the field of new network infrastructures[24]. In other words, complementary investments have been or should be realized on time, at the appropriate level. Moreover, these investments could sustain and make viable the more recent innovation process. Competitive adjustments could appear in the form of fluctuations in market shares of equipment suppliers[25], the former 2G leaders being dismissed by new 3G challengers. Apparently, competition in the different subsystems could favour a higher innovation frequency, which appears as a crucial element of the viability of the process. Summing up, because operators cannot afford to delay the recovery of licenses' huge costs, 3G systems could be developed quickly and, presumably at a competitive price[26]. On the other hand, however, it is also possible that, given the change in costs conditions implied over time by expensive licenses, operators could charge higher prices, with the consequence of slowing down the growth of final demand (and its diversification). In this perspective, once again, the complex interaction between low price operators from the beauty contest and high price operator from the

spectrum auction may produce very uncertain results, and potentially competitive adjustments in the organization of the industry.

5. Concluding remarks

The purpose of this paper was to understand the dynamics of the organization of the telecommunications industry. Apparently this dynamics cannot be captured on the basis of a pure application of existing industry models (either mainstream or life-cycle), in a deterministic manner. Rather, what is needed is an in-depth analysis of the strategic choices implemented by firms, especially their innovative choices. In this perspective, we showed that innovative choices by firms within the info-communications industry structured step by step the organization of the industry, here decomposed into different vertically-related subsystems. Even if entry was favored initially, innovations such as the high speed Internet or 3G mobile phones may now proceed within a new structure of the industry characterized by a process of shakeout. Especially, shakeout is likely to appear in two complementary forms. Firstly, shakeout may occur in the form of mergers and acquisitions which are necessary to ensure the consistency of different types of investments among firms, namely the complementary and the competitive investments. Secondly, shakeout may be obtained by exits of firms when unexpected disequilibria emerge despite the relative consistency of investments. The characteristics of innovation, and the conditions of its implementation – both in terms of incentives and adaptability – are thus crucial to the analysis of the evolution of the industry.

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Notes :

[1] We should also mention numerous bulletins and reports published by regulators, especially FCC in the US, OFTEL in the UK and ART in France.

[2] These applications are generally termed as 'POTS', for Plain Old Telecommunications Services.

[3] The observed differences between a pure vertical integration and vertical restraints (i.e. bilateral monopolies) are not significant because, within this specific organization of the industry, equipment suppliers only had one customer (the monopoly carrier). However, the 1995 divestiture of ATT – that led to the upstream creation of a new equipment supplier Lucent Technologies – occurred in a period of a new competition between operators. More generally, as shown by Fransman (1998), the specific relationships between operators and equipment suppliers play a determinant role on the process of competition within the telecommunications industry.

[4] Voices, however, started to advocate that telecommunications carriers were not always endowed with the adequate incentives to minimize costs and, more importantly, that large disparities in final prices remained from one country to the other. In Europe, a gap of up to 100% (sometimes more) in prices was observed for similar connections. In 1986, for instance, the price for a standard communication (3 minutes) towards any EC country was : 1,62 Ecus for Germany ; 1,65 Ecus for UK ; 2,05 Ecus for France ; 2,92 Ecus for Italy ; 3,15 Ecus for Spain ; and 3,47 Ecus for Irland (Cf. Eurodata Foundation Voicebook, 1986 ; reprinted in Ungerer, 1988). In most countries, telcos were induced by regulation to implement a tariff rebalancing, implying that subscription charges were set higher (low subscription charges were insufficient to cover the costs of the local fixed-line network), while domestic long distance and international tariffs were decreased in reference to underlying costs.

[5] These laboratories and research centres developed the main technologies that carriers used to connect people and to ensure the exchanges of information through different applications (telephony, fax and 0800 services): RTC, RNIS. More recently DSL technologies were developed to ensure a broadband traffic for voice, data and video through the existing infrastructures of telecommunications operators. Nevertheless, the IP technologies directly linked with the development of Internet networks were generally neglected by these research centres, or not considered as a priority by incumbent (ex-monopolies) telecommunications operators.

[6] See, for instance, EC Programs such as ESPRIT for research and development in the domain of the information technologies, RACE for large band integrated communications in Europe, and STAR for the development of high tech services and network in low performing regions in Europe, but also EVE, INSIS and CADDIA.

[7] Pretty Amazing New Services, or PANS.

[8] These systems are part of the « incentive or performance-based reform ».

[9] This element justified for a long time the predominance of a natural monopoly for the telecommunications industry.

[10] In this case, and in most countries, regulators impose to the incumbents a list of the unbundled elements to be leased by the entrants : local loops, switching, interoffice transmission facilities, databases and signaling systems, operator services and directory assistance (see Laffont and Tirole, ibid, p. 24). Regulators protect entrants from specific incumbents' behaviors, such as 'ties', 'bundling' or 'requirements contracting'.

[11] The author refers directly to the 'prime movers', 'fundamental impulses' or 'engines' formerly emphasized by Schumpeter (1966). According to Fransman « It is not claimed, however, that this approach offers a panacea. Apart from the additional complexity that it adds, it raises the difficult problem of how the industry's dynamics or driving forces are to be identified. At present, the author's only answer to this problem is that a good deal of knowledge of the industry is necessary. But this, clearly, is inadequate in view of the interpretative ambiguity that is likely to arise, even among those knowledgeable about the industry, regarding what *the* driving forces of the industry are ». (Fransman, 1998, p. 5, author's emphasis). The analysis developed by this author is not reduced to evolutionary frameworks : it deals also with post-marshallian notions developed by Penrose or Richardson. This is why his analysis is termed here as « evolutionary-based », rather that purely « evolutionary ».

[12] As a matter of fact, the new competition between incumbents and entrants implies that the strategies are now moving "away from equipment-oriented R&D towards the achievement of other objectives such as service differentiation (that may depend on software development), speed of response to market opportunities, reliability of services, etc." (Fransman, 1998, p. 17).

[13] See also www.Telecomvisions.com.

[14] The notions of 'activities' and 'competences' which are used here refer directly to Richardson (1972).

[15] The notion of 'process of production' also refer to Richardson (1972).

[16] Both lags must be taken into account in the analysis, because cancelling one of them also cancels the co-ordination problem (Krafft and Ravix, 2000).

[17] The stability of the industry is here to be taken in a Marshallian sense, that is in reference to the satisfaction of consumers needs.

[18] FCC 5th report and Order and further notice of proposed rule making (1999), pp. 11-12. This point is also emphasized in Telecommunications Act (1996) (L 104-104), and Access Reform 1st Report and Order (1997) (12 FCC Rcd at 15985, 16094).

[19] Note that this acquisition involved important divestitures especially of Internet activities by MCI.

[20] Most of these firms – especially Ascend and BayNetworks – were later acquired by traditional equipment suppliers – resp. Lucent and Nortel.

[21] We should note that these two domains are closely linked, because both of them relate to the new competition between fixed and mobile telecommunications carriers at the age of the Internet.

[22] See Abbate (1999) and Antonelli (2000) for further details on the development and generalization of the Internet.

[23] The reverse scenario – integration from Subsystem 3 towards Subsystem 2 – is less documented, but cannot be neglected if we consider market capitalization of Internet-related companies.

[24] e.g. Alcatel has acquired Newbridge and Assured Access, which have developed skills in transmission of data (Internet Protocol) and concluded an alliance with Fujitsu specialized in radio transmission.

[25] e.g. Nortel has contracted with British operators, Cellnet and British Telecom, and with the Spanish Airtel

[26] Paradoxically, the choice of the beauty contest to the detriment of auction bidding in France, while it should result in lower fees for the licenses, could be a threat for the viability of the innovation process, because it delays the adoption of the new technology.