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Conference Paper

Creative and adaptive responses in technological change

23rd European Regional Conference of the International Telecommunications Society (ITS), Vienna, Austria, 1st-4th July, 2012

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Cecere, Grazia (2012) : Creative and adaptive responses in technological change, 23rd European Regional Conference of the International Telecommunications Society (ITS), Vienna, Austria, 1st-4th July, 2012, International Telecommunications Society (ITS), Calgary

This Version is available at:

<http://hdl.handle.net/10419/60396>

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Creative and adaptive responses in technological change

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Abstract

Drawing on Schumpeterian concept of creative and adaptive responses literature the article analyses how different firms' behaviour can influence structural and knowledge change at both firm and industry levels. We use this theoretical framework to analyse a qualitative case study analysing the transformation occurred in the telecommunication industry on the bounce of Voice over Internet Protocol (VoIP) in the consumer voice market segment. Both new entrants and incumbents have used and developed the technology but they have had different responses to the development of VoIP. The analysis of the case study shows that transformation in the industry structure takes place only once firms intentionally react creatively to change by exploiting all innovation features while adaptive responses reduce the pace of changes.

Key word: creative and adaptive responses, technological change, VoIP

JEL: L26, O32, O33

1. Introduction

When new innovation emerges, there are different possibilities of development and these have diverse impact in the definition of the industry structure. There is a co-evolution of technology development, firm behaviour (Nelson, 1994) and users' needs which can affect the industry structure and its boundaries generating a complex web of interactions (Antonelli, 2003). Once adoption takes place, the development of the technology does not end (Gelijns and Rosenberg, 1994), it continues thank to the extensive use and the adaptation of the firms activities. Technological change has been largely studied in industrial dynamics literature; there are three main levels of analysis: (a) the structural dimension of industrial dynamics, (b) the industry life cycle and (c) the understanding of industrial structural evolution (Krafft, 2002, 2006; Malerba and Orsenigo, 1993). The present article belongs to the third level of analysis as it aims at understanding how diverse firm behaviour influences the structural evolution of an industry along with technological change. There is a large body of theoretical and empirical literature in innovation economics which investigates the interconnection between technological innovations and industry evolution. This theoretical framework shows that the characteristics of innovations induce changes in the industry structure. What remains insufficiently addressed is our understanding on the effect of firm behaviours in the industry evolution. The distinction between creative and adaptive responses based on Schumpeter framework sheds light on our understanding how firms' behaviour can affect technological change (Peneder, 2010; Antonelli, 2008; Schumpeter, 1947). When new innovation comes into existence, firms can choose different pattern of development which has different effects in the definition of the industry structure, the theoretical framework based on creative and adaptive responses permits to understand the nature and the consequences of diverse firm behaviour.

We draw on creative and adaptive response framework to study the behaviour of new entrants and incumbents in the bounce of Voice over Internet Protocol (VoIP) in the telecommunication and Internet consumer market segment in the major OECD countries. VoIP is an emerging technology that enables voice communication (Corrocher, 2003) which can be qualified as a general purpose technology (GPT) since it can be applied in different environment and it can generate different applications, thus the path and depth of technological change depends upon the firms' behaviour.

Both new entrants and incumbents adopted VoIP but their responses to technological change were different. New entrants' reactions to change can be qualified as creative responses because new entrants have identified and exploited a series of innovative opportunities which have contributed to change the industry structure. On the contrary, incumbents' responses to change are characterised by adaptive actions as they have simply adopted and added VoIP within their network without introducing changes and novelty. We need a deep analysis of the technology evolution to assess the pattern of innovation development and to understand the co-evolution of technology and firms' behaviour. The reconstruction of the history of technology development covers 15-year period (from 1995 to 2006) which includes the initial development and the diffusion process of VoIP in the telecommunication industry.

The article is organised as follows. Section 2 presents the review of the literature creative and adaptive response framework. Section 3 illustrates the case study. It delves into the technical and economics characteristics of VoIP. Section 4 draws on the theoretical framework to understand the case study. Conclusion and Discussion follow.

2. Review of literature of technological change and creative/adaptive responses

In the Schumpeterian tradition, innovations are essential in the evolution of the industries, particularly 'destructive innovations' are seen as innovative forces which can destroy industry paradigm and create new paths. The disruptive effect of the innovation depends on its degree of innovativeness and on the strategy adopted by firms. Technological process is complex, the simple introduction of technology in the economy is not enough to generate benefits and increase productivity. Firm behaviour can influence the direction and depth of technological development as adoption decision is the result of decision-making process (Antonelli, 2006) where different actions can take place. The process of technological change is seen as an endogenous process and it follows a path dependent process. Technological change is the result of learning by using and learning by doing process, where agents' actions take place in localised technological space (Antonelli, 2008) firms act within the boundaries of their cognitive map (Weitzman, 1998). Once technological change emerges firms choose overtime if to exploit, explore or ignore new technologies (McKelvey and Texier, 2000), thus firms' behaviour plays an important role in the development of the new innovations. Profit-

seeking behaviour drives the decision of entrepreneurs (Kirzner, 1997; Schultz, 1975) which encourage competition among agents. Firms are heterogeneous in term of their knowledge and expectations (Malerba, 2002).

Any response to change is endogenous and it entails the exploitation of internal resources and the exploration of external knowledge located close to the firms' localised technological space. Changes can take place once firms are able to recombine differently internal competencies and if they have the absorptive and dynamics capabilities to effectively assess and external knowledge located close to their cognitive maps. Entrepreneurs play an important role as they bring innovation to market and they are those individuals who can both foresee innovative opportunities and assess market needs (Acs, 2008). As Richardson (1972) argues, firms are good at engaging on new activities when their existing knowledge is closed related to new activities. According to Langlois (2007), entrepreneurial firm is a new firm or a firm that is willing to engage in activities different from the existing one.

The industrial dynamics literature is rooted by the Schumpeterian tradition which identifies two patterns of innovation. The Schumpeter Mark II is characterised by the presence of big firms that adjust their activities to new technology. The Schumpeter Mark I is characterised by 'creative destruction' where entry is possible and entrepreneurs and new firms have a major role in innovative activities (Malerba, 2002). Alternatively, big firms can also hinder the development of new innovation because of their core rigidities (Pavitt, 1988) and structural inertia. Existing firms can see the technology opportunities but they might not have the incentive to exploit them.

As knowledge is dispersed (Hayek, 1945) among the agents, the cost of accessing to external knowledge are different which made creative responses opposed to adaptive responses (Antonelli and Barbiellini, 2011). According to Schumpeter, firms' reactions to change can be adaptive or creative (Schumpeter, 1947). Both creative and adaptive response implies that agents move within their knowledge space and it can act close to the knowledge frontiers.

The Schumpeterian framework has rooted the theory of entrepreneurship (Peneder, 2010). Creative response implies to be able to react to changes with innovative activities such as new products, new

organisation of the production which can ensure competitive advantages (Antonelli, 2009). Firms react creatively to changes once they are able to exploit their existing knowledge and combining it with the external knowledge. "Intentional and selective strategies are necessary in order to generate new knowledge" (Antonelli, 2009: 739). According to Schumpeter (1947), creative actions are characterised by three conditions: (1) creative actions can be understood only ex-post, ex-ante it is not possible to identify the change. (2) Creative response should influence the economics and social system where agents are embedded. (3) Creative responses depend upon the characteristics of the individuals and the decision of individuals, which can result on the transformation of the industry structure.

Creative responses imply a large degree of novelty as outcomes can be identified only ex post and the recombination of internal and external knowledge is non-trivial. "Novelty is something that was unknown before a particular point in time and that, hence, was discovered or created at that point in time" (Witt, 2009: 312). Creative responses cannot be foreseen ex-ante as they generate unexpected outcomes which induce uncertainty. Two levels of uncertainty emerge: on the market (which results on industrial structure changes) and on the internal organisation of the firms.

Adaptive responses can define as "whenever an economy or a sector of an economy adapts itself to a change in its data in the way that traditional theory describes" (Schumpeter, 1947:150). Adaptive actions imply a reaction to change which contains low level of new knowledge and changes can be foreseen ex ante. These classes of responses cannot change the social and economic system so they fail to meet the second condition of creative responses. Adaptive responses are located close the knowledge frontier of the firms and external knowledge are costly. Firms have not the possibilities to recombine external knowledge within the internal boundaries as they cannot interpret external innovative opportunities. Thus, adaptive responses rely essentially on internal knowledge, so once firm adopts a new technology and techniques, firms implement innovation by adding it to their existing technical and economic system. The irreversibility of production factors (both labour and capital factors) engaged firms to adapt to change without create structural change of internal firms' organisation. In the case of innovation development and adoption can take place but the result of adoption does not generate technological change.

2.1 Creative and adaptive response in competition

The second characteristics of creative responses involves that firms are able to change the economics and social systems, they “creates situations from which there is no bridge to those situations that might have emerged in the absence” (Schumpeter, 1947:150). Creative response introduces unexpected events (first characteristics) which can affect industry structure (second characteristics). As actions take place in an embedded system, relevant changes in one side of system have effects on other agents.

The creative responses introduce unexpected changes in product and factor market as firms identify and exploit all economics and technology features. Beside creativity, these classes of reactions ensure diversity which is peculiar for economics development as ‘if everyone had identical endowments and preferences, then one would have any reason to trade’ (Scott, 2010: 17) and “If the market had no diversity, not much would happen” (Scott, 2010: 17). The existence of diversity ensures creativity and increases the pace of competition. It turns out that diversity involves complexity as agents are embedded in a web of connections and reputations. Once changes take place agents should reallocate their resources to response to change, the reallocation process favour competition. The changes in the industry structure and its redefinition are part of the innovation process (Geroski, 1998).

To analyse competition, Hayek (1968) distinguished between competition discovery and successful search. Peneder (2008) has demonstrated that the entrepreneurial discovery opportunities represent essential characteristics of the competitive process as firms are able to realise new profit opportunities. Competition discovery results on a discovery of something (new products, cost-saving technology) unknown before by other market participants (Foss and Klein, 2004). On the other hand, successful search refers to something that exists already and it has been just disclosed (Hayek, 1968). Adaptive response can result on successful search as they imply low level of exploration of new activities. Economics systems are characterised by continuous discovery and exploitation of profit opportunities. Particularly, discovered incomes are not the share of the market but they are the result of the discovery of new incomes before unknown. In adaptive response, the successful searches are not able to create new sources of incomes as they do not create new market.

2.2 Nature of innovation and creative/adaptive responses

In the Schumpeter theoretical framework, innovations emerge in gales so they are not the results of isolated actions. The degree of knowledge cumulateness within the firms can inform about the ability of firm to create new knowledge (Peneder, 2010). Creative responses are characterised by high level of cumulateness and transformative effects. Cumulateness refers to the fact that the innovation is based on a previously existing knowledge (Antonelli, 2005; Consoli, 2005a) which is recombined within firm's boundaries. The transformation effect implies that the technology can be applied in a creative way to broaden its utilisation. Once firms exploit the transformation effect, they demonstrate to have dynamic capabilities (Teece et al., 1997) as they can explore and exploit all technology features that are within their cognitive maps. The dynamics capabilities of agents allow them to react creatively to changes exploiting their existing knowledge and combining it with the external knowledge. Dynamic capabilities permits to firms to exploit different possibilities opened up by new innovations (Teece, 2007). In term of knowledge dynamics, it is important to underline that creative responses are the result of recombination of internal competencies and rely on knowledge externalities coming from space located close the cognitive map of the firm. Knowledge externalities can come from universities, research centres, other firms and so forth.

Low level of cumulateness reduces the exploitation and recombination of internal knowledge so the firms' responses are adaptive as firms cannot fully exploit the existing knowledge. Adaptive responses are more distant from the firm technological frontier (Peneder, 2010) and they cannot generate new economics opportunities.²

3. VoIP development in the voice market

We draw on the foregoing theoretical framework to analyse the development of VoIP on the residential fixed voice segment in the telecommunication industry in OECD countries from 1995 to 2006. To consider the historical accounts, we construct the evolution of the technology in order to assess the effect of the different firms' behaviour in the industry structure. We collect data for different resources¹ to triangulate the information.

¹ Specialist journals, newspaper archives, official reports and newsletters from the regulatory authorities, OECD reports and telecommunication operators' websites

Firstly, the telecommunication sector has been always characterised by multiple dimensions of technological-economic paradigms (Mansell, 1991) where the upcoming of new innovations bring at the forefront further innovations. The technological paradigms have evolved and created uncertainty in the market which have obliged established firms to change their activities and their geographic localisation (Sadowski et al., 2003). VoIP has represented a turning point in the voice market segment for both fixed and mobile segments. In order to assess the disparities of technological change and the variety of actors, we identify the industry structures relying upon the layer analytical framework. Secondly, the development of VoIP has been characterised by different firms' behaviour, we interpret new entrants' and incumbents' strategies in the light of the Schumpeterian reaction and adaptive response framework. We draw on the layer analytical framework which permits to disentangle competencies from functionalities and to identify the industry hierarchical structure and the interdependencies among firm activities. The layer method has been widely used in telecommunication and informatics study because it identifies and interprets technological and industrial changes.

3.1 Technical and economics implications of VoIP

To assess the co-evolution among technology, industrial structure and users' needs is important to analyse the characteristics of the innovation, as the nature of the technology can influence the type of management and corporate organisation (Pavitt, 1988). The development of VoIP has been initiated by computer industry firms based in Israeli VocalTel in 1995. VoIP is an alternative technology to the traditional public switched telephone network (PSTN), which is the traditional telecommunication technology used for voice transmission (Cecere, 2009). VoIP applies packet switching and asynchrony transmission to voice communication which leads on substantial cost saving in the voice transmission as it uses less bandwidth than the traditional network.

It is possible to identify three different Internet telephony configurations (1) Phone-to-Phone, (2) PC-to-Phone or Phone-to-PC (3) PC-to-PC (Corrocher, 2003). Phone-to-Phone applications exploit the broadband wire or wireless network (WoLAN); this application is developed essentially by incumbents, ISPs and cable operators. PC-to-PC, PC-to-phone (giving also the possibility to receive

calls Phone-to-PC) applications exploit the Internet network by offering peer-to-peer voice communications, consumers have to download a free software to have access to the voice service.

Once information technologies are involved, there is no unique pattern of diffusion and adoption. In the innovation economics literature, there are different studies looking at the wide application of ICT with the aim to assess the structural changes they can induce (Carlsson, 2004), particularly VoIP ensured a cascade of specific applications in various domains and shaped different customer services, the degree of novelty of the exploitation depend upon the firms' behaviour. After Vocaltel has introduced Pc-to-PC calls, in July 1996, IDT, a US calling Card Company promoted the first commercial Internet which introduced the first PC-to-phone software in the market (The Economist, 1996)². This service allowed consumers to employ IDT's calling centre as a channel. IDT also offered the option Net2Phone a "home gateway equipment" (Cawley, 1997) which transforms voice into packets for the traditional network (The Guardian, 2005a³) introducing the Phone-to-Phone VoIP service. CableLab experimented VoIP into TV cable network and Qwest tested the technology into the optic-fiber network (Ono and Aoki, 1998). In 1997, Worldcom introduced VoIP to send international faxes (The Economist, 1997a)⁴.

A successive number of applications have been created by innovative and dynamics firms engaged in creative responses process firms as they have they have identified new market niche and exploited all technical characteristics. VoIP can be qualified as a modular application because it can be applied to different environments/modules because it is interoperable and interconnected to different wire and wireless networks and at the same time it can be associated with value added services. Features of interoperability and interconnection have been always important characteristics of the telecommunication sector (David and Steinmueller, 1994).

The pace of VoIP development has been rapid as it ensured cost cut at supply side and low tariffs to the demand side. In consumer market segment, the reduced price of communication compensates the

² Anonymous (1996) Ringing the unwired, The Economist, 340(20 July), p. 55.

³ Macdonald (2005, April 7) Online: it's your call, The Guardian, p. 19.

⁴ Cairncross (1997) From circuits to packets, The Economist, 344(13 September), p. T79.

initial low quality of communication (Fransman, 1997). The technology appeared soon as more cost effective at the supply side as it ensures an efficient transmission and network management (Corrocher, 2003) and at the same time it gives the opportunity to cut costs e.g. "billing and accounting" (Cawley, 1997: 523) and provides a fast route into the market for new entrants. In the mid-1996, on average a regular transatlantic call costs \$1 per minute; while VoIP providers were able to charge it at \$0.04. Additionally, the heavy demand for VoIP spurred the development of number of firms. The effects of decreasing costs of voice communication turned against incumbents and paved the way to remarkable changes in the industry. Most of the existing literature on Internet telephony defines the technology as creative destructive innovation (Constantiou and Kautz, 2008; Rao et al. 2006; Garcia-Murillo and Mcknight, 2005).

Technically, the transportation of a bit (byte) of information over the IP network led to a substantial cost savings in respect to the PSTN which enable to create economics of scale and scope as well as economies of density and variety. The economies of density are associated to the reduction of unit costs due to the reutilisation of the same network and economy of variety implies that the firm value is based on the different services offered. Incumbents and businesses have foreseen these costs advantages.

We identify three categories of operators exploiting VoIP: IP network voice providers, Software voice providers and Incumbents. IP network voice providers and Software voice providers are new entrants in the voice layer. Both new entrants and incumbents have capabilities in the informatics and computer industry or in the connectivity telecommunication layer however the responses to change have been different.

(i) IP network voice service providers offer free calls (national and international) and other bundled services in form of Double or Triple play, e.g. Iliad/Free (France), Vonage (US), FastWeb (Italy). These operators entered on the market between 1999 and 2001 as Internet providers. IP network providers first entered in the market as ISP taking advantage of technical regulatory. They have exploited the technical characteristics of VoIP by offering double or triple play services giving access to unlimited voice communication under subscription fees.

(ii) Voice software-service companies were founded by informatics and computer developers coming from sectors such as videogames and online music downloading (Cecere, 2009). These firms have taken advantages of knowledge exchange from universities and research centre (Fransman, 2010). They exploit VoIP interoperability with internet network. Examples of these operators are Skype, Yahoo voice messenger, Google Talk-to-Talk, JAJAH. These operators could be defined as facilities-less and facility dependent, as they did not have direct access to the internet access and they exploit the internet as a highway. Using free download software, consumers can make free PC-to-PC calls among the same operators.

(iii) Incumbents in the telecommunication sector such as France Telecom in France, Telecom Italia in Italy, and British Telecom in the UK. They started to invest in VoIP technology in the mid-90 with the aim of bolstering their network capacities and reducing maintenance costs on the supply side. They simply add the technology to their existing network.

3.2. The diffusion of VoIP: A layer analysis

To understand technological change at the industry level, it is important to identify the industry structure as it permits to evaluate how creative and adaptive responses have influenced industrial dynamics. The configuration of layer method includes five layers developed by Fransman (2002) and Krafft (2003) and it shows the interdependencies existing in the sector before the introduction of VoIP.

Each layer includes firms that have similar activities, while upstream/downstream layers include companies with complementary capabilities (Krafft, 2010) which allow characterising the layer boundaries and understanding the changes in the bounce of VoIP development. The Table 1 presents the stylised characteristics of each layer. The first layer - Equipment Production - concerns the production of devices such as switches, routers, etc. The second layer is the essential Physical Equipments, which includes network/transmission and management, where are situated essentially incumbents and Internet providers. Voice service was essentially offered by firms operating in layer II. Firms belonging to this layer provide the physical infrastructure to consumers, and the end-to-end services such as voice services. The network layer (layer I, II) is crucial as it is strictly linked to regulatory policy and technological developments. The liberalisation has allowed the entry of new

firms in these layers. IP Network service belongs to this layer. The third layer - Connectivity - involves offering Internet access and linked services, ISP and Access service providers (ASP) belong to this layer. Deregulation has encouraged the entrance of facilities-less operators. These operators can choose different regulatory network access: the bit stream access, full unbundling or they can construct an alternative network. The fourth layer -Navigation and Middleware Operators- includes browsers and search engines. These operators play the role of intermediation between the huge amounts of information on the web network and consumers' needs. The fifth layer develops content and packaging of the Internet based services e.g. broadcasting, e-commerce. Software voice service providers belong initially to layer IV and V.

Before the introduction of Internet Telephony, the voice service was offered 'on the top of the physical infrastructure' (Gong and Srinagesh, 1996: 1233) by vertical integrated companies belonging to the layer 2. With VoIP, voice can be offered by firms belonging to different layers so the technology reduces the technical barriers to enter in the voice market segment. New entrants in voice 'layer' has been encouraged by the liberalisation of the sector and by the creative adoption of VoIP which has further stimulate the economics activities.

[TABLE 1 ABOUT HERE]

4. Creative and adaptive responses in VoIP development

In order to assess the disparities of firms' behaviour, the present Section draws on the theoretical framework on creative and adaptive responses in order to understand the VoIP development. Table 3 summarizes the implications of creative and adaptive responses in the case of VoIP development.

4.1 Incumbents' exploitation of VoIP

Detailed researches on European incumbent behaviour of different European countries e.g. France Telecom, Telecom Italia show that since mid-90s carriers have massively invested in VoIP technology to reinforce their network capacity and reduce maintenance costs on the supply side. So they have adopted the technology largely before two main new entrants.

However, they have continued to base their revenues on voice traffic since mid-2000 which was the largest source of revenues for carriers. It should be noticed that at the beginning of VoIP evolution, (up to 1997) many European countries reserved VoIP technology exploitation to incumbents; some countries even later (Cawley, 1997). Carriers have partially exploited all functionalities of VoIP as they added it to their backbone without offering innovative tariffs to their consumers, in other words they were engaged in *successful search*. Hence, adoption takes place but the reactions to change can be qualified as adaptive as they simply VoIP to the existing techno-economics system and their actions can be foreseen *ex ante*. Until 2006, the percentage of carrier revenues derived from voice services was still extremely high; Telecom Italia voice revenues were close to 80% and the Deutsche Telekom more than 60%. These figures show that the incumbent business model was still based on voice service. Paralleling in 2006, the voice revenue of incumbents registered a rapid fall of about 10% for France Telecom, 6% for Deutsche Telekom and 5% for BT⁵.

Typically the literature has showed that incumbents hamper the development of new technology because 'the transition to a new technique is often slowed by the extreme difficulty of breaking away from the old forms and embracing the different logic of a new technique or principle' (Rosenberg, 1972: 14). In the case of VoIP, incumbents have adopted VoIP but they have showed to have a structural inertia in the exploitation of all VoIP features. Incumbents choose to adopt the technology without any creative actions, in other words the technological development followed by incumbents cannot permit changes in the industry structure. Incumbents started to offer reduced tariffs and value added services well after new entrants (Cecere, 2009). With the introduction of VoIP, voice services are not longer a major source of income. The BT firm can illustrate the inertia of incumbents; the company has installed the technology in the backbone since the end of 90s. In the BT Annual report in 2000, the firm declares that "*BT's operating profit was derived predominantly from fixed-network calls in the UK. Calls on the UK fixed network accounted for approximately 32% of group turnover in the 2000 financial year*" (BT, 2000:10). It shows that the company based their incomes on voice even though they have adopted the technology in the mid-90s to reduce their internal costs. Four years later in BT Annual Report the company declares that "*our aim is to continue to increase profitable revenues from data and advanced*

⁵ Anonymous, (2006) 'The end of the line', *The Economist*, Vol. 381, 12 October, p. 10. Data collected by Westhall Capital. http://www.economist.com/surveys/displaystory.cfm?story_id=7995301 (October 2008).

broadband and internet services, further reducing our dependence on revenues and profit generated by traditional fixed-line voice services” (BT, 2004: 7). With the emergence of new entrants and the pressure of the reduced income from voice traffic, BT underlines that “ ‘Technology substitution’ is also having a significant impact in our traditional voice markets, where fixed-to-fixed voice revenues were down in both the consumer and business markets. This is both a challenge and an opportunity. We have to respond to those changes in technology, the market and behaviour, at the same time as working to accelerate them” (BT, 2004: 5). This statement shows that incumbents respond to change in technology to react to changes induced by new entrants. Following the pressure of new entrants and the changes in the industry, BT decided to diversify their activities. Incumbents have been forced to enlarge the boundaries of their activities; they have followed the dynamics generated by new entrants as they need to diversify their activities to finance their business. Adaptive responses have slowed down the industrial dynamics.

4.2 The evolution of knowledge base and creative responses

Both IP network providers and Software voice services have offered voice service giving access to different services and unlimited voice calls. They have perceived and exploited different VoIP features and they have transformed them in economics opportunities, hence creative response are represented by innovative services and reduce voice tariffs. The creative responses are the results of the combination of existing competencies in information and internet with the technological characteristics of VoIP. Before the introduction of Internet Telephony, voice retail communication was essentially ensured by incumbents that belong to layer 2. Telephony was considered as an infrastructure based service (Shin, 2006) offered by carriers; with the introduction of VoIP, voice can be offered by firms belonging to different layers as module applicable to different layers.

The creative responses introduced have generated changes in the knowledge based in the industry. VoIP development has favoured the ongoing telecommunication industry decentralisation process started with the liberalisation of the sector (Davies, 1996). VoIP had allowed to computer industry to enter in the telecommunication sector and particularly in the voice market segment which was the most important source of incumbents’ revenues. Since mid-90s, the development of the internet in the

telecommunication sector has transformed the sector into info-communication industry⁶ (Fransman, 2001; Krafft, 2003). VoIP development can be ascribed in the general diffusion of internet paradigm in the telecommunication industry moving the sector towards the info-communication industry for two reasons. On the one hand, it permits to computer firms to enter in the sensible market segment and on the other hand, it favours the interaction between traditional voice services to internet-based communication such as instant messaging and so forth. Both the decrease costs of voice communication and the competitive entry of new firms have challenged the incumbents' position.

4.3 The evolution of industry structure

Creative reactions permit to new entrants to exploit all VoIP features, hence they built up new services and complementarity assets. The evolution VoIP is characterised by two types of trajectories: *cumulative* and *transformative*.

The cumulative changes are direct consequences of the continuous application of GPTs on a given set of application. With respect to the IP, VoIP technology has some characteristics similar to GPT. VoIP is characterised by cumulativeness, because IP is the first (basic) generation innovation and VoIP is the second generation innovation. The cumulativeness allows the intra-layers combination of activities which creates the condition for economics of scale and scope where different applications share the same technical platform. In the case of Software voice service, VoIP cannot be dissociated from Internet connection as it accommodates further applications that relies both on Internet and VoIP. VoIP has enabled the computer to become a channel of voice communication which has reduced the interdependencies existing between down-side and up-side layers.

The transformative effect results of the creative employment of VoIP where creative reactions possible and enabled firms to actually introduce productivity enhancing process and create new business opportunities which were unknown previously. The transformative characteristics are possible only once agents exhibit dynamics capabilities (Consoli, 2005a). The more creative application can generate

⁶ The info-communication industry has a different industry structure compared to the traditional telecommunication industry, entry barriers are reduced and the technological development is based on an open system of innovation which contrasts to the former closed innovation system. Technological development is rapid and encourages competitive entry.

industrial dynamics. The firms are able to broaden the range of services offered by exploiting creatively their competencies combined it with VoIP characteristics.

New entrants have initiated the production of different products by using their existing technology combining it with external knowledge. They have reacted creatively to changes offering a series of innovative services which has encouraged diversification of firms' activities. ISP such as Iliad/Free in France or FastWeb in Italy offer network interconnection (layer II, III); search engines (layer IV), VoIP as well as mail (layer III) and video (layer V). Skype creators founded Kazaa which was based in layer IV; hence they enlarge their activities by fully exploiting their competencies. The Table 2 shows some examples of transformative effects of activities which has in turn changed the structure of the industry and the system of services delivery. IP network voice service providers offer voice in the form of triple or double play under flat rate. Software Voice service providers have exploited their capabilities in computer and informatics sector creatively for offering voice which was essentially a telecommunication service. They allow video conferencing, file sharing and instant messaging enlarging the communication functionalities.

[TABLE 2 ABOUT HERE]

Diversification occurs in the bounce of VoIP development as consequences of the new entrants' actions. The diversification of the activities has enabled economies of scope and scale and thus economics of variety. The resource based view can interpret these diversification activities (Penrose, 1959). Thus, sharing inputs in order to produce multiple outputs is considered to be efficient. Software voice providers have exploited their competencies in software edition to offer voice (similar activities) in peer-to-peer network which has allowed them to offer complementarity activities such as instant messaging (complement activities). In the case of VoIP, new entrants have recombined their activities blurring of technical boundaries between sectors of the economy. Diversification allows firms to operate in different market segments, in other words firms expand their market boundaries (Geroski, 1998) which has consequences in the nature and direction of competition.

In term of competition, new entrants have ensured a competition discovery process as the outcome of their creative responses were unpredictable as they offer new services and reduce tariffs or free voice service, they have create new markets. On the contrary the incumbents have reduced their internal costs and thus they have undertaken a successful search as they have identified economics gains simply introducing the new technology in the backbone.

At knowledge dynamics perspective VoIP contributes to change the technology-base of the industry and the interdependencies existing in the voice market segment. In knowledge based sectors, knowledge dynamics are rapids and there is a complex and interrelated system where the actions of firms are interrelated, in other words firms are embedded into a system of innovation (McKelvey, 1998) so change in one side of the system affect the behaviour of other firms.

Conclusion and Discussions

The present article sheds light on the influence of firms' behaviour in technological change process. The adoption and development of new technologies have been largely studied however much attention should be given to how firms' behaviour influences technological change. Once new innovation emerges and firms cannot assess and exploit all technological features, and adaptive responses can prevail technological change can take place as firms adopt the new technique or innovation but the structures of the system do not change so there is no competition discovery process. Creative and adaptive response framework sheds light on the implication of different technology development for the industrial dynamics and the competition. To enhance creativity and increase the diversity, firms should exploit all possibilities opened up by new technology which in turn can generate industrial dynamics. In other words, entrepreneurship is ensured by creative response activities. Firm behaviour is essential to enable industrial structure changes as once firms do not exploit new technology features they can hinder industrial dynamics and reduce the growth and competition in the industry. Diversity is essential to create economic growth (Nelson, 1991). Hence, policy makers have to carefully evaluate the behaviour of the firms to assess their economics performance and the impact that business can have in the economy. Particularly, the case study shows that both new entrants and incumbents have applied the technology but the response to change is different. The direction and the depth of technological change depend upon firm behaviour.

The process of technological and industrial change initiated with the VoIP development has generated industrial dynamics. Small firms have ensured technological change as following entrepreneurship framework (Acs and Audretsch, 2005) and Schumpeter Mark I approach. Industrial dynamics takes place because there are new firms entering in the market; and at the same time creative responses have enabled to change the industry boundaries. In the case of VoIP development, both new entrants and incumbents have applied the technology, but they have had different responses to change. In the end, both new entrants and incumbents diversify the activities, but incumbents have been forced to react to creative adoption initiated by new entrants. Creative adoption takes place as new entrants have combined their knowledge with creativity exploiting dynamics capabilities which results to diversification process. Their creative reaction is characterised by intra layer combinations of activities which contributes to enlarge firm boundaries. At the same time, incumbents have been obliged to diversify their activities to react to industrial change, in other words they react to the technology development without creative actions. The reduce incomes coming from voice does not guarantee long sustainable revenues. They offer value added services as new entrants did, because they follow the new entrants' strategy in order to be competitive and to find new business revenues. The creative application of VoIP has had two main impacts in the competition based and industry structure which in turn have an impact on the knowledge dynamics. Firstly, it has increased the competition because it reduces the technical barriers to entry to the voice segment enabling the entry of diversified firms. Secondly, it has contributed to change the sector's knowledge-base, shifting competition towards the distribution of value added services. As voice traffic is no longer the main source of income for telecommunication operators. These trends create the conditions favouring industrial dynamics, in other words incumbents are under competitive pressure and entry requires highly innovative and creativity strategies. Policy makers have to understand the conditions supporting creative responses are as this can favour economics growth. The limitations of the paper should be pointed out. Firstly, it would be interesting to couple the analysis of VoIP development with the development of other innovations in the telecommunication sectors. Secondly, it is difficult to disentangle the effect of one innovation development in a knowledge based industry from the effect of other innovations as there are different innovations emerging.

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Table 1 Layer method

Layer	Activities	Firms
V	Application layer and content diffusion/production	AOL -Time Warmers, MSN
IV	Navigation (browsers engines, electronic payment security)	Google, Yahoo
III	Internet connectivity	ISP-Internet service providers; ASP-service access providers
II	Network transmission (optical fibre, ADSL, cable, wireless - Wifi, Wimax)	France Telecom, BT, AT&T, NT
I	Equipments and software (transmission equipments, switches)	Alcatel/Lucent, Cisco, Nortel

Source: Fransman (2002) and Krafft (2003)

Table 2. Diversification of firms' activities

Firms	Former layer	Layers occupied today
Google et Yahoo	IV -navigation middleware	IV - search engines III - voice and email service V - Information, translation.
Skype	IV- Kazaa inventors (music downloading)	III- voice V- games, number telephone searching
Iliad/Free	II - Internet providers and network	II- wire and wireless Internet connections III- voice and email service IV- search engines V - video diffusion

Table 3. Creative and adaptive responses in VoIP development

	Cumulative and transformative effects	Nature of response	Industry changes	Layer structure	Competition according to Hayek (1968)
IP network voice service	Unlimited voice service Voice bundled with video and internet	Creative response	Entry in the voice market segment and blurring the industry boundaries	Create the condition for vertical specialisation as they bundled activities in the Layer III and V	Competition discovery
Software voice service	Free to PC-to-PC voice communication Voice communication with instant messaging and video-conference	Creative response	Entry in the voice market segment and blurring the industry boundaries	From the layer IV and V, they enter in the layer III	Competition discovery
Incumbents	VoIP on the backbone (no change)	Adaptive response	Changes are responses to new entrants actions	----	Successful search