School of Economics and Management

TECHNICAL UNIVERSITY OF LISBON

Departament of Economics

João Caraça, João Lobo Ferreira & Sandro Mendonça

A chain-interactive innovation model for the learning economy: Prelude for a proposal

WP 012/2007/DE

WORKING PAPERS

ISSN Nº 0874-4548

A chain-interactive innovation model for the learning economy: Prelude for a proposal

João Caraça
(Gulbenkian Foundation and ISEG)

João Lobo Ferreira
(Agência da Inovação and ISEG)

Sandro Mendonça
(Department of Economics, ISCTE University, and SPRU, University of Sussex)

March 2007

Version 2.0

Work in progress. Please cite with permission. Comments welcome.

Abstract:

The implementation of innovation has a central role in the dynamic knowledge economy of the twenty-first century. The ability to assemble new expertise and commercialise new business propositions constitutes one of the central characteristics in today's globalising, learning-intensive, fast changing economic life. This paper sets out to articulate a stylised understanding of the modern innovation process on the basis of the currently available understanding in the innovation studies tradition. The conceptual model seeks to capture the essential features of organisations engaged in developing dynamic factors of competitiveness.

Keywords: *innovation, innovation process, conceptual model*

JEL code: *L20, O33, O34*

1 Introduction*

Innovation is an old but evolving phenomenon. And it has accelerated with the Industrial Revolution of the XIX century. But it also displays some regularities which makes it a viable object of scientific inquiry. Today innovation studies, and in particular its neo-Schumpeterian economics tradition, is a vibrant field of research. And if this is the case it must not only be because innovation is a fascinating, puzzling and unfolding subject, but also because analytical approaches to must have somehow provided illuminating insights, robust generalisations and classification systems, as well as managerial and policy-making benchmarks about the organisation and dynamics of economic innovation. This paper is informed by this agenda. Moreover, the theoretical motivation behind this paper assumes the innovation phenomenon to be subject to the major operational categories first employed by the classic authors of political economy, who focused on the long term conditions for economic development (Freeman, 1977). Researching the causes, properties and consequences of innovation makes one aware of the importance of notions such as division of labour, interdependence and coordination. In particular, this paper explicitly adheres and contributes to the systemic and history-friendly view of innovation.

On the basis of a number of recent books (e.g. Faberberg et al. 2004, Hanusch and Pyka, 2007, Tidd et al. 2001) and journal special issues (e.g. in *Research Policy* and *Industrial & Corporate Change*) taking stock on the advances developed over the past 30 years one could reasonably state that the process of innovation proceeds along a lengthy and complex network of two-way roads linking multiple actors and institutions with different objectives and rules of engagement. In the words of Kline and Rosenberg (1986, p. 285), "innovation is neither smooth nor linear, nor often well behaved." Along with Pavitt's (1984) empirical taxonomy, Kline and Rosenberg's (1986) conceptual model has become a very successful, influential and heavily cited summarising device for making sense of the structure and diversity of patterns of the innovation process. Both exercises broadly follow the bottom-up, empirically empowered mode of framework construction that Nelson and Winter (1982) have labelled "appreciative theorising". However, if Pavitt's taxonomy of industrial innovation has been validated (e.g. Marchi et al, 1996) refined (Bell and Pavitt, 1993), upgraded (Tidd et al. 2001, added a new sectoral category), and extended to the service sectors (Evangelista, 2000) and the realm of small and medium sized firms (Jong and Marsili, 2006), revised versions of Kline and Rosenberg's framework are more difficult to find. This paper takes up the challenge of updating their work. Here we articulate a schematic representation of the "complex, variegated, and hard to

* The present paper is a very early and sketchy and preliminary depiction of a broader research work that is still under way. We wish to acknowledge a number of individuals who helped us ito reach this far in our reflection by providing comments and positive criticism: Filipa Rapazote, Isabel Caetano, João Dias, Manuel Mira Godinho, Marcelino Pousa, Tiago Santos Pereira and Vítor Corado Simões. COTEC provided indispensable financial support to the venture. All errors and limitations remain our own responsibility.

measure" (Klin and Rosenber, 1986, p. 285) interactive dynamics of innovative business behaviour in the learning economy through a conceptual model.

Structuring the conceptual model presented in the next chapters followed four basic guidelines:

- to update and extend for the learning economy the classic and useful model of inter-connected innovation steps originally presented more than twenty years ago by Kline and Rosenberg (the chain-linked model);
- to accommodate the concepts of the 3rd edition of the Oslo Manual (2005);
- to consider innovation not only in the industry sector ("goods"), but also in services ("intangible goods");
- to consider innovation not only in sophisticated sectors ("high-tech"), but also in traditional ones ("low-tech").

This paper is a first sketch of reflection in progress along these lines. The paper proceeds by focusing on some methodological considerations. Section 3 nails down the theoretical regularities that borrow empirical substance to the paper's proposal. Section 4 introduces the model. Section 5 concludes.

2 Representing the dynamics of innovation

This paper tries to capture the innovation process, conceptually and figuratively, by identifying its key aspects and depicting the dynamic network of qualitative links between its major features. Operationally speaking it tries to fill a gap in the literature seeking to update and go beyond the influential chain-linked model of Kline and Rosenberg (1986). It intends to do so by stressing the interactive and permanently unfinished character of innovation, while extending the potential coverage of the model beyond R&D intensive manufacturing industries.

Our modelling exercise aims at being *representational* without having any ambition of being representative. The model is no description of the mechanics of innovation in some given sector obtained by inference from a set of data from which, in turn, predictions or strategic prescriptions may be deduced. Rather, the idea is to nail down a set of categories and stylise a set of relations of interest (robust regularities derived from the large stream of empirically embedded neo-Schumpeterian and evolutionary literature) that may be of use for organising one's thought about the innovation process. The theoretical model is an attempt to offer a concise and empirically valid representation of the innovation phenomenon. The model has

explanatory value as it allows for the derivation of explicit and non-trivial propositions concerning its object (Walliser 2002, p. 150). The model also tries to be general enough as it assumes a set of major working principles, i.e. a systemic view of innovation, that are interpretable under local circumstances. To paraphrase Nelson and Winter (1982), this is an essay on appreciative modelling.

In basic sciences modelling is a fundamental streamlining activity since it allows the researcher to understand something; in the applied sciences models are central because they allow action to occur (Nouvel 2002, p. 3). Thus, this heuristic instrument is also conceived to be a tool for those stakeholders involved in the innovation process. In this it also serves an argumentative function, facilitating communication between those actors involved in innovative conversations by deploying a vocabulary and a set of denotations and connotations (Walliser 2002, p. 150).

This model, as any other, underlines certain traits judged important in the phenomenon under analysis. It therefore neglects other aspects. However, the depiction of something that may not be directly observed, may lead to some insight into it. It is certainly a simplification of reality, but it may carry some understanding about the characteristics of a complex process. The model is general, but not too general. What may be regarded as a major limitation is that it abstracts from the daily production and distribution routines which make up every business and from which plenty of important, however "low-brow", innovations flow. Another limitation may be found in the focus on a stereotypical organisation, where the locus of innovation under capitalism still resides. In other words, the model puts the business organisation at centre stage and it does not attempt to supply a representation of the essentially distributed character of innovation in the age of informational capitalism (Castells, 2000).

To summarise, this paper is concerned almost entirely with innovation in the broad sense. It pretends to supply a representational, not a representative, description about the pre-conditions, the process and the outcome of economic innovation. The model that we put together is intended to supply a useful conceptual framework for students of innovation, R&D managers, marketing managers and policy-makers.

3 The nature and nurture of the innovation process

Innovation results from an idiosyncratic and unpredictable chain of actions and feedbacks between (*i*) the firm's well tried, tested and trusted business routines, (*ii*) its efforts to deviate from its own track record and (*iii*) the signals and responses of its relevant techno-economic environment. This means that innovation is not just a matter of having the right technologies

and then applying a receipt to develop new concepts, produce and marketing them, neither it is only about knowing what the market is demanding and then supplying it. This is an old discussion with one major conclusion: there are numerous factors in this game. In a macroeconomic evolutionary approach, to which this paper adheres, “the evolutionary worldview is one of historical circumstances, complex causal mechanisms that change over time, and, above all, turbulent growth patterns that appear to be far from a steady state” (Verspagen, 2005, p 488).

Turning back to the microeconomic approach, firms don’t innovate because they want, but because under capitalist competition they will be pushed to it, by need. This Schumpeterian argument bears the fact that firms renouncing to it will be at pains to survive (Fagerberg, 2005). And if firms feel the need to innovate, they will only do it successfully if they are able. Business routines must be robust, that is, the firm must have built the competences and capabilities to answer to its changing environment and must be capable to adapt its proceedings, or even build new ones, without loosing its track. These capabilities are not limited to a technological bundle, but they comprise human and organisational skills, crucial for the innovation process. To be able to successfully innovate does not imply that the firm will be in control of the situation at all times. Being part of a system, or inserted in a techno-economic environment, implies that exogenous threats, opportunities or limits will define the possible actions of the firm and that its innovative capacity will depend on extensive interaction with the environment (Fagerberg, 2005). The Schumpeterian perspective of technological competition allows viewing the sustainability of such a process, as stated by Fagerberg (2005, p. 18): “innovations … open up possibilities for new business opportunities and future innovations, and in this way set the stage for continuing change”.

So, the models that simplify the innovation process to a linear representation, with its stages starting with the investments in science research, then the engineering of the nurtured ideas, its manufacturing and marketing (the so called *technology push models*), are nowadays believed to erroneously interpret innovation (Kline and Rosenberg, 1986). The *demand pull models*, also based on a linear conception of innovation but, instead, stressing the marketplace as the main source of ideas for innovation, are subject to the same criticism. Hobday (2005) summarizes the six major criticisms to the type of models that presume firms moving linearly from one stage to another: i) the sequential nature of activities is seldom validated by evidence; ii) feedback loops from later to earlier stages, interactions between actors involved in the process and inter-dependencies between the stages, not represented in these models, are very common; iii) many innovation activities are often concurrent and there are commonly overlaps between activities and/or departments; iv) evidence does not support general claims regarding stages; v) the wider environment of firms is not considered as a source of inputs; vi) the chaotic nature of the innovation process is underestimated, thus illustrating innovation as a rational orderly

process. Nonetheless, claims the author, some tribute must be paid to these models because they served as basis for more sophisticated ones, while providing “useful insights and hypothesis into the nature of innovation and decision making requirements at the level of the firm” (p. 127).

Criticisms to the linear perspective of innovation have already been raised in the 70’s, for example by Freeman (1977) supported by articles of the 60’s (Ames, in 1961 and Williams, in 1967). Freeman gives a particular attention to the work of Ames, who developed an interesting representation of the inputs and outputs of the R&D system, highlighting “the interdependence of the whole R&D system and the role of ‘feedback’ inputs throughout” (pp. 232). The claim of these works is that R&D is not the only source of inventions. Furthermore, by those days it became more obvious that in some industries (e.g. mechanical engineering) R&D had little or no relation with inventions, that is, the source of ideas was somewhere outside the formal R&D system. Based on the work of Jewkes from 1958 and 1969, Freeman suggested that even major radical inventions have their source outside the R&D laboratory, though formal R&D activity is required most of the times in this particular kind of innovation. Thus, this literature starts to settle the role of systematic and prolonged R&D in a much more realistic approach than the linear model, that is, R&D is considered an important step for the emergence of successful innovations, sometimes essential and sometimes not, though its relative position in the process of innovation is not necessarily in the beginning, while the role of the interdependence between stages of the development process of innovations is stressed.

Kline and Rosenberg (1986) provided us with an important and influential theoretical tool for understanding the nature and nurture of the innovation process that surpasses many of the above criticisms. For its relevance on innovation studies, it was a starting point for the model that we put up.

3.1 The chain-linked model and its importance

The best way to comprehend the innovation process at the firm level is to assume it as a complex process. A complex process involving the action of different actors (e.g. firms, clients, networks, institutions, governments, cultures, histories). Oversimplifications will only lead to inaccurate conclusions. As discussed by Fagerberg (2005, pp. 5) an innovation is a continuous process that requires firms “to combine several types of knowledge, capabilities, skills and resources” and it is not a solitary happening since every new innovation require previous inventions and innovations. The overview of innovation performed by Kline and Rosenberg (1986) shares this standpoint and leads the way to a conceptual model of the innovation

process based on the assumption that “innovation is complex, uncertain, somewhat disorderly, and subject to changes of many sorts” (idem, p. 275).

According to these authors innovation emerges from the interaction between two forces, leading way to a highly uncertain process: the commercial and the technological opportunities. Nevertheless, both these forces carry limitations to the process because either the market response can be uncertain or the technical infrastructure not enough developed. Furthermore, these authors present a set of arguments to introduce the *chain-linked model of innovation* that deserve to be summarized:

- The greater the changes introduced, the greater the uncertainty;
- Technical success is not the only measure of economic usefulness;
- Technical infrastructure or nature can be a barrier to innovation;
- Commercial success requires the optimization of many factors;
- The right timing for the introduction of the innovation can be crucial;
- Reaction to users’ feedback is an important part of innovation;
- Economically important innovations don’t necessarily imply sophisticated technologies;
- Sophisticated technologies are not, *per se*, valued in the marketplace;
- Newness is not, by itself, an economic advantage.

Looking inside what they call the “black box”, that is, analyzing the process of technological innovation or, in other words, how and why innovation occurs, one of the first conclusions is that among different sectors of economic activity and even among different firms there are different approaches to the creation of novelty. Secondly, they argument, innovation is more than science. Other types of information beyond scientific knowledge are often essential to this process, which makes of scientific research and development (R&D) only a part (not absolutely necessary) of innovation. A third conclusion of analyzing the *black box* is that “much technological change is of a less visible and even, in many cases, an almost invisible sort. A large part of the technological innovation that is carried out in industrial societies takes the form of very small changes” (ibidem, p. 282). The on-going character of innovation is also stressed when arguing that innovations are subject to an improvement process achieved through a cumulative learning practice which ultimately is the responsible for its economic significance.

The bases for the conceptual model of the innovation process called the “chain-linked model” were by now launched. This model puts the emphasis on the feedback loops between different stages of the innovation process and, most of all, on the linkage between science and

technology alongside all the development process. So, two main features are suggested to think clearly about the phenomena of innovation at the firm level. On the one side, the interaction between contingent steps of the innovation development is a regular phenomenon that must be incorporated in the analysis. For example, when testing a new prototype, the information produced will be useful to, if needed, go back to a design phase and make the required improvements before building a new prototype. Among the most important feedbacks are the dialogs between the perceived market or user needs and enhancements in any stage of the process in "the next round of design". The other feature is about the role of science (stored knowledge together with research) in innovation, which is to be viewed as an important but limited input:

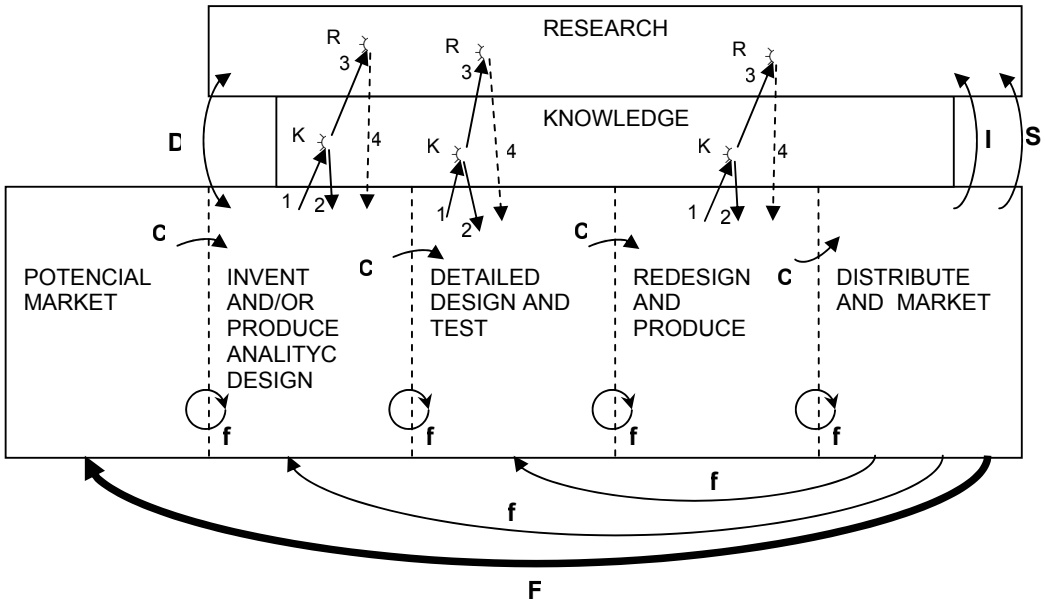
> "Most innovation is done with the available knowledge already in the heads of the people in the organization doing the work, and, to a lesser extent, with other information readily accessible to them. It is only when those sources of information fall short of solving the problem that there is a need for research in order to complete a given innovation" (ibidem, p. 288).

> "When we confront a problem in technical innovation, we call first on known science, stored knowledge, and we do so in serial stages. Only when all stages fail to supply the needed information, as often happens, is a call for the second part of science, research, needed and justified" (ibidem, p. 291).

Thus, the chain-linked model opens space for learning as a crucial part of the cumulative innovation process. And "innovation is a learning process involving multiple inputs" (Smith, 2005, p. 150)

Though it is recognized that new science is rarely linked to the initiating step of innovation, the chain-linked model also points the direct link between scientific research and the invention or design stage as a possible source of innovation. If this is the case we may be in the sight of some radical innovation susceptible to create new industries. Finally, the model incorporates the possibility that the outcomes of innovation are used to produce new science, giving as examples the case of the microscope, of the CAT scanner or of the digital computers.

Figure 1 - The chain-linked model



Chain-linked model showing flow paths of information and cooperation.
Symbols on arrows: **C** = central-chain-of-innovation; **f** = feedback loops; **F** = particularly important feedback.

K-R: Links through knowledge to research and return paths. If problems solved at node K, link 3 to R not activated. Return from research (link 4) is problematic – therefore dashed line.

D: Direct link to and from research from problems in invention and design.

I: Support of scientific research by instruments, machines, tools, and procedures of technology.

S: Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain.

Source: Kline and Rosenberg (1986)

An interesting observation about this model and about other works of Nathan Rosenberg is made by Smith (2005), when he argues about their implications for the development of quantitative measures of innovation and, more precisely, for the development of the OECD's innovation manual known as the Oslo Manual (OECD, 1992) – we will examine this manual and its relevance further ahead. According to Smith, there are two ideas emerging from the chain-linked model that deeply affected the Oslo Manual' conception and the development of indicators of innovation: first, the idea that innovation is not just about the creation of absolutely new products or processes, but also about small changes in existing ones that may have, in the long run, important techno-economic implications, and secondly, the relevance of other inputs to innovation besides R&D. These ideas are, in fact, in the origins of and embedded in the text of the Oslo Manual.

3.2 The Oslo Manual 3rd edition

The years after the Second World War transformed the way in which science and technology were perceived in terms of its impacts on structural economic changes. From these days on innovation started to be widely seen as a determinant factor in explaining the success of firms, regions and countries, either in academic as in institutional means. For instance, the responsibility for the beginning of formal public policies on science and technology is often credited to Vannevar Bush's report dating from 1945 to President Roosevelt on how to seize the large capacity of science that had been rendering services to war through its reconversion on peacetime science for national welfare.

The decades to come started to establish a consensus on the important role of science, technology and innovation and on the need to study these items from different points of view. The development of concepts, methodologies and theoretical models by authors in the line of Freeman, Nelson, Winter or Rosenberg allowed a deepening understanding of these phenomena (Godinho, 1999) while governments and national and international institutions became more and more interested in obtaining quantifiable measures of their innovative performance. Additionally, the development of such measures became a central issue on the agenda of such institutions as the OECD, mainly concerned with a conceptual and methodological approach harmonized between all its member countries able to monitor this area. By the beginning of the 60's it had developed a manual for the measurement of science and technology activities: the Frascati Manual, at present in its sixth edition (OECD, 2002). This manual, for its clear-sightedness in the definition of R&D and its components, has been adopted in R&D surveys throughout, being its main scope the measurement of human and financial resources for R&D.

After that, the work undertaken in this area has started to show how focusing only on R&D inputs could be an incomplete measure of innovative capacities. As Freeman (1977, pp. 249-250) highlights "a number of writers (Charpie, 1967) have suggested that R&D is a low proportion of the total costs of launching a new product or a new process and have pointed to the importance of the other costs which are incurred by the innovating firm, such as tooling, detail design, and sales promotion". This understanding led to future improvements in the Frascati Manual and also to the emergence of a series of methodological manuals known as the "Frascati Family": on innovation (the Oslo Manual – OECD/EU/Eurostat, 2005), on human resources (the Canberra Manual - OECD/EU/Eurostat, 1995), on the technological balance of payments (TBP Manual – OECD, 1992 b) and on patents (Patent Manual – OECD, 1994). Additionally, other relevant methodological guidelines and handbooks were produced on

productivity measurement (OECD, 2001), on globalisation indicators (OECD, 2005 a), on the information society (OECD, 2005 b) and on biotechnology statistics (OECD, 2005 c).

The Oslo Manual (OECD, 1992 a) arose in a context of consensus around the need for better measures of innovation to provide policy makers with a more accurate map of the state of affairs. During the 80's and the beginning of the 90's a set of national trial surveys based on the direct observation of innovation at the firm level ("subject" approach (Smith, 2005)) draw the bases of what was to be the Oslo Manual. This manual, prepared jointly by the OECD and the Nordic Fund for Industrial Development (Nordisk Industrifond, Oslo), established a framework of analysis focused on technological product and process innovation in manufacturing firms, thus leaving non-technological innovation, such as organisational change, and the services sector consciously outside of its scope. This first edition served as reference for the first large-scale innovation survey produced in 13 European countries, the Community Innovation Survey (CIS), covering the three year period from 1990 to 1992, which, in turn, largely influenced the first revision of the manual. The second edition (OECD/Eurostat, 1997) comes out when terms as "knowledge-based economy" or "National Innovation Systems" are stressed all over in the context of innovation policies "only recently emerged as an amalgam of science and technology policy and industrial policy" (§ 8). The main difference of this edition is its extension to services, while non-technological innovation remains uncovered:

> "The previous version of this manual dealt only with innovation in manufacturing industry. Since then the spotlight for employment and production issues has turned to services, hence the need to find out more about their technological activities. It is already clear that services are the main users of innovation generated in manufacturing industries (OECD, 1995). Recent R&D surveys suggest that they are playing an important role in generating knowledge (OECD, 1996). In many fields the limit between industry and services as innovative sectors is blurring (*e.g.* software takes an increasing share in most innovations reported as coming from industry). Hence the need to extend innovation surveys to the services" (OECD/Eurostat, 1997, §126).

Further progresses made within the Community Innovation Surveys framework, as well as new findings in economic literature, altogether with the own changing nature of innovation and thus of policy needs concerning to it, compelled the Oslo Manual to a new revision completed in 2005 (OECD/EU/Eurostat, 2005). Innovation in services was not properly covered by the definition of technological innovation proposed in the previous edition (OECD/EU/Eurostat, 2005, pp. 3), which led to the most important change in this revision: the scope of the term "innovation" has been expanded to include what many innovation studies addressed as important sources of change for value creation in the firm context: marketing and organisational innovations.

Thus, what is considered an innovation in the newest Oslo Manual approach can be separated in four areas: product, process, marketing and organisational. The first two are considered technological innovation, while the other two are the non-technological ones. What can be the implications of such an extension? Considering that the Oslo Manual, for its provenience, scope and influence, is now an important guideline for innovation studies, while providing a conceptual framework for the reflections about the nature and the process of innovation, we may view this extension as a generalisation of the significance of the organisational and marketing components for the firms' strategies towards innovation. This extension allows considering many more relevant innovation activities, performed by lower tech industries or by smaller enterprises, than what is traditionally associated to innovative activities. And allows a more realistic approach to what goes on in the diversified services sector (this is discussed in more detail in the next topic). Discussions on innovation easily comprise what goes on in high technology industries, but just about the more recent years other sectors were brought into the debate (e.g. von Tunzelmann and Acha, 2005 for innovation in low-tech industries). Knowing about the economic weight of low and medium-technology industries, or small and medium sized firms in the context of the western capitalist societies and, furthermore, the relevance of services innovation and its contribution for the whole economic growth, emphasized in recent innovation studies (e.g. Miles, 2005 and Howells and Tether, 2004), we can conclude that the Oslo Manual approach is a step forward to think innovation in the context of a globalised knowledge-based society. On the other side, it is subject to criticisms, as any approach, in particular due to the freshness of the non-technological innovation concepts. Nevertheless it's a clear and organised framework.

3.3 Innovation in services

One of the guidelines for the outset of the model presented was to illustrate that services show some particular features in what concerns innovation that should not be neglected. In fact service innovation, both in services or in manufacturing firms, shows distinct characteristics from innovation in goods. Nevertheless, we bear in mind that services, and thus services innovation, are hard to conceptualise or measure.

Services sector is, as manufacturing, composed of many different sub sectors. Any generalisation in what concerns to the services innovation process may suffer from the same criticisms pointed to generalisations in industry innovation. Miles (2005) stresses these differences intra-services in terms of patterns of technologies used, relevant markets' characteristics and technical skills required. As for the technologies there can be a distinction between small-scale business services, FIRE (fire, insurance and real estate services),

distributive services, HORECA (hotels, restaurants and catering), social and collective services and business services, each of them relying on technology in very different intensities. When looking at the services markets, they can operate on human clients, physical artefacts or data, symbols and information. As for the technical skills demanded they may range from minimal to professional qualifications. And combinations of these characteristics can lead to much diversified services sub sectors.

In the approach proposed by Howells and Tether's report to the European Commission on innovation in services (Howells and Tether, 2005), the heterogeneity in services is classified into a fourfold typology of different service activities and conditions: services dealing with physical transformation (transport, handling and storage, for example), services engaged in the transformation of information (data processing services, for example), knowledge-based services (design, for example) and services acting on people (health care or care for the elderly, for example).

Anyway, there are common features that distinguish services from industry, for example the intangibility, the difficulty to protect innovations via patent mechanisms, the interactivity between supplier and client or the simultaneity of production and consumption (Miles, 2005). One important fact to bear in mind when thinking about innovation in services is that "the sector includes the most concentrated, knowledge-intensive, and IT-intensive sectors in modern industrial economies (banking, professional services, etc.), as well as the least (retail, cleaning, etc.)" (Miles 2005, pp. 436).

Hertog (2006) developed a four dimensional model of service innovation that can help us to illustrate some general characteristics that apply to innovation in services. So, according to Hertog, two major distinct characteristics in the new service concept bloom: new services are typically intangible and not physical and often correspond to a new idea or concept of how to organise a solution to a problem. This leads to a subsequent characteristic: conceptual innovations (application of an existing service concept within a new market) "are much more likely to be found in service firms than in pure manufacturing firms" (pp. 7). The client interface is another dimension of distinctive characteristics, that is, service firms frequently innovate in the design of this interface, he claims, specifically through the client-specific marketing, production or even pricing. In business services, particularly, it turns out that "increasingly, there is no clearly identifiable point where the producer's activity stops and the users' activity begins" (pp. 8). A third set of distinctive characteristics within service innovation is, highlights the author, the major role of the service delivery system and of the internal organisation for the new service delivery while part of the client interface. Finally the fourth dimension of his model stresses the role of non-technological service innovations, while technological innovations work mainly as a

"facilitating or enabling factor, to something much closer to supply-push, technology-driven innovation" (pp. 9).

What innovation studies are by now concluding is that services are no longer mere technology adopters, though the adoption of technology produced in other sectors still is a major type of innovation, and recent empirical studies have shown that R&D is also a common feature in some services firms (Miles, 2005). Another conclusion of innovation studies is that the focus on innovation in services should not be centred in Knowledge Intensive Business Services (KIBS), but rather attention should also be pointed towards less complex and more routine services, for two main reasons: they are deeply affected by technological and organisational innovations and they employ the majority of people employed in the services sector (Howells and Tether, 2005).

Therefore, customization, incremental change, organisational innovation, intangibility, production-consumption simultaneity, supplier-client interactivity or delivery system relevance are characteristics frequently pointed as associated with services (and with services innovation) and that differentiate them from manufacturing firms by its foremost role in this sector' firms. Not mentioned before, but not least important for our analysis, is the generalised use of Information and Communication Technology (ICT) in the last two decades, that made possible a transformation within services provision that, not being exclusive to this sector since all other economic sectors where effected, spilled all over the socio-economic system. To use the picture suggested by Miles (2005), the ICT relevance for information-processing activities can be seen the same way as revolutionary innovations in energy technology (as the steam engine or electric power) were marks for the manufacturing activities.

In fact, in the last years services have invested more than manufacturing in the development of ICT, though there is different ICT exploitation among services. For example, considering the Howells and Tether (2005) fourfold typology mentioned before, ICT introduction can range from low to high innovative effort in each of these types of services. Financial services are nowadays among the higher investors in the development of new ICT applications while, on the other side, ICT introduction can mean merely new computers or mobile phones. But, as a result of the generalised use of increasingly sophisticated ICT among services we can identify some important aspects for innovation in services (that at the same time work as a cause of this generalised use and increased sophistication) (based on Miles, 2005): i) ICT is often introduced to improve service quality to customers (e.g. call centres); ii) ICT allows to automate many back-office work; iii) ICT is a powerful tool towards customisation; iv) ICT allows for a change in the spatial location of services; v) ICT allows for a change in the relation between firm and client; vi) ICT is a foundation for the creation of new services (e.g. online banking or mobile telecommunications); vii) ICT is an important tool to allow for other service innovations.

3.4 Innovation in low tech firms

The emphasis put up on high tech innovations, on science-based knowledge or on new technologies tends to overweight the role of high-tech firms in the analysis of innovation. Some authors have claimed that the knowledge economy has been habitually and erroneously associated with high-tech industries, despite the fact that these industries account no more than 3 per cent of the value-added in the OECD countries (Hirsch-Kreinsen et al, 2003). In contrast, the most important employer in the manufacturing sector in the European space is by far the firms in the low tech and medium-low tech sectors, with roughly 60 per cent, showing a remarkable stability in the latest years (Hirsch-Kreinsen, 2000). Moreover, in the European context of economies trade-specialized in low technology products (Hirsch-Kreinsen et al, 2003) the study of innovation in firms operating in such sectors is of outstanding importance. For the purpose of the model of the innovation process that we present further ahead it is essential to outline some characteristics of the innovation process in these sectors. Like many innovation studies, we will treat the “low and medium-low tech” sectors together and name them LMT.

3.5 Innovation in small firms

Innovative practices and business proposition often begin small, in small organisational settings. Small and medium sized firms innovate, but they tend to be more reliant than larger firms on external sources and conditions, in particular on national resources, research institutions, specialised suppliers and equipment providers (Jong and Marsili, 2006). Our framework should also accommodate the characteristics of innovative small firms.

4 The chain-interactive model

The innovation process may be assumed to begin from an insight of a gap in a potential market. The activities of technological scanning and monitoring, benchmarking and foresight, weak signal analysis, customer analysis, internal creativity, organisational capabilities, allow the emergence of new ideas to open new market segments, to improve products or processes, to improve the organization of the company or for best channelling the existing supply to its users. Some of these ideas are selected and become projects. The invention, basic design or the conception of the service are the first step in these innovation projects. At this point, the development of new goods and of new services can differ. The services have some peculiar characteristics. Their production and deployment tends to happen simultaneously. The innovation process proceeds then to include the commercialization or implementation phase

where many surprises occur, which eventually bring back the process to the drawing board. Ongoing results may be product innovations, process innovations, marketing innovations or organisational innovations.

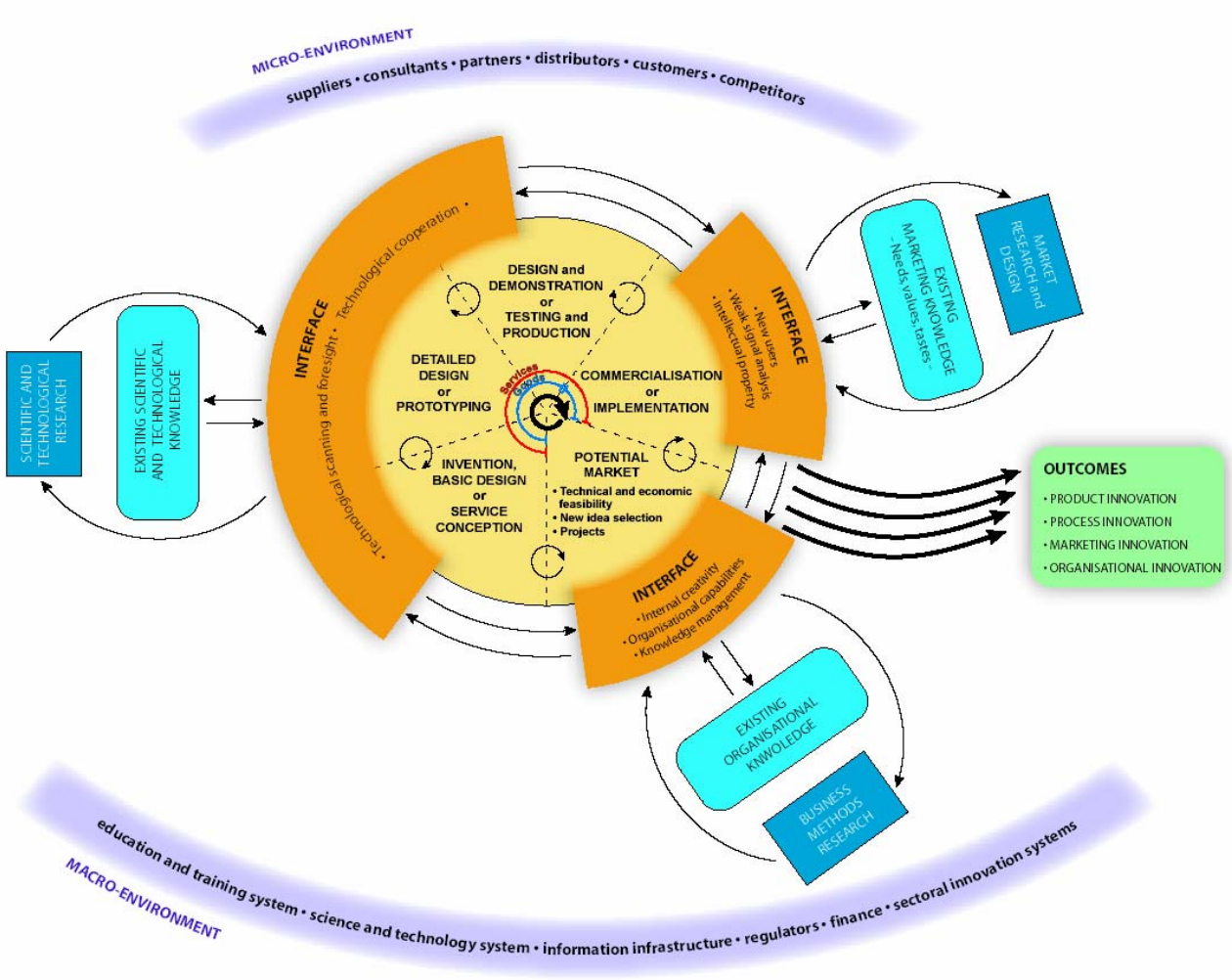
Along the innovation process interactions with other actors and feedback loops between phases are commonplace, making innovation a complex chain-linked and interactive process. The main transfer of information, from and to the external environment, happens between the commercialisation or implementation phase and the beginning of a new phase of potential market. The knowledge of the market and the sensitivity to users' needs are important assets for the development of ideas (conceived whether by the firm itself or by its users) that can originate new innovation projects.

The fundamental knowledge to develop the innovation projects can be readily available internally as part of the body of knowledge already existent in the business structure (core competences of the innovation process – an ensemble of established routines) or obtainable from the outside. On the other hand, new knowledge will have to be developed internally or externally through painstaking R&D, marketing research and organisational and business methods research activities (innovating routines). Thus, exploiting existing economically useful knowledge (organisational, technological, marketing expertise) and exploring new cognitive avenues constitutes the essence of business innovation.

The innovating firm is not disconnected from its context. An integrated approach to the phenomenon of innovation has to complement what goes on in the firm with a systemic understanding of the external climate that influences, facilitates, and inhibits the innovating efforts.

Figure 2 captures these considerations.

Figure 2 - Conceptual model of the innovation process in the knowledge economy - The chain-interactive model



Source: this article

According to our model there is not one single best way orchestrating the efforts conducting innovation. Dynamic capabilities that subvert old ways of doing business are always fed by three *knowledge pools*, which are composed by existing and perpetually renewed bodies of knowledge produced by society at large:

- Technological and scientific knowledge;
- Marketing knowledge;
- Organisational knowledge.

Innovation management depends critically from creating and managing interfaces. The model proposes the existence of three interfaces that are fundamental for an effective governance of innovative open (business) systems. In our model, interfaces represent the ability to

communicate, and communication is key to launch new learning cycles. Interfaces are composed by:

Technological awareness: systematic observation of external developments;

Technological cooperation: partnership activities with other institutions and organisations, with view of sharing technical and scientific information and jointly developing products and processes.

Technological scanning, monitoring and forecasting: systematic sensing of technological opportunities and efforts of futures research concerning the link between emerging technologies and new products.

New users: observation and analysis of potential customers and new markets;

Weak signal analysis: specialised perception of indicators of future change;

Intellectual property: using the possibilities of the intellectual property regime to protect, assimilate and disseminate ideas;

Internal creativity: procedures that leverage strategic awareness of opportunities and threats to the firm;

Innovation-friendly governance: organisational structure that favours innovation;

Organisational capabilities: strategic conception of organisational structures that favour innovation;

Knowledge management: generation, validation, codification and diffusion of in-house knowledge and management of knowledge needs.

At the core of the model we have the key steps involved in the innovation process: the eye of the creative gale of the innovation process. The nucleus of the figure refers to an ensemble of innovating routines (Pavitt, 2002) that constitutes the endogenous force of innovative economic activity. To that ensemble one may call the core competencies of the innovation process. To those integrated innovative routines plus the interfaces one may call dynamic capabilities.

Thus the centre of the picture shows the basic innovative activities that are networked between themselves. Again, they may be called the innovative routines that make up the core competencies behind the innovation process:

Potential market: phase of identification of opportunities for making new businesses, selection of ideas and innovation projects, study of technical viability and economic feasibility;

Invention, basic design or conception of the service: the innovation projects can have their origin in this phase. The basic design is applied mainly to goods, while the conception is applied mainly to the services.

Detailed design or prototyping: fine-tuning of the invention through the working out of details;

Re-design, demonstration or test and production: phase of adaptation of the innovation in cause to the results of the demonstrations or tests. In the case of goods, production begins.

Commercialisation or implementation: commercialisation of goods in the market or implementation of the developed services.

Actors and institutions make up the environment surrounding the innovating firm. Actors and institutions that form the context can be classified in the following way:

Macro-environment: complex set of factors in evolution that indirectly affect the probability of technical success and commercial profitability of the innovation, such as the education system and the public research infrastructure;

Micro-environment: closely situated elements that directly interact with the innovative procedures of the firm, such as suppliers, competitors and customers.

The innovation process generates outcomes, namely:

Product innovation: new or significantly improved goods and services;

Process innovation: new or significantly improved production or delivery methods;

Marketing innovation: fundamental or incremental changes in the ways of product design, packaging, placement, promotion or pricing;

Organisational innovation: fundamental or incremental changes in the structure (e.g. workplace organisation, external alliances) and strategy (e.g. business practices) of the firm and in the organisation of productive labour.

5 Final reflections

This paper advances a simple interpretative scheme that may be used both for deepening the understanding of the innovation process as well as acting upon its reciprocating dynamics. The model emphasises the open and interactive nature of innovation and at the same time provides managers and policy makers with a check-list of categories and links that may be used to nurture the innovation process itself. It is important to acknowledge this duality: first, and foremost, the model organises an understanding about innovation; secondly, it suggests ideas for filling gaps and correcting imbalances in actual innovation systems. It is a policy-friendly appreciative model, a working synthesis based on the systemic view of innovation. This paper is a preliminary introduction to the challenge, which we hope to develop in the future.

Bibliography

AENOR (2002), Gestión de la I+D+I: Requisitos del Sistema de Gestión de la I+D+I – norma española experimental UNE 166002 EX, Grupo 11, Asociación Española de Normalización y Certificación.

AENOR (2002), Gestión de la I+D+I: Requisitos del Sistema de Gestión de la I+D+I – norma española experimental UNE 166002 EX, Grupo 6, Asociación Española de Normalización y Certificación.

Bell, M. and K. Pavitt (1993), "Technological accumulation and industrial growth: Contrast between developed and developing countries", *Industrial and Corporate Change*, Vol. 2, No. 2, pp. 157-210.

Bush, V. (1945), Science The Endless Frontier: A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, United States Government Printing Office, Washington

Castells, M. (2000), *The Rise of the Network Society*, Vol 1, Second Edition. London: Blackwell Publishers.

Chesbrough, Henry (2003), *Open Innovation*, Cambridge, MA: Harvard University Press.

Cohen, W.M. and D.A. Levinthal (1990), "Absorptive capacity: A new perspective on learning and innovation", *Administrative Science Quarterly*, Vol. 35, pp. 128-52.

Evangelista, R. (2000), "Sectoral patterns of technological change in services", *Economics of Innovation and New Technology*, Vol. 9, pp. 183-221.

Fagerberg J. (2003), "Schumpeter and the revival of evolutionary economics: An appraisal of the literature", *Journal of Evolutionary Economics*, Vol. 13, Nº 2, pp. 125-59.

Fagerberg, J. (2005), "Innovation: A Guide to the Literature", in *The Oxford Handbook of Innovation*, Oxford University Press.

Fagerberg, J., D.C. Mowery and R.R. Nelson (eds) (2004), *The Oxford Handbook of Innovation*, Oxford University Press.

Freeman, C. (1977), "Economics of Research and Development", in *Science, Technology and Society: a cross disciplinary perspective*, edited by I. Spiegel-Rösing and D. Solla Price, London: Sage.

Godinho, M. M (1999), "Inquéritos à inovação em Portugal", in *O futuro tecnológico: Perspectivas para a Inovação em Portugal*, edited by Manuel Mira Godinho and João M. G. Caraça,

Hanusch, H. and Pyka, A. (eds) 2007. *The Elgar Companion to Neo-Schumpeterian Economics*, Cheltenham, Edward Elgar, forthcoming

Hargadon, A.B. & R.I. Sutton (2000), "Building innovation factory", *Harvard Business Review*, May-June, pp. 157-66.

Hargadon, A.B. (1998), "Firms as knowledge brokers: Lessons in pursuing continuous innovation", *California Management Review*, Vol. 40, No.3, Spring, pp. 209-27.

Herstatt, C. and B. Verworn (2004), *Innovation Process Models and Their Evolution*, in Bringing Technology and Innovation into the Boardroom: Strategy, Innovation and Competence for Business Value, European Institute for Technology and Innovation Management, Ch. 15, pp. 326-346, Palgrave.

Herstatt, C. and B. Verworn (2004), *The 'Fuzzy Front End' of Innovation*, in Bringing Technology and Innovation into the Boardroom: Strategy, Innovation and Competence for Business Value, European Institute for Technology and Innovation Management, Ch. 16, pp. 347-72, Palgrave.

Hertog, P. den (2006), *Knowledge Intensive Business Services and their role in innovation*, Presented at OECD KISA Conference, March 22, 2006, Sidney.

Hobday, M. (1998), “Product complexity, innovation and industrial organisation”, in *Research Policy*, Vol. 26, pp. 689-710.

Hobday, M. (2005), “Firm-level innovation models: Perspectives on research in developed and developing countries”, in *Technology Analysis & Strategic Management*, Vol. 17, No. 2, 121-146, June 2005.

Howells, Jeremy and Tether, Bruce (2004), “Innovation in Services: Issues at Stake and Trends – A Report for the European Commission”, INNO-Studies 2001: Lot 3 (ENTR-C/2001=, Brussels.

de Jong, J. and O. Marsili (2006), “The fruit flies of innovation: A taxonomy of innovative small firms”, *Research Policy*, Vol. 35, pp. 213-29.

Kamoche, K. and M. Pina e Cunha (2001), “Minimal structures: From jazz improvisation to product innovation”, *Organization Studies*, Vo. 22, Issue 5, pp. 733-64.

Kline, S.J., & Rosenberg, N. (1986), “An overview of innovation”, in R. Landau & N. Rosenberg (eds), *The Positive Sum strategy: Harnessing Technology for Economic Growth*, pp. 275-306, Washington, DC: National Academy Press.

de Marchi, M., G. Napolitano and P. Taccini (1996), “Testing a model of technological trajectories”, *Research Policy*, Vo. 25, pp. 13-23.

Miles, Ian (2005), “Innovation in Services”, in *The Oxford Handbook of Innovation*, Oxford University Press.

Nelson, R.R., e S. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, Mass.: Belknap.

Nouvel, P. (2002), “Introduction”, in P. Nouvel (ed.), *Enquête sur le Concept de Modèle*, Paris: PUF, pp. 1-4.

OECD (1992 a), *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual*, Paris, OECD.

OECD (1992 b), *Proposed Standard Method of Compiling and Interpreting Technology Balance of Payments Data – TBP Manual*, Paris, OECD.

OECD (1994), *Using Patent Data as Science and Technology Indicators – Patent Manual*, Paris, OECD.

OECD (2001), *Measuring Productivity Manual*, Paris, OECD.

OECD (2002), *The Measurement of Scientific and Technological Activities: Proposed Standard Practice for Surveys on Research and Experimental Development – Frascati Manual*, Paris, OECD.

OECD (2005 a), *Handbook on Economic Globalisation Indicators*, Paris, OECD.

OECD (2005 b), *A Guide for Information Society Measurements and Analysis*, Paris, OECD.

OECD (2005 c), *A Framework for Biotechnology Statistics*, Paris, OECD.

OECD/EU/Eurostat (1995), *The Measurement of Human Resources Devoted to S&T – Canberra Manual*, Paris, OECD.

OECD/Eurostat (1997), *The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual*, second edition, Paris, OECD.

OECD/EU/Eurostat (2005), *The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Innovation Data – Oslo Manual*, third edition, Paris, OECD.

Pavitt, K. (1984), “Sectoral patterns of technical change: Towards a taxonomy and a theory”, *Research Policy*, 13, pp. 343-73.

Pavitt, K. (2002), “Innovating routines in the business firm: what corporate tasks should they be accomplishing?”, *Industrial and Corporate Change*, Vol. 11, No. 1, pp. 117-33.

Prencipe, A., A. Davies, and M. Hobday (2003), *The Business of Systems Integration*, Oxford: Oxford University Press.

Tidd, J., J. Bessant and K. Pavitt (2001), *Managing Innovation*, John Wiley and Sons.

Tunzelmann, Nick von and Acha, Virginia (2005), "Innovation in "Low-Tech" Industries", in *The Oxford Handbook of Innovation*, Oxford University Press.

Verspagen, Bart (2005), "Innovation and Economic Growth", in *The Oxford Handbook of Innovation*, Oxford University Press.

Walliser, B. (2002), "Les modèles economiques", in P. Nouvel (ed.), *Enquête sur le Concept de Modèle*, Paris: PUF, pp. 147-60.