Essay on a new form of co-production of competence between academia and industry

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【Abstracts】

This paper attempts to construct a general framework which could serve as a common ground for the different studies trying to combine the new form of knowledge creation with the formation of high-skilled scientific and technical workers (academics, scientists and engineers). In this domain, complex interactions between higher education and research system, education/scientific policy agencies and firms play a crucial role in determining the functioning of labours markets and shaping its structure. It is one of reasons why we need both to combine its analysis with the general dynamics of innovation and to insert it into a global picture of the institutional configuration of R/D. Within such context, we will tentatively describe both the nature of new space of innovation and the dynamics of high skill/knowledge creation.

【Keywords】

Science-industry relationship, Competence creation, Hybridization, High-skilled workers, Labor market

Introduction

The production and diffusion of the knowledge required for production now take place within networks linking hitherto independent institutions: firms and their financiers and managers, on the one hand, and universities and research institutes, on the other. It might even be hypothesised that the changes we are witnessing represent, for the most part, attempts by these institutions to exploit to the full the new value attached to innovation and scientific research.

It is true that, for THE LAST four centuries, production generally developed at the same pace as scientific and technical knowledge. However, how was the knowledge required for work made available to firms? It was first developed and diffused largely within the workplace itself. It was then acquired by individuals through a specific learning process and recognised and evaluated by employers through various forms of codifications, particularly skill scales.

New innovation and employment norms are today calling into question traditional systems. Firms are forging crucial links with academic institutions and paying the salaries of researchers whose work is still coordinated and supervised by the academic
institutions to which they are affiliated. At the same time, teaching and research establishments are developing alongside commercial firms. Undoubtedly, it is often the case that the synergy of such relationships is more apparent than real, with the academic institutions simply being obliged to give way to the demands of their paymasters. However, is the phenomenon not wider than this in its scope and can the various phenomena observed not be conceptualised together as heralding new configurations of skill formation and joint innovations?

Perhaps there are grounds for supposing that a single corporate structure is gradually emerging, within which research and production will be increasingly unable to remain autonomous. Within this structure, institutions of different kinds and scope will come together, break up and confront each other – firms, states, university, and local or international interest groups - all of them increasingly closely linked by a shared set of principles animating both production and research.

The purpose of this paper is to construct a general framework which could hopefully provide a common ground for the different studies attempting to combine the new form of knowledge creation with the formation of high-skilled scientific and technical workers (academics, scientists and engineers). In this domain, complex interactions between higher education and research system, education/scientific policy agencies and firms play a crucial role in determining the functioning of labours markets and shaping its structure. It is one of reasons why we need both to combine its analysis with the general dynamics of innovation and to insert it into a global picture of the institutional configuration of R/D.

In the first part, we will start with a short overview of some selected literature on the innovation, from the standpoint of academia/industry relationship which structures the high-skilled or scientific labour market.

In the second, we attempt to link insights drawn from the overview to the labour market issues and to identify significant emerging phenomena in this domain.

In the third, we will seek out some analytical issues which could be relevant to future investigations.

Finally, we will conclude by some considerations on the new space of skill formation which is hypothetically emerging.

I. From conceptual antinomy of academia/industry relationship to integrated mode of innovation

i) The production and the use of scientific knowledge and technical competences have been for a long time considered as separated actions between academia and industry. Some scholars advanced a general model in which the weakness of the links between them was explained by the fact that the two belonged to two contradictory “worlds”. Academic teaching and research were viewed to be closed in upon themselves, locked into a mode of structuring and organising power dominated by the academic community. Universities provided education, firms provided training: the knowledge and expertise dispensed by these two institutions were considered to be wholly different in nature. It was natural for
basic science to develop independently of technology and of social needs.

From this perspective, the academic community is the key actor in higher education and academic research, with this "social circle", this "invisible college" (Crane, 1969) defining and limiting its own sphere of activity. The disciplinary matrix, the value and rule systems and the conflicts and controversies within the community in question constitute the principle by which this sphere exists. The members of community share a common paradigm and are therefore able to subscribe to the same regulatory mechanisms and to construct common interests and beliefs. These are acquired through contact with other academics and the habits and customs of their particular disciplines. They are transmitted during the socialisation process and shape the behaviour and professional identity of individual academics. The knowledge and expertise that serve as a basis for these various learning processes are usually theoretical, generic and formalised within an academic discipline. Adherence to the rules, values and interests of the community, which is reinforced by the system of symbolic gratification and by control of the profession, contributes to the construction of the "academic citadel" (Merton 1973, Dasgupta & David 1994). Finally, Academic labour market is auto-generative and reproductive.

Firms, in contrast, could be characterised by a mode of operation shaped by the competition to which their products are exposed in the market place, by short-term profitability and a hierarchical mode of organisation geared to the fulfilment of specific strategic and financial objectives. The researchers/engineers are governed by explicit rules of career competition that could be both external and internal to the firm and under the control of the owner of the capital or of his representative. The knowledge and expertise produced are applied to a given economic objective; they may be formalised but are often tacit and firm-specific. The incentive mechanism corresponds to an usual - and standard - maximization of individual monetary gains.

This type of model is based on the simplified stereotype of individual agents as well as the linear trajectories of collective entities (research organisations, firms, laboratories, teams). It takes no account of the interactions between agents and privileges certain occupational categories to the detriment of others. Nor does it take any account of the division of labour or of the way it is organised. On the one hand, it focuses on the links between scientists that exist within the academic community but ignores the role and knowledge distribution between scientists, engineers and technicians as well as the variety of different sources of funding (Callon 1994, Nelson et al. 1993). On the other hand, it restricts researchers’ activities to those that the academic community recognises and legitimates, that is it fails to take into consideration the relationships that academic organisations, laboratories, research teams and individual scientists have with their environment, and particularly with firms (Latour 1996).

The agents in these two "worlds" are supposed to be sufficiently far apart from each other for relationships between them to be sporadic and fraught and to amount to little more than attempts by one to control
the other. Thus, the academic community is considered to be more or less incapable of understanding industrial needs, while fulfilling a commercial objective or meeting a specific social need is incompatible with its fundamental task of producing knowledge. It responds to social demand, only because it is forced to do so, particularly as a result of cuts in public funding, which have had a negative impact on the quality of its output. Firms, for their part, have no other objective than their own financial profitability and invest only in targeted research carried out externally. From this perspective, relationships between the two “worlds” are possible only through the intervention of “intermediaries” (individuals, organisations or institutions) capable of bridging the gap (Carlson, 1994; Dodgson & Bessant 1996) between firms and academia.

ii) The second model contrasts with the linear view over the links between academia and industry. This approach tends to consider that there are much more complementarities and analogies between academia and industry. Markets and hierarchies inform both systems, their objectives might be compatible, if the compromises were well arranged. Occupational identities of agents in the two “worlds” (for example the researchers) could be closely related, even though there exists a difference of incentive mechanisms. It is therefore possible to establish networks of productive relationships between the two, linked either to the construction of competences or to the production of knowledge. These networks are both a vehicle for information flows and the means by which the resources of all those involved in innovation are coordinated (Knorr-Cetina 1982; Laredo, Callon & Mustar 1992). By strategically devising relationships and creating trust between the partners, the research contracts make it possible to extend the boundaries of economic organisation beyond the firm. Thus Aoki (1988), Dusgupta and David (1988) or Cohen and Levinthal (1989) note that the increasing co-operation on R&D both between firms and between firms and the higher education and research system may indicate that a new form of industrial organisation is emerging. This model emphasises the strong and recurrent interactions between the initial socialisation in higher education system and the construction of competences in firms. From this perspective, it is no longer relevant to think in terms of a clear distinction between the basic research carried out by scientists in academic institutions and the applied research performed by engineers in firms. Any analysis must take account of the dynamic of the innovation cycle, the construction of competences, the knowledge flow and the various incentive systems in the integrated and interactive ways. These processes tend, through a multiplicity of feedback loops, to bring into play different functions/expertises/resources within research organisations and firms (Kline and Rosenberg’s chain-link model, see Kline and Rosenberg 1986). From this point of view, there are "grey zones in which academia and industry interbreed" (Callon and Foray 1997). This non-linear model thus stresses the possibilities to reduce the diverging gaps - cognitive, strategic and occupational etc. - between academia and industry, although reckoning the very existence of tensions and conflicts between interests, norms and values.
The global idea advanced here is that these two models could be put on the historical evolution of innovation systems. Such view is explicitly expressed by the school of triple helix (Erzkovitz & Leydesdorff 2000 a and b).

Taking transfer mechanisms of knowledge and competence as their starting point, the triple helix theorists extend the analysis of the innovation dynamics to embrace not only the relations between firms and the academia but also the state. Each of the three helices represents one of the spheres (Industry, Academia and Political power) and has its own internal coherence, dynamic, strategy and capacity for change. They argue that while these spheres have been for a long time relatively independents each other, in recent years they begin to interact mutually and produce overlapping spheres of interference. Thus, firms are forging strategic alliances among themselves or with higher education and research systems. The latter are not only producers of qualifications and knowledge but are also economic agents, as reflected in the emergence of the "entrepreneurial university". The state is opening up itself to various public actors (various groups and institutions) characterised more by the production of public goods at different levels (local, regional) than by their participation in acts of government. Each time these various partners establish relations, the interaction between the different modes of coherence and dynamics produces a range of non-homogeneous and non-synchronised reactions that act upon and disrupt the principles animating the partners' actions. This disruption forces each of the partners to negotiate and put in place a series of "arrangements", both internally and vis-à-vis its partners.

Finally, such repeated interactions end up creating an "overlapping sphere" where various principles, rules and practices hybridise.

The concept of "helices" is very similar to that of "spaces" utilized by "societal analysis" (Lanciano, Maurice, Nohara and Silvestre 1998; Lanciano-Morandat, Nohara 2013) in conceptualising the context in which the actions are structured and in the highlighting the varying degrees of compatibility between different dynamics. But the triple helix theory, based on the macro-political science, seems to lack eventually the construction of "actor" which behaves in context.

II. Dynamics of Labour market for researchers\(^1\) in an Integrated Mode of Innovation

i) Specific role of high-skilled labour market

It doesn't seem unreasonable that we take very seriously the propositions made by the Triple helix theorists as to the emergence of new dynamics of innovation. At least, as a working hypothesis, we could agree with them about the fact that the new forms of science/industry relationship are being forged. If it is the case, we must ask ourselves the double question of how the scientific labour market is affected by this trend and of

\(^{1}\)The notion of a labour market for researchers used in this paper is defined as "a labour market for individuals engaged in research activities, whether they be public or private, basic or developmental and whether the activities in question may properly be deemed to be those of a researcher or those of a scientific assistant contributing to the actual realisation of research activities" (D'Iribarne 1987).
how the new actors appearing in the labour market contribute to shape the new space of innovation at the intersection of academia/education and industry.

To do so, we can mobilise many conceptual tools forged by labour economists or sociologists which might be complementary. For example, neoclassical economists use often the human capital theory, implicit contracts theory, signalling theory etc. in the analytical framework of "new economics of science" (Stephan 1996). With the rigorous methods, these approaches produce some significant results and bring interesting insights to the institutional and descriptive analysis of labour market for scientists. Focused heavily on the scientific production with the bibliometry, they however offer little works on the labour mobility of researchers or on the transfer of knowledge between academia and industry.

Sociologists also develop some useful tools like a concept of network which can be used in the analysis of labour mobility. As Callon (1991) stated it, knowledge and competences must take on a tangible form for its circulation: scientific articles, data, patents, technical objects, computer programmes, trainees, engineers, post-docs, etc. These various objects/actors connect each other through networking, which creates the "alignment" process of divergent interests. Although it is the task of the scientific community to formalise or codify knowledge, some knowledge remains tacit: a part of the new knowledge generated remains embodied in human actors in the form of competences. Since knowledge is fundamentally 'sticky' (von Hippel 1988) and tacit knowledge is context-dependent, it cannot easily be separated from the contexts or individuals that generated it. Although Callon argues that technical objects are also actors that serve as a medium for human capacities and play a part in constructing networks, it seems to us necessary, nevertheless, to attribute a particular status to human actors such as researchers, post-docs, professors, technical experts and so on. They only have an autonomous/endogenous -although partially- capacity of interpreting the context/object and changing the nature of networks.

That signifies that the high-skilled labour market (academic, scientists, and engineers) plays a specific role, which is not reducible to alignment of objects, in the dynamics of innovation. These human actors could be privileged tools for analysis of the structuration of the hybrid space that is emerging at the interface between academia/education and industry. The human actors are constructed, as occupational categories (scientist, teaching staff, engineers etc.), through the interdependent relationships between, on the one hand, forms of socialisation forged within the higher education and research system and, on the other, modes of organisational behaviour structured by firms' R&D and human resource management practices. The principles governing the functioning of institutions and of the linkage between the academia, public agencies and firms, which are often unique to a region or country, are encapsulated in these human actors. At the same time, these communities of actors draw on the cognitive resources at their disposal and on the principles governing their professional modus operandi in order to help to specify this hybrid space and to construct specialisations in various technological fields.
In view of the importance of human actors in the circulation of knowledge, the formation and mobility of the competences embodied in workers - that is properly the labour market issues - become a crucial factor in any analysis of innovation dynamics. For this reason, it seems useful to introduce a new notion of labour market with a view to fully seizing this complex, fluid and transient state. We could name it, temporarily, “intermediate labour market” which might help us to capture the new modes of coordination between universities and firms in the domain of co-production and transfer of competences. This intermediate labour market can be seen also as one of the “bridging institutions” that function as intermediaries in the transfer of knowledge/competences between the academic and industrial spaces. It goes without saying that this mobility, embedded as it is in a set of societal/local contexts, has to be captured across the entire set of institutions that contribute to the production and circulation of competence.

ii) Hybridisation of the academic and industrial spaces

As technology and science converge to produce interactive innovation in accordance with the chain-linked model (Kline & Rosenberg 1986), industry and academia, represented by the scientific community within the higher education and research system, intersect and begin to merge partially with each other. The “scientific” labour market, hitherto divided into the “republic of the scientists” and the “kingdom of the technologists/engineers”, cannot remain unaffected by such a trend. Although these two spaces still have their own aims, their own principles governing the utilisation of results and their own modes of evaluation, their convergence gives rise, nevertheless, to hybrid forms of rules and coordinating practices. It seems to us that at least three new types of segments could be identified, all of them produced by the hybridisation of two spaces, which give rise in turn to new modes of functioning, new forms of mobility or new actors at the interface between academia and industry.

a) Hybrid occupational segment

The restrictions, relative to their growing needs, on the resources available not only to universities and research organisations but to firms as well, combined with an increasingly short innovation cycle, have led to changes in their innovation strategy. They are all now seeking to establish partnerships in order to pool resources, minimise risk or increase synergy effects. Thus, collaborative relations between research units and firms are proliferating and taking on forms that are increasingly contractual, long-term and productive for both parties. Such collaboration may take the form of a framework ‘research agreement’ laying down the conditions for a series of contracts between the two parties over a stipulated period, a research consortium, a joint laboratory or even jointly funded doctoral programmes, in which the students are jointly supervised by the firm and the research institution to which they are affiliated. These links give rise to networks through which not only knowledge but also, and above all, scientists themselves (private and public-sector researchers or research-active university teaching staff) circulate on a temporary or permanent basis.
This increasingly two-way traffic, although generally considered as weak in European countries, compared with USA, constitutes a segment that we denote by the term “hybrid occupational”. It is in this first segment that the greatest share (in both quantitative and qualitative terms) of “hybrid” careers straddling the academic and industrial spaces.

**Figure - The new scientific labour market: an intermediate labour market based on the hybridisation between academia and industry:**

Co-ordination effort by the authorities

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**b) New type of leaning segment**

Similarly, the formation of competences is increasingly taking place on a collaborative basis. As a result, a growing share of scientists/engineers is being jointly produced by the Higher education and research system and firms, which is creating what might be called a learning segment. There are two typical scenarios in this second segment. In the first, Universities and Firms tend to co-manage some teaching programme for engineers, or to organise jointly the internship for graduate students. In view of their numbers, they constitute a pool of expert flux that is essential to
cement academic or university research units and industrial activities. In the second, increasingly frequent scenario, students are enrolled in programmes whose content is common to firms and academic or university research units; examples would include the CIFRE programme in France and the CASE scheme in the UK. Doctoral students are selected and jointly funded on the basis of criteria negotiated between the academic and industrial partners and their academic progress and/or work in industry are jointly monitored and evaluated. Increasingly, they are guaranteed subsequent employment in the organisation in which they have completed their education.

c) Transitional segment

The third segment, which we describe as “transitional” between the academic and industrial spaces, is characterised either by the creation of “new services”, such as consultancy services, that contribute to the innovation process and straddle the academic and commercial worlds, or by spin-offs set up by researchers or universities. Post-doc contracts proliferate in this segment. Located half-way between “training” and precarious scientific employment, such contracts give firms access to a highly skilled workforce, a veritable repository of new knowledge and know-how, without them having to commit themselves to a period of employment greater than one and half years. They also enable research institutes to employ new PhDs to work on projects while they wait for a permanent position or to implement technology transfer projects aimed at industry. Sometimes, the same individual may hold a succession of post-doc positions, particularly in high-tech areas such as the biotechnologies. Nevertheless, this holding of a succession of post-doc positions, which is caused by the “queuing” phenomenon, often makes it more difficult for the individuals concerned to obtain a permanent academic position (Mangematin 2000; Mangematin, Robin 2003).

Thus the “scientific” labour market is evolving from a form in which there was a clear distinction between academic and industrial careers towards increasingly less “pure” and increasingly more “mixed” or “hybrid” forms.

iii) The emergence of the “intermediate labour market”?

The existence of these various, mutually interacting segments might be leading to the construction of a new type of labour market in which the networks through which scientists and high-skilled experts circulate and new career paths, such as those offered by academic spin-offs for example, are disrupting the previously well-established mobility system. We don’t think inappropriate to use, as at least working hypothesis, the concept “intermediate labour market” to denote this new form of market, because it is the product of different dynamics jostling up against each other in a new hybrid space and because at its core lies the threefold relationship between industrial, academic and public actors as we saw it (Ezkovitz & Leydesdorf 2000).

From our point of view, the intermediate labour market denotes a set of coordinating mechanisms by means of which two (or more) partners are able to procure the human resources, competences or expertise required
to generate new ideas or realise innovations. This notion goes beyond the general definition of the labour market as a system for allocating the production factor “labour” through pure price mechanisms. It is a notion in which the principles governing markets and those governing organisations interpenetrate, reflecting a process of hybridisation between what economists customarily describe as the “external market”, in which adjustments are realized through both the price mechanism and the free choice/movement of individuals, and the “internal market”, whose rules (embodied in incentive systems) guide the construction of career paths over time. This hybrid space is essentially structured around the use of mobility networks, which give tangible form to the compromises that emerge from “bilateral governance”\(^2\) - in the sense of the term ascribed to it by Williamson (1985). Within this space, and despite differences arising out of frequently contradictory institutional objectives, the strategies of universities and those of firms, together with the individual choices made by students and researchers, come up against each other in order to determine common interests.

In our view, the methodological and analytical value of introducing the concept of “intermediate labour market” into our analysis is threefold.

a) It allows us to focus not on the exchange of already formatted or certificated competences but on the **co-production of resources or competences** (Lundvall 1998), which is playing an increasingly central role in the non-linear model of innovation. The notion of the intermediate labour market takes us beyond the rules governing market transactions in order to describe the institutional arrangements that enable resources to be shared and knowledge and competences to be jointly produced at the interface between academia and industry.

b) It helps us to take account of the fragmentations of this intermediate space that necessarily arise out of the tensions between the principles animating the academic and industrial spaces, which are sometimes complementary and sometimes contradictory. Since the compromises between the two worlds are always fragile, there is a need for flexibility that leaves its mark on the intermediate space. The fragmentations frequently manifest themselves as pairs of opposing characteristics, such as precarious/stable, statutory/non-statutory, education-training/work, wage work/non-wage work and so on. The intermediate labour market can impart an overarching meaning not only to a particular configuration of the various segments but also, and above all, to their permanent reconfiguration, since the boundaries of each segment remain porous, permeable and shifting.

c) It enables us to incorporate into our analysis the temporal aspect of the overall dynamic. The adjective “intermediate” denotes

\(^2\)We are in fact dealing here with “trilateral governance” if we include the state as an actor intervening in science or higher education policy. This last actor, whose activity varies in intensity from country to country, has the capacity to structure the intermediate labour market by various means, including grants, research funding, management of university posts and so on.
the positioning not only at the interface of two spaces (the mediating function) but also between two states in the evolution of organisational forms. For example, a spin-off from academia evolves over time, moving, if it is successful, from the status of publicly-funded researcher/project group to a standard corporate form, via an intermediate status such as 'company founder nurtured in academia', 'new start-up consisting of a founding team', 'unincorporated' company and so on. As that example clearly demonstrates, the notion of the intermediate labour market is a tool for analysing a temporary state that exists prior to the solidification of an organisational form. In this sense, our approach is closer to that adopted by Callon (1995), which involves studying 'knowledge in the process of being created' (competences here in our case) by making a distinction between the "cold" world of economists, that is the market, and the "hot" world of sociologists, that is the space in which the creative activity takes place.

III. what analytical issues should be addressed in international perspective

The "hybridisation" of science and technology is creating a new intermediation space between academia and industry. The creation of this new space has been accompanied by the emergence of new structures, such as academic start-ups, university incubators, public-private mixed labs, research consortiums etc., whose purpose is to facilitate the interactive circulation of knowledge between the academic and industrial spaces (David & Foray 1995; Stephan 1996). The emergence of what we called the "intermediate" labour market as a mechanism for the co-production and transfer of competences is an important element of this general phenomenon.

Although this "hybridisation" is taking place everywhere, it might take different forms depending on the characteristics of the national space whose pre-existing institutional arrangements exert a strong influence over the actors and the functioning of intermediate labour market. Indeed, higher education and research institutions, which in all the countries are the heirs to a considerable national heritage (Maurice, Sellier, Silvestre 1986; Buechtemann & Verdier 1998; Lundvall 1992; Lanciano-Morandat & Nohara 2013), shape the basic architecture on which the arrangements, rules and practices governing university/industry relations are based. The construction of scientific competences occurs in such overall societal context.

At the same time, a national set of basic arrangements could be, to variable degree, modified according to disciplinary nature of science, or adapted to local (regional) and sectoral contexts (Mangematin 2000). Equally, the emergence of supranational rules/practices at the European level exerts a heavy pressure on the national framework of higher education and research system. Therefore, it is vital to question to what extent the national characteristics of "intermediate labour markets" are modified by disciplinary/sectoral elements - which could be considered as "universal"- and the local (regional) contexts which are by definition idiosyncratic.

Beyond this generality, it is possible to point out three strategic domains of research which might in a way correspond to research lines underlined in the future programme.
As we pointed out above, we can identify three different segments on the “intermediate labour market” in emergence.

i) What we called “new type of leaning segment” constitutes important analytical objects. There are two categories of actors to be analysed in an articulated way.

Firstly, it embraces various issues on the (re)production and distribution process of PhDs, namely, modes of doctoral training, PhDs financing problems, modes of training-job transition, determinants of occupational bifurcation etc. These issues, in particular PhDs demand/supply matching, can be dealt with econometric tools on the ad hoc hypotheses. Also, the existence of longitudinal micro data on the insertion of PhDs in the labour market (in some countries) allows the quantitative investigations, which could bring out precise pictures of training-job transition. Methodologically, these works are likely to be based on the individual choice model, like human capital, signalling or labour queue theories etc.

From another analytical perspective, we can present a complementary way of analysing these issues. We define the position of PhDs – and of doctoral students – as a conjunction of three functions: i) they are the resources used to produce the scientific output of the teams ii) the pool from which the next generation of scientists in academia will be drawn. iii) the primary vector for the transfer of knowledge between academia and industry.

In order to complete these different functions, various institutions (university, lab, research team, funding organism, government agencies, firms etc) interact. The PhDs put themselves in different forms of division of labour in the scientific production. Thus, the production/distribution of PhDs brings into play a multiplicity of institutions at various national or local levels and mobilises the various resources available to them. Put it differently, PhDs can be considered as an institutional product who reveals the characteristics (qualitative) of national regime of higher education and research.

The observation of their evolution could provide us a good indicator which monitors the way the “hybrid” space or “intermediate labour market” are being forged in each European country. From this point of view, the development of CIFRE programme in France and the CASE scheme in the UK, where doctoral students are selected and jointly funded and monitored by the academic and industrial partners, is a good example of “hybridisation” of academic and industrial principles. We must investigate further this type of cases, based on the field research and statistical study, in different countries (Lam 2000, Lanciano-Morandat & Nohara 2013).

Secondly, it could be fruitful to enlarge the horizon of labour market for scientists and to address some specific questions about the category of “engineers” who play a crucial role both in the division of labour in academic research system3 and in the transfer of academic knowledge to the industry. The engineers have different range of problems

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3. As big science needs a huge range of big equipments, the co-operation between scientists and engineers has been one of determinant elements in scientific production. More recently, the industrialisation of scientific production with more division of work needs a complex mode of coordination between different categories of research workers (David & Foray 1995).
from that of PhDs. There might in particular exist two: the first concerns the skill certification problem at higher education level and the second the “internship system” for the future engineers. These questions, if treated correctly in a comparative perspective, could bring a new light on the high-skilled labour market.

Competence and certification

Labour market transactions are always characterised by uncertainty caused by informational asymmetries. One of the ways in which this uncertainty can be reduced is to evaluate individuals and their competences on the basis of the signals they transmit in the form of qualifications, experience, areas of specialisation, research topics, institutional affiliation, etc. These signals include, on the one hand, more or less objectified elements, such as degrees and publications record, which constitute a form of certification of competence and quality and, on the other, subjective elements, interpreted by the actors, which provide the basis for reputations. Thus “certification” and “reputation” are two major modes of coordination around which the encounter between supply and demand in the labour market is organised. Nevertheless, these modes of coordination become increasingly less satisfactory as subject corpora evolve ever quicker and the boundaries between disciplines become blurred in certain areas of scientific/technological specialisation. Nor do they any longer provide an absolutely sound basis for matching supply to demand in R&D activities. As a result, an alternative mode of adjustment is emerging at the interface between the academic and industrial spaces: networks make it possible not only to identify, contact and sift the talents that best match specific needs but also, and above all, to co-produce them through university/industry collaboration (Callon 1991). The recruitment of engineers depends, to a fairly large extent, on these types of mechanisms.

However, these mechanisms, which are intended to reduce uncertainty or to bring the two spaces closer together, are deployed within a set of national institutional arrangements, including national certification system. In consequence, they are regulated differently and have meanings that differ considerably from country to country, particularly as far as the recruitment of engineers is concerned.

This issue is closely connected to the vast problematic of trans-border labour mobility.

The internships, a form of University/Industry co-operation

The engineers' internships-training in the firm might be thought to be one of the fundamental elements cementing higher education and research system/industry relationship, even if this phenomenon often has little visibility. The flows of students repeatedly crossing the borders between the two worlds each year thus constitute the main networks structuring the labour market and feeding the intermediate space of innovation. Although it is difficult to measure, the effectiveness of the internship undeniably strengthens the firms' abilities to anchor themselves in the innovative environment.

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4. This argument is common, as for PhDs who go to the industry after their thesis.
which is notably true for the SMEs. There seem to be different reasons pushing the partners to dialogue and co-operate in this area, often going beyond considerations of the short-term cost/advantage calculation.

For the firms, the organisation of the internship may permit the creation of a pool of future hiring candidates or the observation and testing of the students' individual qualities beyond the formal signalling of their academic certification, or the assignment of an intermittent technical study or the gaining of advanced information or knowledge about certain technologies through the interns.

For the universities, the internship is one means of placing students in the labour market, gaining current information about the technological needs of a constantly changing industry and improving the quality of training or reorientating research through the resulting feedback. The graduate engineers, meanwhile, develop their professional ability by complementing their academic competence with practical work experiences aimed at solving concrete problems.

One should take a closer look at these different mechanisms and its evolutions, taking in account an institutional set of engineering formation. It might shed a new light upon the coordination mechanism between Higher education system and Industry.

ii) “Hybrid occupational segment” comprises the institutional changes both in the scientific/professional trajectory in academia and in the scientists/engineers’ career path within industry.

Inter-organisational motilities

Recently, OECD issued an important report on the labour mobility of high-skilled workers in some Scandinavian countries, based on the existing micro-data. One of main themes is about the mobility of “higher educated staff” between public and private sectors. The very effort of quantifying such movements between public and private sectors is important, because this type of mobility corresponds to the diffusion of knowledge/competence embodied in human actors. This type of works must be kept in the pipeline.

At the same time, we must put forward more qualitative problems on the compatibility/incompatibility between the academic and industrial careers of scientists/engineers. These issues should be addressed in a comparative way, to bring together into consideration the evolutions of academic promotion system and personnel management system of R/D staff in firms.

In academia, several European countries have already tried to reform the academic careers in Universities or in the Public Research Institutions. Some countries abandoned so-called “tenure system” playing main incentive mechanism in academic careers, or other countries made more rigorous the selection/promotion process of academics.

It now could be possible to attempt the first assessment of whether these changing work rules, procedures and selection models in academia (University and National Research Institution) boost the labour flexibility for science (and scientific productivity?) and

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5 These different motivations vary from one sector to another: the ICT companies often use interns as a supplementary workforce, while in pharmaceuticals it tends to serve as a hiring filter (Mangematin & Mandran 1999)
increase the institutional compatibility of access between public and private sectors.

On the other hand, we know little about the career management of scientists or R/D engineers in firms, apart from some stereotyped images. In particular, it is necessary to distinguish the characteristics of incentive mechanism put in place in the R/D functions from more general model within firm (Lanciano-Morandat & Nohara 2001). Then, it doesn’t seem impossible, for example, to construct a salary model of R/D engineers in the private sector and to compare with that of academic scientist, which could conduct to estimate so called “opportunity cost” for (public) researchers or mobility barrier between private and public sectors.

Start-up by the scientists

In number of European countries, universities and national research institutions are encouraged to organise “incubators”, in order to boost academic start-ups. This is the most direct way in which the academia can transfer its knowledge/competence to the Industry. They therefore put in place a range of supporting or incentive policies (Business plan consulting, IP management, funding aids, marketing etc.), to fulfil a huge gap separating the academia from commercial activities. Along with such institutional arrangements, the administrative measures concerning the personnel status of (public)researchers (paid leave for an incubation period, possibility of return to prior position after launching start-up, compatibility of academic status with private ownership etc.) are also taken. Beyond these administrative aspects, we might however investigate to know how launching a start-up is articulated with the academic trajectory of researchers, and what meanings such event could have in the evolution of professional/academic careers for scientists or academics (Muster 1998; Jolivet et al. 2009).

In short, it could be fruitful to consider the creation process of academic spin-off as a professional trajectory of actor(s) and at the same time as competence construction in evolution. This type of competence analysis in association with professional trajectory study could well complement more general analysis on the spin-offs research.

iii) “Transitional segment”

The third segment communicates with the recent destabilization of labour market for research. There exist, in some countries, some evidence showing the precarious state of young scientists, which indicates the increase of flexible/insecure scientific employment. As mentioned yet, post-doc contracts proliferate both in academia and in industry. Both academic competitive pressure due to the budget contraction (diminution of permanent posts) and flexibility demand from the industrial research put certain fringe of PhDs or young scientists under a heavy strain. The “queuing” phenomenon for obtaining a permanent academic position leads some PhDs to hold successive temporary contracts (Dany & Mangematin 2004; Lee, Miozzo, Laredo 2010).

These tensions create a distortion of “normal” academic careers and could end up in a vocational crisis. In some countries, the number of new enrolment in doctoral courses begins diminishing. Is the (actual) lack of career perspective in academia a normal process of readjustment between demand and supply? Should the (current) level of PhDs
production be maintained or even reinforced politically, in order to strengthen the scientific production? These issues are not easy to assess, but might at least be tackled by some econometric exercises.

At the same time, this transitional segment is a very interesting observation field, because it tends to produce new type of “services activities” which hybridise further the traditional borders of academia. Some create scientific consulting companies or patent-relating activities... In some case, the academic spin-off could be used as an alternative way of continuing the research activities (neither fully academic, nor purely commercial). Although numerically limited up to now, this movement enlarge the “academic space” and enrich what we call “academic career paths”. Such new trends might be monitored by case study survey.

IV. Conclusion: A new relationship space between Science and Industry

Reciprocal relationships have always existed between the education and research system and firms. Engineers, for example, are trained and assessed by universities in order to fit them for the tasks industry requires them to carry out. Although the evaluation of engineers’ quality remains influenced throughout their careers by the initial judgements made by the institutions in which they trained, they nevertheless leave the academic ‘world’ to take root in the industrial ‘world’ when they join a company. For their part, academic research institutes have always worked for industry, whether their aim was to train researchers for industry or to solve certain specific scientific and technical problems. Firms then appropriate the results of the collaboration and assume control of them in order to meet their own needs. At the same time, academic researchers have always made use of phenomena observed in industry in order to give impetus to their research or to design their experiments. Thus, each of the institutions had a clearly defined role in the relationship that existed between them: training and invention, on the one hand, innovation, on the other. The product of the collaboration was clearly defined as belonging either to the academic sphere or to the industrial sphere. However, and this is perhaps the key point, the dynamic and ultimate control of projects, and the evaluation of the various actors involved, was until now the prerogative of the entrepreneur or commissioning firm. Academic research establishments were used solely to meet commissioning firms’ needs and played no part in defining or evaluating those needs.

The production of knowledge and the production of goods took place in separate institutions and involved completely different categories of workers (Clark 1993). It is this separation that seems to be disappearing, since innovation processes are increasingly leading each of the partners to use the other’s resources, thereby blurring the boundaries between their respective responsibilities (Gibbons et al., 1994). At the same time, workers (and equipment) are now attached to both organisations. It is no longer the

6IP issues become extremely complex for example in biotechnologies. There exists an increasing demand for highly skilled people, PhDs... (Jolivet et al., 2009)
case that the organisation defining the project is always the one controlling it. The organisation managing individual employees is not necessarily the one paying their salaries. Researchers in firms, hired to work on programmes planned and evaluated in the academic sphere or attempting to implement them in an ad hoc unit, remain members of the research group that keeps them supplied with information and expertise.

Such cross-fertilisation between industry and academia is considered as beneficial to both sides and is encouraged by the public authorities in all countries. Researchers seconded from the university system may, under certain conditions, return to it. There are various administrative procedures that seek to formalise and regulate the mobility of academic staff. It would be wrong, however, to suppose that they are the primary cause of the phenomenon, which is linked more to the gradual intertwining of an increasingly experimental productive system and a multifaceted academic world, both of which use the same procedures and the same information processing language.

Among the new structures created by this process, spin-offs in particular are one of the most novel. They are new units to which a research institute or firm has transferred part of its activity, or even the production of a specific tool linked to the innovation processes taking place in the parent establishment. The parent establishment may either outsource operations that were already being carried out in isolation within its organisational structures or else encourage the establishment of the new unit from scratch.

The commissioning firm, or the research institute, uses one or other of these procedures depending on which one fits in with their current strategy. The main objective may be to concentrate effort and resources on the core activity in order to maintain or strengthen the parent establishment’s position. In other cases, the new firm will seek to exploit its independence in order to forge links with better resourced organisations, become involved in a greater variety of collaborations or discover unexpected applications. Ultimately, either the parent company becomes a customer of the spin-off or the spin-off becomes a customer of its parent company. The market relationship that develops between the parent establishment and the new unit may, incidentally, be more or less exclusive, and possibly much more complex.

The medium or vehicle for the spin-off is knowledge that is not being utilised by one of these institutions. It may take the form, for example, of a scientific discovery that has not yet been adapted to a market or a technological process used in research for which a new use has been developed. In order to exploit the innovation economically, that is to bring a product or process to market, the spin-off has to complete it by adding some scientific and/or technical knowledge and specifying it for a particular clientele. It invents the process that will enable it to develop its activities by involving partners (Alkrich et al. 1988). In this way, it gradually sets itself apart from the research institution that inaugurated the innovation and itself becomes the ‘producer’ of a specific segment of activity, and then a firm in its right. This process is a specific one, in that the firm thus created generally remains linked to the parent organisation. The spin-off remains
part of the network of knowledge, initiatives and resources that gave rise to it, even if relations between the various organisations may obviously vary depending on the development of the various agents. If the parent organisation was a research centre, the spin-off will try to take advantage of the new knowledge and expertise being developed there. In some cases, the new company may help to launch a new research topic by disclosing to the parent institution the questions and difficulties raised in the course of its activities and passing on its experiences.

A spin-off that originated in a company will seek to take advantage of the parent company’s financial and productive resources. Depending on the circumstances, it may also merge again with the parent company or succeed in making the parent company dependent on an innovation it has itself developed. As we observed in the productive network in the micro-electronics industry in Provence, control of the innovation process in certain areas of activity can pass in this way from one institution to another. In the first case, control remains in the hands of firms whose immediate objective is to produce economic value. In the latter case, it moves between commercial organisations and establishments whose task is to produce knowledge and competences.

The various studies we have carried out show that it is now much more difficult than in the past to disentangle industry and academia (Lanciano & Nohara 2003; Jolivet et al. 2009). There seems to be a dual trend at work: firms are changing in order to take advantage of input from academia, while education and research establishments are putting in place the structures required to take advantage of knowledge and expertise generated by industry and to produce skilled individuals, knowledge and tools likely to be of interest to entrepreneurs. In any attempt fully to account for this phenomenon, it has to be accepted that a new dynamism is emerging between academia and industry. Not only does it seem that productive networks are no longer configured so exclusively around large firms, which for too long were regarded as the only stable driving force, but it is also becoming apparent that large firms are also increasingly losing overall control of such networks. Research and production initiatives are being organised and controlled by various institutions, in such a way that a new productive system is being put in place in which no single element is dominant. It is such spaces, which can no longer be likened to extensions either of firms or of universities, which have now become the necessary locus of any attempt to describe the career trajectories of new scientific/academic workers and to ascertain who manages them (Freeman, Daniel, Goroff 2009).

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