Giancarlo Provasi
Flaminio Squazzoni

ACADEMIC ENTREPRENEURSHIP AND
SCIENTIFIC INNOVATION:
MICRO-FOUNDATIONS AND INSTITUTIONS

DSS PAPERS SOC 06-07

Giancarlo Provasi and Flaminio Squazzoni are respectively full and assistant professor of economic sociology at University of Brescia, Faculty of Economics. Mail address: Department of Social Sciences, University of Brescia, Via San Faustino 74/B, 25122 Brescia, Italy. E-mail: {provasi, squazzon}@eco.unibs.it. This paper is the first deliverable of the Department of Social Sciences Unit within the research project on “Academic Entrepreneurship at the Edge of Economic Incentives and Institutional Settings: Some Comparative Case-Studies”, co-granted by MIUR (Italian Minister of University and Research), PRIN 2006. The authors would like to thank Francesco Lissoni, Luigi Orsenigo, Giuliana Gemelli and Anna Guagnini for suggestions and remarks on a first version, and PhD student Beatrice Tosio for her invaluable contribution to this paper. Usual disclaimers apply.
Indice

1. The State of the Art ................................................................. 10

2. Getting Back to Schumpeter: The Quest of Innovation in the Economy and in Science ...................................................... 13

3. The Merton-David Institutional Model of Science & Technology Realms ........................................................................ 21


5. The Influence of Institutional Settings on AE: Stylized Facts and Working Hypotheses .......................................................... 37

6. Concluding Remarks and Implications ........................................ 48

References ........................................................................................ 52
Abstract

This paper elaborates on academic entrepreneurship suggesting a theoretical framework based on Schumpeterian and institutional foundations. Rather than describing the multifaceted realising of the entrepreneurial transitions of scientists and universities, as in most of the literature in this field, we aim at gathering more insights on all the different micro-macro behavioural and institutional mechanisms that are involved in the social processes of valorisation of scientific discoveries, as well as on the consequences of these processes at a science system level. First, we begin by reframing the problem of academic entrepreneurship to take a Schumpeterian science-based innovation perspective. Such a perspective allows pinning down a taxonomy of entrepreneurial figures embodied in academic institutions, and dissecting the different institutional mechanisms that preside over their emergence. Then, we identify some relevant consequences of these figures for the reproduction of science as a public good and the innovative capacities of universities and countries. At the end of the paper, we suggest some open questions and elucidate on some prospects and challenges in this field.

Keywords: academic entrepreneurship; science and technology institutions; innovation in academic institutions; institutional settings; entrepreneurial universities.
The controversy on the new entrepreneurial role played by universities and scientists is very much alive today, both in the realm of science, the media and the public opinion, affecting policy making agendas and university management practices (Gibbons et al. 1994; Slaughter and Leslie 1997; Novotny, Scott and Gibbons 2001; Gee 2001; Geuna, Salter, Steinmueller 2003; Mowery et al. 2004). Much of this controversy resolves around a changing nature of the societal mission of universities (Mowery and Sampat 2005; Rudy et al. 2007). Universities appear to be increasingly encouraged in pursuing a threefold mission:

a) contributing to the education of the new generations and of socio-political elites;

b) promoting scientific research in the public sphere;

c) setting up institutional and organisational arrangements to promote science and technology transfer to the private sector (Etzkowitz 2003; Etzkowitz, Asplund and Nordman 2001).

To be honest, this is not a genuine novelty in history, since three species of universities, namely the classical medieval university, the technical university, and the “land grant” university, with functions of teaching, research and technology development, have competed throughout Western history (Martin 2003). But, the nowadays novelty is that universities are called to synthesise such multiple missions, which are often the cause of unbalanced consequences, under the same framework (Siegel, Wright and Lockett 2007).

In this respect, most of the analysts emphasise the comparison between US and Europe, which are conceived as two ideal-types of institutional and academic settings in a way. The US case is taken as an
example of entrepreneurial transitions towards the threefold mission, while the EU case would constitute an example of pure and simple research and education institutions. Many analysts have questioned the so-called “European Paradox”, according to which Europe, compared to the US, would exhibit scientific research of the highest quality, but a low level of science-based technology transfer to the business sector (European Commission 1995; Dosi, Llerena, Sylos Labini 2006).

Several studies have attempted to grasp the basics of these large scale changes, at the edge of science, universities and business, in particular in economics, technology management studies, and in sociology. Bruno Latour was among the firsts in trying to understand the contemporary changing relationships of science and technology. He made use of the term “techno-science” to emphasise that the concrete activity of contemporary scientists is quite similar to that undertaken by business managers or entrepreneurs. Scientific practices are increasingly looking like management practices, since current scientists are increasingly seeking for inter-sectoral relationships to accede to relevant assets for their scientific activity and the survival and development of their labs/teams, like research funds, research infrastructures, and enlarged markets for discoveries’ implementation and validation (Latour 1987). Entrepreneurial efforts of scientists are therefore instrumental in developing scientific activities. Along the same lines, John Ziman emphasised the emergence of the so-called “post-academic science” (Ziman 1996), so as to illustrate the convergence between the current practices in science and in industrial R&D. Other have suggested to frame such changes within the overall development of the “academic capitalism” (Slaughter and Leslie 1997; Searle-Renault 2006), and the diffusion of the “academic entrepreneurship” (Shane 2004), trying to understand how changes at the level of scientists
and changes at the level of scientific institutions, in particular of universities, combine each other. Others, again, have illustrated how universities and science are changing in this new era of “corporate science”, in which there is a competition of public and private actors on scientific scopes (Rudy et al. 2007).

The overall tendency towards the increasing commercialisation of the scientific discoveries and the managerial and entrepreneurial attitude displayed by universities and scientists has been evaluated from contrasting perspectives (Martin 2003; Mowery and Sampat 2005; Garnsey 2007). Quite a few scholars have emphasised the positive features of science-business relationships, which appeared with the growing societal relevance of everyday technology innovations and science-based applications. Like in the famous theory on “Mode 1”/ “Mode 2” by Gibbons (Gibbons et al. 1994) or on “triple helix” by Etzkovitz and Leytesdorff (2000), the new trend in science seems to be the growth of a multi-disciplinary, pluralistic, networked innovation system across public and private sectors, given the increasing diversity needed in knowledge inputs that is associated with techno-scientific networks (Mowery and Sampat 2005). In an opposite direction, some scholars have emphasised that such a change could hide a dramatic defeat for the autonomy, universality and independency of the “open science” institutions and the university (Novotny, Trute, Schmidt 2005). For example, a recent case-study on UC Berkeley-Novartis agreement, which involved NADI-Novartis Agricultural Discovery Institute and the Plant and Microbial Biology Department in 1998-2003, reported a lot of points of contention between supporters of the public nature vs. private exploitation of scientific discoveries. The authors have vividly described a genuine struggle between supporters of sustainable agriculture and advocates of biotechnologies that allows illustrating in a
striking way the relevance of the problem of long-term consequences of academic entrepreneurship on the constitutive principles of universities (Rudy et al. 2007).

This paper aims at suggesting a theoretical framework on academic entrepreneurship (from now AE), based on knowledge-based Schumpeterian and institutional foundations. The first section briefly explores the state of the art and summarises the main evidences in the literature. Most of the abundant literature on AE is very much inclined towards describing the multifaceted realising of the entrepreneurial transitions of universities, with empirical cases and comparisons. Not so many attempts have been made to gather more insights on the behavioural and institutional mechanisms that can explain the emergence of AE, as well as its diversity at a local and global scale. The second section aims at zeroing in on the basics of a Schumpeterian approach to AE. A close confrontation between the basics of innovation in the economy and in science allows to reframe the question of AE, so as to emphasise the presence of alternative institutional mechanisms propelling and regulating knowledge-based innovations. In this line, the third section attempts to further develop on an institutional foundation of AE, by reweaving the Merton-David theoretical model of scientific knowledge and discovery in the “republic of science” and in the “realm of technology” (Dasgupta and David 1994; David 2004a). We believe that this model still constitutes one of the most valuable theoretical standpoints on these issues. The fourth section aims at elaborating the Schumpeter-Merton-David connection, suggesting a taxonomy of innovation in academic institutions, according to a micro and macro perspective able to combine attention both to behavioural and institutional foundations of AE. This section depicts a
taxonomy of the innovative entrepreneurial figures involved in academia, to be then compared with academic institutions, in the fifth section.

The fifth section aims at elaborating the Schumpeter-Merton-David connection towards an institutional analysis of the main factors involved in influencing the diversity of AE at a country/local scale. Based on well recognised stylized facts on AE and on theoretical contributions from the sociological literature on institutions, this section aims at dissecting different institutional mechanisms that can influence AE. The purpose is to suggest some working hypotheses that will be investigated in detail in the next future, by means of empirical case-studies and comparisons among country-specific institutional settings\(^1\). Finally, the last section summarises the main findings of this paper, suggests some open questions to be further investigated, and elucidates on some prospects and challenges in the field of AE.

\(^1\) This paper is intended as a theoretical guideline for the second deliverable of Department of Social Science Unit, that is, a paper on empirical case-studies and comparisons among country-specific institutional settings of AE that is planned to be realized in 2008. A first draft on theoretical hypotheses and empirical analyses can be found in the paper 2.
1. The State of the Art

The common interest in AE is significantly increased in recent years, both in economics, sociology and policy and technology management literature. The numbers of publications, literature reviews and special issues explicitly devoted to this topic have rapidly increased in last years (i.e. Shane 2004; Franzoni and Lissoni 2007; Rothaermel, Agung and Jiang 2007; Wright et al. 2007). Many case-studies in USA, Europe, Japan, and China have been reported, also in comparative fashion (Klofsten and Jones-Evans 2000; Degroof, Roberts 2004; Gittelman 2006; Jong-Hak, Lee, Guisheng 2006), as well as case-studies confronting departments or labs of particular universities (Jong 2006).

Very different definitions of the term “academic entrepreneurship” and “academic entrepreneur” have been suggested:

“the attempt to increase individual or institutional profit, influence, or prestige through the development and marketing of research ideas or research-based products” (Louis et al. 1989);

“all commercialisation activities outside of the normal university duties of basic research and teaching” (Klofsten and Jones-Evans 2000);

“an integration of novel roles and resources into existing organizational contexts, triggering the creation of new models of what a researcher should be doing” (Colyvas and Powell 2003);

“transitioning to for-profit science” (Stuart and Ding 2006);

the establishment of a new company “to exploit a piece of intellectual property created in an academic institution” (Shane 2004);

“the development of commercialization beyond the traditional focus upon licensing of innovations to the creation of new ventures that involve the spinning-off of technology and knowledge generated by universities” (Wright et al. 2007).
The broad spectrum of these definitions ranges from what Franzoni and Lissoni called a “straightforward definition” of AE, which solely focuses on the setting up of business companies by academic scientists (professors, post-doc researcher, PhD students) to commercialise the results of their research, to a “broader definition”, according to which the entrepreneurial behaviour of scientists would also refer to the strategic management of academic careers and the creation of new disciplines or institutions, perhaps with the commercialisation strategy being just instrumental in the development of scientific groups or institutions, that is just a part of a broader strategy followed by academic scientists (Franzoni and Lissoni 2007).

The same diversity of definitions can be seen when scholars have tried to define the features of entrepreneurial universities. Clarke (1998) has identified in particular the relevance of boundary spanning structures and mechanisms to interact with industry, the diversification of funding base, and the establishment of trans-disciplinary research projects. Etzkowitz (2003) insisted on five key elements of AE at the university level, among which, in particular, the capacity of organising firms within universities, the presence of quasi-firm organised research teams, the presence of university-industry research centres, and the organisational and institutional arrangements for protecting intellectual properties.

In any case, most of these contributions share the same overall uncontested evidence, that is that the entrepreneurial activity at university and at the single scientist level, in forms of patents, licensing, spin-offs, and research inter-sectoral joint-ventures, is dramatically grew up in last 25 years. This growth seems to be related to the following events:
a) the overall reduction of public funding for science and its institutions and the increasing recourse to market and private funds to undertake scientific research in academic institutions;

b) the rise of tighter relationships between corporate and public actors involved in basic and applied research projects, frequently associated with the rise of new (science-based) businesses, like academic spin-offs;

c) the presence of stronger incentives for public institutions to commercialise scientific discoveries, both at a country and a local level.

Most of the attention of scholars has been devoted to the understanding of the contingent factors influencing the level and the features of AE, as well as the organisational and the societal implications of this novelty (Siegel, Wright and Lockett 2007). The huge literature on technology transfer has emphasised the relevance of the institutional arrangements to understand the way in which technology is transferred from university to industry (Shane 2004). The neo-institutional literature has particularly focused on the relevance of institutions and history in explaining the diversity in shapes and features of AE in different countries (Powell and Owen-Smith 2001). The sociological literature has emphasised the societal consequences of commercialisation of scientific knowledge, with a particular attention to the risk that market drains away the science well without being able to offer good incentives to re-generate it (Nowotny, Trute, Schmidt 2005).
2. Getting Back to Schumpeter: The Quest of Innovation in the Economy and in Science

The recent neo-Schumpeterian economics literature places a strong emphasis on the relevance of knowledge, innovation and entrepreneurship at the micro level for the understanding of the roots of the contemporary knowledge-based economies (McKelvey and Orsenigo 2006; Hanusch and Pyka 2007). One of the main driving force of the contemporary economies is the growing relevance of the social production of science-based knowledge and the capacity of economic systems to translate it in concrete innovations on markets.

The Schumpeterian standpoint is that, at the basis of innovation in the economy and science, there are entrepreneurs seen as bearers of endogenous development, thanks to their capacity to introduce “new combinations” in the market. As he wrote:

“Development in our sense is then defined by the carrying out of new combinations. This concept covers the following five case: (1) the introduction of a new good [...] or of a new quality of a good. (2) The introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new [...]. (3) The opening of a new market [...] whether or not this market has existed before. (4). The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created. (5) The carrying out of the new organisation of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position” (Schumpeter 1912, 66).

The entrepreneur is the person, or the group of persons who are responsible for carrying out such “new combinations” (Schumpeter 1912,
The added social value of these novelties is that “carrying out a new plan and acting according to a customary one are things as different as making a road and walking along it” (*id*, 85). The function of entrepreneurs is indeed “the doing of new things or the doing of things that are already being done in a new way (innovation)”, neither the management of organisations (this is the manager’s function), nor the ownership of the production means (this is the capitalist’s function) (Schumpeter 1947, 412-413). The entrepreneurial type is characterised by a permanent tension toward the novelty, a “mental freedom” against status quo, and the capacity to resist against conservative forces in the society (Schumpeter 1912, 85-87). Suggesting a close analogy between the resistance against innovation within the economy and within science, Schumpeter emphasised that “we find it exceedingly difficult to adopt a new scientific point or view or method”, because of the “very nature of the fixed habits of thinking, their energy-saving function”, as well as of the presence of strong institutional disincentives (Schumpeter 1912, 86).

The “new combinations” are not pure and simple “inventions”, but knowledge-based innovations that have been carried by the entrepreneur into practice (Schumpeter 1912, 88-89). Recalling what Jean-Baptiste Say already wrote in the mid-1840s, Schumpeter emphasised that the entrepreneur can use new ideas, knowledge, and methods, which have not yet been applied in the economy, to produce a new product, actualising, in so doing, the new knowledge in a tradable good (Grebel 2004). As a matter

2 Schumpeter (1949, 260) wrote: “The entrepreneurial function need not be embodied in a physical person and in particular in a single physical persons. Every social environment has its own ways of filling the entrepreneurial function. For instance, the practice of farmers in this country [the US] has been revolutionized again and again by the introduction of methods worked out in the Department of Agriculture and by the Department of Agriculture’s success in teaching these methods. In this case then it was the Department of Agriculture that acted as an entrepreneur”.

Academic Entrepreneurship and Academic Innovation

of fact, knowledge is the most important successful resource of entrepreneurs (Grebel 2007).

Through the introduction of these novelties, entrepreneurs fulfil “the dreams and the will to found a private kingdom”, driven by the wish of being successful, the “joy of creating, of getting things done”, the pleasure to design and manage, all things often perceived as the only “chance of achieving social distinction” (Schumpeter 1912, 93). This allows entrepreneurs to gain an extraordinary profit, which is the index for success, disturbing the prevailing order and constituting the kernel of unbalanced developments (Hanush and Pyka 2007).

In this perspective, innovation in academia should ideally comply with the principles of innovation in the economy. Swedberg correctly noted, among others (1991, 60), that Schumpeter himself, in his famous book “Business Cycles”, suggested that his theory of innovation should be applicable not only to changes within the economy, but also to other spheres of the social life. Schumpeter precisely wrote that “the theory here expounded is but a special case, adapted to the economic sphere, of a much larger theory which applied to changes in all spheres of social life, science and art included” (Schumpeter 1939, 696).

What are the common features of innovative activities in the economy and in science? They are as follows: competition on priority, temporary monopoly gain, institutionalisation of rewards, trial/error experimental discoveries in uncertain environments, functional relationship with stakeholders and risk socialisation, first movers/followers dynamics, the presence of market segmentation and niches, self-propagation of innovation, and increasing returns to adoption.

As we summarise in Table 1, innovative scientists in academia are remunerated for the innovation they are able to introduce in their ‘market’,
through a temporary surplus that the innovation itself generates to their organisations, like economic entrepreneurs within firms. The principle of priority reward on competitors that drives innovation in business is the same driving innovation in the scientific community. The reputation-based monopoly of pure scientists on innovation is not dissimilar to the principle of monopoly revenue characterising the added value of innovation in the economy. In a narrow Schumpeterian sense, profit and reputation are the rewards for the economic/scientific function accomplished by innovative entrepreneurs, that is for their capacity and effectiveness in introducing innovation in the economy/science. The institutional arrangements that helps preserving the ratio of the investment in innovative projects are patents, tacit know-how, secrecy in business corporations, and quotations and impact factors in academic institutions.

The economic entrepreneurial profit is different from the reward for the entrepreneurial risk of shareholders, as well as from the reward for the coordination of business activity of managers. The same holds true confronting the reward of innovative scientists and the reward of their stakeholders, namely the State, and indirectly the citizens of a given country who fund universities through duties, and the reward for university staff managers. The growing relevance of the continuous capacity to innovate products and services provides a sound incentive for capitalists and shareholders to promote and protect the entrepreneurial function within their organisations. The same holds true in the case of academic institutions. The relevance of the university research output for the capacity of university managers to attract funds, talented researchers, and students provides incentive to stimulate innovation. The role of entrepreneurs for combining and capitalising production factors in innovative ways is therefore a strategic asset both in economic and in academic organisations.
Innovative activities, both economic and academic ones, are naturally characterised by uncertainty and ambiguity. These last are bounded up with the trial and error experimental method that is typical of innovation. The possibility of unloading the financial risk of innovations on the shareholders’ shoulders, that is, on capitalists and the enterprise owners, in the case of economic entrepreneurs, and on State and scientific public institutions, in the case of innovative scientists, allows individuals to face uncertainty on effective results and competition rewards. The return of the investment is profit and innovative products for business corporations and reputation and knowledge generation for academic institutions. As Schumpeter persisted in outlining, “the entrepreneur is never the risk bearer […] the risk-taking is in no case an element of the entrepreneurial function” (Schumpeter 1912, 137). As a matter of fact, this completely also holds for the entrepreneurial function carried on by scientists within academia.

Like in the economy, the population of actors belonging to academic world can be divided in first-mover innovators and follower emulators, differentially involved in exploration and exploitation processes. The market of science is characterised by a segmentation of producers, sectors and market niches like business markets. Scientists are divided in disciplines, more or less influential in terms of funds, number of journals, size of the community, societal recognition and so forth, with different types of journals, community and social audience. The publication market is based on a segmentation between top class journals and middle-low level journals, referring to different targets, like national or international audience. The producers of science can be relatively isolated innovators, working like craftsmen, with low technological infrastructures, or scientist involved in big teams, laboratories, institutes or departments, that is, in big
organisations endowed with high level technology infrastructures, able to reach mass production-like high scores in the scientific outputs.

The same supply and demand model could be used to determine at the same time the market success of an innovative product and the success of a scientific innovation. For instance, let us consider the case of a discovery or an innovation presented in a published paper as the supply and the usage of the paper, measured in numbers of quotations by other scientists, as the demand. The supply will be able to increasingly meet the demand on the scientific market depending on how much large is the number of quotations, that is, the number of scientists using the piece of knowledge presented in the paper. The functioning of the market in the economy and of consensus in science seems to follow the same rule.
Table 1. A Schumpeterian analogy between innovation in the economy and in science.

<table>
<thead>
<tr>
<th><strong>What they do?</strong></th>
<th><strong>Economic Entrepreneurs</strong></th>
<th><strong>Innovative Scientists</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>They introduce innovations in the economic system, in terms of “new combinations” giving rise to new products and methods of productions</td>
<td>They introduce innovations in the scientific system, in terms of discoveries, new theories, new disciplines, and paradigms</td>
<td></td>
</tr>
</tbody>
</table>

| **Why does innovation succeed?** | **They are able to perceive un-satisfied costumers’ needs, or to anticipate future needs** | **They are able to tackle with scientific puzzles unsolved by peers** |

| **What is the added value of innovation?** | **Priority on competitors** | **Priority on competitors** |
| **What is the effect of innovation?** | **Profit and temporary monopoly** | **Reputation and temporary monopoly** |
| **What is the evaluation mechanism of the innovation introduced?** | **Costumers feedback (and quality standard certification, if any)** | **Peer reviewing** |

| **What should the knowledge produced be capable of?** | **Satisfying consumers’ needs (i.e. generating a market share)** | **Satisfying peers’ expectations (i.e. generating a consensus share)** |

| **What is the time horizon of innovation strategies?** | **Ex-ante uncertainty on what to do, but perhaps fast ex-post evidence on what did happen** | **Ex-ante uncertainty on what to do and perhaps long-term evidence on what did happen** |

| **What is the source of learning searched out to further improve the result?** | **Costumers’ decision and feedback** | **Peers’ opinion and feedback** |

| **Whose forces is innovation confronted to?** | **Increasing/decreasing returns to adoption** | **Increasing/decreasing returns to adoption** |

| **What is the institutional arrangement that helps preserving the rationality of the investment in innovation?** | **Patent, tacit know how, secrecy** | **Quotations, impact factor** |

| **What is the approach to societal usage of innovative discoveries?** | **Disinterestedness** | **Disinterestedness** |
The investment in the search for innovation can be protected, to some extent, via patents, seclusions and know-how in the economy and via quotations and impact factors’ recognition in science. According to Schumpeter and his contemporary followers, the path of innovation is marked by three stages: invention, or the generation of new ideas; innovation, or the development of new ideas into marketable products and processes; and diffusion, or the spread of innovation across its potential users. This last stage presents a set of intriguing and controversial issues. The Schumpeterian view is based on a self-propagating mechanism in that, once begun, diffusion has its own momentum, according to two forces, namely emulation and price changes. Innovation brings with itself a process of imitation, driven by late entrepreneurs attracted by the profit gains realised by the first mover, and a gradual reduction of profitability of the innovation introduced, as imitators succeed in copying the innovator, with the consequent decrease of the entry barriers into market originally built upon innovation (Stoneman 2007). The decreasing returns of innovative output would constitute a market signal able to stimulate economic entrepreneurs in investing in other products, areas and in further innovations. On the contrary, the presence of increasing returns to adoption, like in the case of competing technologies, would explain the particular path-dependent and nonlinear shape of the evolution that characterises innovation in the economy and science (Arthur 1994).

Finally, as regards to the societal usage of innovation, both the economic entrepreneur and the innovative scientists are usually driven by the social norm of disinterestedness. These innovative figures are socially rewarded for their capacity to define the innovation frontier, for their capacity to offer knowledge findings to societal users, with no direct
interest in the ways through which scientific discoveries are socially used and exploited.

3. The Merton-David Institutional Model of Science & Technology Realms

The Merton-David model allows grasping the features of science and technology as two different institutional spheres that presides over the generation and dissemination of science-based innovations. The model is first intended to explain the prevalence of distinctive norms and institutions governing university science and industrial R&D, and then to examine implications of these different institutions for the efficiency of economic resource allocation at a societal level. It is not a matter of a difference of “knowledge workers”, but a difference between “the social organisation of science and technology” (Dasgupta and David 1994, 495) which impacts on factors such as monetary payments, peer recognition, and working conditions of knowledge workers, among others. As they wrote:

“It is the nature of the goals accepted as legitimate within the two communities of researchers, the norms of behaviour especially in regard to the disclosure of knowledge, and the features of the reward systems that constitute the fundamental structural differences between the pursuit of knowledge undertaken in the realm of Technology and the conduct of essentially the same inquiries under the auspices of the Republic of Science […]. What makes a knowledge-worker a ‘technologist’ rather than a ‘scientist’ […] is not the particular cognitive skills or the content of his or her expertise […]. What matters is the socio-economic rule structures under which the research takes place, and, most importantly, what the researchers do with their findings: research undertaken with the intention of selling the fruits
into secrecy belongs unambiguously to the realm of Technology” (id, 495).

Public institutions preside over the allocation of resources for basic scientific research because of the following reasons: the economic value of basic research is difficult to forecast and to evaluate in retrospect; the exploitation of basic research would be impeded if intellectual property rights would be introduced; scientific communities have been historically developed through the Mertonian logic of rewards; and the production of basic research can stumble into a market failure, which would naturally result in a societal underinvestment in science (id, 490). Market mechanisms preside over the allocation of resources for applied and technology research, providing incentives to private investments in R&D activities through intellectual property regimes.

Science is based on the rule of priority, a peer-to-peer reputation-based reward system and an institutional integrity based on autonomy and self-determination of objectives and practices. As Merton argued in his classical contributions, the institutionalization process of science as a social institution and the codification of the societal role of scientists have presupposed the emergence of a set of values and norms that have profoundly moulded the functioning of the scientific community, its social structure and its constitutive institutions (Merton 1938, 1942). The historical evolution of science has converged around an institutional equilibrium, what Merton defined “the social stability” and the “institutional integrity” of science (Merton 1938, 259), built upon cultural resistance and defences against social pressures from outside the community oriented towards imposing internal changes of scientific practices, objectives, and priorities. The “purity” of science, as well as the
fact that “science must not suffer itself to become the handmaiden of theology or economy or state”, imply “the persistent repudiation by scientists of the application of utilitarian norms to their work”, which could be imposed by means of criteria established from outside the community. This integrity can be defended just if the “particular types of social structure”, which scientists are dependent upon, can be preserved (Merton 1942, 267).

Merton emphasised four institutional imperatives on the base of “the ethos of science” and its institutional integrity: universalism, communitarianism, disinterestedness and organised scepticism (Merton 1942). Universalism means that “truth-claims, whatever their source, are to be subjected to pre-established impersonal criteria”, so that scientific results are judged independently from the idiosyncratic characteristics of the scientist who is responsible for them. Communitarian values imply that scientific discoveries and results are public goods, and that scientists should be recognised for the contribution to the scientific progress they are able to offer. These values are “incompatible with the definition of technology as private property in a capitalistic economy” (id, 275). As Merton emphasised:

“Property rights in science are whittled down to a bare minimum by the rationale of the scientific ethic. The scientist’s claim to ‘his’ intellectual ‘property’ is limited to that of recognition and esteem which, if the institution functions with a modicum of efficiency, is roughly commensurate with the significance of the increments brought to the common fund of knowledge” (Merton 1942, 273).

Disinterestedness does not mean any reference to motivational forces behind scientists’ behaviours, like self-interest or altruistic motives. It
means that scientists are subjected to adhere to norms related to integrity, openness, and public accountability. Scientists do not stand vis-à-vis “a lay clientele”, do not exploit information asymmetries to their personal advantages, and are not tempted to take advantage of “frauds, chicanes, and irresponsible claims”. Finally, organised scepticism is both a “methodological and an institutional mandate” of science. It is methodologically rooted in the peer reviewing of scientific claims, and in the collective and distributed tests of scientific discoveries, but above all in the institutional mandate of the critical evaluation of every supposed certainty, with no respect to social beliefs which “have been crystallized and often ritualized by other institutions” (id, 277).

The normative structure of science and the reward structure behind scientific discoveries are the foundations of science as a social institution (Merton 1957). Priority rule is the first incentive for scientists to produce scientific knowledge as a public good. The personal interest in recognition shown by any scientist is “the motivational counterpart on the psychological plane to the emphasis upon originality on the institutional plane” which is typical of science (Merton 1957, 294). This implies a race for scientific discoveries among scientists, with a public evaluation and recognition mechanism based on peer reviews and publications. Priority is of utmost importance for scientific progress, because “there is no social value-added when the same discovery is made a second, third or fourth time” (Dasgupta and David 1994, 499).

The pre-condition of “the winner takes all” principle of priority is the flat salary for entering science and the public nature of the research job. This allows for socially distributing the risk that is typical of any scientific enterprise:
“If the losers of a scientific race were to receive absolutely nothing, the rule would place all the risks involved in the production of knowledge firmly on the shoulders of scientists. This cannot be an efficient system if scientists, like other mortals, are adverse to taking risks which involve their survival and comforts […]. We conclude, then, that those who regularly engage in basic science research need to be paid something regardless of the extent of their success in the scientific races they choose to enter” (id, 499).

The standard twofold mission of universities, which assign resources to scientists both for teaching and research activities, allows university scientists to count on a set of complementary activities that can reduce the effect of a failure in the competition race for discoveries. Moreover, the ever-increasing number of journals and publications at scientists’ disposal leads to a segmentation of the publication market, for instance, between top-class and middle level journals, or between nationally and internationally recognised journals, which reduces the unrelenting selection strength of the “winner takes all” competition race. This situation of “there is room for everybody” allows also reducing the possible dysfunctional consequences of the excessive “emphasis on priority”, with ‘the priority turned into an end in itself’, on which Merton insisted when he described the relevance of multiple discoveries and redundant explorations for the scientific progress (Merton 1957, 321-322).

The degrees of autonomy and self-determination for scientists in selecting fields, subjects, and in developing theories and discoveries, at the micro level, generate a capacity to follow a parallel exploration at the level of the entire system of science. In consequence of this, society at large can benefit from such a distributed allocation of scientific investments, if the result is “the emergence of a diversified societal research portfolio” (Dasgupta and David 1994, 507). Such a result can be strengthened if
diversity of approaches, methods, paradigms can be preserved in the scientific community.

The Merton-David model implies that the university’s mission to promote technology transfer to the industry falls into several obstacles. The main obstacle is the information asymmetry between producers and users of knowledge involved in a university-industry transaction. Given the tacit knowledge that is usually involved in effectively realising such a transaction, it is difficult to transfer knowledge without transferring know-how, at the same time. This could perhaps explain the recent growing relevance of spin-offs and direct involvement of scientists in technology transfer businesses. In most cases, to solve such a structural obstacle, a reform of the “social contract” of university scientists would be necessary, but with a serious negative effect on the public disclosure of discoveries, circulation of knowledge and the maximisation of long-run growth of the stock of scientific knowledge at a societal level (David 2004b). As Baskaran and Boden (2004, 6) have emphasised, the “commodification of science” implicitly brings with itself the rupture of “the pre-existing social contract between science and citizens”.
4. The Schumpeter-Merton-David Connection: A Taxonomy of Innovative Figures in Academic Institutions

The Schumpeterian foundations and the Merton-David model described in the previous sections allow emphasising the difference between university science and technology business and the relevance of how scientific innovation is generated and disseminated at a societal level, according to a set of institutional values, norms and incentives. To deepen such arguments, it is worthwhile elaborating a comprehensive taxonomy of the innovative figures involved in science.

Some studies have already attempted to depict different types of academic entrepreneurs. For example, Louis et al. (1989) have identified five types of academic entrepreneurs: scientists engaging in large scale research (externally funded); scientists earning supplemental income; scientists gaining industry support for university research; scientists obtaining patents or generating trade secrets; scientists directly involved in commercialisation. The problem with such taxonomies is that they have been based just on the representation of phenomenon not on sound analytical concerns. The focus is on what academic entrepreneurs do rather than on why they do it.

For the sake of our purpose, it is worth distinguishing between three different types of social actors involved in innovation practices in academic institutions. These types are based on a first difference between what we call pure academic scientists, who conform to Mertonian principles, and the other two figures, respectively called the academic entrepreneurs 1 and 2, which are two different versions of contemporary business-oriented
scientists. These figures are intended as ideal-types in a pure Weberian sense\textsuperscript{3}. Their features are summarised in Table 2.

Table 2. A taxonomy of innovative figures in academic institutions.

<table>
<thead>
<tr>
<th></th>
<th>Pure academic scientists</th>
<th>Academic Entrepreneurs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>AE1</strong></td>
</tr>
<tr>
<td>Reasons</td>
<td>Scientific progress</td>
<td>Development of a research team/lab</td>
</tr>
<tr>
<td>Rewards</td>
<td>Reputation in peer networks and communities</td>
<td>Access to private assets (e.g. funds, know how, technologies) to develop scientific projects</td>
</tr>
<tr>
<td>Community</td>
<td>Scientific community</td>
<td>Techno-scientific community</td>
</tr>
<tr>
<td>Beliefs</td>
<td>Civil servant</td>
<td>Management of a scientific enterprise</td>
</tr>
<tr>
<td>Means</td>
<td>Publication</td>
<td>Inter-sectoral collaboration networks</td>
</tr>
<tr>
<td>Nature of goods</td>
<td>Public</td>
<td>Club</td>
</tr>
</tbody>
</table>

\textit{Pure academic scientists} are Mertonian citizen of what Dasgupta and David called “the Republic of Science” (Dasgupta and David 1994). They are scientists, mostly working in a basic science, who seek for innovating

\textsuperscript{3} Ideal-types are “unified” theoretical constructs that abstract away some relevant components from the intricacy of single aspects that characterise a given class of empirical phenomena (Weber 1904). The aim of ideal-types is not to fully represent the empirical target they refer to, but to offer an heuristic guideline for theory building (Willer and Webster 1970).
existing scientific practices, e.g. suggesting new theories, discoveries, new fields of inquiry, and new paradigms, with the aim to contribute to the scientific progress, without any interest in technology and business applications. Their goal is to maximize reputation in peer-to-peer networks and community. They are subdued to the distributed community control/sanction mechanisms that are typical of science. They conforms to the publishing or perish rule, trying to take advantage of priority of discoveries as regards to competitors. They treat knowledge as a public good, voluntarily contributing to knowledge externalities and to social dissemination of knowledge. Their reward is reputation and the result is the advancement of their careers within academic institutions. They exploit university assets to do public research.

*Academic entrepreneurs 2* (from now AE2) are scientists who seek for innovations that have a potential/concrete market value. Their goal is to patent or license a discovery, and/or to set up a spin-off or a business, in order to capitalise it and to maximise economic profit from it. Their mission is not to contribute to the scientific progress, but to search for technology innovation. Their reference community is composed by technologists, businessmen, and the technology market. They treat knowledge as a private good, voluntarily retarding the rate of circulation of knowledge at a scientific and societal level. Their career often spans across sectors. In most cases, they patent to avoid the private sector's free riding, that is, the exploitation of scientific discoveries, which have been produced within academic research projects, by corporate business for free.

*Academic entrepreneurs 1* (from now AE1) are scientists who seek to innovate by fostering inter-sectoral collaborations, so as to find economic/knowledge resources to support their research project/team and to enrich it through inter-sectoral/multi-disciplinary contaminations. They
try to maximise the growth of their controlled ‘organisations’ (e.g. teams, labs, institutes), by raising public/private economic and knowledge-based resources. Their reward is the access to private assets and the growth of their scientific organisations in reputation and size. They are used to leverage public and private assets, with the purpose to gain new insights, technologies and experiences also from private sector. In particular, they are interested in collaborating in multi-disciplinary research projects going beyond standard pure disciplinary approaches.

The main differences between these three entrepreneurial figures call for two relevant factors. The first is the presence of two types of incentives for innovation, that is reputation within scientific communities and profit on markets. The second one concerns a possible difference in the usages of the rewards of innovation by rewarded scientists. Rewards can be used for personal purposes (e.g. personal economic profit or carrier advancement), or for institutional purposes, in case that they are re-invested in research activities within a team, lab or institute (e.g. new positions for young researchers, or new technologies and infrastructures made available for the research organisation).

Although their respective difference, pure academic scientists and AE1 make use of the rewards of scientific community (reputation) or business sectors (economic assets) to reinvigorate the public nature of the science enterprise and of its institutions. On the contrary, AE2 bear publicly funded assets away within the private market. Therefore, between AE1 and AE2, and their respective link to the private sector, there is an inverse relationship as follows: AE2 drain away public assets for private purposes (e.g. privatising scientific discoveries or establishing a new business, or offloading young university researchers), while AE1 bring private assets into the public sphere of science (e.g. using private funds to develop an
university lab or department). Unlike AE1, who often plug away on long-term research projects, the AE2 are sometimes really into short-term projects to be quickly finalised to market.

Such three figures imply very different problems. Pure academic scientists run the risk of being too much academically self-referent in the selection of their scientific subjects. As a matter of fact, self-reference can be an added value to carry on independent and autonomous investigations in a basic science, but this implies the cost of giving up private funds and collaboration experiences, as well as multi-disciplinary researches. Academic scientists could be discouraged from pursuing interesting applications of their discoveries, because of the stronger incentives not to commercialise that are embodied in the rules of academic career (Lacetera 2007). Therefore, science would not be able to significantly weigh on economic development.

Moreover, let us suppose that all the scientists of a given population were uninterested in giving ear to the incentives coming from technology applications and markets. In such case, the result, at the science system level, could be an overall congestion of scientists selecting basic science fields and subjects and a disequilibrium between pure sciences and transfer sciences or technology research, with potential dramatic consequences for the technology development of a country.

Finally, it is worth stressing that also reputation-based competition and evaluation, and the reward structure that is typical of science can generate sub-optimal macro consequences for the scientific progress, since they can hide some dysfunctional selective pressures, like in the famous case of the “Matthew effect” described in Merton (1968). In this case, reputation acquired by scientists within the scientific community tends to crystallise over time, thereby undermining the principle of “universalism” of science.
and influencing the good functioning of peer-to-peer evaluation mechanisms. In this case, the exposure of scientists to inter-sectoral commitments, their belongings to multiple reference communities, the pursuing of diverse interaction experiences, and their capacity to offer different kinds of results, like scientific discoveries, technology applications, science-based business companies, could be the source of a socially shared mechanism of evaluation and control of individual capacities and performance that could be more accurate and exhaustive than scientific reputation alone. On a contrary, the “Matthew effect” could promote long-term inefficient monopoly gains of highly reputed scientists, who could be strongly discouraged from innovating\textsuperscript{4}.

\textit{AE2} run the risk of selecting research subjects and goals under the sole imperative of commercialisation. This would imply different potentially dramatic consequences. The first is that the short-term interests of commercialisation, with the need for hot results and quick marketing of scientific results, could railroad the standard practice of scientific community, which is based on careful peer-to-peer examinations and scrutiny. Innovative scientists, who have in hand a scientific application with market high-potentials, could be therefore tempted to move out of the scientific standard. Secondly, the intellectual property on scientific results inevitably would slow down the knowledge production/dissemination cycle that is typical of science as a social institution. Moreover, \textit{AE2} can be often tempted to free ride, that is to exploit public assets (e.g. university

\textsuperscript{4} It is worth outlining that the “Matthew effect” works also in the case of some leading social scientists, in particular those who are increasingly committed to invest in copyrights on best sellers book market. Such social scientists are inclined towards launching new labels, concepts and histories that should meet customers’ interest. As a matter of fact, such social scientists are discouraged from spending time and efforts in serious empirical researches, to submit their findings to peers’ scrutiny and to respect evaluation and validation mechanisms that are typical of science.
departments, public contracts, PhD students and young researchers) without contributing to the public good’s reproduction (e.g. they can promote the placement of the best young university researchers in the private sector). As a consequence, the presence of too much _AE2_ in the Mertonian “Republic of Science” would cause a crisis in the capacity of science and its institutions to regenerate itself and to progress toward the public good. _AE2_ are the foremost producers of the so-called “tragedy of the anticommons” (Maurer 2006). By protecting scientific knowledge and preventing others from using it, they slow down the circulation of scientific discoveries and, separately, they contribute to waste the resource (scientific knowledge, in this case) by under-utilising it at a societal level (Heller and Eisenberg 1998). In particular, the excessive fragmentation of intellectual property rights can slow down research activities, as well as product development, because the knowledge owners can block each other (Dosi, Llerena and Sylos Labini 2006).

_AEI_ run a more delicate risk, that is, of being unable to normalise the public nature of the scientific enterprise with the need for private monopolisation of the scientific results emerged out of a public-private network initiative. These figures are typically involved in public-private networks in which there is a mix of mechanisms that are used to exploit scientific knowledge and to solve the traditional problems of market failures, which can damage both public and private actors involved in any scientific/technology innovation enterprise. As Geuna, Salter and Steinmueller (2003) correctly emphasise:

“The drawing of scientific and technological research into close interaction suggests an alternative model for the science system, one based upon a ‘network’ of distributed knowledge. Some parts of this network may function effectively by employing the traditional social
norms of ‘open science’ [...]. Other parts of the network may require the negotiation of exchange [...]. While both types of networks are subject to the problems of market failures [...], the negotiated access part of the network is also subject to further market failures resulting from failures in coordination, transaction or knowledge discovery, that is, the identification of things worth knowing. These factors may be collectively termed ‘scientific network failure’” (Geuna, Salter and Steinmueller 2003, XIX).

In point of fact, the strengthening of these public-private networks is used by the actors involved as a kind of “club good”, so as to protect the innovation effort against the failures mentioned above, appealing to, for instance, cartelization, restriction of membership, price control, social monitoring and punishment, with the cost of the network’s establishment and defence recouped and passed on to costumers and final users (Geuna, Salter and Steinmueller 2003, XX).

The belonging of AE1 to such networks, and the present lack of specific institutional arrangements able to preside over the network failures involved implies the emergence of a frontier of public science and private technology sectors characterised in great measure by institutional instability. The lack of stable and recognised institutional arrangements to regulate scientific network intellectual properties, as well as preconditions and consequences of these inter-sectoral collaborations, in general and at a country level, leave room to the focal role played by the single universities in controlling, managing and promoting the initiatives of AE1. Without the presence of entrepreneurial universities, able to set up appropriate institutional arrangements, these network initiatives run the risk of opening a conflict between the public nature vs. the private exploitation of scientific discoveries. The recent case-study on the Berkeley-Novartis controversy in the US, reported in Rudy et al. (2007), testifies the potential dramatic consequence of such a conflict that involves situated networked actors.
seeking to forge a working consensus or a position of autonomy within unstable institutional settings.

Finally, a further difference between these three entrepreneurial figures concerns the science and technology link they bring with themselves. As it is summarised in Table 3, pure academic scientists and \( AE2 \) require a standard linear model of science and technology links. Both the “open science” and the “patented science” rely on the separateness of science and technology, as different and sequential stages of the innovation process. At the first stage, there is the scientific discovery made independently by scientists. Then, there is the application and the transfer process made by private actors, paying or not paying royalties for the first stage.

The situation of \( AE1 \) is quite different. They are carriers of an interactive model of science and technology links. In fact, the recent development of this model does not emphasise the distinct and separate features of these two spheres, but perhaps the logics and the effects of their interaction (Arora and Gambardella 1994; Archibugi, Howells and Michie 1996; Geuna, Salter and Steinmueller 2003). Science and technology innovations seem more and more dependent upon a branched chain of networked actors specialised in particular but interrelated competences (Casper and van Waarden 2005).

In this perspective, two features seem to be very relevant for our purpose. The first is that techno-scientific collaboration networks allow fostering science-based technology applications and the transfer of scientific discoveries into market, with relevant advantages for the business sector of national/regional economies involved. The second feature is a by-product of such collaborations, that is, the evidence that such collaborations allow producing technological artefacts that can heavily contribute to
modify the basic sciences, by allowing the emergence of new research
questions that were unforeseen before the technology applications, and by
offering new technology tools and methods available for doing basic
scientific research. Although these public-private collaborations, in the
worst case scenario, could simply result in a private exploitation of publicly
funded scientific assets, thereby giving rise to negative consequences for
the public reproduction of science, they could end up with technology
innovations that are of great help and inspiration for scientific purposes.

If the Merton-David model correctly emphasises the consequence of
an unbalanced growth of entrepreneurial activities on the knowledge
production and dissemination that are typical of science, the interactive
model allows emphasising the benefit of inter-sectoral collaborations, as
well as of market incentives, in the production of science-based technology
applications that can have a positive impact on basic public research. This
is the reason why AE1, who are typically involved in public-private
collaborations, but who remain primarily interested in promoting and
developing science as a public good, are the most interesting and in
continuous progress figures. They are at the edge of these recent
developments across the board.

Table 3. Institutional models of knowledge generation across science and
technology realms.

<table>
<thead>
<tr>
<th>Science &amp; Technology</th>
<th>Institutional Model of Knowledge Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open Science</td>
</tr>
<tr>
<td>Linear Model</td>
<td>Pure academic scientists</td>
</tr>
<tr>
<td>Interactive Model</td>
<td>AE1</td>
</tr>
</tbody>
</table>

The influence of institutional arrangements and historical contingencies on AE is commonly recognised in the literature (Owen et al. 2002; Ylijoki 2003; Shane 2004; Landry, Amara and Rherrad 2006; Jong-Hak, Lee, Guisheng 2006). A good example is the analysis by Colyvas and Powell (2003), who have investigated the relevance of the degree of institutionalisation of AE in the case of biomedical field at Stanford from 1970 to 2000. Another example is the analysis by Searle Renault (2006), in which she has reported an empirical survey on 98 top scientists in 12 universities in the US, upon which she concluded that the most significant influence on entrepreneurial propensity is the beliefs about the proper role of universities in the dissemination of knowledge, as well as the primary role of institutional incentives on this decision.

This same evidence is recognised in the broader sociological and neo-institutional literature on entrepreneurship (Swedberg 2000; Aldrich 2005; Licht and Siegel 2006; Ruef and Lounsbury 2007), as well as by economic sociologists, who have launched the concept of “institutional embeddedness” (Swedberg 1991, 2003; Guillen et al. 2002). Institutions can affect entrepreneurship by favouring cognitive and socio-political legitimacy on entrepreneurial practices concerning particular social norms, as well as by reducing uncertainties and making predictable entrepreneurial behaviour. Colyvas and Powell (2003) have correctly argued that AE has “both a social and an economic side”, and that one of the most relevant issue is whether AE is institutionalised or not in particular institutional settings. This also calls for the problem of the relevance of social and non-
market institutions for explaining the innovation process in science (Dosi, Marengo, Pasquali 2006).

For the sake of our purpose, it is however necessary to distinguish between two different levels of institutional influence on AE. This difference conforms to the influential theory of institutions put forward by North (1990; 2005) and Williamson (2000).

Institutions can be first defined as formal or informal sets of socially shared models of behaviour, habits, norms, established practices, rules, laws that regulate the relations and interactions between individuals, groups and organisations (Edquist 2005, 188). They should be distinguished in regulative and constitutive ones. Regulative institutions are formal incentives influencing both individual choice and the aggregation outcomes, by altering the rational preferences of individuals. Constitutive institutions are an ex-ante set of constraints and possibilities upon individual cognition and actor’s identity, in terms of beliefs, socially shared mental models, norms, and conventions that contribute to set out individual action, influencing even the individual choice of means and goals. Institutions are therefore not simply a set of external formal rules and macro incentives impacting individual action, like many economists firmly believe, but they also play a cultural and cognitive role, contributing to frame individual cognition and identity according to socially shared patterns (DiMaggio 1994; Scott 1995; Hodgson 2004).

As North correctly emphasised, the interesting problem is that “while formal institutions can be changed by fiat, informal institutions evolve in ways that are still far from completely understood and therefore are not typically amenable to deliberate human manipulation” (North 2005, 50). This means that a sound understanding of AE depends on the capacity of
social scientists to combine attention both to formal or informal incentives and to unfathomed cognitive and cultural factors.

In this institutional perspective, institutional settings of AE should be viewed as the whole spectrum of contextual and contingent factors, composed of constitutive informal institutions, like values and norms, and regulative formal institutions, like incentives and sanctions, that can influence scientists in front of the dilemma of behaving like pure academic scientists, \( AE1 \) or \( AE2 \). These settings are often country-specific, depending on historical and contingent factors. As a consequence, on one hand, there are the Mertonian institutions that exercise a homogeneous pressure over scientists. On the other, there are country-specific institutional settings that can influence scientists’ behaviour, shaping both incentives and belief systems they confront to, at the university level, and, in so doing, producing heterogeneity of local conditions.

Institutional settings regulating universities at a national level can be of two types: centralised and decentralised. In the first case, universities reproduce homogeneous features at a local level, since they are influenced by the centralisation of funds, standard rules of carrier advancement, flat wages, and a low degree of autonomy and freedom for local universities in giving rise to particular set-ups of incentives and initiatives. In the second case, universities are encouraged in giving rise to particular set-ups of incentives and initiatives that are autonomously defined at a local level by university administrations and structures. This results in a higher degree of institutional heterogeneity among university settings, with the consequence of a higher relevance of contingent factors on the way in which universities express constitutive and regulative institutional pressures over scientists. In this second case, it is expected to find stronger institutional permeability of
universities towards AE (Owen-Smith and Powell 2003; Rothaermel et al. 2007).

As it is represented in Table 4, on the constitutive side, one of the most important institutional factor affecting AE is the degree of social recognition of the multiple mission of scientists and of the entrepreneurial nature of science (Lee 1996; Kenney and Goe 2004; Searle Renault 2006). The evidence that the entrepreneurial mission of scientists is socially approved and that scientists themselves believe that such a mission is part of their imperatives can influence their decision to contaminate with the technology realm. As we know, the US case is the best example in which such a multiple mission is socially approved and promoted in general, while the EU case is an example of conflicting perspectives, with examples of countries and universities, in which the entrepreneurial mission is increasingly promoted, like in the Netherlands, and examples of strong resistance, like in most universities in Italy and France.

Another influence can be played by the societal recognition of the social benefit of competition along different dimensions, that is, between scientists and universities. Again, such a recognition should be higher in institutional settings characterised by heterogeneity and autonomy, like in the US or in most of private academic institutions. In any case-study on AE, one of the strongest institutional factors that seem influencing the diversity of AE, both among counties and, within countries, among different universities, is in fact the degree of institutionalisation of the principles of competitive allocation of resources and of difference in rules of placement and career advancement. As it is know, the EU policies at a country level are mostly based on a top-down bureaucratic distribution of resources from the State to the universities, a low level of autonomy for universities, flat wages for employees, and career advancement on seniority
rule (Wright et al. 2007). This implies that the market incentives are not embodied in EU academic institutions and that the prevalent cultural frame of scientists conforms to the civil servant ethos. As a consequence, the entrepreneurial efforts in patenting, licensing and spinning-off do not constitute a recognised value for career advancement of scientists, like in many US universities (Searle Renault 2006; Franzoni and Lissoni 2007).
### Table 4. Influence of regulative and constitutive institutions on AE

<table>
<thead>
<tr>
<th>Institutional Features</th>
<th>Regulative institutions</th>
<th>Constitutive institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Definition:</strong> set of incentives upon individual action</td>
<td><strong>Definition:</strong> set of possibilities/constraints on individual cognition and identity at societal and cultural level</td>
</tr>
<tr>
<td></td>
<td>Carriers: formal institutions/formal rewards and sanctions on behaviour</td>
<td>Carriers: values, social norms, cognitive frames, socially shared models of behaviour/social control</td>
</tr>
<tr>
<td>Economic incentives</td>
<td>Can a scientific discovery be ‘capitalised’ by the inventors, at level of economic rewards or of career’s advancement?</td>
<td></td>
</tr>
<tr>
<td>Organisational incentives</td>
<td>Are there explicitly dedicated financial/human/university assets that can help scientists in commercialising their discovery?</td>
<td></td>
</tr>
<tr>
<td>Legal incentives</td>
<td>Do regulations at national/local level clearly define features, boundaries, responsibilities and consequences of inventors?</td>
<td></td>
</tr>
<tr>
<td>University incentives</td>
<td>Are there regulations at a local level that recognise the possibility to spend time and energy in entrepreneurial efforts and that promote this?</td>
<td>Is entrepreneurial mission of scientists approved at a societal level? Do scientists believe that AE is part of their mission?</td>
</tr>
<tr>
<td>Societal recognition of the mission of scientists</td>
<td>Is competition and difference of resources focal principles that are embodied in the institutional settings presiding over universities and scientific communities?</td>
<td></td>
</tr>
<tr>
<td>Societal recognition of the competition principle along different dimensions (among scientists and universities)</td>
<td>Is profit motivation of scientists formally or informally accepted by peers?</td>
<td></td>
</tr>
<tr>
<td>Social acceptance of the market incentive within science</td>
<td>Do scientists belong to scientific communities that share the entrepreneurial mission of science?</td>
<td></td>
</tr>
<tr>
<td>Degree of openness/closure of scientific communities towards entrepreneurial efforts</td>
<td>Are there cultural and organisational pressures towards AE at the university level?</td>
<td></td>
</tr>
<tr>
<td>Degree of institutionalisation of AE within the academic culture of universities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
On the regulative side, one of the most important factors affecting AE is the availability of formal incentives, like the recognition of economic rewards for inventors at the university level, the presence of dedicated university organisational/financial resources explicitly addressed to support inventors, as well as the availability of regulations and laws that can manage potential conflicts among all the interests involved. The strength of these regulative institutions on the quality and shape of AE is commonly recognised in the literature (Shane 2004; Rothaermel, Agung and Jiang 2007; Wright et al. 2007). These institutions allow reducing the uncertainty that is typical of any innovative effort and helping actors involved in solving coordination problems. In doing this, they set conditions and remove obstacles to the entrepreneurial propensity of scientists. Finally, it is worth noting that the effect of regulative institutions is more recognised in literature than the influence of constitutive institutions, on which we are rather insisting in this paper.

At this point, some working hypotheses can be derived from these standpoints on institutions. The first one is that institutional settings, included historical path dependence that is typical of institutional systems and other national and local contingencies, can mould the distribution of the three ideal-types, described in the previous section, in the academic population at a national/local level. Institutional settings can allow explaining the great heterogeneity we expect to find in the empirical reality, both among universities at a local level and among countries at a national level, other factors mostly being equal. For the needs of current
knowledge-based economies, a certain equilibrium between these figures appears to be of vital importance\textsuperscript{5}.

After all, the argument on the difference of institutional settings to explain the diversity of AE transition paths, for example between the US and Europe, is pretty commonly recognised in the literature. For instance, Gettelman (2006) has explained the difference between the US and France in the technological performance in biotechnology in terms of difference in the country-specific institutions governing the career ladder and the professional identity of scientists. Unlike the US, in France, academic career and market-oriented behaviours are not aligned, with the result that “the embeddedness of scientists’ value calculations in professional, political, and cultural contexts means that their decisions are not instrumentally explained by technological opportunity on the one hand or economic incentives on the other”. The same evidence in the biotech sector across the US and Europe has been found by Riccaboni et al. (2003). Goldfarb and Henrekson (2003) have compared the US and Sweden, coming to the conclusion that the difference is conditioned by the peculiarity of the country-specific institutional context. The decentralisation, autonomy and competition along different dimensions that are typical of the US university system sets against the centralisation, civil servant’s functions and standardisation of the Sweden university system. This same evidence has been suggested in Henrekson and Rosenberg (2001), in which there is a careful argumentation on the weakness in the

\textsuperscript{5} Although the entrepreneurial propensity of universities should be seen as a positive feature to have a certain mix of innovative figures in academic institutions, this does not imply any support to the argument of the restriction of public funding for science, which seems creeping in within the political spheres at different levels of magnitude (Franzoni and Lissoni 2007).
Swedish incentive structure towards entrepreneurial attitudes and efforts of scientists.

The same relevance of institutional diversity has been also found at a local level, through fine-grained empirical analyses. An influential example is the field work on university campuses of two comparable US universities described in Owen-Smith and Powell (2003). Although similar in terms of aggregate research capacity, measured through number of active researchers, total R&D expenditure and publication volume, the two universities investigated show a relevant difference in the rate of invention disclosure that is explainable with some distinctive institutional contexts that mould the inter-sectoral transfer of scientific knowledge. Along the same line, Colyvas and Powell (2003), in a case-study on the biomedical field at Stanford, have emphasised the relevance of “the work context”, that is “the context of laboratory life, the career ladder of the academy, and patterns of recruitment and reward within departments and, more broadly, inside the university”, in shaping the propensity of scientists to adopt entrepreneurial behaviour. In a case-study on some south-eastern US universities, Searle Renault (2006) has emphasised the relevance of what we have defined as “constitutive institutions” on the heterogeneity of entrepreneurial behaviours. She has founded the strength of the belief systems of scientists concerning the proper societal role of science and university research.

Therefore, it is worth stressing that particular differences at university level often seem to combine with institutional peculiarities at a national level in shaping a set of incentives/disincentives on entrepreneurial activities of scientists. The relevance of country-university-specific institutions should be taken into account also in understanding the reason why similar policies and incentive structures at national level could give
rise to different answers at a local level, depending on the heterogeneity and peculiarity of behavioural expectations of scientists (Wright, Birley and Mosey 2004). This argument can allow explaining why it is so difficult to generate expected performance at a country level merely by transplanting particular institutions across countries, like intellectual property rights regimes, through policy making strategies. This is what emerges from the vast literature on the controversial effect of the Bayh-Dole Act and its doubles in Europe (Movery and Sampat 2005; Granstrand 2005; Dosi, Marengo, Pasquali 2006).

Another working hypothesis is that the entrepreneurial attitude of universities make a real difference. It is arguable that pure academic scientists are figures which are typical of centralised and bureaucratic traditional universities, $AE_2$ can spread over both in centralised/bureaucratic and decentralised/autonomous universities, while the roots of $AE_1$ are particularly found within entrepreneurial universities (see Table 2). Since traditional bureaucratic universities have a few incentives and resources to control and manage the activities of their scientists, those who are involved in the commercialisation of their discoveries are strongly discouraged to become entrepreneurs within the academic institutions, could be tempted to free ride (using public assets for private purposes) and to profoundly contaminate with private sector, for instance, by patenting within extra-mural networks or participating to business ventures. This implies that the entrepreneurial effort of these scientists do not generate any resource and advantage for their universities and, as a consequence, for the reproduction of science as a public institution.

Such hypothesis could help explaining the high level of corporate patents of academic inventors recently found in the EU case (Lissoni et al. 2007). According to a recent survey, over 60% of academic patent
applications in France, 72% of Italian academic patents, 81% of Swedish ones are owned by business companies, while, conversely, universities in these countries own around 10% of patents in France and Italy, and less than 5% in Sweden. In general, this results in the low skills developed by university administrations in Europe in handling property rights, compared to the US case.

Vice-versa, the best examples of AE at local/university level, like, for instance, Stanford in the US, Warwick in the UK, Twente in the Netherlands, or Chalmers in Sweden, seem to be dependent on an effective coherence and alignment between entrepreneurial culture, autonomy and organisation of the university, on one hand, and entrepreneurial efforts of the single scientists, on the other. In many cases, the strength of the university administrative structures in promoting AE can even overcome the resistance of departments or teams against entrepreneurial propensity of scientists, at a more local level (Franzoni and Lissoni 2007). In other case, the alignment of universities and scientists towards AE propensity allows avoiding the possible free riding of scientists engaged in entrepreneurial activities, by means of the university control and management upon patents, licensing and spin-offs, generating going-back strategic assets for intramural basic research. This is possible because of the presence of particular institutional settings at the university level that help regulating what scientists should do, what is the effect of what they do, and how much they are called to contribute to sustain their universities and their structures with the proceeds of their enterprise. This obviously calls for the quest of autonomy and freedom of universities in decentralised institutional settings.
6. Concluding Remarks and Implications

In this paper, we have elaborated on a theoretical framework that can be of help in understanding some intriguing issues concerning the recent development of AE. The purpose was to frame the quest of AE in sociological sense, finding some theoretical guidelines in order to identify a comprehensive set of open issues to be further investigated in empirical analyses. The connection among Schumpeter, Merton, Dasgupta & David, and the recent sociological and institutional analyses on entrepreneurial science, on which we have tried to elaborate, has been aimed to enlarge the usual perspective on AE, by taking more seriously into account the complicate paths of the science-based innovations which involve university scientists.

In our view, the added value of such a mere theoretical paper should be even more justified if one looks upon the literature in this field. According to a recent and full-scale review, only 2% of papers on AE are driven by theoretical aims and in 50% of papers the micro-unit of analysis is the university and not the scientist (Rothaermel, Agung and Jiang 2007). No doubt that such a situation calls for future studies able to improve the theoretical framework on AE, in order to dissect sound micro-macro explanatory mechanisms and to produce “middle range” theories of these phenomena (Hedström 2005).

From this paper, several questions remain to be answered, calling in particular for future empirical analyses able to combine the level of institutional settings, that is the attention to constitutive/regulative institutions and country-specific institutions, with the level of scientists’ behaviour.
The first one concerns the ideal-typical distinction of the three innovative types we have suggested before (pure academic scientists, \textit{AE1} and 2). It could be that such a distinction should be reformulated as these figures were different stages in the life-cycle of a single scientist (Audretsch, Aldridge and Oettl 2006). Young scientists are more concerned towards peers’ recognition, since they are at the beginning of their academic career and they need good reputation. Senior scientists could be more inclined toward becoming \textit{AE1}, given the responsibility they have acquired on their teams/lab/department, with the consequent increase in fund-raising and management functions they cover. Or, they could be more inclined toward becoming \textit{AE1}, above all if they are confronted with a strong private sector that prompts patenting and licensing activities. In any case, we expect that the institutional settings will influence such a ideal-typical life-cycle.

A second question concerns the fundamental role played by entrepreneurial universities. In this paper, we have considered the entrepreneurial figures at the single scientist level. It is evident that universities are playing an entrepreneurial role that significantly influences the particular institutional settings within which scientists decide what to do. Universities are a pivotal part of the institutional arrangements that we said influence entrepreneurial propensity of scientists. For instance, entrepreneurial universities can counterbalance the self-interest motivation of their innovative scientists and the possible “tragedy of anticommons” that can be a possible outcome of scientific discoveries’ commercialisation. It is expected that, within country-specific institutional settings characterised by heterogeneity and competition among universities, the degree of coherence and alignment among constitutive and regulative institutions towards AE at country and university level would improve the
fine-tuning between entrepreneurial culture and assets of universities and entrepreneurial propensity and results of scientists.

The possible drift of AE, on which both Merton and David have paid close attention, calls for a focal role to be played by universities. As we have said before, the free-riding of innovative scientists seems easier if these last are embedded in non-entrepreneurial universities. The more the universities to which innovative scientists belong is entrepreneurial in itself, the more they are encouraged to behave like AE1, the more the results (also economic ones) of the discoveries patented or licensed can be turned down to fund more basic researches or used for funding university research infrastructures. The more entrepreneurial is the university, the more the scientists can be motivated to patenting for his/her university, and the more the university is able to leverage and manage the potential conflicts between private commercialisation and public nature of science, that is between the two different institutional mechanisms clearly illustrated by Dasgupta (1994). As a matter of fact, if entrepreneurial efforts of scientists are not placed within such a framework, universities run the risk of being not able to defend their real “comparative advantage” in the innovation system, as regards to private actors involved, that is, their incomparable capacity to produce science (Nelson 2001). The resolution of the intrinsic principal-agent problem between universities and scientists involves a stronger entrepreneurial propensity of universities.

This seems a fixed course to manage the “co-existence of two value sets” within academia, that is, market-oriented values and traditional academic values and ideals. As Ylijoki has correctly concluded in her interesting analysis on the AE in the Finland case:
“The challenge for the future is: how can academia adapt to the changing environment in such a way that, while being flexible and responsive, it would also preserve its uniqueness and core commitments, maintain its appeal among senior academics, and attract competent and committed junior researchers in the figure?” (Ylijoki 2006, 332).
References


Academic Entrepreneurship and Academic Innovation


Clarke B. (1998) 


David P. A., (2004a) 

David P. A., (2004b) 
**Can “Open Science” Be Protected from the Evolving Scheme of IPR Protection?**, in “Journal of Institutional and Theoretical Economics”, 160, 1.

DiMaggio (1994) 

**The Relationships between Science, Technologies and their Industrial Exploitation: An Illustration through the Myths and Realities of the so-called ‘European Paradox’**, in “Research Policy”, 35: 1450-1464.

**How much should society fuel the greed of innovators? On the relations between appropriability, opportunities and rates of innovation**, in “Research Policy”, 35, 1110–1121.
Edquist C. (2005)


European Commission (1995)


Garnsey E. (2007)


Gee K. (2001)

**Academic Entrepreneur- An Oxymoron?**, in “Molecular Interventions”, 1: 186-188.


**General Introduction**, in (Eds.) **Science and Innovation. Rethinking the Rationales for Funding and Governance**, Cheltenham Northampton: Edward Elgar, .

Gittelman M. (2006)


Granstrand O. (2005)


Grebel T. (2007)

Grigg T. (1994)


Hedström P. (2005)


Henrekson M. and Rosenberg N. (2001)


Jong S. (2006)


Lacetera N. (2007)
*Academic Entrepreneurship*, PhD Dissertation, MIT:


Lee Y. S. (1996)


Maurer S. M. (2006)

McKelvey M. and Orsenigo L. (Eds.) (2006)
*The Economics of Biotechnology*, Cheltenham and Northampton: Edward Elgar.
Merton R. K. (1938)

Merton R. K. (1942)

Merton R. K. (1957)

Merton R. K. (1968)


Mowery D. C., Sampat B. N. (2005)


North D., (1990)
North D., (2005)  


**To Patent or Not: Faculty Decisions and Institutional Success at Technology Transfer**, in “Journal of Technology Transfer” 26, 99-114.


Schumpeter J. A. (1912)  

Schumpeter J. A. (1939)  

Schumpeter J. A. (1947)  

Schumpeter J. A. (1949)  


Academic Capitalism and University Incentives for Faculty Entrepreneurship, in “Journal of Technology Transfer”, 31, 227–239.


The Rise of Entrepreneurial Activity at University: Organizational and Societal Implications, in “Industrial and Corporate Change”, 16, 4: 489-504.

Slaughter S., Leslie L. L., (1997)  
Stoneman P. (2007)
Technological Diffusion: Aspects of Self-Propagation as a Neo-Schumpeterian Characteristic, in H. Hanuch and A. Pyka (Eds.), 377-385.


Swedberg R. (1991)


Weber M. (1904)

Willer D. and Webster M. (1970)


Wright M., Birley S., Mosey S. (2004)
