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THE ECONOMICS OF UNIVERSITY: A KNOWLEDGE GOVERNANCE APPROACH

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THE ECONOMICS OF UNIVERSITY: A KNOWLEDGE GOVERNANCE APPROACH[1]

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ABSTRACT. University is becoming the beam of the new emerging mode of governance of the generation and dissemination of knowledge as it reveals remarkable institutional advantages both to provide a solution to the knowledge trade-off and to reduce agency costs. The typical academic labor relation emerges as an appropriate institutional device to handle the principal-agent problems when creative talents are required. The unique institutional setup of the academic system creates the supply of certified skills that are ready to operate on a professional base. Such academic consultants can be paid on an ex-post per job base matching their variable costs only. This supply leads to the creation of a specific market for research services where the demand is provided by the knowledge outsourcing of corporations

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1. INTRODUCTION

The great ingenuity of economics resides in the asserted coherence between profit maximization at the agent level and social welfare, at the system level. When markets are competitive, returns are constant and all products are economic goods, profit-seeking and profit maximizing agents, interacting in the market place exclusively by means of full fledged transactions, are able to identify the best combination and hence to generate the maximum amount of social welfare. The markets can perform successfully such functions only in a context where profit-maximization and maximum social welfare are jointly achieved. In turn, as it is well known, this can be achieved only if appropriate information is available on the technological competence of perspective partners and the future paths of technological change and technological knowledge are perfectly known to everybody.

As it is well known only future prices make it possible to solve the problems of dynamic coordination. When a vector of future prices is available for all products, agents can identify the correct amount of resources to invest in each activity and the effects of the trajectories of demand and future entry and exit can be assessed. When

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future markets and future prices are available, the market is able to perform properly its basic function of dynamic coordination among the expectations and conducts of a variety of agents and hence fails to provide the indispensable consistency in the long-term allocation of the resources.

The production and circulation of knowledge do not match these conditions. High levels of uncertainty characterize the generation of knowledge. It is very difficult to anticipate the outcome of a research process, its duration, its actual economic value, and even its specific content. Serendipity plays a crucial role. The organization of the division of creative labor within firms is consequently very difficult. Strong incentives push towards the definition of ex-post mechanisms of compensation. At the same time however it is clear that a social support is necessary to sustain the early phases of the generation of new scientific activities and the provision of general knowledge that is fungible, i.e. relevant for a wide variety of knowledge generating activities.

In this context, it is clear that agents differ greatly in the capability of both generating, using and understanding technological knowledge: knowledge asymmetries are intrinsic. Information about knowledge is not only asymmetric but also intrinsically limited: opportunistic behavior and bounded rationality are not exceptions but rules. Moreover different levels of uncertainty can be found and hence different levels of complexity in the solution of the typical problems rose by information and knowledge asymmetries, knowledge transaction costs and principal-agent relations in the generation of new knowledge.

The identification of each bit of complementary and useful knowledge as well as the interaction with the agents holding specific bits of knowledge and the assessment of their complementarity, both with respect to their present and future needs and opportunities, the correct definition of the flows of entry into new knowledge modules and the exit from declining ones, the proper combination of the incentives to invest in the generation of new knowledge, and the incentives to disseminate and use external knowledge, are all essential functions that spontaneous governance mechanisms in place perform poorly. When increasing returns associated with knowledge cumulability, compositeness and fungeability are at play, especially within the modules that characterize technological systems; corporate governance mechanisms at work are a necessary but not sufficient condition to achieve dynamic efficiency. With increasing returns the case for dynamic market failure emerges.

Because of the complementarity, between internal and external knowledge, and among modules of knowledge related by weak indivisibility, especially if the latter is specified in terms of a multiplicative relationship, the aggregate outcome of both market transactions and interactions is unstable and sensitive to interactions and subjective decision-making. When both demand and supply schedules are influenced by externalities, multiple equilibria exist. The amount of knowledge each firm can generate depends upon the amount of external knowledge available that is upon the amount of knowledge that other firms, especially when involved in complementary research projects, have generated and cannot appropriate or are willing to exchange. An iterative dynamic process is at work with no stable attractors: both negative and positive self-reinforcing mechanisms can take place (Antonelli, 2005 and 2006).

Inclusion needs to be coordinated and managed. Free riding can take place, although reciprocity and mutuality in interactions based upon knowledge barters, implemented by repeated and long-lasting exchanges, can help reducing the extent and the effect. Exclusion is dangerous for the risks of missing the relevant complementary input, which characterizes the generation of new technologies. Multiple equilibria and micro-macro feedbacks affect the working of bureaucratic coordination, networking interactions and transactions in the markets for technological knowledge and their outcome. The dynamic coordination of agents plays in this context a central role.

A divide takes place between the results of the maximization of profits and the conditions for the maximum social welfare. Governance mechanisms in place appear to provide a set of incentives that may or may not lead the system towards stable and fair solutions. Tradability is a necessary but not sufficient condition for dynamic efficiency to be achieved, bureaucratic coordination and networking do not assure that profit maximization coincide with social welfare. The aggregate outcomes of the governance mechanisms at the firm level are far from being attracted by a single equilibrium point (Nelson, 2005).

In such a context, where the organization of the generation and use of knowledge are afflicted by a variety of economic problems such as transaction costs, agency costs, networking and communication costs, the creation and adaptation of appropriate institutions for the governance of the generation and dissemination of knowledge is all necessary to solve the key problems of the correct identification of the appropriate incentives mechanisms and the selection of the areas where to invest new resources, so as to increase the amount of knowledge available in an economic system

The organization of the production of knowledge in advanced economic systems is facing a rapid shift away from the corporate model established in the second part of XX century in the US towards a new University based model (Zeitlin and Herrigel, 1999; Etzkowitz and Leydesdorf, 2000; Etzkowitz, 1998). The old model was based upon the pivotal role of the large corporation and was articulated on the key role of direct public subsidies to firms investing in research and development activities, strong public demand of goods and services incorporating high levels of knowledge intensive products and the complementary role of the academic system supported by public funding. The new model, still emerging, seems to assign to the academic system the new pivotal role, small firms play much a stronger role in the process as complemented by the new venture capitalism and the emergence of new surrogate markets for knowledge intensive property rights that is the result of the blending of financial markets and the markets for knowledge (Antonelli and Teubal, 2006). Corporations are performing a declining part of research and development activities while they remain active in the funding of the generation of new knowledge and its eventual purchase in the form of mergers and acquisitions of new innovative small firms and research contracts assigned to the academic system (Chesbrough, 2003; Chesbrough, Vanhaverbeke and West, 2006). Etzkowitz (2002) proposes the successful metaphor of the triple helix where government, universities and firms are the three elements of a dynamic process of interaction and interdependence.

The academic system is emerging as the key player in the new model as it appears to be an institution, which is more apt to manage creative talents. Specifically the university is now regarded as an institution, which has elaborated a set of rules and

routines, articulated in a unique mix of incentives, and contracts that is especially efficient in the organization of the generation and dissemination of knowledge as an economic process. Such an assessment is the result of a closer analysis on the role of the academic system as an institutional device that favors the management of creative talents from a principal-agent viewpoint.

The academic system is more and more regarded as a form of intermediate governance mechanism that has gradually emerged through centuries with specific characteristics that, if properly identified and implemented, make it possible to coordinate some levels of division of labor and exchange. So far the academic system seems able to fill the wide gulf between the two extreme cases of the State as the single provider of knowledge as a public good and the Corporation as the appropriate institution for the provision of knowledge as a quasi-proprietary good.

Here the characteristics of knowledge matter and the application of the basic tools of information economics provides major opportunities to grasp the rationale of knowledge governance mechanisms. In this context the application of the tools of information economics to understanding the economics of knowledge and the working of the economic institutions of the knowledge economy makes it possible to explore new facets of the reasons for the increasing role of the academic system as a viable institution (Stiglitz, 2000 and 2002).

2. FROM OPEN SCIENCE TO THE ACADEMIC MANAGEMENT OF CREATIVITY

University is a long-lived institution. Since its origins, in Bologna in 1088, it is has been able to survive and change, adding new facets and new aspects. The new emerging role of University as the pivotal beam of the new organization of the production and dissemination of knowledge pushes to try and understand the reasons for such an extraordinary story of success and adaptation from an economic viewpoint. It is in fact commonly agreed that the academic system is an effective institution for the governance of the generation and dissemination of new knowledge characterized by high levels of tacitness. Scientific knowledge, even when it takes the form of a highly codified expression, has high levels of tacitness and requires high levels of competence to be generated, transmitted and communicated. Many different reasons to explain why the academic system is an effective institution can be found. Different interpretative frameworks seem useful both to understand its vitality and to guide its evolution.

The work by Dasgupta and David (1987 and 1994) has been long regarded as the most comprehensive analysis of the economic foundations of the academic system. Daguspta and David in fact shown that the academic system provides a viable institutional set-up to combine the incentives to the dissemination and the generation of new knowledge. University makes it possible the working of open science, that is the peculiar combination of the incentives to generate new knowledge and yet to disseminate it into the economic system.

In so doing Dasgupta and David have provided a clue to the economic analysis of such a peculiar institution where knowledge-producers have a clear set of incentives

to generate new knowledge and yet to dispossess of it, via its rapid dissemination by means of its publication. The open science mechanism works when an academic institution provides the necessary monetary and hierarchical rewards to scientists, according to their qualification and their reputation. The reputation of scientists is built upon publications scrutinized by peer review. In open science the production and dissemination of new knowledge signals the levels of competence and the skills of the scientist and hence disseminates new knowledge. Because of its effects in terms of reputation and hence ultimately inclusion in the academic system, however, the pursuit of publication is at the same time, an incentive. This mechanism works properly as long as the costs bored by the system to fund the academic system is compensated by the externalities generated by the academic system. Here both the amount of knowledge actually produced and the part of it, which is effectively communicated to the rest of the system matter. With high levels of knowledge generation but low levels of effective knowledge communication, the amount of costs bored by the economic system can become higher than the revenue.

The analysis of Dasgupta and David is based in the Arrovian tradition of analysis of the economics of knowledge and specifically it can be regarded as an insightful elaboration of the well-known knowledge trade-off. Along the lines of the Arrovian approach in fact, knowledge, is regarded as an economic good that suffers of many limitations and drawbacks, namely non-appropriability, non-divisibility, and non-rivalry in use (Arrow, 1962a and b, 1969). Moreover knowledge is at the same time an output of a specific activity and yet an input, not only in the production of other goods, but also and mainly in the production of further knowledge. Hence the knowledge trade-off between the incentives to increase appropriability and hence an appropriate stream of economic benefits for inventors, and the contrasting need to increase the access to the existing knowledge so as to facilitate its use in the production of new knowledge. Working in this analytical context, Dasgupta and David have made it possible to understand the original and innovative combination of incentives that can be found within the open science system. The academic system makes it possible to provide a solution to the knowledge trade-off. It works, however, if and only if the provision of public funds makes it possible to secure a reward for the inventor, after the publication –the dispossession- of the new knowledge has been made, with tenure and an appropriate wage.

Diagram 1 provides a synthetic account of the interpretative rationale elaborate by Dasgupta and David (D-D). The system is based upon a triangle where the insertion of State makes it possible the indirect relationship between the demand and the supply of knowledge that the knowledge trade-off impedes to operate directly. The business system accepts to pay some taxes that are transferred by the State to the academic system. The latter in turn manages the open science system which incentives the generation and eventual dissemination of knowledge by means of chairs assigned to creative scientists. The creativity of scientists is measured by their publications. Tenured scientists are requested to teach and publish at the same time: in so doing they create and disseminate new knowledge.

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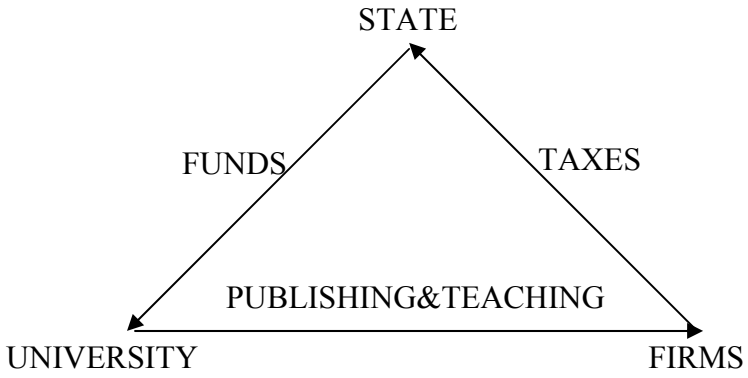
DIAGRAM 1. THE D-D FLOW CHART OF THE ACADEMIC SYSTEM



The interpretative approach elaborated by Dasgupta and David suffers from three main weaknesses. First, it provides no understanding of the criteria that it is necessary to identify the correct amount of public resources to be provided to the academic system. Second there is no clue to the identification of the criteria for the distribution of public funds within the academic system across academic disciplines and scientific fields. Thirdly it provides poor guidance to allocate a given amount of public funds in a given discipline among different possible academic institutions. In a pure 'open science' system a chair should be given to the best scientist with no prior identification of its discipline or location. Consequently the amount of resources that should be transferred to the academic system should be based exclusively on the number of scientists that fetch some absolute levels of scientific excellence.

As a matter of fact a variety of spurious mechanisms are at work. Rules of thumb are used to fix the general amount of resources that the State transfers to the University. Didactic factors play a strong role. The numeric pressure of students has a strong effect, even when scientific reasons would not suggest funding the growth of some schools and some universities instead of others. Here the typical problems of the principal-agent relationship emerge. Academic institutions may have specific internal incentives to direct the public funding towards field A instead of field B that do not necessarily coincide with the optimization of welfare. All exercises of technological and scientific forecasting have proven limited reliability. Here the risks that hierarchical control, within the academic system, pushes towards the misallocation of funds, away from fertile and productive new field in defense of tradition and established academic corporations is very strong.

The application of the tools provided by the economics of information to analyzing the economics and the economy of knowledge and the basic institutions of the knowledge economy can be fertile (Antonelli, 2006).

The academic system can be considered a viable institution for the governance of the generation and dissemination of new knowledge from another, complementary and yet well distinct viewpoint: the principal-agent approach. From this perspective the

typical non-exclusivity that characterizes the employment contract within universities and the freedom to enter the markets for professional services traditionally recognized to academics plays a crucial role. Academics publish to signal their competence and attract resources to fund their activities. The publication is part of a dynamic process where the scientist has a direct incentive to publish at time t1 as a way to attract resources at time t2 (Spence, 1973). From this viewpoint the need for public funds is much less relevant. In the extreme case, the academic system comes closer to a special form of professional order: membership in the academics system provides the basic qualifying conditions to operate in the markets for high quality knowledge intensive professional services.

The academic scientist is often also a member of the professional community for which the new knowledge is directly relevant in the daily professional practices. In other words, publications are signals that are directly valuable in the adjacent professional community, overlapping with the scientific one. Hence the close overlapping between the recognition within the scientific community and the professional reputation is a strict, necessary condition for the system of incentives to work. According to this approach the academic system seems much a more viable institution than the corporation for the governance of the generation of knowledge characterized by high levels of uncertainty and serendipity where the principal has little chances to assess properly and ex-ante the true creativity of the agents, the amount of the efforts actually made, the outcome of the research process both in terms of timing and specific content.

3. THE COMPARATIVE ECONOMICS OF AGENCY COSTS: THE UNIVERSITY AS AN EFFECTIVE INSTITUTION TO SOLVE PRINCIPAL-AGENT PROBLEMS IN CREATIVE WORK.

High levels of uncertainty characterize the generation of knowledge: serendipity and creativity play a crucial role. Even if the heroic assumption that the need for a specific module of knowledge can be identified, and consequently a hierarchy and a sequence of possible necessary modules of knowledge can be agreed upon and an amount of resources can be funded, it is clear that the process is still affected by basic uncertainty. Once the amount of resources has been fixed and an objective has been identified, in fact, basic unpredictability about many different aspects of the knowledge generation process emerge: **if** the new knowledge will be generated, **when** the new knowledge will become available, **where** - in which field - it will be generated and even **how** – by means of what modules of pre-existing knowledge- it will be generated.

It is very difficult to organize and manage employment relations in such context. Principals have major problems in assessing the actual levels of creativity and effort of their agents and to value their output.

3.1. AGENCY COSTS IN CORPORATIONS.

The costs of hierarchical coordination, articulated in agency and organization costs limit severely the size and the span of knowledge-intensive activities conducted within the boundaries of a single unit (Arrow, 1974). Agency costs limit the use of

hierarchical command of the activities that are necessary to generate and use technological knowledge within the boundaries of the firm for two classes of reasons. Knowledge asymmetries do play a major role within organizations as well. Because of the key role of serendipity and creativity in the generation of new knowledge it is difficult for principals to control the actual content of the operations that lead to the generation of a given amount of standardized knowledge.

The management of research activities within corporations is harmed by the problems associated with the identification of a correct system of incentives. This has negative consequences because of the characteristics of the distribution of creativity. Large empirical evidence confirms that high levels of asymmetry - close to a typical Pareto distribution - characterize the distribution of actual scientific creativity among qualified and competent scientists. A small share of scientists is responsible of a large share of all publications and an even larger share of all references (Patrucco, 2006). Any mistake in the identification of the actual creative minds and even worst all mistakes in the implementation of an appropriate incentive structure able to motivate the creative efforts of the few creative minds have major negative consequences on the output of the research activities and hence on their average costs.

As it is typical in these conditions two sources of possible errors can easily take place:
i) The failure in the identification of the true creative minds. The rare skills of the true creative minds are lost because of the lack of actual incentives and mistakes in their identification, and
ii) The appreciation of agents who are not, as a matter of fact, truly creative. Non-creative agents can try and take opportunistic advantages of the basic information asymmetries with respect to principals about: A) the perspective value of the knowledge produced and B) the actual effort and work that has been necessary to use to generate it.

Agency costs in the generation of knowledge within complex organizations are consequently very high also because of the limitations in anticipating the outcome of a research-in progress not only in terms of rates, but also and mainly in terms of directions. The outcome of a given research project can be relevant but in fields of application that differ from the expected ones. The traditional organization of labor in knowledge-intensive activities characterized by high levels of craftsmanship and self-employment with strong professional content is clearly explained by the high levels of agency costs in monitoring efforts, outputs and applications in the generation of knowledge (Holmstrom, 1989, and Garicano, 2000),

Internal organization costs as well limit the number of complementary activities that can be internalized by each firm and hence the amount of knowledge that can be generated, implemented and exploited internally. Unit organization costs are elastic not only to the size of activities but also and mainly to the variety of activities that need to be internalized. The larger is the rate of increase, with respect to the number of activities, of unit organization costs and the larger is the number of complementary activities that cannot be retained within the boundaries of the firm. Because of hierarchical coordination costs, incumbents miss important opportunities. Large corporations are unable to implement all the opportunities they contribute to create. Coordination costs in fact apply both the specific activities that are required to

generate new knowledge and to the production processes that are necessary in order to use and exploit the knowledge generated (Arrow, 1974).

In such conditions it seems clear that the larger is the uncertainty of the research projects and the larger is the un-predictability of the outcome and the lower is the efficiency of traditional business systems to manage the generation of new knowledge. Firms have a strong incentive to rely more and more, not only upon the traditional dissemination tools of the knowledge generated by universities, i.e. publications and the PhDs, but directly upon academic consultants that can be hired on a professional basis, as intermediate knowledge-intensive inputs to perform a research activity. Intramuros research and development is substituted or strongly complemented by the services provided by the academic system.

Corporations act more and more as system integrators of large research programs that are performed by a variety of academic centers. The corporation retains of course the command of the division of labor and manages the integration of the different modules of knowledge within an internal knowledge platform. The chief scientist of the corporation organizes the general research project, and elaborates its structure in complementary modules of knowledge. Part of the research is performed intramuros and part is outsourced to competent academics. The identification and selection of the academic individuals and academic centers able to provide the necessary modules becomes crucial.

3.2. AGENCY COSTS IN THE ACADEMIC SYSTEM.

Alternative institutions are necessary to manage the production of such a specific and idiosyncratic kind of good. Here the departure from the arrovian tradition of analysis is clear. The emphasis of this analysis is no longer concentrated on the allocative problems, but rather on the generation problems.

By contrast, the organization of creative work within the academic system can be appreciated for its unique combination of sophisticated ex-post compensation and a two party incentive system. From this viewpoint the academic system seems to be based upon the certification of creative talents. The principal rewards the creative workers with the provision of a certificate that qualifies the actual levels of creativity of the workers. The qualification, indeed, is based upon the reputation acquired in the open science system. The qualification, however, entails more than tenure and the attached wage. It enables the scientific worker to enter both the markets for knowledge services and the related markets for professional services. In the former the worker can sell her specific research capabilities to firms that are ready to hire competent researchers for the performance of specific research tasks where the scientific worker has accumulated competence and expertise. In the latter, the scientific worker can provide directly specific services where her competence is established.

In order to obtain such a certificate, the scientific worker has a strong incentive to establish her own reputation by means of publications. The actual compensation scheme however is broader than the one considered by Dasgupta and David. Hence the mechanism identified by Dasgupta and David to solve the knowledge trade-off is

at work, but in a broader system of incentives and agency costs. The principal agent approach however makes it possible to explore these other aspects.

In the open science system identified by Dasgupta and David, the principal bears all the agency costs stemming from the need to control the efforts and the actual creativity over time of its tenured workers. The risks of opportunistic behavior and declining creativity are high.

A closer analysis of the working of the academic system reveals two basic features that make it possible to reduce the agency costs and to bear a limited amount of the costs of scrutiny and assessment of the actual creative skills and efforts of its workers. The academic system is in fact characterized by a) its intrinsic diversification in two markets: the market for education and the market for knowledge, and a) the non-exclusivity of the employment contract and the related dual ladder structure of the compensation scheme.

Scientific workers, after qualification and formal entry into the academic corporation, are expected to provide basic training services. The labor contract with the university includes basic teaching duties for the scientific worker. The university pays a salary that is not expected to remunerate the full marginal productivity of such labor, but only a part of it, close to the component stemming from the marginal productivity of the teaching activities.

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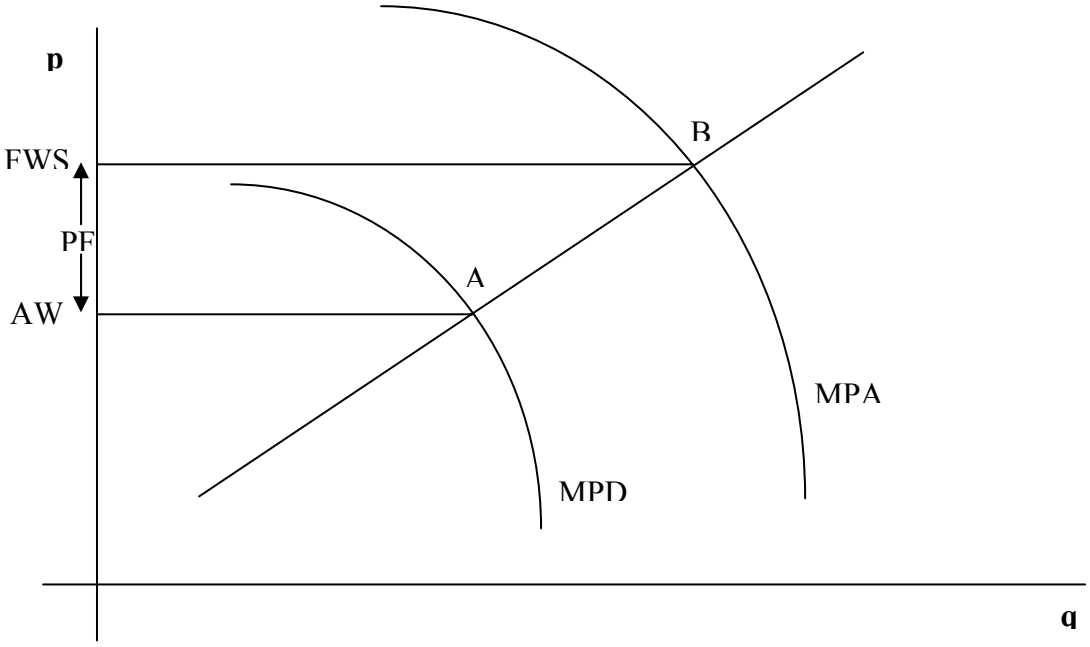
DIAGRAM 2. THE TWO-PARTY COMPENSATION OF ACADEMIC PAY



As Diagram 2 shows, the marginal productivity of academic work (MPA) can be split into two components: the marginal productivity of didactic activities (MPD) and the marginal productivity of research (MPR). In diagram the distance between MPD and MPA measures MPR. Universities pay a salary (AW) that is defined by the marginal productivity of didactic activities. Professional fees (PF), earned in the markets for knowledge, either directly as private consultants or indirectly via contractual relations between the university and the firm, pay for the marginal productivity of research activities and, added to academic wages, compose the full wage of scientific workers (FWS).

Relevant economies of scope in the generation and dissemination of knowledge and in monitoring costs provide the foundations for the viability of the joint production of training services and new knowledge. The university has a clear incentive to hire qualified scientists who have been able to build up a consistent reputation by means of publications because of the strong complementarity between the quality of teaching and the quality of scientific competence. Training services can be better controlled: the amount of efforts in teaching, the competence of teachers and, to some extent, the output of didactic activities can be better assessed, with respect to the activities leading to the generation of new knowledge.

At the same time, in so doing the university certifies the actual talent of the scientific worker and provides her with the opportunity to enter the markets for research and professional services. The non-exclusivity of the labor contract, typically practiced in the academic system, makes it possible for the certified creative talent to sell her competence and creativity in the markets for research and professional services. Here creative minds can find the compensation for the marginal productivity of their competence. In some extreme cases certified, creative talents, i.e. university professors, can buy-back their teaching time, renounce to all wages paid by the university and spend all their working time in the markets for research and professional services[2]. Eventually however if and when creativity slows down, professors can come back to provide teaching services and earn the wages paid by the university.

The academic system emerges as a viable institution for the governance of the generation and dissemination of knowledge from two complementary and yet distinct economic arguments. First, the academic system combines in a single and unique institutional set the solution to the knowledge trade-off. Second, the academic system, articulated in the combination of didactic activities, certification of the competence and skill of creative workers, and non-exclusivity of labor contracts, provides the institutional setting which engenders the creation of an efficient supply of certified knowledge workers to the rest of the economic system. In so doing the academic system provides basic signals about the actual supply of creativity and competence and their distribution across fields.

The incentives to the generation and eventual dissemination of new knowledge are no longer provided exclusively by the academic system. The scientific reputation

[2] Many 'traces' in the institutional setting of the academic system reveal that wages paid by universities are mainly related to didactic activities. In many US universities the University corresponds a yearly wage based upon 9 months of full paid wage. The 'buy-back' procedure enables professors to escape teaching paying to the university a large if not substantial part of their wage.

acquired by means of scientific publications and certified by the academic system can engender some wages paid by the academic system. A second component however can be identified in the compensation scheme for certified creative talents. Scientific reputation engenders now actual monetary rewards that can be earned in the markets for research and professional services.

Such rewards can be capitalized especially when the conversion of generic knowledge into highly specific and idiosyncratic applications is both necessary and not easy[3]. The second important condition for such a system to work is the high level of knowledge fungeability. Fungible knowledge can be applied to a variety of specific cases. Idiosyncratic applications cannot be easily imitated and replicated. Finally, reputation plays an important role when the opportunity cost of choosing the wrong expert are high for the wide gaps between ex-ante and ex-post conditions: patients praise most the reputation of their doctors when their life is at risk. Heavy investments in irreversible industrial projects suggest using the best experts available to minimize the technical and commercial risks of the undertaking and to avoid to scrap huge amounts of brand new fixed capital. Spontaneous epistemic communities based on nested interactions and transactions are especially successful in the academic communities and in the adjacent professional markets (Antonelli, 2006).

The unique institutional set-up of the University makes it possible both to reduce the negative effects of the principal-agent problems when the production process is characterized by uncertainty and basic information, actually knowledge, asymmetries, and to create a supply for professional research services.

The understanding of these features make also possible how the combination of non-exclusivity in the employment relationship and the joint-production of didactic and research services leads to the creation of a market for professional research services.

3.3. MARKETS FOR RESEARCH SERVICES

The institutional ingenuity of the academic system engenders the creation of a supply for professional research services. On the supply side of this special market in fact we find academics, both as individuals and as academic centers that are certified and qualified with respect to their actual levels of creativity. Moreover the compensation schemes practiced in the academic system allow the supply side to operate on a variable cost base. Fixed costs of the academics, as a matter of fact, are covered by the internal payment for their teaching activities provided by the academic system. The supply in this market is now characterized by high levels of signals about the actual quality of the supply and reduced costs, as the total cost of academic supply can be shared between universities as institutions and the customers of the research services. The position of the supply curve is much lower than it would be without the academic system.

[3] This mechanism of indirect reward can take place also in a broader context: often academics become political leaders, consultants to large banks and financial corporations if not directly members of their boards, occasionally they are appointed in high level bureaucratic posts and even in parliaments and governments.

On the demand side moreover transaction costs and specifically search and screening costs are much lower for two reasons: first suppliers are qualified and signaled by their academic career based upon reputation and ultimately upon publications and other scientific scores based upon references and quality of journals. Second, suppliers are ready to work on a professional base and to accept a compensation that is clearly based upon the actual delivery of the knowledge module. In other words academics are not seeking for a permanent employment contract with firms, but operate on a professional base. This in turn allows the working of ex-post payments based on actual delivery of an output. In so doing the academic is paid by the job.

In the markets for research and professional services the demand for knowledge inputs of the firms can meet the supply of certified, part-time talented workers with a significant reduction in the costs of using the markets. Qualified and certified scientific workers can earn substantial rewards in the supply of their creative talents in the markets for research and professional services. In this market scientific workers can be paid by the job as professionals.

Firms that are exploring external sources of knowledge constitute the demand side, in the markets for research and professional services. Firms are ready to substitute internal research activities with scientific skills and competence that can be acquired in the market place. Outsourcing of research activities to qualified academic laboratories becomes common practice. Firms perform less and less the research activities with a high scientific content within their own laboratories and rely upon the competence of universities. This is especially relevant when technological knowledge is codified and composite: in this case firms should command a wide array of scientific fields with little chances to achieve high levels of specialization and competence in each. The systematic access to the wide range of competence provided by universities in fact makes it possible to increase the chances for effective recombination and eventual generation of new knowledge at much lower costs.

Firms can take advantage of the supply of scientific and creative competence of the academic system either directly, hiring individuals that operate as professionals, or indirectly when the contractor is the university itself. The latter case is typically used when teamwork is necessary to perform the research activities. Individuals in this second case however do retain the right to share with the university the rewards stemming from their professional services. In this case the University performs the functions of an associated partnership well practised in the legal services and other markets for professional services.

Universities can be selected according to their reputation and competence and a variety of contingent contracts can be activated with highly specialized laboratories. When technological knowledge exhibits lower levels of codification, the relations between universities and firms are typically based upon long-term broad contracts within framework programs that cover many different contracts and include funded chairs and bilateral transfer of personnel, as well as the systematic hiring of students who have finished a doctoral program. The more structured the fabric of contractual relations and the lower the risks of leakage and premature disclosure by scientists seeking visibility and extended reputation. Firms try and exert a strong control on the results of the research activities by means of intellectual property rights and specific contracts based upon timing and priority in dissemination. Scientists however need to

reconfirm their reputation and hence have a strong incentive to publish. The reputation-seeking behavior of scientists prevents the reduction of dissemination and hence favors the solution of the knowledge trade-off.

The creation of new firms, by former scientists, is often the direct result of the exploitation of new knowledge, which, as such can be traded only if incorporated in knowledge-intensive-property rights. Scientific entrepreneurs are inventors, which cannot rely on the markets for disembodied knowledge and prefer to exploit the rents associated with their knowledge by means of the production and sale of the products that embody, either as a product or a process innovation, the new knowledge. Scientific entrepreneurship becomes a viable mode of exploiting technological knowledge generated within universities especially if and when complementary institutions such as venture-capitalism and new dedicated markets specialized in the trade of knowledge-intensive-property rights, such as the NASDAQ, have gradually emerged in the new institutional system for the governance of knowledge. Eventually new-born high-tech companies created by scientific entrepreneurs with the assistance of venture-capitalists enter the new dedicated financial markets with an initial public offering and can be acquired, via mergers and acquisitions, by large corporations. Dissemination of the new knowledge is hence made possible via the working of the new financial markets (Antonelli and Teubal, 2006).

3.4. A SIMPLE GEOMETRIC EXPOSITION

The analysis conducted so far can be stylized with the help of a simple geometric exercise. Let us assume that the Principal in the economic system is able to identify the correct quantity of knowledge that it is necessary to pursue the correct level of economic growth. A clear minimization problem can be set: the economic system has a strong incentive to try and minimize the institutional mechanism that makes it possible to reduce the costs of the necessary knowledge. The correct amount of knowledge that is necessary is identified in diagram 1 by Q* on the horizontal axis. Let us now consider three alternative institutional solutions for the provision of that quantity of knowledge. Respectively the Open Science (OS), the Corporation (CO) and the Academic Outsourcing (AO).

The cost function of knowledge (KC) in the corporation mode is characterized by decreasing returns to scale for the sharp effects of monitoring and screening activities. Principals have limited capability to value the actual creative skills of their scientific workers, the levels of their efforts and even the value and the timing of output. Formally we see that the cost function of the corporate mode exhibits a positive slope with a positive second derivative:

(1) KC (CO) = a(q) with a'>0 and a">0.

The cost function of knowledge in the pure academic mode (OS) is characterized by a two party scheme. Total costs are composed by fixed and variable costs. Fixed costs are anticipated by the principal, i.e. the public sector that acts as an intermediary between taxpayers (ultimately firms) and the wages of scientific workers. Variable costs that are necessary to account for the activities of dissemination and absorption that are necessary for the effective communication of the knowledge produced within

the academic system to the rest of the economy. Formally we see a positive slope of the variable costs:

(2) KC (OS) = A + b(q) with b'>0 and b"= 0.

Finally, the cost function of knowledge with the academic system that includes academic outsourcing (AO) and hence the active role of the derived demand of firms in the markets for research and professional services as customers of intermediary inputs for the production of new knowledge provided by certified creative minds that are part-time academics is characterized by some fixed costs that it is necessary to pay part-time scientific workers and variable costs for the actual generation of knowledge intramuros. This second component exhibits decreasing returns to scale, but of a lesser degree that in the case of the corporate mode. The basic activity of signaling provided by the certification of the academic system and the professional type of relationship that is established between firms and academics helps reducing screening and assessment costs and hence to minimize agency costs. Formally we see:

(3) KC (AO) = Z + c (q) with c'>0 and c"> 0, c" < a", Z < A.

INSERT DIAGRAM 3 ABOUT HERE
DIAGRAM 3. ALTERNATIVE INSTITUTIONS FOR KNOWLEDGE GENERATION AND DISSEMINATION

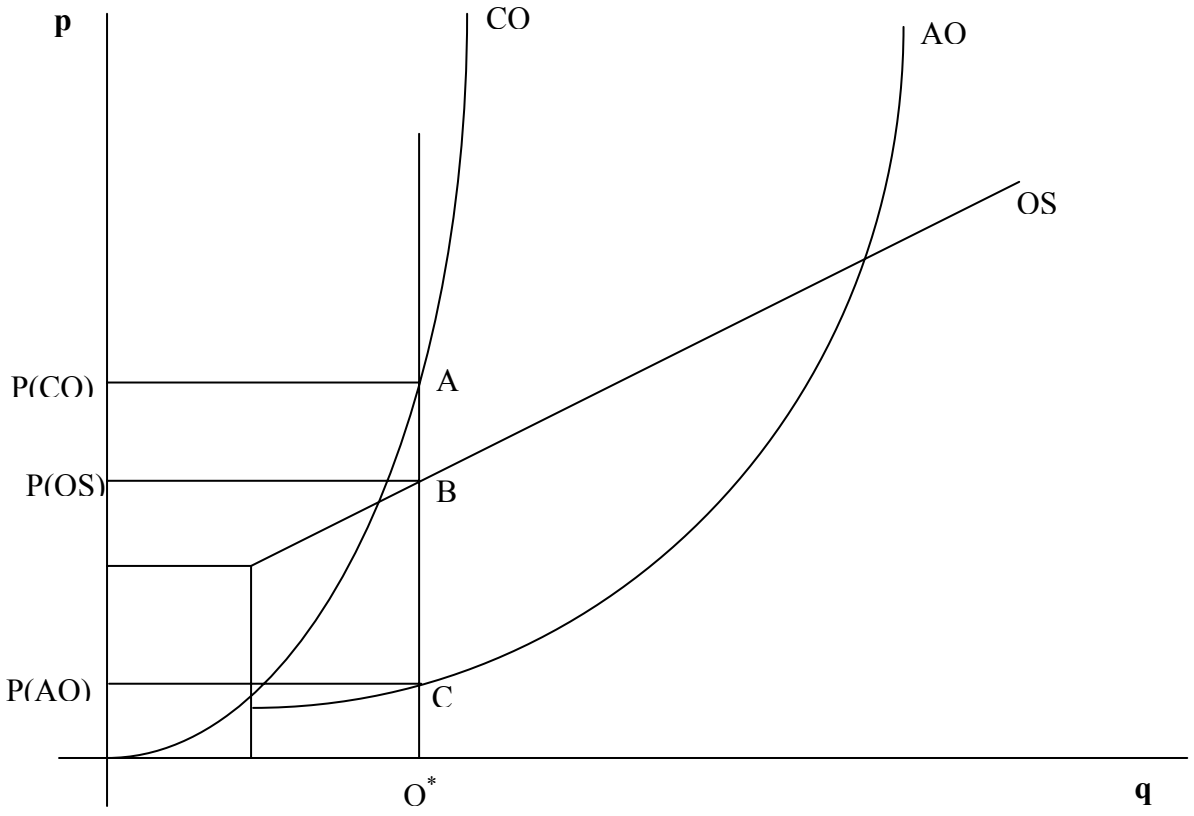


Diagram 3 provides a geometric expression of our basic argument. The vertical axis exhibits the difference in the costs of the given quantity of knowledge that a system

requires. The costs for the provision of the desired quantity of knowledge (Q*) are larger with the corporate mode especially if and when Q* is large. Actually with low levels of Q* the corporate mode where the generation and dissemination of new knowledge rests upon the central role of in-house research and development laboratories funded and operated by large corporations is more effective. The pure academic mode is more effective than the corporate mode, provided the slope of the communication variable costs is not too large. The solution provided by the academic outsourcing mode are clearly the lowest. This reveals the competitive advantage of the combination of the academic provision of qualified and certified personnel which enters the markets for the provision of research and professional services on the supply side. On the demand side, firms are ready to purchase such services, on a spot basis, with compensation schemes that are tied to specific performances and tasks within a broader organization of the division of scientific labor still managed by corporations. The latter however are exposed to lower levels of agency costs for the lower need to control and assess the performance, efforts and actual creativity of their professional inputs.

We can explore how this situation changes when the quantities of knowledge that are considered necessary for the system change. If we consider the region before Q*, it seems clear that the lower is the quantity of knowledge and the larger the competitive advantage of the corporate solution. This can be regarded as the stylized representation of the period comprised between the 1950 and 1990. Research and development activities funded and performed by large corporations are the main source of knowledge. University is left in an ancillary condition. Actually corporations try and reduce the amount of public resources for the academic system on the ground that research and development activities conducted intramuros are far more efficient in terms of selection of the goals and objectives, performances and close interaction with users.

The region identified by a quantity of knowledge slightly on the left of Q* can be considered a reliable approximation of the transition towards the knowledge economy at the end of the XX century. The corporate mode is becoming less and less effective. The traditional academic system where research in mainly conducted within universities and knowledge communication is expected to take place via the combination of scientific publications cum graduates hired by corporations gains momentum, although the limits of this traditional system of knowledge communication emerges quickly as the main constraint and source of inefficiency.

The region on the far right of Q* can be considered as the stylized representation of the new emerging knowledge economy where knowledge becomes an essential input for economic development especially for advanced countries specializing in the provision of knowledge intensive business services and high-tech products to the rest of the world economy in the XXI century. Now the limits of the corporate-based model become evident. The fast increasing slope of the costs of knowledge produced mainly by corporations reveals all the drawbacks of the limits of organizations in managing principal-agent problems. Aging scientific personnel with declining creativity within corporations becomes a burden with little scope for useful job rotation. Opportunistic behavior spreads. Firms are more and more reluctant to fund large internal research laboratories as they have major problems to cope with low levels of predictability in the timing and content of scientific output while costs are

increasing fast. Here the advantages of the renaissance of the university based model become apparent. Provided that effective interactions between the academic and the business community take place. The new university mode of knowledge governance reveals its superiority especially if it is effectively implemented with the systematic application of long standing traditional practices such as non-exclusivity of labor contracts and active entry in the markets for knowledge and close interaction between research and didactic activity, especially above college levels in graduate schools.

4. CONCLUSIONS AND POLICY IMPLICATIONS.

Technological and scientific knowledge is a collective, highly imperfect and heterogeneous activity. First of all it is not only an output, but also an input, an essential intermediary production factor that is relevant both in the generation of new technological knowledge and in the generation of other goods. The dynamic efficiency of each firm and of the system at large depends upon the factors affecting the generation and dissemination of knowledge.

The application of the basic tools of information economics to the economics of knowledge provides an interpretative frame able to appreciate and to reveal one aspect of the institutional economics of university that has attracted, so far, little attention. The academic system, because of its traditional characteristics, emerged through a historic process that lasts now for over nine hundred years since its origins in Bologna, appears to possess a unique mix of incentives and rewards that makes it especially apt to handle the deep and complex principal-agents problems that characterize the employment of creative talents at large.

The analysis of the academic system in the context of the principal-agent approach makes it possible to identify the reasons why university has been a flourishing institution for centuries. More specifically, the application of the principal-agent approach provides a clue to understanding why the shift in the governance of knowledge generation and dissemination is taking place, away from the corporation based model, and towards the renaissance of an academic based model that praises the active participation of academic workers to the markets for knowledge and the combination of educational and research activities.

Clearly, the application of the principal-agent approach to understanding the advantages of the academic system provides important policy guidelines to implement its positive aspects. The implementation of the joint production of research and didactic activities and of the non-exclusive employment relations, both in its direct and indirect forms, is necessary to increase the viability of the academic system as a cornerstone of the social organization of the generation and dissemination of scientific and technological knowledge.

An important implication of this approach and a strong reason for the implementation of the academic outsourcing mode of knowledge governance can be found when the basic issue of the allocation of public funds across scientific disciplines is considered. When the principal-agent approach is applied and the academic outsourcing mechanisms is implemented, the feed-backs signals from the markets for research and professional services towards the academic system can be better appreciated and valued. The static and dynamic characteristics of the demand for research and

professional services can be considered an important input in the identification of the scientific fields where public funds should be allocated. Although in a limited time frame, in fact, the directions of the demand for research services can be considered reliable signals of the relevance of some scientific fields with respect to others. The provision of public funds can now be directed taking into account the signals about the relative importance of some fields with respect to others. Of course the demand for research services provides direct funding itself. Hence the public bodies responsible for the decision-making about the allocation of public funds for academic research can assess whether such public funds should be used to defend minimum levels of knowledge creation in some fields and/or to further encourage the specialization of the academic system in new emerging fields where many firms are willing to purchase the professional services of certified creative scientists.

These results need to be considered in the broader context of a knowledge public policy. The need for an economic policy for the production and dissemination of knowledge seems stronger than ever. Spontaneous knowledge governance mechanisms need to be complemented by a public policy action. The implementation of the institutional set up by means of policy actions that reduce uncertainty and create information, so as to reduce the effects of bounded rationality and information loads, seems to be a viable strategy to reduce the divide between profit maximization and social welfare. Public policy can reduce the major limits of the knowledge governance system so as to favor a more effective production and circulation of knowledge with interventions directed to increase the amount of information each agent has access to. Public policy is expected to be the key component of a dynamic process which brings together universities and firms, yet respecting their basic mission: respectively the production and dissemination of generic knowledge with high levels of fungeability and its application to specific and idiosyncratic contexts.

Public knowledge policies can play a key role for the emergence of dynamic coordination among the variety of heterogeneous players involved in the generation of knowledge as a collective, complex and collective process. Specifically the State can specialize in the direct supply of knowledge, by means of University and Public research centers, only when it has high levels of fungeability, that is, knowledge with a wide scope of applications in a broad array of activities and high levels of incremental enrichment. Second the State can favor the activity of interface bodies that have the specific mission to increase the dissemination of scientific knowledge and its communication to potential users. This role is especially important when knowledge generated in scientific bodies can feed the generation of technological knowledge by means of recombination within firms. The public implementation of the access conditions to such knowledge, viewed as an essential facility, is key to dynamic efficiency in the generation of new knowledge.

Universities and public research centers play a central role in the provision of minimum levels of accumulation, generation and dissemination of general knowledge. The academic system reveals to be a viable institution not only to solve the knowledge trade-off between the appropriation and dissemination, but also and mainly because it is an effective institution for the management of creative talents. The unique blending of non-exclusivity in the labor relations and joint-production of educational and research services seems especially appropriate to implement a dual ladder system of incentives and compensation. University provides the key role of a

standardization committee that certifies the quality of the scientific worker. It remunerates the didactic activities and the production of basic knowledge. Non-exclusivity in the labor contracts, implemented by partnership when teamwork is necessary, helps the creation of the supply of research and professional services. The matching with the demand for research and professional services by the business sector provides ample opportunities for a second tier compensation of the creative skills of certified scientific workers.

The new assessment of the role of knowledge indivisibility and external knowledge provides new support to the defense of universities as knowledge commons. Now the argument is reversed with respect to the tradition based upon the notion of knowledge as a public good.

The basic function of public funding to the knowledge commons is the defense of thresholds of efficiency in entertaining and implementing the stocks of knowledge across the board. Because of the multiplicative relationship between bits of knowledge and the key role of the stock of knowledge for all eventual progress, it is clear that the fall of the competence and expertise in a few knowledge modules can have dramatic consequences in all the system. Minimum levels of efficiency have to be identified and presidia have to be created. Scientific presidia have to be kept both across scientific fields and across regional space.

A public university system can be funded on the solid ground of public funds, allocated with a clear methodology based upon the notion of knowledge fungeability. The larger the fungeability of each bit of knowledge and the larger is likely to be its relevance in terms of indivisibility and hence its multiplicative role for the whole system.

The working of the knowledge commons can take advantage of the opportunities offered by the demand for scientific and technological outsourcing of firms as a way to implement the budget available in selected areas, provided the non-exclusivity of the knowledge generated is implemented and its dissemination is not foreclosed by obstacles created by proprietary assignment of the results of the research undertaken with private funding. The interaction between the public academic system and the market for knowledge intensive services should be increased also a way to take advantage of the relevant economies of scale associated to the sheer size of some research facilities and of the ubiquitous economies of density stemming from the relevant fixed costs associated to the creation of dedicated skills with high levels of specialization (David, 2004).

In this context, universities and public research centers at large are pushed to enter the markets for knowledge on the supply side. Academic departments become suppliers of knowledge intensive business services to firms that rely more and more on the outsourcing of research intensive activities formerly conducted within their internal laboratories. Knowledge generated by academic departments within the context of specific contracts with firms risks to become proprietary with clear reductions of its the dissemination. At the same time however, according to much economics of information, the working of competition in a market characterized by radical knowledge asymmetries provides an important counterbalancing effect when the role of signaling is appreciated. Academic departments in fact have a strong incentive to

signal to perspective customers the quality of the research in progress and to disseminate information about the scientific scores. Academic publication, no longer viewed as the distinctive mission of publicly funded researchers, is now pursued as a signal to attract new potential customers for their services.

Spontaneous knowledge communication is far below the required levels. As a matter of fact knowledge communication takes place at appropriate levels accidentally and occasionally in a few regional and institutional settings. Knowledge communication between the academic and the business community seems especially poor. Publications work poorly as effective vectors of the information about new scientific discoveries seen as possible areas of development and implementation for technological knowledge. The relationship between top-down process of deductive 'scientific' work and bottom-up generation of technological knowledge is often characterized as an 'uneasy alliance'. The direct association and participation of scientists and technologists into common ventures seems able to reduce the gaps.

The creation of interface agencies with the mission to increase knowledge communication flows and hence to reduce the gaps between demand and supply, can increase the efficiency in the working of the knowledge governance systems. Public interface agencies can help identifying the supply buried in the stocks of knowledge, often in the public domain, in Universities and other public research centers, and stir the demand for their application. The role of public interface agencies is to push the academic community towards the market place and selected segments of the business community towards the academic one. Small firms are not even able to search in the knowledge markets. Minimum threshold in the performance or research activities is often above the size of small companies.

In conclusion, a closer analysis of the working of the academic system reveals one more peculiar aspect of this old and yet evolving institution that has shaped and characterized the European economy for centuries. The university is indeed an efficiency institution to solve the knowledge trade-off, that is the contrasting need to increase the incentives to the production of knowledge and yet to disseminate it as much as possible. The university however is also an efficient institution to manage the generation of a highly un-predictable activity such as the generation of knowledge. The fast transition of the advanced economies towards a knowledge economy suggests to study carefully the advantages of the academic institution as a system that makes it possible to select, incentive and reward creative talents. Its foundations might be imitated and applied to the rest of the economic system and spread in other institutional contexts. The working of many professional communities seems in fact very close to that of the academic system and a process of mutual interaction between the evolution of professional orders and academic systems seems at work.

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