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KNOWLEDGE, INSTITUTIONS AND ECONOMIC POLICY: AN INTRODUCTION

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KNOWLEDGE, INSTITUTIONS AND ECONOMIC POLICY: AN INTRODUCTION

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Understanding the limits of knowledge as an economic good and specifically its limited appropriability, intrinsic information asymmetries and tradability discovery together with divergence between generation and transmission costs, and the radical uncertainty that characterize the recombinant knowledge generation process are the cornerstone of the Arrovian postulate about the knowledge market failure and consequent undersupply of knowledge. In turn, the Arrovian postulate has provided the foundations for knowledge governance. Knowledge governance is the result of a complex web of institutional and organizational devices that make possible a division of labor and the participation of a variety of agents with different incentive mechanisms in the generation and exploitation of knowledge as an economic activity (Ostrom and Hess, 2006; Ostrom, 2010).

Historically we can observe two periods. In the first, knowledge governance was characterized by a knowledge policy aimed at contrasting the risks of knowledge undersupply with direct public interventions. In the second implemented in the new century the focus of public intervention is shifting towards the quality of the systems in terms of knowledge interaction.

Let us analyze them in turn. The first knowledge governance approach was based upon a three-pronged set of tools: a) the provision of public subsidies to firms willing to engage in research activities and hence exposed to the risks of the limited appropriation of the results of their efforts, b) the direct supply of knowledge by means of the creation of an extensive public research infrastructure that includes, in many countries, a large part of the academic sector, c) the creation and enforcement of the intellectual property rights that should reinforce the capability of inventors to retain a large(r) part of the revenues of their inventions. As a large literature suggests, each of these tools, implemented to counterweight knowledge market failure and knowledge undersupply, experiences, in turn, significant successes as well as clear failures.

Public subsidies to R&D performing firms help reduce the cost of knowledge and hence the supposed gap between actual costs for inventors and actual returns. In order to avoid the undersupply of knowledge, the lower the appropriability levels then the larger the public subsidies should be. Yet the provision of public subsidies may have crowding out effects, increasing the costs of the inputs in knowledge generation and hence increasing the final cost of knowledge. Automatic subsidies granted to any kind of research activity offer substantial room for the opportunistic behavior of firms that label an array of activities as research and hence receive subsidies for a variety of costs. Subsidies often replace internal funds: firms perform the research projects already planned and use the additional financial resources for other purposes (David, Hall, Toole, 2000).

This happens much less when public subsidies target specific research programs. In this case, the State can use the provision of public subsidies to effectively influence the direction of the research activities in the business sector so as to increase their compatibility and complementarity helping the emergence of economics of scope at the system level. In this case, however, the State, is credited with levels of technological foresight that are rarely available. Targeted research subsidies find a safer application ground in countries and industries that have a clear technology gap with respect to other countries: in this case the scope for potential complementarities is already documented (Hall and van Reenen, 2000; Loskin and Mohnen, 2012).

The provision of credit for knowledge may help to reduce the negative effects of radical uncertainty of the knowledge generation process in terms of credit rationing with the well-known asymmetric consequences that favor large incumbent public companies that can rely on internal funds and access to the equity markets, and disadvantage small firms and entrepreneurship which cannot rely on credit. In this case the public intervention consists more in the provision of bank guarantees than in incentives finalized to reduce the cost of knowledge.

The direct supply of knowledge by means of a public infrastructure consisting of dedicated research centers and, most importantly, the academic system has indeed played a major role in increasing the supply of knowledge and its dissemination in the economic system (Geuna, 1999; Stephan, 1996). A large literature has assessed the positive effects of academic research on the technological advance of economic activities localized in surroundings (Mansfield, 1995; Audretsch and Stephan, 1996; Autant-Bernard, 2001). Solid empirical evidence confirms that the spatial distribution of innovation is strictly associated with the role of academic quality (Della Malva and Carree, 2013). The basic research freedom that characterizes the academic community helps turning the limits caused to business research by the radical uncertainty and intrinsic serendipity of the knowledge generation process into an opportunity. The unlimited freedom of search and exploration helps increasing the chances of generating radical breakthroughs at the crossing of scientific fields rarely explored (Merton and Barber, 2004; David, 2008).

The actual composition of the bundle of knowledge is, in fact, a major limit of the direct intervention of the State in the generation of technological knowledge, especially if it takes place through the academic system. Public funding of the academic system supports a system of incentives that the market is unable to create. Inventors are willing to publish the results of their research and make it available to all perspective users, provided that they can become professors and receive a salary. It is, indeed, possible to ensure adequate levels of internal efficiency of the academic system by reducing the opportunistic behavior of tenured professors and assessing the quality of the screening process. In this way it would be possible to orient the generation of a bundle of academic knowledge that is actually useful to the economic system (Stephan, 1996; Antonelli and Link, 2015).

The distinction between knowledge as a final good and knowledge as an intermediary good becomes most relevant in this context. The direct participation of the State in the generation of knowledge by means of the academic system is justified by the Arrovian postulate. The limits of knowledge are at the origin of the undersupply of knowledge. The undersupply of knowledge has evident negative consequences in terms of both static and dynamic efficiency. This argument holds as long as knowledge is regarded as an intermediary good that enters as an essential input into the generation of new knowledge and the production of all the other goods. As soon as we realize that knowledge is not only an intermediary good, but also a final good that is consumed by households to increase their well being, the negative consequences of the knowledge market failure are much less harmful. The bundle of academic activities that are supported by public funds should take into account the distinction between knowledge as a final good and knowledge as an intermediary good and direct accordingly the allocation of resources across scientific fields (Antonelli and Fassio, 2014)

Intellectual property rights play a key role not only in increasing the necessary appropriability, and hence the incentives to generate technological knowledge, but also in contrasting the active search for secrecy as the extreme remedy implemented by 'inventors' to reduce non-appropriability. Without effective intellectual property rights, ‘inventors’ may try and disguise the knowledge that they have been able to generate by relying on secrecy to the detriment of the generation of new technological knowledge. Patents, even with exclusive property rights, disseminate effective information about the existence of new technological knowledge. At the same time, intellectual property rights may become an obstacle not only to static efficiency and the working of competitive product markets but also to the actual use of technological knowledge as an input for the sequential generation of new technological knowledge (Coriat and Weinstein, 2012).

The discovery of the dual role of knowledge as an output and an input unveils an inter-temporal bundle of trade-off(s). The exclusive intellectual property rights traditionally associated with patents provide patent holders at time t with the exclusive use of knowledge as an input in the production of knowledge at time t+1 (Scotchmer, 1991). Hence, patent holders can generate new technological knowledge at incremental costs while all the other knowledge producers should either bear the full costs of rediscovering the knowledge that is possessed by the inventor or wait until expiry of the patent to use it as an input for the generation of new technological knowledge with major social loss in terms of a reduced pace in technological advance (David, 2011).

A clear dynamic asymmetry takes place between incumbent inventors and perspective ones. The former can use their existing technological knowledge as an input and bear only the costs of the additional costs while the costs of the existing knowledge are already sunk. Incumbent inventors enjoy the benefits of substantial economies of density from which non-patent holders are excluded. If perspective inventors cannot replicate the existing technological knowledge by means of inventing-around strategies, the monopolistic rights are likely to be reproduced indefinitely and actually increase over time: knowledge cumulability displays its exclusive effects over historic time. In both cases, it is clear that monopoly rights at time t are likely to become persistent and convey asymmetric cost advantages that are most likely to reduce not only static efficiency in product markets, but also dynamic efficiency in the long-term generation of knowledge (Antonelli, 2013).

As Heller and Eisenberg (1998) show, the strengthening of the intellectual property right regime that has characterized recent decades may actually deter innovation and make the case for an anticommons. The current intellectual property right regime together with high transaction costs in the markets for knowledge and excess expectations of patentees regarding the value of their knowledge assets produce a fragmented knowledge landscape where owners of small complementary bits of knowledge are unable to participate in the collective effort that is needed to generate new knowledge as an output while using existing knowledge an input (David, 2011).

The portfolio of direct public interventions to support research and innovation includes two powerful tools: public procurement and state owned enterprises. Both tools seem to play a positive role to reduce the radical uncertainty of the technological knowledge. Public procurement has been very effective when and if it consists in the demand for knowledge intensive products. Public procurement in other words appear an effective tool for knowledge governance only when it consists of a highly qualified demand able to direct and actually support the generation of new knowledge in order to meet the advanced standards of the new products. The positive effects of the public procurement of weapons on the introduction of major technological innovations with important spillovers to the rest of the economy can and should be replicated with a civilian public demand able to express similar levels of competence (Ruttan, 2006). Large empirical evidence confirms that public procurement is an effective tool of knowledge governance able to promote the introduction of technological innovations when it meets the requirements of a competent demand pull i.e. it is directed to intermediary rather than final sectors that produce capital goods and intermediary inputs with high levels of research intensity.

The competent demand pull is successfully stirred by public procurement when it is able to activate user-producer interactions between parties that are both knowledge intensive (Edquist and Zabala-Iturriagagoitia, 2012; Antonelli and Gehringer, 2015).

State owned enterprises have played quite an important role in the European economy through most of the XX century. Antonelli, Barbiellini Amidei and Fassio, (2014) investigate the role of state owned enterprises as effective mechanisms of knowledge governance in the Italian experience of 1950-1994. They show that state owned enterprises have been one effective providers of knowledge externalities to the rest of the system and a powerful tool of public procurement with the active participation in the creation of basic infrastructure. Research activities carried out by state owned enterprises were mainly based in upstream industries, with multiple user-producer interactions with firms active in downstream industries, and aimed at implementing a knowledge base characterized by high levels of generic content and a wide scope of application. The concentration of state owned enterprises in upstream sectors favoured the working of the competent demand pull mechanisms. The public demand for infrastructure could find on the supply side state owned enterprises which acted as general contractors coordinating the activity of a large array of smaller firms. The systematic use of outsourcing worked as an effective mechanism for the transmission of advanced technological knowledge to the rest of the economic system. These characteristics helped the dissemination and implementation of relevant knowledge externalities that played a positive role in the introduction of technological innovations in downstream sectors supporting the growth of total factor productivity in the second part of the XX century in Italy.

Although some of tools implemented by public policy to remedy the Arrovian postulate had positive effects in specific circumstances, the results of a large empirical literature together with the advances in the economics of knowledge have shown the limits of the rationale of traditional knowledge policy tools. and stirred the search for alternative approaches.

According to a growing literature, an alternative approach to the apparent deadlock in which knowledge policies seem to find themselves is slowly but effectively in progress. The analysis of knowledge as an emerging system property and an appreciation of the positive effects of knowledge limited appropriability on the generation of technological knowledge help to better appreciate and understand the effects of reducing the user cost of knowledge stemming from its limited appropriability and cumulability on the recombinant generation and use of technological knowledge. A reduction in the cost of technological knowledge stemming from the effects of this intrinsic property of knowledge on its recombinant generation process, where new items of technological knowledge are generated only by means of the recombination of existing ones, both internal and external to each firm, has major consequences for the actual amount of technological knowledge that a firm and a system are able to generate. The larger the pecuniary knowledge externalities are, the larger the chance to generate new knowledge items and hence, with a given research cost, the lower the unit costs of new technological knowledge and the larger the actual amount of knowledge generated.

Knowledge cumulability applies both to the internal stocks of knowledge generated by each firm and to the external stocks of knowledge available in the economic system at large. No firm can generate new technological knowledge and introduce technological innovations from scratch and neither can a firm command all existing knowledge. The access and use of a stock of external knowledge, i.e. the components of the total stock of knowledge that have been generated and are possessed by the other firms in the system is a non-disposable input, for nobody can command all the knowledge available at any point in time. The strict complementarity between internal and external knowledge combined with its low costs stemming from its limited appropriability accounts for a possible reduction in the costs of knowledge and the growth of the equilibrium demand for knowledge, even beyond the levels of a ‘standard’ good.

An improvement in the access and use conditions of existing knowledge to generate new knowledge as well as all the other goods is likely to play a strong role in supporting the actual amount of knowledge available in a system. All public interventions aimed at fostering knowledge interaction and complementarities between learning agents have substantial effects on reducing the costs of external knowledge and hence of knowledge in general.

The quote of Thomas Jefferson's famous sentence is most appropriate: “He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper [(candle)] at mine, receives light without darkening me. That ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition, seems to have been peculiarly and benevolently designed by nature, when she made them, like fire, expansible over all space, without lessening their density in any point, and like the air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation.” Along these metaphoric lines, the quality of the institutional set of an economic system from the viewpoint of the most effective use of technological knowledge seems to consist of the architectural design of the distribution of mirrors that is able to maximize the amount of light produced by each candle.

Economic systems where knowledge governance is better and hence access conditions to existing technological knowledge are better, enjoy substantial pecuniary knowledge externalities: indeed, external knowledge is accessed at costs that are below equilibrium levels. In such conditions, economic systems, where the stock of existing knowledge both internal and external to each firm can be accessed at more cost-convenient conditions, are able to react more creatively to unexpected out-of-equilibrium conditions. Firms succeed in coping with unexpected changes in product and factor markets by introducing technological innovations.

The properties of the system in which firms are embedded play a crucial role in assessing the actual access and use conditions of external knowledge. The quality of the knowledge of an economic system improves actual access to the stock of knowledge and reduces its absorption costs without endangering the incentives to its generation. Large absorption costs of existing knowledge, in fact, are likely to reduce the positive effects of the dynamics of the stock of knowledge. Knowledge governance consists of a set of rules, procedures, modes and protocols that organize the generation, dissemination and use of knowledge viewed as a collective process and an emerging system property. It includes the conditions that make actual use for economic purposes of the scientific knowledge supplied by the State possible through direct support to the academic system and the implementation of an intellectual property right regime characterized by low levels of exclusivity (David, 2008; 2013).

When and where the quality of knowledge governance and connectivity of the system is rich and access to existing technological knowledge can be done at low costs, the generation of new technological knowledge can take place at costs that are below equilibrium levels. The supply curve of technological knowledge shifts downward and identifies an equilibrium supply of technological knowledge that can be even larger than it is for technological knowledge with quasi-perfect appropriability conditions. In such an extreme case, the Arrovian postulate does not hold: there is no need for public intervention to support the supply of additional technological knowledge to compensate for market failure.

When the quality of knowledge governance and the connectivity of the system is poor, on the other hand, the cost of access to the stock of existing knowledge is high and the positive effects of the increasing size of the stock of knowledge do not take place. Intellectual property regimes characterized by strong exclusivity and long duration may actually impede access to the existing stock of knowledge. When the quality of the knowledge governance is poor and the institutional set-up of the system is weak, the access to external knowledge is too expensive to compensate for its limited appropriability. Only in these extreme cases, Arrovian market failure with consequent knowledge undersupply actually takes place: the incentives are not sufficient to generate adequate quantities of knowledge.

In a system characterized by high levels of knowledge connectivity and high levels of knowledge governance, there is little risk of knowledge market failures and systematic undersupply as predicted by the Arrovian postulate. The institutional characteristics of the system that are able to support the creative reaction of firms play a crucial role in this context since they affect the user costs of the stock of technological knowledge.

The structure of knowledge interactions and transactions among agents within the business sector and between the business sector and the public research system becomes the central issue. Good knowledge governance mechanisms are able to improve the knowledge connectivity of the system and hence access conditions to existing knowledge. Countries with good knowledge governance able to implement good knowledge connectivity protocols can enjoy not only a large supply of technological knowledge but also low costs of technological knowledge and hence a competitive advantage. Countries less able to command good knowledge governance practices and implement high powered knowledge connectivity protocols suffer the negative effects of Arrovian market failure, an undersupply of knowledge and a clear competitive disadvantage compared with countries where the absorption costs of the stock of existing knowledge are lower.

Too much attention has been paid to the presumed undersupply of knowledge stemming from a failure of the markets for knowledge. Too much effort has been made to compensate for presumed undersupply with public interventions aimed at increasing research efforts with the provision of subsidies to firms performing R&D activities, public procurement and, most importantly, the direct supply of scientific and technological knowledge with the creation of a large public research system, including the academic system. This approach only applies when the positive effects of knowledge externalities on the costs of external knowledge cannot compensate for the negative effects of limited appropriability on its use as an input in the production of all the other goods.

The achievements of the economics of knowledge, on the other hand, suggest an array of policy tools designed to increase system connectivity and the viability of knowledge interfaces between firms and research institutions as well as among firms. The open innovation approach has successfully contributed to this research agenda and stresses the importance of external knowledge as a necessary and indispensable input for the generation of new technological knowledge. In this approach, external knowledge is strictly complementary to other internal inputs such as R&D activities and learning processes (Chesbrough, Vanhaverbeke and West, 2006; Laursen, Salter, 2006).

Venture capitalism has favored a substantial increase in the levels of tradability of knowledge by means of its embodiment in knowledge-intensive property rights such as the sharing of knowledge-intensive start-ups. The creation of a new institutional set that includes a variety of tools to channel financial resources into the exploitation of knowledge with new specialized markets dedicated to managing financial transactions of the new knowledge-intensive property rights has further reduced the limits of knowledge stemming from its limited appropriability (Avnimelech and

Teubal, 2004). Intangible investments can be better appreciated and their economic value of knowledge is assessed by a variety of financial transactions (Hall, Jaffe and Trajtenberg, 2005).

The intertwining of markets for knowledge with financial markets helps to radically widen the range of opportunities for the exploitation of technological knowledge (Arora, Fosfuri and Gambardella, 2001). Venture capitalism and the new financial markets in knowledge-intensive transactions appear to be an alternative to the corporation as the single mechanism characterized by its institutional superiority in the joint generation and exploitation of knowledge (Langlois, 2003).

The new financial markets for knowledge intensive equity enable to cope with the radical uncertainty that characterizes the recombinant generation of new knowledge managed internally by each agent. The actual outcome of the research activity is unpredictable in terms of timing and content. Firms that engage in the internal generation of new knowledge face serious problems to cope with the serendipity of the process that may yield unexpected results, instead of the desired ones. The venture capitalism mechanism enables to take advantage of the properties of financial markets in the both the knowledge generation and exploitation phases (Kortum and Lerner, 2000). Venture capitalists distribute widely the risks associated with the implementation of new technological ideas. The supply of technological ideas is left to pre-entrepreneurial activities. Their selection favors the implementation of the most promising. The entry in the financial markets creates knowledge intensive equity that are traded in the stock exchanges and enables further fund raising by means of repeated capital increase. In so doing venture capitalism reduces the well-known problems of credit rationing to knowledge-intensive start-ups. Their eventual merger with existing corporations provides the final users with a large supply of highly diversified knowledge inputs that can be directly used to feed the planned introduction of specific technological innovations (King and Levine, 1999; Antonelli and Teubal, 2008).

Venture capitalism consists in a multilayered system of risk distribution that enables to reduce the problems associated with the radical uncertainty of the recombinant generation of knowledge in two ways (Lerner, 2002). First it provides firms with knowledge-ready-to-use so as to implement their market strategies speeding the innovation process. Second it reduces the exposure to substantial dis-economies of scope of large incumbents. Because of the low levels of knowledge tradability corporations were forced to diversify beyond the limits of their organizations in order to exploit the unexpected results of the internal knowledge generation process (Antonelli and Teubal, 2010).

Finally, venture capitalism enables 'inventors' to retain a larger share of the pecuniary effects of their 'inventions' identified by Hirshleifer (1971). According to Hirshleifer inventors could take an indirect and hidden advantage of their knowledge by means of its price effects in both factor and product markets, anticipating the future changes stemming from the introduction of the technological innovations. These gains could compensate for the limited knowledge appropriability, even in absence of intellectual property rights. These gains however could be actually appropriated only with major investments. The pecuniary effects of the introduction of the new knowledge and the related technological innovations, instead, can be embodied directly in the augmented market value of the knowledge intensive equity that reflects the present and future profitability of the start-ups as foreseen by the stock market (Hirshleifer, 1971).

The positive experience of free software has attracted much attention in this context and suggests that this specific evidence may be generalized. Software technology provides strong evidence regarding the central role of knowledge complementarity and cumulability in the recombinant generation of new technological knowledge. New software produced by each developer impinges on the source that has been generated in the past and in the myriad of applications that have been and are being, at each point in time, generated by other developers. In the software industry, it seems quite clear that a bottom-up spontaneous mechanism of knowledge governance centered on the practice of a general public license for advances in the software source being made available by each developer to another has become common (David and Rullani, 2008; David and Shapiro, 2008).

An economic system that is able to increase and make repeated use of technological knowledge to generate new technological knowledge easier, as well as all the other goods, with governance mechanisms such as open innovation, is likely to increase the positive effects of knowledge complementarity on the costs of knowledge as an input (Nelson, 1993).

For this reason, public interventions should be directed not only towards increasing the public supply of knowledge and the incentives to its generation but also to improving the dissemination of existing technological knowledge and favoring interactions between knowledge users and producers and the mobility of creative workers. Interactions between the public research system with special attention paid to the academic system and firms should be the object of dedicated interventions. In the same token, user-producer interactions among firms should also be enhanced. The mobility of skilled personnel, with a focus on inventors, among firms and between firms and the public research systems should be supported with dedicated policy interventions. Although knowledge externalities have a strong local character, international flows of technological knowledge can be strengthened with public actions that link the imports of knowledge-intensive products to enhanced user-producer interactions with a strong local content. An improvement in the institutional set-up and the quality of knowledge governance mechanisms in an economic system favors the viability of creative reactions and the speed of the endogenous growth process.

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