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THE TRADE-OFF OF INTELLECTUAL PROPERTY RIGHTS RECONSIDERED: TECHNOLOGICAL KNOWLEDGE AS AN ESSENTIAL FACILITY [1]

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ABSTRACT

Intellectual property rights have a twin effect on the economic system. On the one hand they favor the introduction of new technological knowledge. On the other they reduce competition and eventually may limit the rate of introduction of new knowledge. A trade-off takes place between such positive and negative effects. The application to the economics of knowledge of the notions of essential facility and liability rule can correct the balance of the trade-off and contribute the rate of advance of technological knowledge and its effective use in the economic system. The tuning of exclusive property rights makes it possible to minimize knowledge rents and favor the dissemination and use of knowledge in the economic system taking advantage of its intrinsic cumulability and complementarity.

KEY-WORDS: KNOWLEDGE RENTS, INTELLECTUAL PROPERTY RIGHT REGIMES, ESSENTIAL FACILITY, LIABILITY RULE,

JEL CLASSIFICATION: O31

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1. INTRODUCTION

According to Kenneth Arrow, knowledge, as an economic good, suffers of many limitations. Such limitations lead to dramatic market failures in the organization of its generation and in the governance of its dissemination. Hence markets are likely to be unable to fund the correct amount of resource to its generation and are unable to organize, spontaneously, the necessary levels of division of labor. The spontaneous generation and the usage of technological knowledge in the market place are afflicted by both insufficient allocation of resources and reduced levels of efficiency: a clear case for undersupply takes place. Intellectual property rights are a major institutional device designed to match the limitation of knowledge as a private economic good. Intellectual property rights however have a number of undesired side-effects that need to be assessed carefully assessed in order to introduce possible institutional changes, such as the implementation of the notion of knowledge as an essential facility and the application of the liability rule. The rest of the paper is structured as follows. Section 2 reviews the emerging evidence about the many facets of the knowledge trade-off. Section 3 elaborates the notion of knowledge rents, makes explicit their positive effects in terms of provision of incentives and resources to the generation of new knowledge and articulates the need, from a social welfare viewpoint to minimize them. Section 4 presents the notion of essential facility drawn from recent advances in the economics of regulation and explores the conditions under which the liability rule can be applied to the economics of knowledge. The conclusions summarize the results of the analysis and puts them in perspective.

2. THE KNOWLEDGE TRADE-OFF RECONSIDERED

According to the basic foundations of the economics of knowledge laid down by Kenneth Arrow and Richard Nelson, technological knowledge, as an economic good, is afflicted by a few relevant characteristics: non-appropriability, non-rivality in use and non-divisibility. Because of these features, tradability is hampered hence arms' length transactions in full fledged markets cannot be used to coordinate in an efficient way the allocation of financial resources into research activities, their selection towards the most rewarding directions and the necessary division of scientific and technological labor in their generation. This leads to low levels of funding, specialization, efficiency and hence systematic undersupply. In this context intellectual property rights and specifically patents were thought to increase the rates of generation of technological knowledge.

Intellectual property rights and patents are institutional instruments designed to increase the incentives of firms to generate new technological knowledge and introduce technological innovations and to increase the viability of market coordination. So far intellectual property right are institutions designed to create markets and hence make possible all the advantages of unplanned and spontaneous coordination among agents, in terms of dissemination of information, signaling of new opportunities, division of labor and specialization. By means of intellectual property rights impersonal transactions can take place and the traditional coordination among agents within markets and among markets can take place without further public intervention. Intellectual property rights can be considered a market-creating activity: property rights on inventions make it possible to trade them with all the well known advantages in terms of division of labor and hence specialization and productivity. Resources can be allocated in the factor markets and knowledge can be exchanged both in the product markets and in the markets for intermediary production factors. Agents and firms can specialize in the generation of knowledge modules where each has a comparative advantage. Markets for knowledge both as an intermediary input for the production of new knowledge and as an input for the introduction of new technologies can flourish.

Intellectual property rights granted to inventors, lead to monopolistic market power in the markets for the products that use the new knowledge. Such monopolistic power provides incentives to innovators to undertake risky activities finalized to the introduction of innovations. Monopoly makes it possible to increase both incentives and resources to the generation of new knowledge via the increased appropriability based on legal barriers to imitation. In so doing intellectual property rights make it possible to grasp the advantages of the dynamic efficiency engendered by the increased amount of knowledge generated and hence the augmented flow of innovations. Now inventors are less scared by the risks of uncontrolled leakage of their knowledge and have an incentive to invest resources in research activities. Moreover the rents stemming from the now proprietary knowledge can be used to fund additional research and hence the creation of further knowledge.

Intellectual property rights have an important role from an informational viewpoint and as such exert relevant consequences. According to the localized technological change approach, technological change is the emergent property of an economic system, if, when and where the latent complementarities among the fragmented bits of indivisible knowledge possessed by a myriad of agents dispersed and isolated, are valorized and

exploited. From this viewpoint the role of patents as signaling mechanisms, that provide information about new inventions and relevant technological applications, seems at least as relevant as their traditional role of appropriability mechanisms based upon the enforcement of excludability.

Patents play a major role as signaling devices, which help the identification of the available bits of complementary knowledge and their owners so as to reduce search costs. With a weak intellectual property right regime in fact the holders of each bit of knowledge have much a stronger incentive rely upon industrial secrets as a way to reduce the informational leakage with the radical reduction of the dissemination of the relevant bits of disembodied knowledge. Secrecy, the alternative to intellectual property rights, to secure exclusive ownership can have dramatic effects generally in terms of networking costs and specifically in the form of technological communication costs, and hence upon the amount of knowledge complementarities which can be effectively activated.

Intellectual property rights moreover are a remedy to tight vertical integration between the generation of new technological knowledge and its application to the production of new goods or to new production processes. The public good nature of technological knowledge pushes the knowledge-creating firm to use it as an intermediary input for the sequential production of economic goods. Vertical integration and direct embodiment of technological knowledge -within the borders of a single company- in the production of goods limits severely the emergence of the markets for knowledge as a good per se, with negative consequences in terms of reduced scope of application of technological knowledge. When technological knowledge has high levels of fungibility, i.e. has a wide scope of application, vertical integration has strong negative effects as it impedes the valorization of such a broader array of possible applications.

In conclusion intellectual property rights perform many positive functions in the economic system. First, they favor appropriability, and hence secure rewards to inventors. In so doing intellectual property rights help increasing the incentives for the creation of technological knowledge and provide resources for its generation. Second, they favor the dissemination of knowledge as they make publicly available the information about new technological advances. In so doing patents act as powerful signaling devices that may favor the distribution of resources among a variety of possible directions in the activities geared towards the generation of new technological knowledge. Thirdly, they reduce the incentives to embody

directly, by means of downstream vertical integration into the production of goods that use the new knowledge, and hence they limit the negative effects in terms of reduced scope of application of knowledge with high levels of fungibility. Finally, they improve the viability of the markets for knowledge and facilitate the interactions among holders of bits of complementary knowledge. Patents in fact can help reducing knowledge transactions costs in the markets for knowledge because they reduce information asymmetries, the risks of opportunistic behavior and make it easier for demand and supply to meet by means of impersonal transactions in market place where a large number of customers and sellers interact. Hence effective property right systems favor the creation of specialized and dedicated markets for disembodied technological knowledge where the firms can specialize in the production of knowledge as a good per se (Arora, Gambardella and Fosfuri, 2001).

Intellectual property rights however have many shortcomings and undesired effects. The literature has been adding new analytical evidence about many such negative effects (Machlup and Penrose, 1950; David, 1993).

2.1. THE FIRST KNOWLEDGE TRADE-OFF

The foundations of the first trade-off between dynamic efficiency and static inefficiency are laid down in the context of competitive analysis. The first trade-off consists in the identification by means of a classical cost-benefit analysis of the balance between the increased dynamics efficiency provided by patents, by means of increased appropriability and hence larger incentives to fund the production of knowledge, and the loss in static efficiency determined by patents, as ingredients for the creation of monopolistic market power in the markets for goods.

Monopolistic power however reduces static efficiency. Firms can charge monopolistic prices and hence appropriate a large share of the total surplus stemming from the introduction and application of new knowledge. The understanding of the increased monopolistic market power engendered by intellectual property rights suggests to limit the scope for patents and their duration, but to rely more and more on intellectual property rights.

The first trade-off has been traditionally regarded as a transient problem. The monopolistic market power in the markets for products based upon proprietary technological knowledge and the technological innovations stemming from its implementation was deemed to be temporary because of the Schumpeterian assumptions about the irreversible flows of entry of

new competitors attracted by extraprofits and able to invent-around and imitate the original technological knowledge of the early incumbent. Hence the welfare losses generated by the divergence between marginal and average costs were assumed to be short lived. The short-term duration of monopolistic power in the markets for goods manufactured with the new knowledge seemed to be a solution to the trade-off between dynamic and static efficiency.

2.2 THE SECOND KNOWLEDGE TRADE-OFF

The second knowledge trade-off is identified as a result of a closer analysis of the implications of the notion of knowledge indivisibility. The new approach is based upon the discovery of knowledge cumulability, i.e. the diachronic complementarity between different vintages of knowledge. Following Newton much emphasis is now given to a famous sentence of the English scientist: "To make science means standing on giants' shoulders". Intellectual property rights limit the access to the new vintages of knowledge, at least for a considerable period of time: in so doing they delay the possibility for new generations of dwarfs to climb upon the shoulders of previous giants.

Intellectual property rights now are seen not only as the cause of the static efficiency associated with monopolistic market power stemming from patents, but as a source of dynamic inefficiency as well. Intellectual property rights in fact increase the incentives to generate new knowledge, but risks to reduce dramatically the efficiency of the generation activity. Intellectual property rights limit the vertical or diachronic dissemination of knowledge: the access and use of prior vintages of knowledge are put at risk. The efficiency of the generation of new technological knowledge is now reduced by the delays in the access to the last vintage of knowledge. The new generations of inventors cannot rely upon the last progress being made. Hence additional resources are necessary to rediscover what has been already invented. Duplication of efforts can take place. In the extreme case the generation of new knowledge can be actually inhibited by the duration of the life of the exclusive property rights assigned by patents to inventors. Intellectual property rights limit the working of knowledge cumulability.

2.3 THE THIRD KNOWLEDGE TRADE-OFF

A third knowledge trade-off has been finally identified when the analysis of the indivisibility of knowledge has made it possible to appreciate the role of external knowledge as an essential intermediary input in the production process of new knowledge. Here in the economics of technological knowledge the issues of externalities on both the supply

and the demand side become relevant and evident. The generation of technological knowledge is now considered to be characterized by relevant and actually necessary externalities, both technical and pecuniary. The notion of user-interdependence makes its foray into the scene when agents value the levels of usage of other agents of certain goods. As far as scientific and technological knowledge is concerned, interdependence among users, hence on the demand side, is very strong. The actual chances of generating a new relevant bit of knowledge for each agent depend upon the levels of accumulation of skills and competence, education and access to information of the other agents in the community. The evidence especially in new information and communication technologies confirms that complementarity matters in assessing the rates of introduction of innovation.

At each point in time the modules of technological knowledge possessed by each agents have high levels of complementarity with other modules of technological knowledge possessed by other firms. No firm can claim to be able to command all the relevant knowledge. External knowledge is an important input in the production process of new knowledge. This major progress is made when the special character of knowledge as a non-exhaustible good that is at the same time an output and an input into the production of other knowledge is grasped and retained at the core of the analysis. Here the derivation from the Arrovian notions of the non-excludability and non-divisibility of knowledge is clear.

The horizontal or synchronic dissemination of knowledge is put at risk by strong intellectual property rights regimes. Poor dissemination and exclusivity put at risk the access to external knowledge for each agent and hence the working of knowledge complementarity. Hence additional resources are necessary to rediscover what has been already invented elsewhere at the same time. Duplication of efforts can take place. This reduces the future flow of additional units of new knowledge.

In sum, intellectual property rights have clear advantages as market-creating institutions that favor the identification of the correct levels of incentives, the allocation of resources, the exchange in the market place of knowledge modules and hence higher levels of specialization and efficiency. Intellectual property rights however engender at least three classes of negative effects. First, monopolistic power in the markets for the products embodying the new knowledge are less efficient for the monopolistic market power assigned to inventors with clear losses in terms of static efficiency. Second, the efficiency in the generation of new knowledge is reduced by the delays in the dissemination of prior

knowledge, associated to the duration of patents. Such delays last as long as knowledge is made proprietary by patents. Third, the efficiency in the generation of new knowledge is hampered by the limitations in the access to complementary sources of knowledge being generated in parallel at each point in time.

Intellectual property rights play a key positive role in the provision of technological knowledge. Yet, the many facets explored by economic analysis about their many negative and unintended consequences push towards an effort to reconsider the basic elements of the knowledge trade-off. The new understanding about the second and the third knowledge trade-off is crucial in this context for the new light brought about the dynamic inefficiency of the present intellectual property rights regimes in terms of missing opportunities to exploit latent increasing returns.

Intellectual property rights are a necessary institution for the enhancement of the social capability to generate new technological knowledge. The present intellectual property rights however needs to be improved in order to take advantage of the potential for increasing returns in the generation of new knowledge stemming from knowledge cumulability and knowledge complementarity. It seems clear that the present intellectual property right regime impedes the working of such increasing returns as a strong contradiction takes place between the need to remunerate the generation of knowledge and the need to increase its dissemination and recombination.

3. KNOWLEDGE RENTS AS A SOCIAL COST

Appropriate tuning of the characteristics of intellectual property rights can lead to an increase in the benefits associated with patents and a reduction in their costs with a clear positive social effect. The debate on the many facets of the knowledge trade-off has highlighted the key negative role of two characteristics: exclusivity and monopolistic market power. Intellectual property rights, and more specifically, patents are characterized by the assignment to inventors of exclusive rights on the use of the new knowledge. The assignees of new patents can prevent other parties from using their proprietary knowledge. Exclusivity is the cause of both excessive monopoly rights and hence static inefficiency and missing opportunities stemming from increasing returns engendered by knowledge indivisibility, and hence dynamics inefficiency. Both monopolistic power in the downstream markets for products and reductions in dynamic efficiency stem clearly from exclusivity. Exclusivity is regarded as the pillar upon which the extraction of rents from the new knowledge is based. The basic argument here is that

without exclusivity, knowledge holders could not command any control on the rents stemming from the application of the new knowledge. It is in fact clear that the right of a payment of rents to inventors cannot be disregarded for their positive role both in terms of incentives, dedicated fund raising and enhanced tradability.

From a welfare point of view, the rents associated to intellectual property rights could be regarded as a cost. A cost that the society is ready to pay in order to increase the amount of goods that firms can produce and consume. Intellectual property rights and the related knowledge rents are a tool, an incentive and allocative mechanism, designed to stimulate the efficient generation of new knowledge, hence new technological innovations and by that mean to increase the general efficiency of the economic system. From a welfare viewpoint neither the generation of knowledge, nor the levels of the knowledge rents that are necessary to stir and fund the activities geared towards the generation of new knowledge, are to be considered as a goal per se. The single, effective goal is in fact the increase in the general efficiency of the economic system and hence the amount of goods that can be produced with a given levels of production factors.

Along these lines a new framework can be articulated, one where intellectual property rights can be regarded as an institutional device designed to pay a fee to inventors and innovators in order to push their production of technological knowledge and the related introduction of new technologies towards the levels of dynamic efficiency that the system is not able to reach spontaneously.

In this perspective it becomes clear that the knowledge rents associated intellectual property rights should be minimized, under the clear constraint that such rents are necessary in order to fund the efficient production of new knowledge that engenders positive effects at the system level, by means of the introduction of new technological innovations, in terms of increased efficiency. The positive outcome of the new knowledge being generated can be easily measured by the consumer surplus stemming from any reduction in costs. Consistently it follows that the design of intellectual property rights should be modeled according to the results of the combined maximization of the consumer surplus generated by new technological knowledge and the complementary minimization of the levels of knowledge rents that need to be granted to inventors.

The net social surplus, stemming from the introduction of new technological knowledge and new technologies, is the result of the subtraction of the knowledge rents paid to inventors and innovators to the consumer surplus. Both the consumer surplus and the knowledge rents are a function of the amount of innovations being introduced. The amount of innovations being introduced, however, depends on the levels of knowledge rents. Knowledge rents, secured by intellectual property rights in fact, as it is well know, are an important mechanism by means of which it is possible to reward inventors and hence a mechanism that makes it possible both to articulate incentives and to provide funds towards the generation of new knowledge. From a social viewpoint it is clear that the net social surplus is the variable that should maximized.

Let us specify formally the points articulated so far, in the following system of equations, where NSS stands for the net social surplus, CS is the consumer surplus, K is the amount of knowledge being generated and KR are the knowledge rents that inventors can appropriate by means of intellectual property rights:

(1) NSS = CS – KR
(2) CS = a (K)
(3) KR = b(K)
(4) K = c (KR)

The traditional maximization procedure applies and makes it possible to identify the optimum level of net social surplus that an economic system can achieve by means of the generation of technological knowledge, where the latter is at the same time the cause of the reduction in production costs and the consequence of the rents paid to inventors by means of intellectual property rights.

Diagram 1 provides the traditional graphic expression of the social profit maximization and helps the identification of the optimum levels of knowledge rent an economic system can fund in order to obtain the optimum rate of generation of technological knowledge. The maximum amount of net social surplus is clearly provided by the quantity of technological knowledge where dCS/dK= dKR/dK

Along these lines it becomes clear that the tuning of the intellectual property rights regime so as to make it possible at the same time the minimization of the rents paid to inventors, the maximization of the net social surplus stemming from the introduction of new technological

knowledge and the maximum level of efficiency in the production of technological knowledge become possible.

The application of the notions of essential facility to the economics of knowledge and the implementation of the liability rule in the design of intellectual property rights help in this direction.

4. KNOWLEDGE AS AN ESSENTIAL FACILITY AND THE LIABILITY RULE

The notion of knowledge rents as a social cost can contribute the debate on the governance of knowledge so that the knowledge trade-off, that is the balanced assessment of both the positive and the negative effects of intellectual property rights can be reconsidered. The new understanding of knowledge as an essential facility and the introduction of the liability rule in the design of intellectual property rights and specifically in the governance of the patent system contribute this undertaking.

The new economics of knowledge stresses the role of both synchronic and diachronic indivisibility articulated in knowledge complementarity and knowledge cumulability. Knowledge is not only an output, but also an input in the generation of further knowledge. Moreover the costs of reproduction are negligible and multiple uses are possible with almost wearing costs. Knowledge indivisibility leads to supermodularity in generation and usage: the larger the number of different knowledge modules that be combined and used and the more than proportionate is the rate of increase of the output. Hence knowledge has all the characteristics of an essential facility itself.

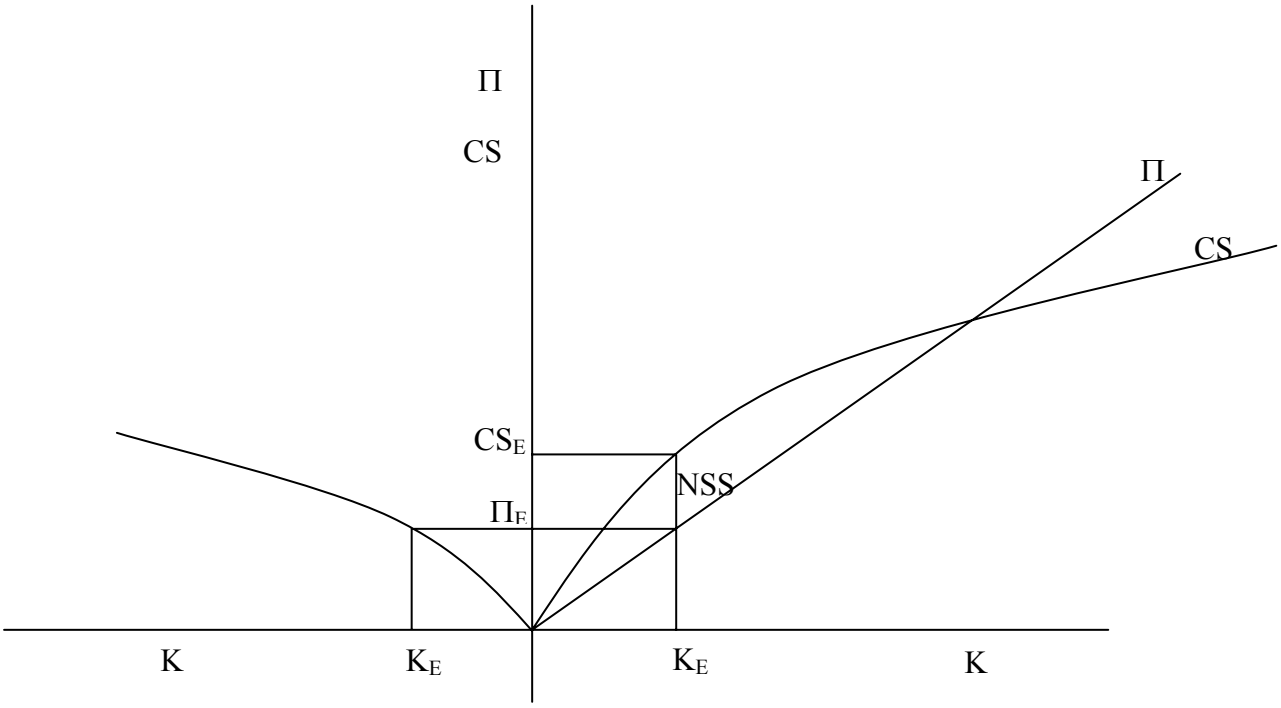
The notion of essential facility, introduced in regulation economics, has a wide scope of application. The notion of essential facility has been elaborated to regulate the problems raised by complementarity and cumulability in network industries. A production factor can be regarded as an essential facility when its use in the production process is characterized by increasing returns stemming from substantial indivisibility. Many different forms of increasing returns are at work: 1) relevant economics of density take place when the repeated use of the same input is possible: when fixed inputs are characterized by long-term duration, excess capacity and little wearing, marginal costs remain below average costs; 2) network externalities on the demand side when the utility of a given good increases with the number of users of the very same good and/or of complementary goods; 3) network externalities on the supply side when the productivity of a given factor increases with the number of users of the very same production factor and/or of other

complementary factors; 4) economies of scope when different products can be manufactured with the same productive platform 5) incremental costs, i.e. the costs of additional production units, display low average costs, lower than total average costs.

The efficient social use of essential facilities requires strong regulation in order to prevent the creation of monopolistic power and sub-optimal exploitation of potential increasing returns. The exclusive use of essential facilities has negative asymmetric effects on competition in the market place which favor incumbents and impedes the entry of new competitors. According to the acquisition of regulation economics the rights to use, access and interconnect a production factor that meets the characteristics of an essential facility, cannot be exclusive. The separation between the rights of ownership and the rights of use is necessary in order for actual and workable competition to be implemented and eventually made possible (Baumol and Sydak, 1994).

The evolution of property rights in network industries has been the result of the understanding of the role of sunk costs and complementarities and their effects in terms economies of density and incremental costs on the actual costs of both incumbents and new competitors in the industry. Mandated interconnection is indeed a significant departure from a full fledged and traditional definition of property rights.

DIAGRAM 1. KNOWLEDGE PROFITS AS A SOCIAL COST



Mandated interconnection has been a major factor of change and evolution in the definition of property rights. The ownership rights on the one hand and the rights of exclusive use on the other, traditionally associated in one single right, have been separated and rights of use of the network have been separated from the ownership rights. Firms do and can own telecommunication networks and can claim their property on all the segments of the network, but cannot claim any longer the right to the exclusive usage. Other firms have the right to access the network and make a selective use of it (Fransman, 2002).

The neutral assessment of the costs of the networks and the definition of a fair level of fees for users is a necessary and indispensable component of the new regulatory regime implemented in network industries after the introduction of the notion of essential facility. Dedicated authorities have been created with the specific task to fixing fair prices for the access to the networks. The network in other word is free to enter, but not free of charge. The correct remuneration of the network operators is clearly necessary in order for networks to be updated, implemented and actually built.

The notion of essential facility and mandated interconnection is directly relevant for the governance of technological knowledge. According to the results of much economics of knowledge, knowledge shares all the relevant characteristics of an essential facility. Knowledge is characterized by intrinsic indivisibility and yet it is dispersed and fragmented in a variety of uses and possessed by a variety of owners. Each bit of knowledge is complementary to each other along chains of weak and strong indivisibilities, which act both synchronically and diachronically. The exclusive access to each bit of knowledge can prevent others from cumulative undertakings.

A reduction of the present levels of exclusivity built in the patent system is appropriate in order to take full advantage of the positive effects of knowledge indivisibility articulated in knowledge cumulability and knowledge complementarity. The application of the liability rule makes it possible to implement compulsory licensing. The guidance about the identification of the optimum level of knowledge rents, provided by the model of constrained minimization of knowledge rents, elaborated in section 4, provides us with the necessary tools to identify the correct levels of royalties that should be paid to inventors.

The ex-post assessment of the actual economic value generated the new knowledge seems necessary: any attempt to fix ex-ante either the costs of

a new knowledge modules or its fair value seems deemed to fail. It should be evident to all that such a thing as an authority with the task the provide a neutral and fair assessment of the economic value and the economic cost of a new module of knowledge from an ex-ante perspective cannot work.

Let us spell out the main points along which the intellectual property regime should be redesigned as it follows:

1) Intellectual property rights should be granted to inventors in order to secure appropriability, disseminate information, prevent secrecy, reduce the incentives to vertical integration, favor the working of financial markets and of the markets for knowledge as an intermediary input for the production of new knowledge and as an input for the generation of technological innovations.
2) Intellectual property rights do not include any longer exclusive property rights. Mandated, or compulsory, licensing applies: users can use the proprietary knowledge protected by intellectual property rights. Users should notify to inventors the actual use of the proprietary knowledge. The application of the liability rule makes it possible to increase the general efficiency in the generation of new knowledge as the working of knowledge complementarity and knowledge cumulability is no longer impeded by exclusive property rights
3) The use of proprietary knowledge is not free of charge. Patent assignees have the right to claim a royalty for the use of the proprietary knowledge. Royalties make sure that inventors receive a compensation for the risks and the costs associated to the activities that have been put in place in order to generate new knowledge. It is clear that mandated licensing with no royalties should expose inventors to the well-known negative effects of knowledge non appropriability.
4) The amount of the royalties is defined ex-post after an appropriate time interval at a time when the actual benefits of the new technological knowledge can be assessed in terms of the social surplus that has been made possible by its use. The ex-ante definition of the economic value of new technological knowledge is not possible. Only the objective empirical evidence that the parties have interest to gather after some time from introduction makes it possible to measure the actual value of new technology.
5) The methodology laid down with the maximization of the net social surplus and the related minimization of knowledge rents makes it possible the definition of the appropriate levels of

royalties that patent assignees should receive from users. The application of compulsory licensing without a methodology for the definition of the correct price for the use of the new technological knowledge risks to be void of any actual use: either inventors claim royalties that nobody should be ready to pay, or users should try and deny the economic value of the use of the proprietary knowledge. Both outcomes would have negative effects.

6) With a clear legal framework patent assignees, ht have received explicit notification of the use of their proprietary knowledge, after a reasonable period of time can claim from the users their fair royalties, calculated from all the parties involved on the basis of the evidence gathered. If and when contractual relations fail to identify a fair royalty, the judiciary system should intervene as the settler of the last resort.

5. CONCLUSIONS

The debate on the knowledge trade-off has been reviewed and the need for a reconsideration of the present intellectual property right regime has been articulated.

Knowledge rents have been identified as a social costs that is necessary to bear in order to stir and fund the generation of new technological knowledge and yet should be minimized. From a social viewpoint it is clear that neither knowledge rents not the rate of technological advance are a goal per se. From a welfare point of view the maximization of the net social surplus generated by the increased general efficiency stemming by the generation and use of technological knowledge is the single acceptable target.

The notion of essential facility, drawn from the economics of regulation, and of the liability rule have been applied to the political economy of knowledge. Their application makes it possible to take advantage of the increasing returns, at the system levels, stemming from knowledge indivisibility, articulated in knowledge cumulability and knowledge complementarity, provided that equitable levels of knowledge rents are paid to patent assignees.

The present intellectual property right regime can be reconsidered and a better balance between the positive and negative effects of the present intellectual property right regime can be found when the optimum levels of royalties can be identified after the actual generation of the new technological knowledge and paid to the assignees of non-exclusive intellectual property rights, by users aware of their emerging obligations.

6. REFERENCES

Antonelli, C. (2001*), The microeconomics of technological systems,* Oxford University Press, Oxford.

Antonelli, C. (2003), *The economics of innovation, new technologies and structural change*, Routledge, London,

Antonelli, C. (2004), The governance of localized technological knowledge and the evolution of intellectual property rights, in Colombatto, E. (ed.), *The Elgar companion to property rights*, Edward Elgar, Cheltenham.

Antonelli, C. (2005), Models of knowledge and systems of governance, *Journal of Institutional Economics* 1, 51-73.

Arora, A., Fosfuri, A. and Gambardella, A. (2001), *Markets for technology*, The MIT Press, Cambridge.

Arrow, K. J. (1962), Economic welfare and the allocation of resources for invention, in Nelson, R. R. (ed.) *The rate and direction of inventive activity: Economic and social factors,* Princeton, Princeton University Press for N.B.E.R. pp. 609-625.

Arundel, A. (2001), The relative effectiveness of patents and secrecy for appropriation*, Research Policy* 30, 611-624.

Baumol, W.J. and Sydak, J.G. (1994), *Toward competition in local telephony*, The MIT Press, Cambridge.

David, P.A. (1993), Knowledge property and the system dynamics of technological change, *Proceedings of the World Bank Annual Conference on Development Economics,* The World Bank, Washington.

Davis, L. (2004), Intellectual property rights, strategy and policy, *Economics of Innovation and New Technology* 13, 399-416.

Fransman, M. (2002), *Telecoms in the Internet age: from to boom to bust to ....?,* Oxford, Oxford University Press.

Kingston, W. (2001), Innovation needs patents reforms, *Research Policy* 30, 403-423.

Landes, W. and Posner, R. (2003), *The economic structure of intellectual property law*, The Belknap Press of Harvard University Press, Cambridge.

Machlup, F. and Penrose, E. (1950), The patent controversy in the nineteenth century, *Journal of Economic History* 10, 1-20.

Madden, G. (ed.) (2003), *Handbook on telecommunications*, Edward Elgar, Cheltenham.

Mazzoleni, R. and Nelson, R.R. (1998), The benefits and the costs of strong patent protection: A contribution to the current debate, *Research Policy* 27, 273-284.

Mokyr, J. (2002*), The gifts of Athena: Historical origins of the knowledge economy*, Princeton University Press, Princeton.

Penrose, E.T. (1959), *The theory of the growth of the firm*, 1st and 3rd editions, Basil Blackwell (1959) and Oxford University Press (1995), Oxford.

Reichman, J. (2000), 'Of green tulips and legal kudzu': Repackaging rights in subpatentable invention, *Vanderbilt Law Review* 53, 17-43. Reprinted in Dreyfuss, R. and Zimmerman, D. (eds.), *Expanding the boundaries of intellectual property*, Oxford University Press (2001) Oxford, pp. 23-54.

Scotchmer, S. (2004), *Innovation and incentives*, MIT Press, Cambridge.

Shavell, S. and Van Ypersele, T. (2001), Rewards versus intellectual property rights, *Journal of Law and Economics* 44, 525-47.

Stiglitz, J., (2000), The contributions of the economics of information to twentieth century economics*, Quarterly Journal of Economics* 115, 1441-1478.

Stiglitz, J.E. (2002), Information and the change in the paradigm in economics, *American Economic Review* 92, 460-502.