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Innovation and Patents for the Software Industry: An Empirical Analysis of the EU and US Cases

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Confusion prevails in the European Union after the directive relating to grant of patents to software innovations was rejected in 2005. There is a surging demand for the harmonization of patent system for computer-implemented inventions across the globe. The article stresses the need to grant patents to software inventions as they trigger research activity in the technological arena which has direct impact on industrial production and ultimately on economic growth. According to microeconomists and academia protecting Intellectual Property Rights helps to escalate the research and development activities. They submit empirical data in support of their argument. Main stream of economic theory is towards protecting IPR. Any restriction in granting of patents to computer implemented inventions will adversely affect the flow of investments into technological innovations and economical growth. The author further suggests

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to create a special fund to encourage research, inventions and innovations in technology and make these available to small and medium enterprises which are not able to allocate funds in their budgets towards such innovations.

1. Introduction

Innovation is the main engine of growth nowadays and the proper functioning of the market for innovations and of the incentives to invest in R&D is at the core of any growth-enhancing policy. Economists have emphasized the role of intellectual property rights and patents in particular in the mechanism leading to innovation and growth, while a lot of political debate has taken place on what are the proper instruments to promote investments especially in high-tech sectors and to strengthen economic progress in the global economy. The European Union has taken seriously this issue including innovation as one of the main priorities of the Lisbon strategy, even if the results on this front are still limited. Moreover, the EU has the opportunity to guarantee a stable future for innovation in the high-tech industries with the harmonization of the patent policy for Computer Implemented Inventions (CIIs). I will approach these issues from an economic point of view with a close look at the recent debate.

In Section 2, I will review the European debate on the patent system for CII, with particular reference to the contrast between the European Council and the European Parliament, the Common position adopted by the former in March 2005 and the amendments proposed by members of the European Parliament to the latter, which ended up in a final rejection of the reform. In my opinion, the discrepancy between the points of view is probably due to misunderstandings on the fundamental role that patents in general, and especially for CIIs, play in promoting investments in innovation and hence technological progress. Hence, in Section 2, I will summarize and discuss what economists have to say about the relation between innovation policy (with particular reference to protection of patent systems), the market for innovations and the aggregate growth of the economy: the main message provided by economic research in the field is that patents are crucial in providing the right incentives to invest in innovation and patents for inventions in high-tech sectors like Computer Implemented Inventions are a main determinant of technological progress and growth. In Section 3, I examine a recent critique of this view according to which patents could stifle innovation by firms active in software related fields. Commenting on the research by Bessen and Maskin (2002) often adopted by opponents of patents for CIIs, I show that the theoretical rationale behind this critique is quite weak and the empirical evidence on the US experience is not in support of such a view, while it may actually suggest a positive effect of patents on innovation. Finally, in Section 4, I will discuss the need for a stronger support to innovation in the European ICT sector on the basis of EU data and in Section 5 I will draw some conclusions on the policy debate, suggesting a strong need for EU harmonization of the patent system and strengthening of the protection of IPRs.

2. The Debate on European Patents for Computer-Implemented Inventions

In 2005, the European Union was about to complete a process of harmonization of the patent system for CIIs, that is inventions whose performance involves the use of a computer, a computer network or another programmable apparatus (that is the use of software, which however is not and will not be patentable as such, but can be copyrighted), to provide proper incentives to invest and innovate. The fast expansion of the Information & Communication Technology which underlies most of the innovations in CIIs makes clear that there is a strong need for such an harmonization to guarantee a sure and well defined legal framework for the patentability of what will soon become the majority of the technological innovations.

The Common position adopted by the European Council in March 2005, established the patentability of computer-implemented inventions under the usual requirements that the inventions are new, non-obvious and with an industrial application plus the additional requirement for which the inventive step must provide a technical contribution. The latter was defined as a "contribution to the state of the art in a field of technology which is new and not obvious to a person skilled in the art" to be assessed "by consideration of the difference between the state of the art and the scope of the patent claim considered as a whole, which must comprise technical features, irrespective of whether or not these are accompanied by non-technical features". This requirement makes sure that a computer program as such remains not patentable, which was also explicitly stated remarking that "inventions involving computer programs, whether expressed as source code, as object code or in any other form, which implement business, mathematical or other methods and do not produce any theoretical effects beyond the normal physical interactions between a program and the computer, network or other programmable apparatus in which it is run shall not be patentable". It was also specified that the mere implementation of an otherwise unpatentable method on an apparatus such as a computer or the mere specification of technical means in the patent claims were not sufficient to make the invention patentable: the requirement of technicality is a substantial one, not a formal one, and it seriously limits the applicability of the patent system to CIIs.

However, inventions solving technical problems can be patented even when they are implemented through software, as long as they are also new, non-obvious and with an industrial application. The definition of technical contribution is clear enough to establish a limit on what cannot be patented, but it has also the advantage of not being too specific, which allows to avoid future unforeseen and undesired restrictions. Indeed, it is important to remember that whenever we talk about inventions, we talk about things which, by definition, we do not know today. Any more specific restriction, beyond creating a discrimination between fields of technology (which is not even allowed by the TRIPS international agreement on patent laws), may soon exclude from patentability inventions which we would not want to exclude. Hence, it appears more reasonable to allow further eventual restrictions within the evolution of the case law. Finally, the Common Position made also clear that the acts required for interoperability which are permitted under copyright protection are also permitted under patent protection, as for instance in case of decompilation. In conclusion, the Common Position simply reaffirmed the requirements already adopted in Europe for the last two decades and it excluded from patentability any pure software, business methods and consulting practices (which can patented in the United States).[1]

Part of the European Parliament proposed a number of amendments which would radically change the current situation, not only excluding most of the innovations in the Information and Communication Technology from patentability, but also creating a lot of uncertainty on the application of the system.[2]

These restrictions on intellectual property rights would have had large negative consequences on innovative investment in the European New Economy, not only in the software industry, but mostly in other high-tech sectors which account for the large majority of CIIs, including hardware, mobile phones, automobiles, consumer electronics, medical instruments, and so on): this would have defeated the all purpose of the Directive on CIIs and would have created a fundamental change in the current situation whose consequences should be carefully studied.

Notice however, that the Common position of the European Council could have also been improved. One general problem with patents, well described by Lind (2004), is that small and medium size firms often do not profit from the opportunity to patent their inventions, probably because of bureaucratic problems and for a lack of knowledge on the advantages of patents for innovators. The Directive could have been more active in providing partial solutions to this problem, and the proposal of a direct involvement of the Commission in addressing it or the creation of a Fund to help and finance SMEs in issues related with patents appear positive proposals. Finally, since the benefits of patents are strictly related with the diffusion of new knowledge, an effort in enforcing a more clear presentation of the inventions in the patent claims would have been welcome as well.

The debate was characterized by a certain confusion on the role of patents on CIIs, partly created by the pressure of the open source community and the free software movement to extend the possibility of free imitation to new fields of technology. As a consequence of such a confusing situation, the European Parliament ended up rejecting the all Directive in July 2005. Unfortunately, it seems that it will take time before the EU will manage to finalize a Directive to properly harmonization between European countries the rules to protect intellectual property rights in general and for CIIs as well.

In what follows, which was written at the time of the debate (see Etro, 2005 a, b), I will try to provide some arguments to this debate with the hope to clarify at least a few issues. The main point, I want to make is that mainstream economic theory is quite clear about the fundamental role of the protection of intellectual property rights through patents in promoting innovation, technological progress and growth, especially in software related fields, which create general purpose technologies and hence are able to increase overall productivity in the economy. While the main social gain from all patents is to promote innovation, the social cost is traditionally associated with the market power of the patentholders.

With CIIs, the social gain is higher than usual, because innovations in this field have a large impact on the productivity of the economy, probably a larger one than for any other inventions. At the same time, the social cost of patents on CIIs is quite limited since, in these sectors of the New Economy, competition mainly works through frequent price-reducing and quality-improving innovations. Hence, the rational for patents on CIIs is much stronger than for other inventions.

2. The Relation between Patents, Innovation and Growth

To approach the issue of patentability, it is fundamental to understand the relationship between patents and innovation and between innovation and growth. If a causal relation between these factors exists, it must go through two steps, one linking innovation policies with investment in R&D (at what economists would define a "microeconomic" level) and another linking innovations and growth (at a "macroeconomic" level). In this section I will discuss both these relations starting from the latter.

2.1 The Relation between Innovation and Growth

A close link between innovation and growth has been pointed out in the academic debate at least since the work of the famous economist Schumpeter (1942). His thesis was that firms innovate and create better technologies to gain patents and market power over their competitors and hence to conquer profits; meanwhile, the new technologies improve the aggregate production possibilities of the economy and create knowledge spillovers inducing further innovations. In a sense, market power (or even monopolistic power) is what drives innovation and growth. Probably the most exciting theoretical and empirical research in the economics of the last twenty years has been exactly on this issue, with the pathbreaking contributions by Romer (1990) and Aghion and Howitt (1992, 1998) and Barro and Sala-i-Martin (2004). This recent research has focused on the markets for innovations as the engine of growth formalizing the ideas of Schumpeter and has presented empirical evidence on what are the main determinants of growth, showing a fundamental link between R&D investment (and other factors correlated with it, as investment in education or in public infrastructures *latu sensu*) and the growth of nations in cross section and panel studies.

More recently, further research has shed new light on the industrial organization of the R&D sector, and in particular on the role of patents in creating the incentives to invest and on the role of leading and small firms in the investment process. On the first point I will return in the next section. Here, I want to briefly focus on the second point, which was after all one of the main initial interests of Schumpeter. A well known fact which is confirmed by wide empirical evidence, is that small firms are often very innovative, in the sense that they often create pathbreaking innovations opening new fields of technology and research: often, these innovative SMEs become large firms afterward, but a lot of anecdotic evidence suggests that many great innovations start from small groups of independent researchers.

At the same time, many secondary innovations and process innovations are often due to large firms (sometimes those small firms which invented new technologies and grew with them to large sizes). As an Economic Focus of the *Economist* (2004, 22nd May, p.84) has recently written, "Joseph Schumpeter, an Austrian economist, pointed out many years ago that established firms play a big role in innovation. In modern times, it appears that many product innovations, in industries from razor blades to software, are made by companies that have a dominant share of the market. Most mainstream economists, however, have had difficulty explaining why this might be so. Kenneth Arrow, a Nobel prize-winner, once posed the issue as a paradox.[3] Economic theory says that a monopolist should have far less incentive to invest in creating innovations than a firm in a competitive environment: experience suggests otherwise. How can this be so?"

Indeed, wide empirical evidence shows that dominant firms invest a lot in R&D and obtain relatively more innovations (see Blundell, Griffith and Van Reenen, 1999). An important economist in the field, Segerstrom (2007) talks about *Intel Economics* referring to a main example of a technological leader, in the chips market, which in 2000 invested 11.5% of its total sales in R&D. High investments can also be found in many other major firms of high tech sectors. In the same year, the R&D/Sales ratio was 15% for Pfizer and 5.8% for Merck, two leaders in the pharmaceutical sector, 16.4% for Microsoft, the leading firm in operating systems, and 5.8% for IBM, and 5.4% for Hewlett Packard, two leaders in computer technologies and services, 11.8% for Motorola and 8.5% for Nokia, leaders in wireless, broadband and automotive communications technologies, 10% for Johnson & Johnson, the world's most comprehensive manufacturer of health care products and services, 6.6% for 3M and 6.3% for Du Pont, which are active in many fields with a leading role, 5.6% for Xerox (mostly focused on the legendary Palo Alto Research Center) and for Kodak, leaders in the markets for printers and photographs.

Recent theoretical research has also provided reasonable rationales for the active and positive role played by market leaders in the R&D sector. For instance, in Etro (2004) I have shown that dominant firms have more incentives to invest in innovation than the outsiders when the market for innovation, or what sometimes is called the patent race, is characterized by free entry (as long as the dominant firms have a leadership, which in economic jargon means just that they can commit to an investment choice before the other firms). The crucial thing here, is that dominant firms often remain dominant thanks to their investments, but this should not be seen as evidence of inefficiency or of monopolistic power, but rather as a proof of the opposite: the competitive environment spurs investment by leaders and consequently induces a chance that their dominance persists.[45] The relevant point for our discussion, however, is that both small and large firms contribute to innovation, though in different ways, and hence, they both contribute to economic growth.

Summarizing, there is a broad and coherent agreement on the positive effects of innovation on growth, and recent work also suggests that small firms have often pathbreaking ideas which open new fields of research, while market leaders are the main responsible for standard investment in R&D leading to constant technological improvements. The crucial point now, is to verify how policy affects investment in innovation, or in other words, to enter inside the engine of growth.

2.2 The Relation between Innovation Policy, Patents and Innovation

This is a much more subtle issue, since any policy generally provides a trade-off between benefits and costs and the interesting and difficult point is to understand what is the optimal innovation policy or the optimal patent system, something on which there is not a general agreement. The discussion will separately focus on protection of IPRs and the patent system first and R&D subsidization afterward.

2.2.1 Patents and Innovations

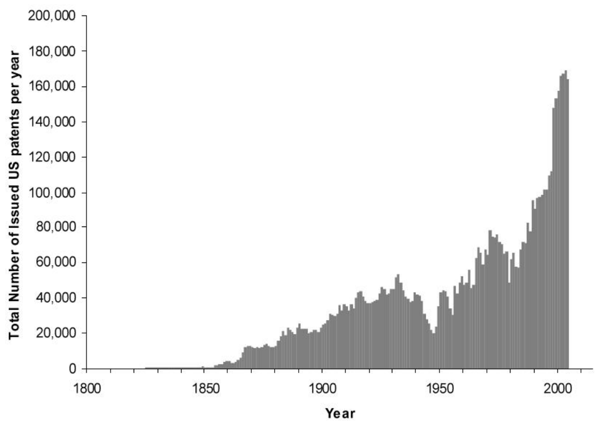
Patents as a promotion of innovations have a long history. Patent protection was already recognized in Renaissance Italy: in 1474 the Republic of Venice issued a decree by which new and inventive devices, once they had been put into practice, had to be communicated to the Republic in order to obtain legal protection against potential infringers. Galileo applied for a patent on an idraulic system in 1593 noticing that "it does not suit me that the invention, which is my property and was created by me with great effort and cost, should become the common property of just anyone." The Venetian Senate assigned him a patent valid for twenty years. England followed with the Statute of Monopolies in 1623. In US, patents where introduced in 1790 (see Fig.1 for their subsequent development).

Talking about a patent system, one should clearly state what are the main benefits and costs of patents: the pathbreaking contribution to the field is the one by Nordhaus (1969).[6] A lot of confusion has emerged on this point in the recent debate, while fewer doubts remain between mainstream economists at least since the contribution by Nordhaus. Patents are nothing else than government-endorsed monopolies for a given technology for a specified period. Hence, they represent the certainty of the monetary reward from an innovation because they allow the innovator to obtain monopolistic profits with its own invention for a certain amount of time. As always in economics, the expectation of this reward is what drives firms to invest and discover new technologies or products. Hence, the stronger is a patent, the larger is this incentive and the higher will be the investment in innovation. On the other side, a patent induces patentholders to price their products above marginal costs and hence it creates a price distortion as long as the patent holds.

The trade-off between these social benefits and costs is what should determine the optimal patent, that is the optimal length of a patent. There is no serious discussion in economics on whether patents should or should not exist for any industry: at most there is a discussion about how long a patent should be or whether its length should be different for different kinds of innovations.

With CIIs, the social gain is higher than usual, because innovations in this field have a large impact on the productivity of the economy, probably a larger one than for any other inventions. At the same time, the social cost of patents on CIIs is quite limited since, in these sectors of the New Economy, competition mainly works through frequent price-reducing and quality-improving innovations. Hence, the rational for patents on CIIs is much stronger than for other inventions.

Fig. 1. US Patents Granted in the Last Two Centuries



Source: US Patents and Trademark Office

Finally, there is a transitional issue. Since CIIs are currently protected in the EU, restricting their patentability now would have two main consequences. The first is maintaining the patents granted until now but deterring further innovations: so there would not be any gain in terms of freely available innovations even in the short run. The second one would be that any new innovation would be kept secret with heavy negative consequences for the disclosure of new knowledge.

Economic research has also studied more complex situations, for instance when there are sequences of innovations. In such a case, an improvement on the leading edge technology is patentable only if it is large enough. This implies that firms are induced to invest for radical improvements rather than small improvements, which clearly has a positive impact on technological progress: we say that patents induce firms to "invent around patents", which implies that firms have to make larger innovative steps rather than small ones. Nevertheless, even small improvements can be brought to the market if the current patentholders license their innovations to the new developers or these sell their improvements to the patentholders: in other words there are always chances to exploit any innovation under sequential technological progress (more on this in Section 3). Again, even in case of sequential innovations, patents are a fundamental tool to promote innovation.

Evidence on the positive role of patents on innovation is also wide. For instance, Blundell, Griffith and Van Reenen (1999) found that the pharmaceutical industry, where patents are strong and well protected, provided the strongest evidence of correlation between market share and innovation. More of this evidence is discussed later on (see Section 3.2).

Concerning patents on CIIs we also have relevant evidence on their positive role for innovations. In a careful empirical study Mann (2005) has shown that patents bestow significant benefits, especially for start up companies, in terms of traditional appropriability, information signaling and cross-licensing revenue, while Merges (2006) looking at patent data in the US software market finds out that "new firms entry remains robust, despite the presence of patents (and, in some cases, perhaps because of them). Successful incumbent firms have adjusted to the advent of patents by learning to put a reasonable amount of effort into the acquisition of patents and the building of patent portfolios. Patent data on incumbent firms shows that several well-accepted measures of 'patent effort' correlate closely with indicators of market success such as revenue and employee growth." In conclusion, it is important to remark that strong patents are a source of strong innovation, and this relation is not weaker for CIIs.

2.2.2 R&S Subsidies

After having made clear the positive effects of a robust protection of intellectual property rights through patents, I want to clarify the role of R&D subsidies in the context of a useful (economists would say optimal) innovation policy. On this point, there is some economic debate which appears quite counterintuitive. While few policymakers would dare denying the positive role of R&D subsidies, part of the economists are doubtful about this role. Indeed, the first generation literature on the relation between innovation and growth emphasized that R&D subsidies could be counterproductive. Aghion and Howitt (1992, 1998), Barro and Sala-i-Martin (2004) and others have shown that competitive markets for innovation may lead to excessive investments in R&D and hence R&D subsidies may have a negative role.[7] Even if this result may belong to the set of those theoretical results which should not be taken too seriously at an empirical level, I would like to stress how such an argument is actually misleading. In Etro (2004, 2006c) I have given a closer look to the engine of growth developing a more realistic theory of the market for innovations which, as noticed by Kortum (1993), Griliches (1994), Cohen and Klepper (1996) and other empirical works, is characterized by relevant fixed costs and decreasing marginal productivity at the firm level: one of the stylized facts pointed out by Cohen and Klepper (1996) is that the number of patents and innovations per dollar of R&D decreases with the level of R&D and this is well grounded empirically (see references cited there).[8]

Under these realistic assumptions, I have shown that the market for innovation is characterized by an inefficient bias toward small firms investing too little in R&D. The intuition relies on the fact that researchers do not internalize the effect of their choices on the entry decision and entry creates wasteful duplication of R&D expenditures, in terms of fixed costs of research: hence, ceteris paribus, firms choose suboptimal investment. This inefficiency implies that the growth process is dynamically inefficient, in the sense that a country could increase its long run growth without increasing investment but just allocating it in a better way (that is increasing investment per firm) or viceversa decrease investment (and increase consumption) without reducing growth! Hence, the optimal R&D policy implies always R&D subsidization, which somehow re-establishes a common sense result.[9]

More important for our purposes is the relation between R&D subsidies and patents. A proper use of both would be optimal, but it should be clear that patents have a more important role in providing incentives to invest since they create the gains from innovations, while subsidies just reduce the costs of the investments. In other words, the effectiveness of R&D subsidies without a well defined patent system would be very small.

3. Recent Critiques of the Patent System for Software

The work by James Bessen and Eric Maskin has been often quoted and used by the open source community and the Free Software Movement in support of their thesis against patents for CIIs. Since their work is almost the only one by mainstream economists claimed to support such a view, and by far the most quoted for this purpose, it is important to examine it in detail. Clearly, *the purpose of this section is not to criticize the scientific research of these two economists, but the interpretation that others have given of their research*. A first version of paper appeared in 1999 but a later, revised and extended version appeared in 2002 (see Bessen and Maskin, 2004, for a summary of the results), while another version recently appeared (December 2004) with the whole empirical part dropped. The 2002 version work includes a theoretical part and an empirical part and I will comment on both. While a certain attention has been paid to the empirical part of the paper, even careful commentators have taken for granted the theoretical results of this work; hence it appears important to provide a comprehensive and balanced analysis of the Bessen-Maskin model before turning to the empirical evidence which is supposed to test this model.

3.1 The Bessen-Maskin theory

Bessen and Maskin propose a theoretical model on "sequential and complementary innovations." Sequential innovation refers to the fact that new innovations improve the old ones, as it usually happens for many though not all innovations: a new chip belongs to a chain of sequential innovations, while a brand new software related invention accomplishing a new task (previously unattended by other products) does not. Complementary innovation refers to the fact that more firms investing in R&D have greater chances to come out with an innovation. Bessen and Maskin compare this dynamic set up with a static set up where just one innovation takes place trying to show the superiority of the dynamic set up: this is quite misleading because most of the previously economic literature has already considered dynamic set ups since at least the beginning of the 80s. Indeed, a wide body of literature has already considered sequential and complementary innovations in a much more general environment and shown that a patent system creates the incentives to innovate, while these incentives are absent without patents [see at least the works by Reinganum, 1985a,b; Denicolò, 2000; Romer, 1987, 1990; Aghion and Howitt, 1992, 1998; Grossman and Helpman, 1991; Barro and Sala i Martin, 2004; Etro, 2004, 2007a,b].[10] The reason is simple: without a patent on the new product, any firm could imitate it and steal some profits from the innovator. Moreover, since anyone could do this, a number of imitators would start competing driving down their individual profits and those of the initial innovator. The latter, after having spent a lot to innovate, will remain with little profits and a lost investment. Clearly, forecasting such an outcome, no one would invest to start with.

The main contribution by Bessen and Maskin (2002) relies on a new simple assumption: without patents there is just one possible imitator, able to collude with the innovator and peacefully share all profits at no cost by imitating the innovation and exploiting it on the market. Once the innovation is obtained by one firm, the two firms are basically assumed to obtain half of the profits each: exactly as if a patent was jointly awarded to them and no other firm was allowed to enter in the market. It is not clear which real world example they have in mind, but it is hard to see here a realistic description of the software market.[11]

Bessen and Maskin want to compare such a system (with no patents but with perfect collusion between the innovator and its only imitator) with a patent system where a patent is attributed to an innovator and this can license it to the other firm to expand research for the next innovations. The result of this comparison is that the patent system does always better than the alternative system without patents in the sense that it always creates more investment in innovation: investment may be inefficiently zero in the system with no patents since the imitation often reduces the expected profits of the innovator below the cost of investment. Unfortunately, Bessen and Maskin mask this result (which actually strengthens the traditional argument in favour of patents) because they decide to introduce another new assumption in their model, which differentiates it from the previous standard literature.

Their second novel contribution relies on the assumption that the cost of the investment can just take two values, a large one or a small one: the exact value is not decided by the firms but assigned randomly, it does not affect the chances to discover the new innovation and it is private information to the firm undertaking the investment. Again, it is not clear which feature of the real world these assumptions are supposed to match, but they do have some consequences. Under the patent system, the innovator, unaware of the costs of the other firm, may end up asking an excessive licence fee for the right to access the technology and do research on it, so that the other firm may not buy that right and may not invest: this happens when investment for the other firm has a large cost and, under some further conditions, it may lead to a chance of smaller investment under the patent system. Summarizing, we have three possible outcomes: (1) the patent system efficiently creates more innovation than the system without patents (for small innovations), (2) both systems are equivalent (for large innovations), and (3) either one of the other system may create more investment (for intermediate innovations). However, notice that Bessen and Maskin hide the complete range of possible outcomes (though it is easy to derive it), emphasizing just the last case in the sub-case where the absence of patents is preferred: this sub-case emerges just when all parameters contemporaneously belong to a limited subset of values. However, in light of the full set of results outlined above, the conclusion by Bessen and Maskin (2004a, p. 40) that "in a dynamic world, imitators can provide benefit to both the original innovator and to society as a whole" is at least a misleading derivation from the model: opponents of the patent system have often played on misleading interpretations of these results.

It is time to pause and reflect on these results. The first thing to notice is that they can hardly be used against a patent system, contrary to what opponents of the patent system for CIIs have repeatedly claimed. In most cases, the Bessen-Maskin model shows that a patent system is better and induces more investment in innovation than a system without patents. The contrary outcome happens only under special and limited parameter values with no clear economic interpretation (they depend on the probability that the imitator has high or low costs of investment) and it collapses under realistic extensions of the model. Even if I already pointed out the peculiarity (or I should say the weakness) of the crucial assumptions by Bessen and Maskin, it is useful to go over them more precisely.

First, Bessen and Maskin assume that only one firm can imitate the innovator and this firm can share profits with the innovator as if they were perfectly colluding, without any competitive forces taking place to reduce these profits:[12] in the real world where new firms could imitate the innovator (since we are assuming no patents) and compete against each other, the profits from the innovation would be eroded and no one would find convenient to invest from the beginning. Consequently, the system without patents would lead to a disaster with no investment at all in innovation. It makes no sense to study a system without patents where two firms can somehow exploit an innovation and no other firms can imitate it, since the same problem with the absence of intellectual property rights derives from the freedom to imitate and crowd out the innovators! Basically, Bessen and Maskin (2002) have developed a model where a patent is jointly awarded to the innovator and the imitator (the first comes out with the idea, the other imitates and indeed they make the same profits), something quite unrealistic if not pointless for a policy discussion.[13]

Second, according to Bessen and Maskin, the only chance for the system with no patents to be better than the patent system happens when the innovator does not know whether the other firm needs a large or a small cost to invest and it takes the risk to ask for an excessive price of the license. The problem would immediately disappear if there were realistically more firms and at least one of them had a small cost of investment: actually in this case, the patent system does even better because it becomes a screening device to sort out another efficient firm (or more than one) to invest in research.[14]

Finally, even taking seriously the unlikely event where a system with no patents promotes innovation, Bessen and Maskin do not provide a convincing intuition for such a result. The mechanism could be summarized as follows. On one side, the patent system creates stronger incentives to invest for a single firm and the patentholder can also sell a license to use its patent, but asymmetric information across firms may prevent this contract; on the other side, in absence of patents, perfect collusion between the innovator and the imitator happens without any contractual problem. The two pieces together are hard to buy and they unlikely represent the core mechanism driving innovation in real world markets.

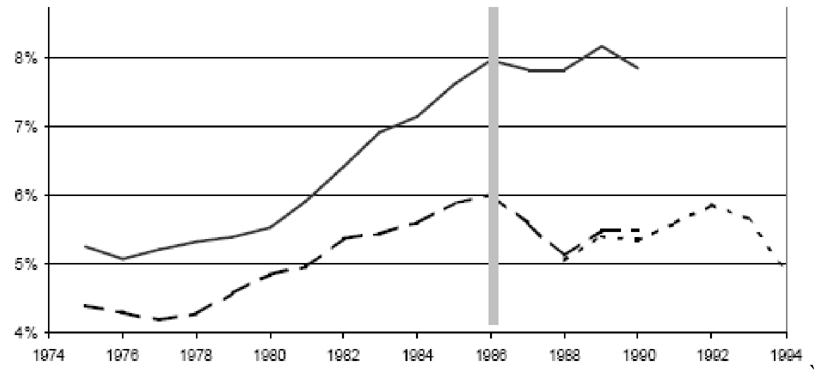
3.2 The Empirical Evidence of Bessen and Maskin

Concerning empirical evidence, Bessen and Maskin provide some data supporting the fact that innovation is both sequential and complementary. More importantly, they show that many sectors are characterized by periods of entry, periods of competition in the market and in the research activities with some exit of firms and a final period where the industry is stable and mature.[15] Anyway, the crucial part of the paper for our purposes concerns the natural economic experiment in software which is claimed to show a non-positive impact of patents on innovation. As the authors explain, in United States, "patent courts subjected the software industry to a natural economic experiment during the 1980s. Before this time, patent protection for innovations was very limited; instead, innovations were protected by copyright. This meant practically that direct copying of a software product was prohibited, but that copying the ideas and concepts embodied in software was not. Market entry therefore required significant investment in development, but entry could not be barred. A series of court decisions in the early 1980s had the effect of extending patent protection to many software ideas. Consequently, the number of patents issued annually covering software grew exponentially from the mid-80s to about 7000 in 1995." The interesting thing is clearly to verify how the innovation activity responded to this shock in the software sector compared to other sectors where this policy change didn't take place and to take into account other possible determinants of this response.

What is strange about the empirical work by Bessen and Maskin (2002) is that this analysis is not done: all what they do is to show the evolution of the ratio between R&D spending and sells for some firms using software patents (Figure 3, p. 52, reproduced here as Fig. 2).[16] They do this for three different samples of firms from 1975 to 1990 (or 1992 or 1994 for the different samples), which in itself is already unsatisfactory, since it would be interesting to look at the last ten years of data as well. The sample on US firms innovating on computer, telecommunications and electronic components is the most relevant since, as noticed by these authors and many others (see Lind, 2004, for a survey) most of the CIIs do not come from the software industry but by a broader sector. Clearly, any time series can be explained by a number of determinants and econometric analysis has exactly the purpose to illustrate what is the role of different determinants: but no econometric analysis is presented on this point.

Fig. 2. R&D/Sales for US Firms Innovating on Computer, Telecommunications and Electronic Components (from Bessen and Maskin, 2002).

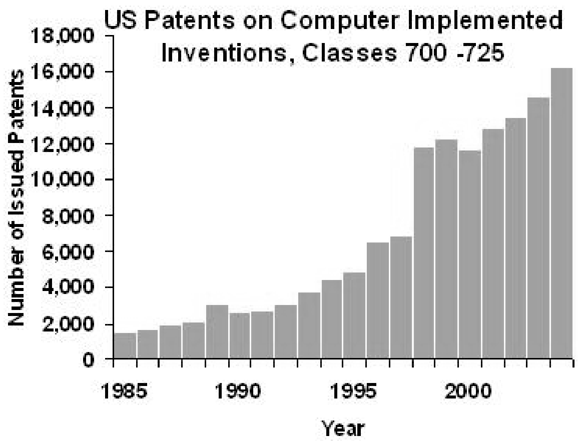
Solid line: NBER index
Dotted line: Top Firms



Source: Bessen and Maskin (2002).

Nevertheless, we are facing a natural experiment due to a policy shock which extends the patent system in the software sector and we can try to verify its impact. First of all, we should know when this shock happened, but Bessen and Maskin just talk about "early 80s" without any further motivation for a particular timing in which the impact should take place. However, the timing of this policy shock is well known and it was 1980 when the Supreme Court forced the United States Patent and Trademark Office (USPTO) to change its position against software related inventions. In the 1981 case *Diamond vs Diehr* (450 US 175) the Supreme Court ordered the USPTO to grant a patent on a computer based invention which used software (more precisely to the whole technical process including a computer program).[17] As an accurate study by Paulsson (2005) has recently observed, "after this case in 1981, the USPTO was left trying to figure out when and if it was a patentable invention and when it was merely an unpatentable algorithm." Hence, a correct timing for the policy shock should be no later than at most 1982.[18] What we see from Bessen and Maskin data for US firms innovating on computer, telecommunications and electronic components (the most relevant data), is a broadly stable ratio R&D/sales since 1975 (the first year with available data) until the end of the 70s and a sharp increase from 1980 until 1990: their NBER index remains between 5% and 5.5% in the 70s and it increases all the way beyond 7% in 1984 and beyond 8% in 1989 (notice that usually R&D/sales ratio tend to be quite stable over time both at the level of the aggregate economy and at the level of single sectors). All what this suggests is that *the data provided by Bessen and Maskin show that the extension of patent protection to many software ideas in the early 80's increased investment in R&D, not only in absolute but even as a ratio to sells, and sharply increased the innovation activity*.

Fig. 3. US Patents on CIIs



It is strange that in front of this data, Bessen and Maskin are able to conclude, without substantial explanation, that the effect of patent protection was absent or even negative. Moreover, these patents kept increasing thereafter, as we clearly show in Fig. 3.

Bessen and Maskin look at the policy shock in the early 80s in the extension of patent protection and take as a reference year 1986: they do not provide any explanation why 1986 should be the right reference in the early 80s. Anyway, even considering 1986 as the reference year for the shock happened in the early 80s, sound empirical analysis should test the impact of patent protection in software on R&D/sales through the following comparison: if in 1986 the increase in R&D/sales for firms investing in software related technologies was smaller (or more negative) than the increase in R&D/sales for firms investing in other technologies, than patent protection had a negative impact on investment in computer implemented inventions. But nowhere in the paper they show this relevant comparison and nowhere in the paper they show data on R&D/sales for the other industries!

Clearly there is no way to support a view against software patents through the evidence shown by Bessen and Maskin. All what we can visually notice from their graphs is a decrease in R&D/sales for firms investing in software between 1990 and 1992. Anyone remembers that that is the time of one of the most severe recessions United States experienced in the last decades and it is clear that this recession may be largely responsible for the above relative decline in the R&D/sales ratio.[19] If Bessen and Maskin had looked at the same data for other firms and other sectors they would have found the same result: during the recession R&D investment relatively decreased.

In conclusion, the empirical evidence by Bessen and Maskin fails to provide any case against patent protection. Most importantly, its interpretation by many opponents of patents has been quite misleading and confusing. The theoretical part of the Bessen-Maskin paper fails to show a reasonable channel through which patents would stifle innovation while it substantially confirms the traditional view that patents promote innovation. The empirical part of the Bessen-Maskin paper does not provide any rigorous evidence of a negative impact of patent protection on software innovation, while it shows that since the extension of patent protection to many software ideas in the early 80s investment in R&D increased a lot.

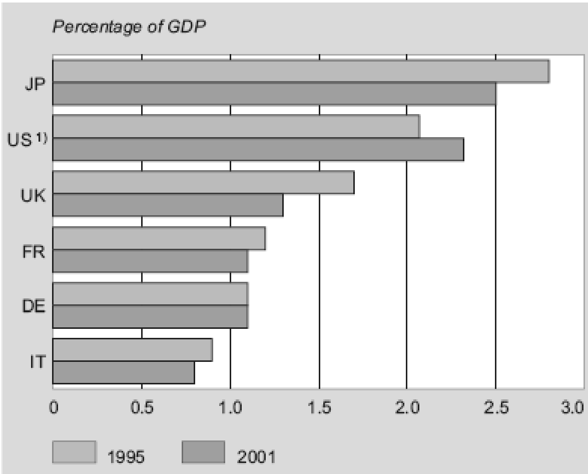
4. Innovation and Innovation Policy in the European Union

In the recent European debate on the lack of growth a lot of attention has been given to promoting competition, innovation and infrastructures. The Lisbon Strategy has closely focused on innovation. The European Council (Barcelona, March 2002) has set the specific target to increase the average level of R&D expenditure in the EU from 1,9% of GDP to 3% by 2010, of which two third should be financed by the business enterprise sector.

This requires a strong promotion of private investments in R&D, which are often more effective than public investment. For instance, Baarsma *et al*. (2004), in an interesting study on private investments in new infrastructures for the EU notice that the Lisbon Strategy "demands large investments in transport projects, broadband networks and energy infrastructure. Despite the widely-acknowledged need for investments in new infrastructures, European and national public funds are scarce in the current economic climate. Moreover, both policy-makers and economists largely agree that the public financing of such investments should no longer be the standard, as it may have been some decades ago. As a result, private investors become increasingly important". As we have seen in the previous sections, the main way to promote private investment in innovative activity is by creating a well defined protection of intellectual property rights which enhances the return on investments. In this sense, a patent system for CIIs can play a fundamental role.[20] Another important way of promoting R&D requires R&D subsidies, as we have repeatedly notices in our previous discussion. However, R&D subsidies imply a number of implementation problems, since their introduction, as the introduction or simple substitutes as the minor taxation on profits that is invested in R&D, induces firms to activate accounting devices for which expenditure that has nothing to do with R&D is reported as R&D

expenditure: this may lead to unfair redistribution and also to inefficient allocation of resources.

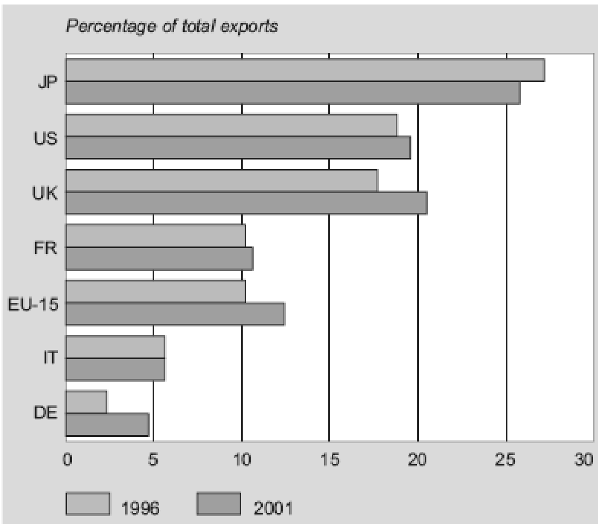
Fig. 4. Value Added in the ICT Sector



1) Own estimates for the years 1996 and 2000.

Source: OECD: STAN Indicators 2004 / ICT Sector Data &Metadata.

Figure 5: Exports of ICT Goods



Source: Eurostat: comextdatabase

To study more closely the need for promoting innovation in the ICT in the EU, let us look at some data recently provided by a Report on the New Economy by the EU (European Commission, 2005). Fig. 4 and 5 show that there is still a wide gap between Europe and both US and Japan in terms of contribution of the ICT sector to both total production and exports: American and Japanese firms of the New Economy have a stronger role than European Firms. The gap is quite large for Italy but also for Germany, while it is smaller but still substantial for UK and France. The average percentage of exports due to the ICT sector in Europe is less than half than in the US.

As we often noticed in the previous sections, competition in the New Economy mainly operates through innovation (notice that public investment in this field has a very minor role). If we hope to expand the strength of European firms in the global development of the New Economy, we should make sure that private investment in R&D is high enough and properly rewarded. Looking at the data on patent applications (Fig. 6-9) we notice that there is a group of (mostly Nordic) countries within the EU where the number of patent applications is high and increasing and where the fraction of ICT patents is large and increasing, while a large group of (mainly Mediterranean) countries lacks behind on all these dimensions. What is sure, and broadly agreed by most commentators, is that there is a substantial need to intervene and promote, more than before, the investment in R&D especially for the ICT sector. In conclusion, the European situation asks for a radical and strong promotion of private investment in innovation: additional restrictions to the patentability of CIIs would just go in the opposite direction.

Fig. 6. ICT Patent Applications with the EPO

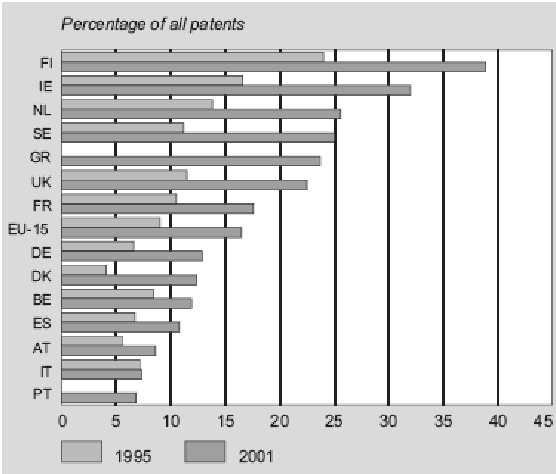


Fig. 7. ICT Patent Applications with the EPO

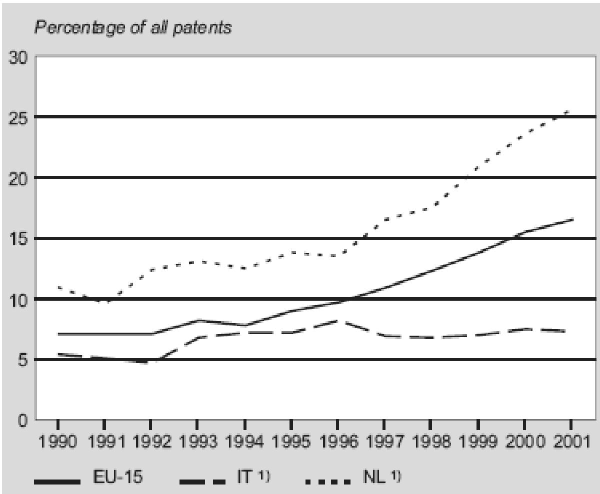


Fig. 8. ICT Patent Applications with the EPO

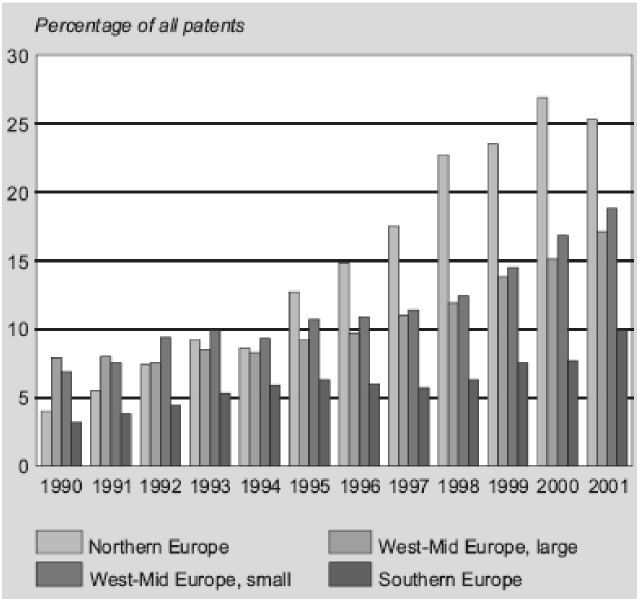
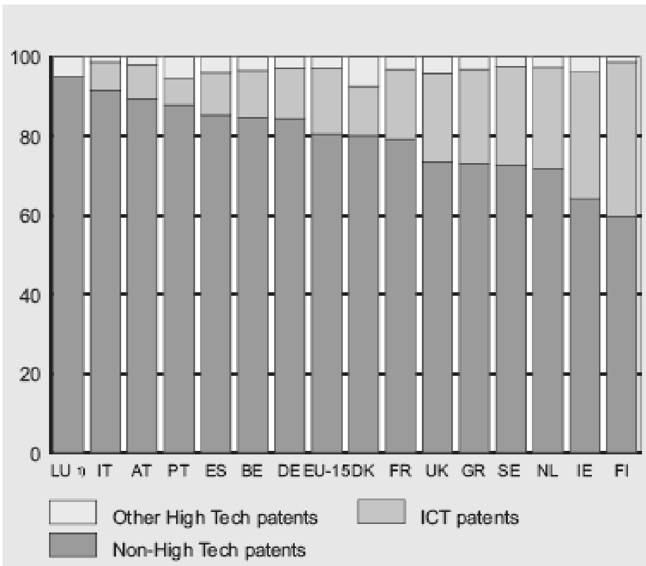


Fig. 9. High-tech Patents in 2001



There is something more that can be derived from these data. It emerges quite clearly that within Europe, countries with a smaller ICT sector in terms of percentage of value added on GDP or percentage of exports, like Italy and other Mediterranean countries, are also characterized by a limited number of ICT patents and a small percentage of ICT patents on the total amount of patents. This suggests a positive correlation between patenting activity and productivity of the ICT sectors, which is something quite important for our purposes. Countries where firms patent more computer-implemented inventions, which represent a large part of the ICT patents, are also those countries where firms from the New Economy are more developed, more innovative and hence more competitive both within Europe and globally. Even if there are issues of double causality, once more this suggests a positive effect of patents on innovation specifically in the ICT sector, and not the other way around.

Recently, a great concern emerged in Europe for the loss of competitiveness in front of the Asian economies, able to exploit a substantially smaller cost of labour, and in some cases also an advanced level of human capital (for instance at the basis of the extraordinary development of the software industry in India). Until now, the threat of East-Asian and especially Chinese competitors mainly derived from the manufacturing sector. Clearly, any limit to the protection of IPRs in Europe would create a new huge opportunity for these East-Asian competitors, which will be able to imitate European technology, reproduce it at a smaller cost and freely sell it in Europe. The negative consequences for the European high-tech industry can be easily imagined.

Table 1. Percentage of ICT Patents

ICT Patents	Percentage of all patents											
Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
EU-15	7.1	7.1	7.1	8.2	7.8	9.0	9.7	10.9	12.3	13.8	15.5	16.5
Belgium	4.0	6.6	8.2	8.4	6.9	8.4	9.9	7.6	9.0	10.2	9.2	11.9
Denmark	-	3.3	2.4	-	1.9	4.1	3.2	5.9	10.4	10.2	11.8	12.4
Germany	6.3	5.9	5.9	6.1	5.7	6.6	7.5	8.8	10.2	11.0	12.5	12.9
Greece	-	-	7.8	6.7	-	-	-	-	6.4	-	6.5	23.7
Spain	1.6	4.0	-	4.1	5.6	6.7	4.3	5.2	7.0	10.3	9.4	10.8
France	8.6	9.2	9.5	10.1	9.9	10.5	9.6	11.2	13.1	15.5	16.5	17.6
Ireland	8.5	9.9	17.7	-	-	16.6	15.1	-	15.5	16.2	27.5	32.0
Italy	5.4	5.1	4.7	6.8	7.2	7.2	8.2	6.9	6.8	7.0	7.5	7.3
Luxembourg	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	10.9	9.6	12.4	13.1	12.5	13.8	13.5	16.5	17.5	20.9	23.6	25.6
Austria	2.3	3.7	1.8	3.5	3.3	5.6	6.0	5.0	5.9	7.2	8.6	8.6
Portugal	-	-	-	-	-	-	-	-	-	-	-	6.8
Finland	5.3	7.5	13.7	-	17.2	24.0	26.1	32.8	36.9	39.6	43.5	38.9
Swedan	5.7	5.8	6.8	9.9	7.6	11.2	15.1	15.6	21.8	22.2	26.4	25.0
United kingdom	9.5	9.5	7.6	10.3	10.5	11.5	12.7	13.7	13.1	16.0	17.2	22.5

5. Conclusions

In this paper I tried to emphasize a main economic point which seems largely lost in the recent debate on the patent system: patents promote innovation and economic growth, and this role is just stronger when they protect high-tech inventions as computer implemented inventions. At this point, I would just like to summarize some suggestions for the debate on the harmonization of EU patents and on the patentability of CIIs which emerged from our economic perspective:

– additional restrictions to the patentability of computer-implemented inventions would jeopardize investment in innovation and technological progress in the leading high-tech sectors of the

European economy with negative consequences on growth and competition in the global economy;

- explicit exclusion of entire fields of technology as data processing from patentability would shift investments toward US and other countries where IPRs are better protected in a large and rapidly increasing number of sectors, and toward emerging countries, like India, where the software sector is experiencing an extraordinary development;
- additional restrictions to the enforcement of the current patent system would open doors to foreign low cost productions which, without patent protection, would be free to imitate European products even in high-tech sectors, with negative consequences on European employment and on innovative (and also non-innovative) SMEs;
- improvements of the effectiveness of current patent system for CIIs should rather promote access to patents especially for SMEs, traditionally less able to exploit this opportunity, to consolidate the European comparative advantage in high-tech sectors where innovation and human capital play a crucial role; and
- enhancement of the spillovers created by the patent system on the diffusion of knowledge could be obtained through further requirements on the disclosure of the patented CIIs.

At the very conclusion, I would like to remember that intellectual property rights are, first of all, property rights. While, after the last century's experiences, we are well aware of the negative consequences of restricting property rights on production and wealth, we should be aware also of the consequence of restricting intellectual property rights. These restrictions reduce not only the level, but even the growth rate of production and wealth (by jeopardizing investment and innovation), which creates huge and permanent negative consequences in the long run.

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Executive Summary

Recently, the European Union tried to complete a process of harmonization of the patent system for Computer-Implemented inventions (CIIs) to provide proper incentives to invest and innovate. The Common position adopted by the European Council in March 2005, established the patentability of computer-implemented inventions when they provide a technical contribution to a field of technology. While this proposal simply reaffirmed the requirements already adopted in Europe for the last two decades and it excluded from patentability any pure software, business methods and consulting practices, part of the European Parliament proposed a number of amendments which would have radically changed the current situation excluding most of the innovations in the Information and Communication Technology from patentability. For instance, amendments which establish vague definitions of "technical" contribution or "field of technology" are going to add significant restrictions on what can be patented, and other amendments which explicitly exclude innovations in data processing are going to avoid patents on most inventions in the digital technology. These restrictions on intellectual property rights would have large negative consequences on innovative investment in the European New Economy, not only in the software industry, but mostly in other high-tech sectors which account for the large majority of CIIs (including those related with mobile phones, audio/video recorders, digital cameras, hardware for computers, wireless connectivity, automobiles, medical instruments,..): this would clearly defeat the all purpose of the Directive on CII.

As a consequence of such a confusing situation, the European Parliament ended up rejecting the all Directive in July 2005. It will take time before the EU will manage to provide a proper harmonization of the rule to protect intellectual property rights in general and for CIIs as well.

The recent debate has been characterized by a certain confusion on the role of patents on CIIs, largely created by the pressure of lobbies willing to extend the possibility of free imitation to new fields of

technology. However, policymakers should always keep in mind that what matters is not the interest of this group rather than the one of the innovative firms driving technological progress, but the interest of the society as a whole, and in particular of current and future consumers who benefit from a higher rate of innovation.

Mainstream economic theory is quite clear about the fundamental role of the protection of intellectual property rights through patents in promoting innovation, technological progress and growth, especially in high-tech sectors, which create general purpose technologies and hence are able to increase overall productivity in the economy. While the main social gain from all patents on CIIs is to promote innovation in the most dynamic sectors, the social cost, traditionally associated with market power of patentholders, is smaller than for other patents since in these sectors competition mainly works through more frequent price-reducing and quality-improving innovations. Hence, the rationale for patents on CIIs is even stronger than for other inventions.

Neglecting these traditional economic insights, opponents of the patent system have often claimed that patents stifle innovation on the basis of few economic works, mainly by Bessen and Maskin. Unfortunately, their theoretical research does not provide any clear-cut result against patents. Even looking closely at the evidence provided by this research on the US experience, it emerges that the extension of patent protection to software related inventions (the first patent for a CII was granted in 1981) was associated with a clear increase in R&D investment during the eighties, even in relative terms: the R&D/sales ratio for US firms innovating on computer, telecommunications and electronic components goes from 5.5% to above 8% in 1989. Anyway, those works do not compare investment in CII with investment in other technologies and do not take into account other (macroeconomic or sector-specific) factors, hence there is no any rigorous conclusion which could be drawn from the data. The misleading interpretation of this inconclusive research adopted by the opponents of patents has created a lot of confusion in the debate.

The following suggestions derive from an economic point of view in the interest of the society as a whole:

1. additional restrictions to the patentability of computer-implemented inventions would jeopardize investment in innovation and technological progress in the leading high-tech sectors of the European economy with negative consequences on growth and competition in the global economy;

2. explicit exclusion of entire fields of technology, as data processing, from patentability would shift investments toward US and other countries where IPRs are better protected in a large and rapidly increasing number of sectors;

3. additional restrictions to the enforcement of the current patent system would open doors to foreign low cost productions (think of China) which, without patent protection, would be free to imitate European products even in high-tech sectors, with negative consequences on European employment and on innovative (and also non-innovative) SMEs;

4. improvements of the effectiveness of the current patent system for CIIs should rather promote access to patents especially for SMEs, traditionally less able to exploit this opportunity, to consolidate the European comparative advantage in high-tech sectors where innovation and human capital play a crucial role and to help achieving the goals of the EU Lisbon strategy. In this sense, some proposals which stress the monitoring role of the Commission on the impact of CIIs on innovation and competition especially on SMEs (including electronic commerce) and suggest to establish a Fund to provide financial, technical and administrative support to SMEs dealing with patents go exactly in the right direction; and

5. enhancement of the spillovers created by the patent system on the diffusion of knowledge could be obtained through further requirements on the disclosure of the patented CIIs: the disclosure of

the invention should be sufficiently clear and complete to be carried out by a person skilled in the art.

Endnotes

1 These important restrictions had and will have an important role in avoiding the problem of "poor patents", that is patents on low quality inventions which are often associated with business methods in the US.

2 Amendments which established complicated definitions of "technical" contribution or "field of technology" were going to add significant restrictions on what can be patented. For instance, old fashioned expressions referring to technical contributions as using controllable forces of nature to obtain predictable results in the physical world appeared mostly inadequate and vague: inadequate because they virtually mean nothing from a scientific (technical) point of view (since anything which moves every other thing, from electrons to airplanes, can be a use of controlled forces of nature) and vague because at the same time these expressions may mean anything (any interpretation of them could be justified). Other amendments explicitly excluding from patentability innovations in data processing and information handling (and stating that the use of information processing methods should never constitute a patent infringement) were going to exclude most inventions in the digital technology and in particular in the fields of video, audio, consumer electronics and even medical information processing. Finally, some amendments introduced huge exemptions from patent infringement which would allow imitation even of patented techniques (for vaguely defined but very broad interoperability purposes) and, most of all, without any license fee which normally should compensate patentholders for imitation by other firms.

3 See Arrow (1962).

4 Clearly, this has strong implications for industrial policy (see Etro, 2006b, 2007). What the above theory suggests, however, is that dominant firms in high-tech sectors investing a lot in innovation may create an efficient situation: "antitrust authorities should be especially careful when trying to stamp out monopoly power in markets that are marked by technical innovation. It could still be that firms like Microsoft are capable of using their girth to squish their rivals; the point is that continued monopoly is not cast-iron evidence of bad behaviour…when one company dominates a market, people should be careful in assuming that it is guilty of sloth. It may be fighting for its life" (*ibidem*). The argument generalizes to a wider context (Etro, 2006a).

5 In Etro (2006c) I have also shown that this implies more investment and a more efficient allocation of resources, and it also enhances growth. In other

words, not only market leaders invest more in innovation, but they also contribute more to the growth process.

6 On the political economy of IPRs see Pugatch (2004).

7 The main rationale behind this result relies on the so called business stealing effect: firms invest too much because they do not take into account the fact that their investment reduces the expected probability for other firms to discover new technologies and appropriate the related profits.

8 From a theoretical point of view, notice that, while in most of the productive sectors there are good reasons to believe that doubling the amount of input total production will double, there no reasons to believe that doubling the amount of inputs in the R&D activity will double the expected amount of innovations (or reduce by half the expected time to innovate).

9 Notice that the dynamic inefficiency of the growth process shows how a country with an industrial structure characterized by small firms achieves inefficient results, and could grow more without losses in current consumption if its firms were increasing in size. This general conclusion may shed new light on the problems of countries that do not grow much and lack large and innovative corporations. This is the case of many European countries, most notably Italy, whose industrial structure is characterized by a large number of small and medium size enterprises whose innovative capacity is quite limited; for recent policy analysis on the benefits of market reforms on growth taking in considerations the market for innovations, see Faini et al., 2004, and Chaudhuri and Flamm, 2004).

10 On patent races see the initial works by Dasgupta and Stiglitz (1980), Loury (1979), Lee and Wilde (1980) and Reinganum (1983, 1985a,b).

11 In the software market: (1) there are many firms and many potential entrants, (2) all firms are quite used to compete in prices and undercut rivals eroding their respective profits and (3) probably few would dare to claim that a leading firm is colluding with other imitators in sharing the profits from innovations.

12 It should be clear that if there were more imitators things would not change (as the 2004 version of the paper shows) but the assumptions of the model would be even less realistic. The real problem with the Bessen and Maskin model is the absence of real competition between the imitators and the innovator: in the real world, this is what drives down the incentives to invest.

13 Moreover, Lind (2004) has noticed another problem with the Bessen-Maskin model: "in a world of sequential and complementary development, there usually isn't a single invention so fundamental that it can't be invented around and there may well be parallel development opportunities. In this case it is not clear that an initial patent can deter future developers who may move to alternative technical paths. Therefore, the paper's dynamic

model, while interesting, may not fit the realities of the development environment."

14 Finally, as well known in the theory of contracting with asymmetric information, efficient signalling contracts are widely available if we endogenized investment as a continuous variable rather than a binary one.

15 Unfortunately this hardly matches the assumption in the Bessen-Maskin model where there are just two firms and no chances to entry and without patents the two firms perfectly collude splitting the profits half and half.

16 Others have also criticized the use of this measure. For instance Lind (2004) disagrees "that either R&D spending or relative R&D spending is a good measure of innovation in an industry. If an industry is growing very rapidly, even constant relative R&D spending may be associated wih a large rise in absolute R&D spending. This is what one might expect from a growing industry going from its early stages to a more mature stage, where both total sales and R&D spending have increased greatly. It is not supportable to conclude that either innovation or more importantly the value of innovation-led growth was lower than it would otherwise have been, simply from the fact that R&D spending has not grown faster than sales over a particular period." This is correct, and it appears quite absurd to imagine that the ratio R&D/sales could keep growing after achieving impressive levels as it did during the last decades. Moreover, Lind also notes that innovativeness measured by market novelty is correlated with patenting while R&D/sales is not.

17 In that case, the invention related to a method for determining how rubber should be heated in order to be best cured. The invention utilized a computer to calculate and control the heating times for the rubber. However, the invention (as defined by the claims) included not only the computer program, but also included steps relating to heating rubber, and removing the rubber from the heat. The Supreme Court stated that in this case, the invention was not merely a mathematical algorithm, but was a process for molding rubber, and hence was patentable.

18 Anyway, since it usually takes at the very least two or three years of research to come out with innovations to patent it is reasonable to imagine that the impact of the shock must have happened at most two or three years before the actual extension of patent protection was effective and in any case no later than that.

19 Given the confusion created on this issue, it is better to explain also why R&D expenditure tends to relatively decrease during recessions. Economists have pointed out two main reasons. The first has to do with a tendency of firms to reduce long run investments in recessions to maintain positive their net profits and limit the negative consequences on earning ratios and stock market valuations: this is substantially an accounting device, but firms pay a close attention to smooth net earnings over the businness cycles. The

second and probably more important reason is that in a recession it is harder to get credit for investment because interest rates go up and because the value of collaterals goes down. For these reasons (and others as well) investment in innovation tends to relatively decrease during recessions. It is quite misleading to draw any conclusion on the 1990-1992 experience without taking this into account.

20 Their work has further important insights for our issue: "According to the traditional dogma of welfare economics, monopoly rents have to be avoided, since they occur when a monopolist exploits his market power by reducing supply and raising prices. The reduced supply constitutes a welfare loss and monopoly rents raise distributional concerns. Moreover, monopolies are traditionally considered as inefficient and not inclined to innovate. Such observations seem to be the guiding principle for many governments and regulators in their attitude towards monopolies. However, modern research shows that this position needs some serious qualifications, especially in a rapidly innovating environment. Not all profits that a monopolist makes, constitute a welfare loss. Without some prospect of a considerable rate of return, private investments in infrastructure will be discouraged. Large profits, which the public will easily perceive as "monopoly rents", are required to cover both the high fixed cost of investments in infrastructures and the risks, which can be particularly high for investments in innovative infrastructures. Moreover, a monopoly or market leader has a greater incentive than any other firm to carry out a lot of research, to keep innovating and thus stay on top. … Regulating away what is perceived by the public as "monopoly profits" tends to increase efficiency in the short run, but particularly in a dynamic environment it may take away the incentives for both the monopolist and possible contestants to invest in new infrastructures. Hence, long-term innovation and infrastructure competition may suffer from over-regulation. This may be the major dilemma for unleashing private investments".