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1. Introduction

The case against patents can be summarized briefly: there is no empirical evidence that they serve to increase innovation and productivity, unless the latter is identified with the number of patents awarded – which, as evidence shows, has no correlation with measured productivity. This is at the root of the "patent puzzle": in spite of the enormeous increase in the number of patents and in the strength of their legal protection we have neither seen a dramatic acceleration in the rate of technological progress nor a major increase in the levels of R&D expenditure – in addition to the discussion in this paper, see Lerner [2009] and literature therein. As we shall see, there is strong evidence, instead, that patents have many negative consequences. Both of these observations, the evidence in support of which has grown steadily over time, are consistent with theories of innovation that emphasize competition and first-mover advantage as the main drivers of innovation and directly contradict "Schumpeterian" theories postulating that government granted monopolies are crucial in order to provide incentives for innovation. The differing predictive and explanatory powers of the two alternative classes of models persist when attention is shifted to the historical evidence on the life-cycle of industries. The initial eruption of small and large innovations leading to the creation of a new industry – from chemicals to cars, from radio and TV to personal computers and investment banking – is seldom, if ever, born out of patent protection and is, instead, the fruits of highly competitive-cooperative environments. It is only after the initial stages of explosive innovation and rampant growth end that mature industries turn toward the legal protection of patents, usually because their internal grow potential diminishes and the industry structure become concentrated.

A closer look at the historical and international evidence suggests that while weak patent systems may mildly increase innovation with limited side-effects, strong patent systems retard innovation with many negative side-effects. Both theoretically and empirically, the political economy of government operated patent systems indicates that weak legislation will generally evolve into a strong protection and that the political demand for stronger patent protection comes from old and stagnant industries and firms, not from new and innovative ones. Hence the best solution is to abolish patents entirely through strong constitutional measures and to find other legislative instruments, less open to lobbying and rent-seeking, to foster innovation whenever there is clear evidence that laissez-faire under-supplies it.

2. Theory and Practice of Patents and Innovation

There is little doubt that providing a monopoly as a reward for innovation increases the incentive to innovate. There is equally little doubt that granting a monopoly for any reason has the many ill-consequences we associate with monopoly power – the most important and overlooked of which is the strong incentive of a government granted monopolist to engage in further political rent-seeking to preserve and expand his monopoly or, for those who do not yet have it, to try obtaining one. Said differently: while the positive impact of patents is the straightforward partial equilibrium effect of increasing to the monopolistic level the profits of the successful innovator, the negative one is the subtler general equilibrium effect of reducing everybody else's ability to compete while increasing for everyone the incentive to wastefully lobby.

In the long run, though, even the positive partial equilibrium effect may be more apparent than real: the existence of a large number of monopolies due to past patent grants reduces the incentives for innovation as current innovators are subject to constant legal action and licensing demands from earlier patent holders. The recent – and largely successful – efforts of Microsoft to impose a licensing fee on the large and expanding Android phone market is but one case in point. With the exception of Motorola Mobility all the handset manufactors have agreed to the fee, and Motorola has recently lost the first battle – fought not in court but in the more receptive domain of the U.S. International Trade Commission.[1]

The basic problem with the patent system – the downstream-blocking effect of existing monopoly grants on future innovation – is greatly increased because modern products are made up of so many different components. The Microsoft-Motorola example is a good illustration as a licensing fee on Android mobile phones is being charged by Microsoft soley over a patent involving the scheduling of meetings – a trivial and rarely used feature of modern smart-phones. This is but one of many thousands of patented "ideas" used in a modern smart-phone, and each owner of each patent potentially can charge a licensing fee. Hence, the main dynamic general equilibrium effect of a patent system is to subject future inventions to a gigantic hold-up problem: with many licenses to be purchased and uncertainty about the ultimate value of the new innovation each patent holder, in raising the price of his "component", imposes an externality on other patent holders and so charges a higher than efficient licensing fee. Boldrin and Levine [2005] and Llanes and Trento [2009] have explored the theory, many case-studies involving patents – and other fractionated ownership problems – can be found in Heller [2008]..

A second widely cited benefit of patent systems – although not so much in the economics literature – is the notion that patents are a substitute for socially costly trade secrecy and improve communication about ideas. From a theoretical point of view the notion that patents are a substitute for trade secrecy fails even in the simplest model. If a secret can be kept for N years and a patent lasts M

[1] Investigation Number 337-TA-744 May 18, 2012. Note that the patent in question is for "generating meeting requests and group scheduling from a mobile device" – not what we ordinarily think of as "innovation" or "invention."

years then an innovator will patent exactly when $N \leq M$. Hence, only those things will be patented for which the secret would have emerged before the patent expired, while those for which the secret can be kept will not be patented. The same remains true in more complex and realistic models such as that of Boldrin and Levine [2004], see also Ponce [2007]. It is also the case that modern "disclosure" in patents is negligible – it is essentially impossible to build a functioning device or software program from a modern patent application, a fact which is especially clear since some patented ideas do not – and cannot – work. A case in point is the patent for moving information through the fifth dimension.[2]

A more subtle point is that secrecy may bias the type of inventive activity away from innovations that are not easily kept secret to those that can be, viceversa for patents. There is historical evidence from Moser [2004, 2005] in this direction. In 19th Century expositions of inventions, while countries without patent systems had overall rates of innovation similar to those with a patent system, they did specialize in innovations which were more easily kept secret. How strong this bias would be if no countries had patent systems – that is, whether it is true that patents encourage innovations that would not otherwise be made, or if they just shift the location of innovation from country to country – is not known.

The related idea that patents somehow improve communication about ideas – a notion key to the "public-private" partnership between governments and private research organization in which the government funds the research and then gives the private organization a monopoly over anything developed in the course of research – is backed neither by theory or evidence. It is impossible to study the history of innovation without recognizing that inventors and innovators exchange ideas as a matter of course and that secrecy occurs, in those cases in which it occurs, only in the final stages of an innovation process, when some ambitious inventors hope to corner the market for a functioning device by patenting it. A good case in point is that of the Wright brothers, who made a modest improvement in existing flight technology which they kept secret until they could lock it down on patents, then used their patents both to monopolize the U.S. market and to prevent innovation for nearly 20 years. This is discussed in Shulman [2003]. The role that Marconi and his patent played in the development of the radio is altogether similar – see Hong [2001] – as are innumerable others. At the opposite extreme we have, again among many, the example of the Cornish steam engine discussed in Nuvolari [2004a, b]. Here engineers exchanged non-patented ideas for decades in a collaborative effort to improve efficiency. The modern and highly successful open source software movement is a more contemporary example of how collaboration and exchange of ideas thrives absent intellectual property. How much public benefit of the various patented – and never-the-less secret – pieces of the Microsoft operating system has occurred?

On the other side of the coin, the rationale for patent systems is weak. In most industries the first mover advantage and the competitive rents it induces are substantial without patents. Again: the smart-phone industry – laden as it is with patent litigation – is a case in point.[3] Apple derived enormous profits

[2] U.S. Patent 6,025,810.
[3] The history of the various smart-phones is documented, for example, in Wikipedia.

in this market before it faced any substantial competition. The first iPhone was released on June 29, 2007. The first serious competitior, the HTC Dream (using the Android operating system) was released only on October 22, 2008. By that time over 5 million iPhones had been sold, and sales soared to over 25 million units during the subsequent year, while total sales of all Android based phones was less than 7 million. In the tablet market the iPad still has no serious competitor despite having been introduced on April 10, 2010. While it is hard to prove this delayed imitation would have occurred also in the complete absence of patents, it is a fact that Apple did not try to use patents to prevent the Android phones from coming into its market and the subsequent "patents' fight" has been taking place largely after 2010, something that the Boldrin and Levine [2004] model predicts. More to the point, companies typically instruct their engineers developing products to avoid studying existing patents so as to be spared subsequent claims of willful infringement, which raises the possibility of having to pay triple damages. Based on sworn testimony by Google's chief of Android development in Oracle vs. Google (see for example Niccolai [2012]) the engineers that developed Android were unaware of Apple (or other) patents, and so were unlikely to have been helped by them.[4]

How valuable financially, for Apple, was the delay in the Android phones entry? Based largely on the fact that Apple has kept its first mover advantage in spite of a large imitative entry in this market, the value of Apple stock – during a severe market downturn – has gone up by a factor of approximately five. While there may have been some delay in competition due to Apple's threat – since executed – of patent litigation, the fact is that similar but less successful devices had been available for a number of years before Apple finally cracked the market.

The market for software and hardware may be viewed as a somewhat special case. Generally the fixed cost of producing software is low – although it is estimated that Apple spent 150 million USD developing the iPhone. This, however, pales in comparison to the cost of developing new medicines – which is estimated to have a present value of closer to 1 billion USD – the same way it does in front of that for developing a new model of automobile, which is in the same range. Interestingly it is also true that – according to both survey and anecdotal evidence – patents play an important role in encouraging innovation in the pharmaceutical industry while playing a minor one in that of cars, insofar as new components and even plants are often developed by consortia or joint-ventures of otherwise fiercely competitive producers marketing different automobile's brands. The relevance of patents in the pharmaceutical industry – then, and contrary to "Schumpeterian" theories – is most likely not due to the high fixed costs but rather the fact that disclosure in the case of drugs is more meaningful than in that of cars and most other products. The chemical formula and the efficacy of the cure as established by clinical trials are available to competitors essentially for free and it is the second (a public good, privately produced due to a political choice) that accounts for about 80% of the initial fixed cost. On the other side,

[4] Note also that these types of policies make something of a mockery of the idea that patents serve to make ideas available.

the downstream cost of monopoly pricing of pharmaceutical products is much higher for life-saving drugs, and the cost of monopoly pricing of other pharmaceutical products is also quite high. Hence various economists, holding differring views about intellectual property, have nevertheless argued that if government intervention is indeed needed in this market a system of prizes would be far superior to the existing system of monopolies.

To understand patents in practice – and in particular why the poorly named "Schumpeterian" theories are not relevant to a proper understanding of either their effect upon, or the determinants of, innovative activity – it is necessary to examine the lifecycle of industries (see for example Jovanovich and McDonald [1994] and Scherer [1990]). Typically a new, hence innovative, industry begins with a competitive burst of entries through which very many innovators try hard to get their products to market. In these early stages, there are many firms bringing different versions of the new product to the market – just think at the American auto industry in the early twentieth century or the software industry in the 1980s and 1990s – demand for the new product grows rapidly and the latter is also rapidly improved. The price elasticity of demand is consequently high: what is important is not to dominate the market but rather try to get your own products quickly to it and to reduce costs. What this means is that your cost-reducing innovation is good for me in the same way that my cost-reducing innovation is good for you, hence let us all imitate each other and compete in the market. As the industry matures, demand stabilizes and becomes much less elastic; the scope for cost-reducing innovations decreases, the benefits of monopoly power grow and the potential for additional product innovation also shrinks. Typically there is a "shake-out" in which many firms either leave the industry or are bought out. The automobile industry is a classical historical example but the much more recent "bursting" of the dotcom "bubble" is, in fact, one we may recall better and that makes this point even more forcefully. At this stage rent-seeking does become important and patents are widely used to inhibit innovation, prevent entry, and encourage exit. If we look at patent litigation in practice – as is predicted by theories such as that of Boldrin and Levine [2004] – it takes place when innovation is low. The dead hand of dying institutions – Texas Instruments was famous for this and now we have the example of Microsoft – gets hold of the industry as they attempt to tax consumers, new entrants and any potential competitor. Far from being encouraged, when an industry matures innovation is blocked by the ever increasing appeal to intellectual property protection on part of the insiders.

It is somewhat conventional to think of welfare losses from distortions as small – the well known arguments about the small cost of the business cycle and of the general idea that welfare triangles due to monopoly power are small, being paradigmatic cases in point. With the monopolies of patents the opposite is the case. The conventional view starts with competitive equilibrium and observes that welfare losses from small price variations are quadratic as a function of the price, hence grow very slowly as the price increases. In the case of full monopoly – as is the case with patents – we are not interested in small price deviations from competition but rather we are interested in pricing near the top of the profit

function. Witness for example the fact that patented pharmaceutical products often sell for hundreds of times the marginal cost of production as some astonishing pricing differences between the US and the European markets show. Here social loss increases nearly linearly with prices, while the deviation of profits from the maximum are quadratic. Hence small price increases have a only a small effect on profits – although still worthwhile from the perspective of the monopolist – with substantial social loss. It is impossible to observe the behavior of modern IP monopolists without recalling this theoretical prediction. Most of the copyright wars revolve around measure to prevent piracy, empirically a relatively minor factor as far as profits of media corporations are concerned (see for example Sinha, Machado, Sellman [2010], Danaher, Dhanasobhon, Smith and Rahul, [2010], Sanchez [2012]). In the case of patents, and particularly pharmaceutical patents, the situation is even more severe. We have made mention of the loss of human life due to the pricing of AIDS drugs. More revealing is the empirical study of the Quinolones family of drugs (Chaudhuri, et al. [2006]). It measures the economic consequences to India of the introduction of pharmaceutical patents for this family of drugs and concludes that the consequence to third world India will be nearly 300 million USD in welfare losses – while the gain to the first world pharmaceutical companies will be less than 20 million USD.

The cost of litigating patents is not insubstantial either. Bessen and Meurer [2009] used stock market event studies to estimate the cost of patent litigation: they estimate that during the 1990s it rose substantially until at the end of the period it constitutes nearly 14% of total R&D costs. A related but more difficult to quantify phenomenon is the rise of uncertainty caused by the legal system. A case in point are the NTP Inc. patents that were used to threaten the Blackberry network with a shutdown. In 2006, posed on the edge of a cliff, Research in Motion, the producer of Blackberry, agreed to pay $ 612.5 million to license the patent in question from NTP. The patent was later invalidated by the court – but Blackberry of course did not get their money back. Further details about this and other NTP-induced cases are available on the Wikipedia's page about NTP. Here the bad behavior of a single judge cost Blackberry more than half a billion dollars. In this setting it is no surprise that patent trolls hope to get rich quickly.

Arms Races and Patent Trolls

Patenting has exploded over the last decades. In 1983 in the U.S. 59,715 patents were issued against 105,704 applications; by 2003, 189,597 patents were issued against 355,418 applications and, even in a slow growth year like 2010, 244,341 new patents were approved. In less than thirty years, the flow of patents roughly quadrupled. By contrast, neither innovation nor R&D expenditure have exhibited any particular upwards trend, not to speak of factor productivity. While patent litigation has increased, few patents are actively used. Patent litigation typically involves dying firms, that have accumulated huge stockpile of patents but are no longer able to produce marketable products, suing new and innovative firms. A once proud firm – one of the first producers of microchips, and who in our generation can forget

their first TI calculator – Texas Instruments was unable to make the transition to the PC revolution and became, for a while, the symbol of a dying company trying to stay alive by suing the newcomers. In more recent times, Microsoft has become the chief among the patent trolls. Once the giant of the software industry Microsoft has been unable to make the leap to portable devices such as telephones and tablet PCs. Unable to create and produce for the marketplace, Microsoft now attempts to claim a share of the profits Googles generates in this market through patent litigation. A firm that when it was young and innovative had a strong position against software patents – Bill Gates said in 1991: "If people had understood how patents would be granted when most of today's ideas were invented and had taken out patents, the industry would be at a complete standstill today...A future start-up with no patents of its own will be forced to pay whatever price the giants choose to impose." – now lobbies in Europe and Asia for the introduction of software patents, which it already obtained in its home country.

To learn more about the actual effect of patents in the real world, let us consider the response of Google to being pursued legally by a large competitor. One response is their recent purchase of Motorola Mobility. Motorola, like TI and Microsoft, is a once proud company that has fallen on hard times. Why the interest of Google? It is buying Motorola Mobility for its patent portfolio. Not for the ideas and innovations in that portfolio – few if any changes or improvements to Google's Android operating system will result from the ownership or study of these software patents. The purpose of obtaining this patent portfolio is purely defensive: it can be used to countersue Apple and Microsoft and blunt their legal attack on Google. Talk to anyone in the software industry – or any industry except pharmaceuticals or medical instruments. Read the Levin et al. [1987] and the Cohen et al. [2000] surveys of R&D managers. The vast bulk of patents are not only useless, they don't represent innovation at all. They are part of an arms race. Any successful large company needs a large portfolio of patents to fend off potential lawsuits by rivals and by patent trolls.

One could argue that purely defensive patenting is pretty harmless – after all it costs only about $40,000 to file a successful patent application, and doing it on a large scale may make it cheaper. However the acquisition of large patent portfolios by incumbents creates huge barriers to entry. We see this in the smart-phone market. Here Apple is the market leader and Microsoft is unable to produce a product that appeals to consumers. Each are incumbent firms with a large patent portfolio. The new entrant and innovator – and it should be pointed out that while Android phones are imitations of iPhones in many respects, their integration with the web is vastly superior to what is promised by Apple in its next generation of iPhones – is Google. Google is a relatively new firm and while wealthy does not have a large defensive patent portfolio. Hence we see both Apple and Microsoft attacking Google with patent litigation. Apple in an effort to keep the market to itself for a few more years; Microsoft because it is better to get a share of Google's revenue than be shut out of the market completely. The actual economic value of Microsoft's patents can be measured by their inability to produce a product that occupies more than a small corner of a large and growing market.

Despite the fact that patents are mostly used for arms races and that these, in turn, are driven by patent trolls, there are not formal models of the way in which this can inefficiently inhibit entry. In the arms race theory, if all firms get counterbalancing patent portfolios and all innovate, then they would have innovated in the absence of patents – hence patents do not serve to encourage innovation. On the other hand if (like Microsoft or other patent trolls) you do not produce a marketeable product you cannot be countersued, and so you can use patents to share the profits without doing the work – hence patents do discourage innovation and are a pure waste from a social standpoint.

A simple model helps to focus these thoughts. We suppose that there are two firms $i = 1,2$ who must choose between innovating (I) and not innovating (N). We have in mind here the creation of a new product, so that the choice to innovate is paramount to entering the market – a firm that does not innovate is assumed to have no product to sell. To focus on the impact of patents on innovation, we assume that taking out a patent is costless. When there is a single firm in the market it earns revenue R net of production costs and if there are two firms, each earns revenue r, where $R > r$. This assumes that there is some substitutability between products, but allows for some complementarity as well since we do not require $R \geq 2r$. Denote by c the cost of creating the new product. To avoid triviality, we assume that $R - c > 0$ so a firm will enter if it is guaranteed a monopoly. About efficiency, we assume that if it is privately profitable to enter the market, then it is socially desirable to do so. Specifically, we assume that it is socially efficient to have two firms in the market if $r - c > 0$. Similarly, we assume that if $R - c > 0$ it is better to have one firm in the market than none.

The key feature of the arms race is that a firm without a product but with a patent can still claim a share of the market against a firm that has both a product and a patent. However, as is the case in practice, it is not necessary to build a product – that is, incur the cost c - in order to take out a patent. Under a patent system, then, both firms will take out patents as it is costless. Denote by ϕ the market share that a firm that has a patent but no product can claim against a firm with a product and a patent. We assume that $\phi \leq 1/2$ so that it is not possible to claim a larger market share by not having a product than by having one. In this setting there is a demand to be a patent troll: to take out a patent – which is relatively inexpensive – in order to tax a competitor who also has a product beside having a patent.

We wish to compare what happens in this game with and without a patent system. Since there may be several equilibria, we will focus on the most efficient pure strategy equilibrium. Bearing in mind that we have assumed that patents never do any good and have no costs of being obtained, we will show that patents and no patents do equally well, except in two cases: (I) $r - c < \phi R$ and $(1-\phi)R - c < 0$ and (ii) $0 < r - c < \phi R$ and $(1-\phi)R - c > 0$. In these two cases a system without patents leads to strictly more innovation and is Pareto superior to a system with patents. To demonstrate this result, we analyze first the simpler of the two games, the game without a patent system. This has the form

	I	*N*
I	$r-c, r-c$	$R-c, 0$
N	$0, R-c$	0,0

If $r-c<0$ then there are two asymmetric equilibria where only one of the two firms enters (and a mixed strategy equilibrium). Note that this is Pareto superior to having no innovation at all. If $r-c>0$ then it is a dominant strategy to enter, so both firms do so – and this is first best.

By contrast, with a patent system the game between the two firms has the form

	I	*N*
I	$r-c, r-c$	$(1-\phi)R-c, \phi R,$
N	$\phi R, (1-\phi)R-c$	0,0

In this game there are four cases:

(i) If $r-c>\phi R$ and $(1-\phi)R-c>0$ then it is a dominant strategy for both to innovate. Since this implies that $r-c>0$ the outcome is the same as when there are no patents.

(ii) If $r-c>\phi R$ and $(1-\phi)R-c<0$ then there is an equilibrium where both firms innovate (the only equilibrium without patents), an equilibrium where neither firm innovates, and a mixed equilibrium. Here the equilibrium in which both firms innovate is first best. The patent system potentially does as well as no patents, except that the patent system allows the possibility of inefficient equilibria which can be ruled out by prohibiting patents.

(iii) If $r-c<\phi R$ and $(1-\phi)R-c<0$ it is a dominant strategy for either firm not to innovate. Without a patent system there is always a positive probability of innovation. The two asymmetric equilibria both Pareto dominate the no innovation solution. Here, evaluated by the best equilibrium, no patents Pareto dominate patents.

(iv) If $r-c<\phi R$ and $(1-\phi)R-c>0$ then there are two asymmetric equilibria where only one of the two firms enters and a mixed strategy equilibrium. If $r-c>0$ then without patents both firms enter: this is first best, so here it is more efficient not to have patents. If $r-c<0$ then the best pure strategy equilibrium in both cases is the same: one firm entering.

3. The Political Economy of Patents

There is little dispute among economists that a well-designed patent system would serve to encourage innovation. There is dispute among economists about whether the patent system as it exists serves to encourage innovation – but, again, there is little dispute among economists that the patent system as it exists is broken. To quote a proponent of patents, Shapiro [2007]:

> *A growing chorus of scholars and practitioners are expressing concerns about the operation of the U.S. patent system. While there is no doubt that the U.S. economy remains highly innovative, and there is no doubt that the patent system taken as a whole plays an important role in spurring innovation, the general consensus is that the U.S. patent system is out of balance and can be substantially improved.*

As we will document in the next section, in our view the evidence is instead clear that the patent system taken as a whole does not play an important role in spurring innovation. While theorists such as Shapiro may dispute our reading of the available data, they are part of a broad consensus about the elements of the existing patent system that are broken – these we have discussed in the preceeding sections. We would not dispute that, if these things were to be fixed and kept that way, the patent system would indeed serve its intended purpose.

If a well-designed patent system would serve the intended purpose, why recommend abolishihg it? Why not, instead, reform it? To answer the question we need to investigate the political economy of patents: why has the political system resulted in the patent system we have? Our argument is that it cannot be otherwise: the "optimal" patent system that a benevolent dictator would design and implement is not of this world and it is pointless to advocate it as, by doing so, one only offers an intellectual fig-leaf to the patent system we actually have, which is horribly broken. It is fine to recommend reform but, if politics make it impossible to accomplish that reform, if they make it inevitable that if we have a patent system it will fail, then abolition – preferably by constitutional means as was the case in Switzerland and the Netherlands prior to the late 19th century – is the proper solution and proposals of reform are doomed to fail. This logic of political economy brings us to the view that we should work toward a progressive dismantlement of the patent system.

Suprisingly, despite the key importance of political economy in understanding why we have the patent system we have, economists have had little to say on the subject and the few papers we know of – Landes and Posner [2004] and Scherer [2009] – stand in evident contradiction with the established consensus about the social usefulness of patents and, especially, of their strenghtening. On the one hand we find the traditional advocacy of ideal patents as designed by a benevolent planner and, on the other hand, the recognition that patent laws are mostly designed by interest groups keen to increase their monopoly rents, not aggregate welfare. Consider the analysis carried out by Landes and Posner in their pamphlet. They recognize the enormeous growth in intellectual property legislation and judiciary activity during the last 30 years but then apply their otherwise sharp analytical tools to a couple of relatively minor features of this phenomenon – specifically why the overall growth in IP protection has benefited copyright's holders even more than patent's holders (it is not clear this is the case, still let us assume it is) and why such an increase has taken place in the midst of the "deregulation oriented" political trend that

began in the late 1970s . They do not attempt to explain why the patent system seems to be capable of only growing larger and larger, stronger and stronger, and costlier and costlier.

In carrying out their investigation Landes and Posner use interesting public choice arguments grounded on the well known observation – valid for all kinds of legislation preventing free-entry and, more generally, for all regulatory activity – that the lobbying effort and power of IP's advocates are bound to be much stronger than those of IP's opposers. This follows from the fact that, once some kind of even marginal IP protection is introduced, extending it will yield substantially higher per-capita rents to the few holders of the right than reducing it would for the much larger number of non holders: the rent of the monopolist is a lot higher than individual consumers' deadweight loss. This, as they note, certainly helps understand legislative actions such as the DMCA that greatly restricted the public domain in order to defend the already substantial rents of a few copyright holders. It does not help, they also claim, to understand why patent laws would be strenghtened in a period during which the ideological and political trend favored the reduction of government intervention generally known as "deregulation". To the latter puzzle our authors provide an "ideological" resolution: supporters of deregulation are supporters of free markets, supporters of free market like private property, and patents and copyright are intellectual "property". Hence, strenghtening them is ideologically and politically consistent with the general principle that "private property is good for growth". Interestingly the two authors do not seem to notice that the basic public choice insight they started with provides a more straightforward economic answer to the same question. An answer that, contrary to the ideological one, would be consistent with plentiful facts we know about the life cycle of industries. In fact, neither Landes and Posner nor, apparently, most industrial organization researchers, seem interested in figuring out why patents are either ignored or scarcely used in new and competitive industries while being highly valued and over-used in mature and highly concentrated ones. The point here seems to be that, being themselves strong advocates of the usefullness of patents in fostering innovations, the authors fail to recognize the intrinsic problem with the design of the institution itself. Being not a "property" right but rather a "monopoly" right, patent possessors will automatically leverage whatever initial rents their monopoly provides them with in order to increase their monopoly power until all potential rents are extracted and, probably, dissipated by the associated lobbying and transaction costs.

The more elaborate writing by Scherer [2009] follows a similar approach and suffers of the very same limitations to an even greater extent. It focuses on a puzzle that is somewhat the reverse of the "IP strenghtening in times of deregulation" that attracted Landes and Posner's attention; this is the fact that "government emphasis on patent systems increased" while academic research was starting to become more and more aware that patents are playing a minor positive role, if at all, in creating incentives for high R&D and in fostering productivity growth. After providing a concise but very well informed historical survey of all major changes in the US patent's policies over the last century or so, the author wonders correctly why would political forces increase patent protection so much in light of the fact

> *[…] that the record of debates on the enabling bill contains no solid evidence that the change would in fact stimulate R&D, and that there is no evidence of an acceleration in company-financed R&D between the 27 years before the bill was enacted and the 18 years thereafter."* [Scherer, 2009, p. 195]

In the rest of his pamphlet he extends the very same argument to the international arena, paying particular attention to the case of pharmaceutical patents. While his language and arguments are strongly critical of current trends in patents and copyright law, in our view the author fails short of leading his analysis to its logical conclusions. That is to say: he neither recognizes that the problem is with the institution of intellectual "property" itself (a word usage he nevertheless harshly criticizes) nor does he attempt to provide an articulate theory of why a set of theoretically sound institutions, such as patents and copyright were supposed to be, ought to degenerate into something so socially damaging exactly during the three decades in which academic research was realizing their limitations and potential dangerousness. The answer, though, seems rather straightforward.

The basic public choice observation recalled earlier implies that there are many players in the patent game but that "consumers" are not among them. On the side of the potential patentees there are individual inventors, corporate inventors and patent trolls who invent nothing but never-the-less fill out patent applications making claims. On the other side is the patent office that issues patents, the patent lawyers who file and litigate patents, and the courts where the litigation takes place. The rules of the game are established – although only in part – by the executive and legislative branches of government, and insofar as the interests of the general public are concerned, it is these players who represent them. Since patenting is a technical subject about which few voters know anything with clarity – and hardly any are likely to have a detailed empirical knowledge of the consequences of patent systems – the interests of voters are not well represented at all, but rather the competing interests of the other players. This is exactly the same phenomenon that Stigler [1971] and other public choice theorists argue to have given rise to regulatory capture in other spheres of government regulation. Hence to understand why the patent system is the way it is, we need to understand the motivation and incentives of the relevant players.

Let us start with the patent office and a case study: the infamous "one-click" patent #5960411 issued to Amazon in September 1999. According to 35 U.S.C. 103, the statute under which the patent office operates in issuing patents,

> *[to obtain a patent] the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains*

Now, consider the facts. The patent in question claims, among other things, a monopoly over

11. A method for ordering an item using a client system, the method comprising: displaying information identifying the item and displaying an indication of a single action that is to be performed to order the identified item; and in response to only the indicated single action being performed, sending to a server system a request to order the identified item whereby the item is ordered independently of a shopping cart model and the order is fulfilled to complete a purchase of the item.

The idea of taking a single action to accomplish a goal is hardly innovative, and applying the idea of taking a single action to making a purchase is obvious to anybody who has ever used a soft-drink machine, let alone someone with skill in the art of – say – marketing. It will hardly come as a surprise to marketers of any generation that it is a good idea to make it as easy and simple as possible to make a purchase. Let us think then logically – even as people not having ordinary skill in computer programming – how this might be accomplished over the internet. First, credit card information is required, so if that is not going to be demanded at the time of the transaction, it better be stored in advance by the retailer. Second, the user must identify itself to the system so that the information can be retrieved when the purchase is made. Those steps – obvious to all of us and more or less necessary to accomplish the desired purpose – are exactly what Amazon describes in its patent, albeit with a few flow-charts thrown into the eleven page patent application. But even with those flow charts it is relatively easy to see that the verbal description of the single-click procedure can apply equally well to what happens on the Amazon site and to what happens in millions of places in the US daily, when people purchase a soda can, or any other item, from a very old-fashion selling machine.

The point here is that words do not mean what they seem to mean. While the patent office routinely grants silly patents on things like swinging a swing or poking objects through the fifth dimension, the Amazon patent was re-examined by the USPO starting in May 2006. After a preliminary finding that, indeed, "obvious" means "obvious" even at the Patent Office, it reversed itself and, in October 2007, re-affirmed the Amazon patent, albeit limiting its scope slightly. So we cannot dismiss such a patently absurd patent as an aberration.

Why then does the patent office interpret the words "not obvious" as meaning "obvious"? Consider who the clients of the patent office are: inventors, patent trolls and patent lawyers. Each and every of these clients shares the same goal: they would like more patents issued. Hence the patent office is constantly under pressure from its clients to be more generous in issuing patents – that is, adopt lower standards of obviousness and steeper standards for what is considered prior art. Eventually – as George Orwell predicted – words come to reverse their meaning. The following statement by the director of the U.S. Patent Office concerning the allowance rate – what fraction of patents are accepted – is revealing

Overall in FY 2010, the allowance rate increased to 45.6%, compared to an allowance rate of 41.3% in FY 2009...So, while we still have a lot of work to do, I think we are on the right path.

Accepting a higher fraction of patents applications is, a priori and without caveat, "the right path": talk about "regulatory capture."

The role of patent lawyers in the political economy of patents should not be overlooked. According to a patent attorney, Quinn [2011], legal fees for filing a patent run upwards of $7,000. In 2010, according to the patent office, 244,341 patents were issued, which would mean roughly a billion and a half dollars in legal fees per year. Obviously patent attorneys, as a group, have a tremendous incentive to see that more patents are issued. This helps us understand better the role of the courts and their relatively recent reform. In 1982 – lobbied by patent lawyers – Congress passed the Federal Courts Improvement Act. This moved patent appeals from the regular court system to a special court system for dealing with patents. Naturally many of the judges for this new court were chosen from the ranks of patent attorneys. For example, in the 1994 Tektronix decision expanding the scope of patents to software, of the six judges who voted in favor (Rich, Newman, Lourie, Michel, Plager, Rader) half had previously been patent attorneys, while of the two that voted against (Archer, Nies) neither had been. What this means is that the referee of the game is biased both materially and ideologically: "That has been the experience with the Federal Circuit; it has defined its mission as promoting technological progress by enlarging patent rights." (Landes and Posner [2004], p.26)

Notice, too, the public goods aspect of defending in many patent lawsuits, especially those concerned with the up-holding of a patent in front of alleged infringement. In these cases, the plaintiff (usually claiming the defendant is not basing his product on previous art and/or that whatever his patent describes is not obvious) appropriates all the benefits of winning the lawsuit. The defender, by contrast, if successful benefits not only himself, but everyone else who might otherwise be sued by the plaintiff. The latter is nothing but the "patent court" version of the, already noted, fundamental asymmetry in the distribution of economic incentives that defines the foundations of the political economy of patents' law.

It should be clear, then, that given this set of players and their incentives, the patent game can have only one equilibrium over time, which is the one we have observed. Starting from a regime of intellectual property protection that, about two centuries back, was restricted in its areas of applicability and limited in both depth and duration over time – that is to say: it was somewhat "reasonable" to the extent it balanced social gains and social costs – we have witnessed a monotone process of progressive enlargment and strenghtening of patent laws. At each stage of this process of enlargment the main driving force were the rent-seeking efforts of large, cash rich companies unable to keep up with new and creative competitors. Patent laywers, patent officials and wannabe patent trolls usually acted as foot soldiers. While this political economy process is theoretically pretty straightforward – especially because it closely replicates similar experiences in other fields of regulation and, especially, in the development of barriers

to free trade – what is still missing is an empirical, quantitative analysis of the stakes involved and of the gains and losses accruing to both the active players and to the rest of society, from the general public to the innovators that, because of IP, never were.

4. Do Patents Encourage Productivity Growth?

We started this paper by stating that there is no empirical evidence that patents serve to increase innovation and productivity, however measured. So far we have run through a variety of empirical and theoretical reasons why patent systems are problematic and why being damaging to social welfare is written in their DNA. Now we need to provide some support for that initial empirical statement: if there is to be any rationale for patent systems, with all their ancillary costs, it must be that they actually do manage to increase innovation and productivity. What is the evidence? How can we say so definitively that there is no evidence that patents have the desired effect?

In Boldrin and Levine [2008] we conducted a metastudy gathering the 24 studies we could find in 2006 that examined whether introducing or strengthening patent protection leads to greater innovation. This includes three studies that are themselves surveys of earlier empirical work. The executive summary: "these studies find weak or no evidence that strengthening patent regimes increases innovation; they find evidence that strengthening the patent regime increases patenting! They also find evidence that, in countries with initially weak IP regimes, strengthening IP increases the flow of foreign investment in sectors where patents are frequently used." Note that the issue of promoting FDI, while a well established empirical consequence of strengthening patent regimes, is entirely besides the point. The same effect could be obtained in many ways – for example by a limited strengthening of the patent regime simply to protect the patents of companies that engage in FDI – and, in any case, FDI is not innovation.

As to the issue of innovation, after failing to find a single study claiming that innovation increased as a consequence of the strengthening of U.S. patent protection in the 1980s, Gallini writes

> *Although it seems plausible that the strengthening of U.S. Patents may have contributed to the rise in patenting over the past decade and a half, the connection has proven difficult to verify.*

Jaffe also examines many studies and concludes

> *... despite the significance of the policy changes and the wide availability of detailed data relating to patenting, robust conclusions regarding the empirical consequences for technological innovations of changes in patent policy are few.*
>
> *There is widespread unease that the costs of stronger patent protection may exceed the benefits. Both theoretical and, to a lesser extent, empirical research suggest this possibility.*

An interesting case in point and counterpoint is a study by Anwar and Evanson. They have data on 31 countries for the period 1981-1990. Using two 5 year averages they find support for the idea that higher

protection leads to higher R&D as a fraction of GDP. There are five levels of IP protection and R&D as a fraction of GDP ranges from a ten year average of .231% in Jordan to 2.822% in Sweden. Since a country with a larger market can more easily pay the fixed cost of innovation, we combine their data with GDP data from the 1990 CIA World Fact Book. We can then regress per capita R&D expenditure on total GDP to find that a 1% increase in the size of a country as measured by GDP increases the ratio of R&D to GDP by 0.34%. More interesting is to see how the level of IP protection impacts the residuals

IP Level	*Average Residual*
0	-0.95
1	-0.46
2	0.20
3	0.20
4	0.10

Increasing IP increases residual R&D expenditure at low level of protection – that is from 0 to 1 to 2. As IP protection is increased further the residual R&D expenditure levels off then falls. Note that at the lower levels we are probably observing primarily the effect of FDI: among poor countries with low IP protection, increases bring in more foreign investment and in doing so directly raise R&D. In richer countries with high levels of IP, foreign investment is not an issue, and increases in IP have little or no effect on innovation.

The Lerner study is especially notable because he examined all significant changes in patent law in all countries over the last 150 years. His conclusion:

> *Consider, for instance, policy changes that strengthen patent protection. Once overall trends in patenting are adjusted for, the changes in patents by residents of the country undertaking the policy change are negative, both in Great Britain and in the country itself. Subject to the caveats noted in the conclusion this evidence suggests that these policy changes did not spur innovation.*

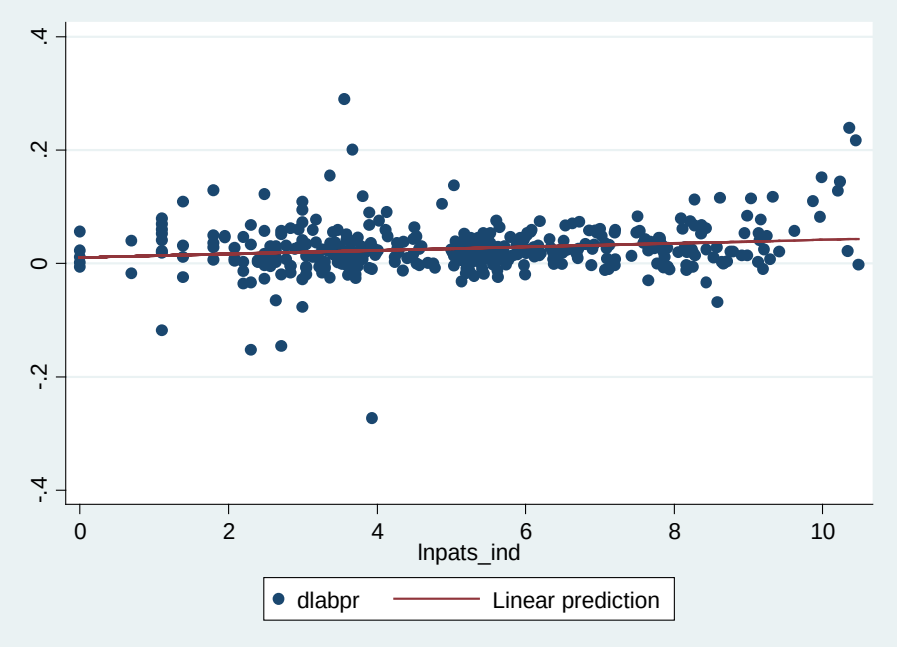
This, in summary, what is currently known as the "patent puzzle" (Lerner [2009]) and which, in the light the competitive theory of innovation (Boldrin and Levine [2008a]) we find not puzzling at all but, instead, substantially coherent with the predictions of economic theory.

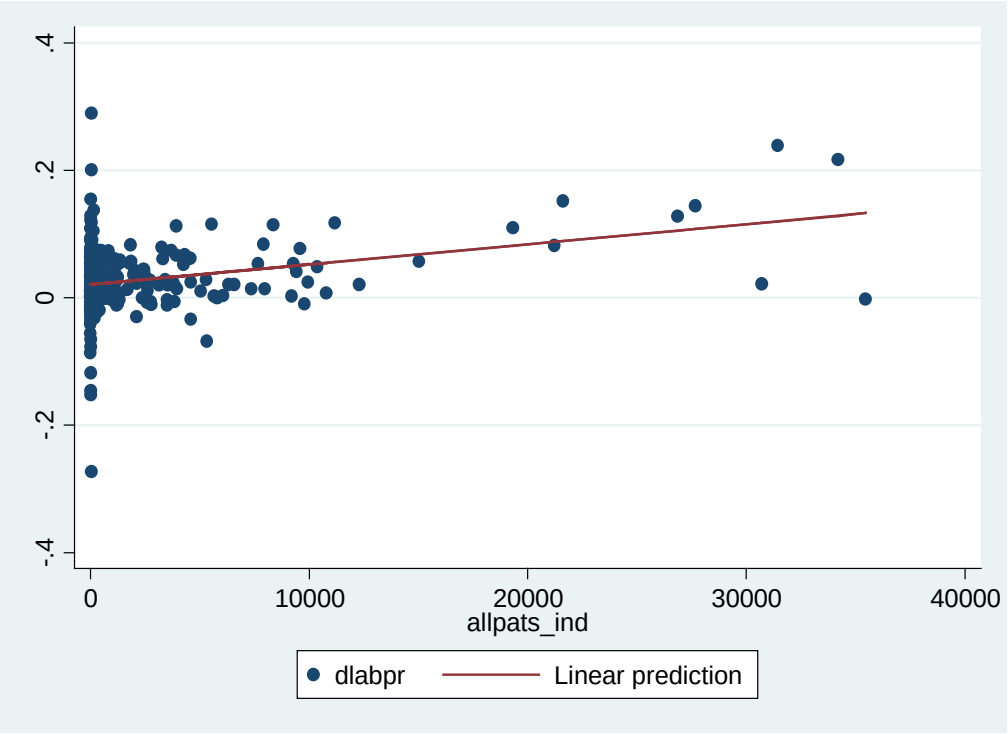
Patents and Productivity

Does more patenting lead to more productivity? In Boldrin, Correa, Levine and Ornaghi [2011] we have tried to shed light on this question by carrying out a sequence of statistical tests and econometric

estimations both on an original microeconomic data set – obtained by combining firm-level information obtained through Compustat, NBER and the BLS (see Appendix I of the cited paper for the technical details) – and on an enriched version of the micro data set used by Aghion, Bloom, Blundell, Griffith and Howitt [2005] to first derive an "inverted-U" relationship between the size of the mark-up (by industries) and a measure of patenting activity. The results show, rather unequivocally that:

1) Except for two of the possible specifications (see below) there is, in general, no statistically significant correlation between measures of productivity (both labor and TFP) and patenting activity (both number and citations). This is a more surprising result than one would expect on the basis of purely theoretical considerations. In fact, one would expect patents to be at least a decent predictor of productivity growth across sectors, certainly for the last couple of decades during which their use was extended to more and more sectors. This finding leads us to conjecture that the use of patents either as a defensive or as a rent seeking tool (Boldrin and Levine [2004]) is actually more widespread than one would predict.
2) The two specifications for which a positive correlation obtains regress labor productivity growth in the sector, in any given year, on the number of patents awarded during the same year (or on their future cumulative citations). This yields a statistically significant, but very small, positive coefficient when using BLS output data, and a coefficient not statistically different from zero with NBER output data. Because a picture is worth a thousand words we reproduce here the scatter plots for these pairwise correlations.





3) Using the same data set we have regressed measures of innovation (patents or patent citations) on the measure of competition (inverse of profitability) used by Aghion et al. [2005]) We find a positive relationship which is remarkably robust to changes in industry classification (SIC4 vs NAICS4), time sample period (1990-2001 vs 1975-2001), set of sampled industries (manufacturing vs all industries).
4) Finally we studied the correlation between the same measure of competitive pressure and objective measures of labor productivity growth. Interestingly, in this data set the correlation displays an inverted-U relationship when one ignores that profitability is an endogenous variable depending on, among other things, productivity growth and a monotone one when one corrects for such endogeneity. Such positive correlation (replicating a pioneering and unfortunately forgotten one, reported in Stigler [1956]) is confirmed when the original firm-level observations are aggregated at the sectorial level and the regression is performed using the sectorial averages on both sides of the equality sign.
5) The estimated correlation is, in fact, quite high. The average annual growth of productivity in the sectors with the highest level of competition is up to 2% bigger than in the sectors with the lowest level of competition. These are strikingly large differences when cumulated over various decades, as it is the case in our data set.

The empirical finding, reported in Aghion et al [2005] and based on a UK data set, according to which the maximum innovative effort obtains at some "intermediate" position between perfect substitutability (competition) and perfect complementarity (monopoly) has been seriously questioned in Correa [2010] and Hashmi [2011]. The latter re-examine the inverted-U relationship by using data from publicly traded manufacturing firms in the US. Contrary to Aghion et al [2005] he finds a robust positive relationship between competition (as measured by the inverse of markups) and innovation (as measured by citation-weighted patents). The investigation carried out by Correa [2010] shows that, in fact, the inverted-U relationship Aghion et al. [2005] found in the UK data does not withstand a more careful inspection. More precisely, by using the same data set of UK firms, Correa shows that the prediction of an inverted-U is overturned when allowing for the possibility that innovations follow a memory process, where the current probability of introducing a new innovation increases when a firm successfully innovated in the previous period. Correa finds that there are 5 industries showing memory in the innovation process, 10 for which the innovation process appears memory-less, and 2 industries for which the innovation processes are difficult to determine. Next, Correa also shows that the model in question, when applied to the same data, generates evidence of enogeneity in the instrument and of structural breaks. His empirical analysis shows, convincingly, that there is a structural break in 1981, in coincidence with the establishment (in the USA) of the Court of Appeals for the Federal Circuit (CAFC) in October of 1982 (recall that the data set in question uses USA patents of UK firms). Once this structural break is taken into account, and the regressions performed separately for the two sub-periods, one finds that there is a positive relationship between innovation and competition during the period 1973-1980, but no relationship at all during the period 1981-1994. Further, considering the instrument endogeneity and the structural break, Correa finds a positive innovation-competition relationship for the memory industries before the 1982 Reform. However, he finds that there is no relationship between innovation and competition for those industries that he classifies as memory-less.

5. Conclusion

In 1958 the distinguished economist Fritz Machlup in a report to Congress famously said

> *If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it.*

One might imagine that if it would be irresponsible to recommend abolishing it, it would be even more irresponsible to further extend it. Moreover, one might hope that if it is indeed worth preserving such a large government intrusion into private activity that that during the intervening six decades evidence

would emerge that patents do indeed serve the desired purpose of encouraging innovation. Sadly the story of the past six decades is the opposite. In new industries such as biotechnology and software where innovation was thriving in the absence of patents – patents have been introduced. Given this continued extension has there been a substantial increase in innovation in recent years? On the contary, it is apparent that the recent explosion of patents in the U.S., the E.U. and Japan, has not brought about anything comparable in terms of useful innovations and aggregate productivity.

The software industry is an important case in point. In a dramatic example of judge-made law, in the early 1990s sofware patents became possible for the first time. Bessen and Meurer in a large body of empirical work studied the consequences of this unnatural experiment, culminating their [2009] book entitled *Patent Failure* the title of which summarizes how effective software patents have been for promoting the common good. With six decades of further study since Machlup's report failing to find evidence that patents do promote the common good, it is surely time to reconsider his recommendation that it would be irresponsible to abolish the patent system. On the contrary: a system that at one time served to limit the power of royalty to reward favored individuals with monopolies has become with the passage of time a system that serves primarily to encourage failing monopolists to inhibit competition by blocking innovation.

Abolishing patents may seem "pie-in-the-sky" and there are certainly many interim measures that can be taken to mitigate the damage: properly interpreting obviousness, requiring genuine disclosure of working methods and an independent invention defense against patent infringement are useful and – among economists – relatively uncontroversial measures. But why use a band-aid to staunch a major wound? Economists fought for decades – and ultimately with great success – to abolish trade restrictions. It will not escape the careful reader that patents are very much akin to trade restrictions as they prevent the free entry of competitors in national markets, thereby reducing the growth of productive capacity and slowing down economic growth. The same way that trade restrictions were progressively reduced until reaching (almost complete) abolition, a similar (albeit, hopefully less slow) approach should be adopted to "get rid" of patents. Moreover the nature of patents as time-limited makes it relatively easy to phase them out by phasing in ever shorter patent durations. This conservative approach has also the advantage that if reducing patent terms indeed has a catastrophic effect on innovation the process can easily be reversed.

There are of course many transitional issues to be worked out. This is particularly the case with respect to pharmaceutical products where patents are only one piece of a complicated regulatory jungle including the approval process and the market exclusivity protections all of which would need to be adjusted as patents are phased out. Because policy proposals are better digested and metabolized when served in the form of small pills, here is our list of small reforms that could be easily implemented.

(1) Stop the rising tide that, since the early 1980s, is both extending the set of "things" that can be patented and shifting the legal and judicial balance more and more in favor of patent's holders.

(2) Because competition fosters productivity growth, anti-trust and competition policies should be seen as a key tool to foster innovation. This is of particular relevance for high tech sectors, from software to bioengineering, to medical products and pharmaceuticals.

(3) Free trade is a key part of competition policies hence the role that WTO-WIPO-TRIPS play should be redefined to move away from the current neo-mercantilist approach toward free trade in goods and ideas. The aim here should be that of stopping the policy of exporting our intellectual policy laws towards other countries while adopting a policy of exporting free trade and competition in innovation. This seems an urgent goal because, within a couple of decades, the "balance of trade in ideas" between US+EU and Asia may easily reverse. At that point the temptation to engage in "mercantilism of ideas" may well affect the now developing Asian countries, leading to a general increase in IP protection worldwide.

(4) Cross industry variation in the importance of patents suggests we may want to start tailoring patent's length and breadth to different sectorial needs. Substantial empirical work needs to be done to implement this properly, even if there already exists a vast legal literature pointing in this direction.

(5) Reversing the burden of proof: patents should be allowed only when monopoly power is justified by evidence about fixed costs and actual lack of appropriability. The operational model should be that of "regulated utilities": patents to be awarded only when strictly needed on economic grounds. This requires reforming the USPO, which is urgently needed in any case.

(6) Prizes and competition. An interesting approach is that of operating to change the role that the NSF and the NIH play in fostering innovation. The basic goal, in this case, is that of reversing the principle according to which federally financed investigation can lead to private patents. As a first step we would advocating going back to the old rule according to which the results of federally subsidized research cannot lead to the creation of new private monopolies but should be available to all market participants. This reform would be particularly useful for the pharmaceutical industry.

(7) With regards to the latter, we advocate reforming pharmaceutical regulation to either treat stage II and III clinical trials as public goods (to be financed by NIH on a competitive basis) or by allowing the commercialization (at regulated prices equal to the economic costs) of drugs that satisfy the FDA requirements for safety even if they do not yet satisfy the current, over-demanding, requisites for proving efficacy. It is ensuring the efficacy—not the safety—of drugs that is most expensive, time-consuming and difficult. All the usual mechanisms of ensuring the safety of drugs would remain firmly in place. While pharmaceutical companies would be requested to sell new drugs at "economic cost" until efficacy is proved, they could start selling at market prices after that. In this way, companies would face strong incentives to conduct or fund appropriate efficacy studies where they deem the potential market for such drugs to be large enough to bear the additional costs. At the same time this "progressive" approval

system would give cures for rare diseases the fighting chance they currently do not have. This solution would substantially reduce the risks and cost of developing new drugs.

(8) If this progressive approval approach works for rare diseases, there is no reason is should not be adopted across the board. The current system favors a small number of blockbuster drugs that can be sold to millions of patients. The coming revolution in medicine will rely on carefully targeting hundreds or even thousands of drugs to the correct patients. But lawmakers must first usher in a new system that makes developing these precision treatments possible. The regulation reform we are suggesting would be a first important step to achieve such goal.

The aim of policy, in general, should be that of slowly but surely decreasing the strength of intellectual property interventions but the final goal cannot be anything short of abolition. Once again, if at the times of Machlup one could still nurture doubts and wonder if the system could not be reformed in a credible and stable form, in 2012 one must ask: is not six decades of failure enough time? Is it not time to take seriously the idea of patent abolition and begin the discussion of these transitional issues?

References

Aghion P., Bloom N., Blundell R., Griffith R. and P. Howitt [2005], "Competition and Innovation: An Inverted U Relationship", Quarterly Journal of Economics 120:701-728.

Bessen, James and Michael J. Meurer [2009], Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk, Princeton University Press.

Boldrin, Michele and David K. Levine [2004], "Rent Seeking and Innovation", *Journal of* Monetary *Economics*, 51: 127-160.

Boldrin, Michele and David K. Levine [2005], "The economics of ideas and intellectual property", *Proceedings of the National Academy of Sciences* 102: 1252–56.

Boldrin, Michele and David K. Levine [2008a]," Perfectly competitive innovation", *Journal of Monetary Economics*, .

Boldrin, Michele and David K. Levine [2008b], *Against Intellectual Monopoly*, Cambridge University Press.

Boldrin, Michele, Juan Correa Allamand, David K. Levine and Carmine Ornaghi [2011], "Competition and Innovation", *Cato Papers on Public Policy*, Vol. 1.

Chaudhuri, Shubham, Pinelopi K. Goldberg and Panle Jia [2006], "The Effects of Extending Intellectual Property Rights Protection to Developing Countries: A Case Study of the Indian Pharmaceutical Market", *The American Economic Review*, 96: .

Cohen, W. M., Richard R. Nelson and J. P. Walsh [2000], "Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)", *N.B.E.R. Working Paper* No. 7552, February.

Correa, J.A. [2011], "Innovation & Competition Relationship in a Memory Process", Ph.D. Dissertation, University of Southampton; forthcoming in the *Journal of Applied Econometrics* under the title "Innovation & Competition: An Unstable Relationship".

Danaher, Brett, Dhanasobhon, Samita, Smith, Michael D. and Telang, Rahul, [2010], "Converting Pirates Without Cannibalizing Purchasers: The Impact of Digital Distribution on Physical Sales and Internet Piracy" (March 3). Available at SSRN: http://ssrn.com/abstract=1381827 or http://dx.doi.org/10.2139/ssrn.1381827

Hashmi, A.R. [2011], "Competition and Innovation: The Inverted-U Relationship Revisited", mimeo, National University of Singapore, February.

Heller, M. [2008], "The Gridlock Economy: How Too Much Ownership Wrecks Markets, Stops Innovation, and Costs Lives," Basic Books.

Hong, Sungook [2001], *Wireless: from Marconi's Black-Box to the Audion*, MIT University Press.

Jovanovic, Boyan and Glenn MacDonald [1994], "The Life Cycle of a Competitive Industry", *The Journal of Political Economy*, 102: 322-347.

Landes, William M. and Richard A. Posner [2004], *The Political Economy of Intellectually Property Law*, AEI-Brookings Joint Center for Regulatory Studies, Washington D.C.

Lee, T. [2007] "A Patent Lie", *The New York Times*, June 9.

Llanes, Gaston and Stefano Trento **[**2009**]**, "Patent Policy, Patent Pools, and the Accumulation of Claims in Sequential Innovation", forthcoming, *Economic Theory*,

Levin, Richard C., A.K. Klevorick, Robert R. Nelson, and Sidney G. Winter [1987], "Appropriating the Returns from Industrial Research and Development", *Brookings Papers on Economic Activity*, No. 3, 783-820.

Lerner, Josh [2009], "The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues", *The American Economic Review P&P*, 99 (2): 343-348

Machlup, Fritz [1958] "An Economic Review of the Patent System," Testimony before the Senate Judiciary Subcommittee on Patents, Trademarks, and Copyrights, 85th Congress, 2nd session.

Moser, Petra [2004], "Determinants of Innovation - Evidence from 19th Century World Fairs", *The* Journal *of Economic History*, 64: 548-552.
Moser, Petra [2005], "How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World Fairs," *The American Economic Review*, 95: 1214-1236.
Niccolai, James [2012], "Android developers ignored Sun patents, Google exec testifies," *Computerworld*, May 9.
Nuvolari, Alessandro [2004a], "Collective Invention during the British Industrial Revolution: The Case of the Cornish Pumping Engine", *Cambridge Journal of Economics* 28: 347-363.
Nuvolari, Alessandro [2004b], *The Making of Steam Power Technology*, Eindhoven Centre for Innovation Studies.
Ponce, Carlos [2007], "More Secrecy...More Knowledge Disclosure? On Disclosure Outside of Patents", mimeo, Universidad Carlos III de Madrid.
Quinn, G. [2011], "The Cost of Obtaining a Patent in the US", *IPWatchdog.com*, January 28.
Sanchez, Julian [2012], "How Copyright Industries Con Congress", on Cato@Liberty, available at http://www.cato-at-liberty.org/how-copyright-industries-con-congress/.
Scherer, Frederic M. [1990], *Industrial Market Structure and Economic Performance*, Houghton Mifflin Company.
Scherer, Frederic M. [2009], The Political Economy of Patent Policy Reform, *J. TELECOMM. & HIGH TECH. L.*, vol 7:167-216,
Schestowitz, R. [2011], "Microsoft Pushing Hard for Software Patents in Europe While Halliburton Makes British/European Patent Lawyers Happy" http://techrights.org/ December 10.
Shapiro, Carl [2007], "Patent Reform: Aligning Reward and Contribution" NBER Working Paper No. 13141.
Shulman, Seth [2003], *Unlocking the Sky*, Harper Perennial
Sinha, Rajiv K., Fernando S. Machado and Collin Sellman [2010], "Don't Think Twice, It's All Right:Music Piracy and Pricing in a DRM-Free Environment", *Journal of Marketing*, 74: 40-54.
Stigler, George [1971], "The Theory of Economic Regulation", *The Bell Journal of Economics and Management Science,* 2: 3-21