Working Paper

Rents and Inefficiency in the Patent and Copyright System: Is There a Better Route?

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Executive Summary

This paper analyzes the evidence for rents due to the patent and copyright systems for financing innovation and creative work. It notes research suggesting that in both the patent and copyright systems, the costs in the form of monopoly pricing and rent-seeking activity outweigh the benefits.

The paper includes a series of cross-country regressions, using data from 1960 to 2010, to examine the impact of patent strength on per capita GDP growth, GDP growth per worker, GDP growth per worker hour, total factor productivity growth (as measured by the United Nations Industrial Development Organization) and the multifactor productivity growth as measured by the OECD. In most of these regressions the coefficient on the patent-strength variable was negative and highly significant, implying that stronger patent protection was associated with slower growth. While these regressions do not provide conclusive evidence that patents are on net a drag on growth, they certainly undermine the argument that stronger patents are conducive to growth.

The paper then proposes an alternative to patent financed research for prescription drugs and medical equipment, the two areas where patent financing is most important and also where abuses have been greatest. The problem in these areas, in addition to the connection to public health, is that the patent monopoly can account for the vast majority of the cost to patients, often raising prices by more than 1,000 percent above the free market price.

In addition to leading to deadweight loss, the quest for patent rents gives drug companies and medical equipment companies incentive to mislead the public about the effectiveness and safety of their products. They also lead to large amounts of waste in the form of marketing expenses, legal fees, and political lobbying. In addition, patents are likely to lead to wasted research spending. The waste is both due to the development of duplicative drugs which would serve little purpose in the absence of patent monopolies and due to the secrecy required to allow companies to maximize the profits they receive from their research.

The paper proposes a system of public financing for research with pharmaceutical companies and medical equipment manufacturers competing for renewable contracts. The condition of the funding is that all findings are made publicly available as soon as practical. In addition, all patents from the research are placed in the public domain on a copyleft basis. This means that others are free to use the patented item as long as any products developed are also placed in the public domain.

All the drugs and medical equipment developed through this system would be available as generics. This means that the latest cancer drugs would sell for hundreds of dollars rather than hundreds of

thousands of dollars. Medical devices, like cutting edge scanners, would be available at marginal cost, so the price need no longer be a major factor in deciding treatments. The cost of this additional research funding could easily be covered by the savings in public sector health care programs like Medicare and Medicaid.

The paper also proposes a halfway system under which the clinical trial portion of research could be publicly funded, while still leaving the pre-clinical portion supported by patent monopolies. This would be sufficient to end some of the worst abuses from the patent system, since the clinical test results would be fully public information. This would allow doctors and researchers to make better assessments of the effectiveness of new drugs.

The paper suggests a system of shortened patent protection (three to five years) for patents in other areas, in exchange for a tax credit on research in the range of 10 to 15 percent. Patents would then be placed in the public domain on a copyleft basis for the rest of their duration. (Treaty commitments require that the United States grant patents that last for 20 years after the date of filing, so patent holders would need to be given incentive to accept shorter terms.) Based on estimates from other research on the costs of patent litigation, the paper argues that the additional cost of the tax credit (compared to the existing R&D tax credit) would likely be less than the savings from the reduction in litigation costs. Such a system should also undermine the efforts of many established companies (documented in the research) to thwart new competitors with harassment suits. The result should be more innovation and lower prices in a wide variety of areas.

As an alternative to copyrights, the paper proposals a system of individual tax credits pegged at modest amount (e.g. $100 per year), which could be used to support the creative worker or intermediaries the person choses. The system would be modeled after the charitable contribution tax deduction. In order to be eligible to receive money through the tax credit system, creative workers would have to register in the same way a non-profit organization has to register to get tax-exempt status. The person or organization need only indicate the type of creative work they do or support. There is no assessment of the quality, only whether they are actually engaged in the work claimed. Eligibility for receiving the tax credit precludes copyright protection for a substantial period of time (e.g. five years).

This system could support a vast amount of creative work that would be available at essentially zero cost over the Internet or the cost of printing for written material. This system could compete side by side with the existing copyright system with the likelihood that it would soon replace it, at least as a system for supporting new work.

The paper also proposes a system publicly funded open-source textbooks, which would be produced under contract. These texts could be freely reproduced or printed out. These texts would compete with textbooks produced under the existing copyright system.

The potential savings from adopting these alternative mechanisms of financing could exceed two percent of GDP (more than $400 billion a year in the 2016 economy). Most of this would be the result of having prescription drugs and medical equipment available at free market prices. This calculation does not include the benefits in the form of better health outcomes which would be a likely result of ending patent monopolies and the perverse marketing incentives they cause.

Introduction

Over the last four decades there have been a wide range of measures, both nationally and internationally, to increase the strength and duration of patent and copyright protection. The explicit assumption behind these steps is that the higher prices resulting from increased protection will be more than offset by the increased incentive for innovation and creative work. Patent and copyright protection should be understood as being like very large tariffs. These protections can often the raise price of protected items by several multiples of the free market price, making them comparable to tariffs of several hundred or even several thousand percent. The resulting economic distortions are comparable to what they would be if we imposed tariffs of this magnitude.

The justification for granting these monopoly protections is that the increased innovation and creative work that is produced as a result of these incentives exceeds the economic costs from patent and copyright monopolies. However, there is remarkably little evidence to support this assumption. While the cost of patent and copyright protection in higher prices is apparent, even if not well-measured, there is little evidence of a substantial payoff in the form of a more rapid pace of innovation or more and better creative work.

This paper examines the extent to which these protections are an efficient means of supporting innovation and creative work and outlines a set of possible alternatives. The first section details some of the increases in the strength and length of protections. The second section reviews the literature examining the costs and benefits of patent and copyright protection. The third section presents some new analysis examining the impact of stronger patent protection on growth and productivity. The fourth section outlines an alternative route for financing innovation that involves more direct public funding and weaker patent protection. The fifth section outlines an alternative mechanism for financing creative work, which could co-exist alongside the copyright system. The sixth section examines the potential impact of these alternatives on economic growth and income distribution.

Stronger and Longer: The Path of Patent and Copyright Protection Since 1970

In the years since 1970, both political parties have been largely supportive of measures that have increased the length of patent and copyright protection, increased the scope of these protections, increased penalties for violations of the law, and sought to extend these protections internationally through trade agreements and political pressure. As a result, protections in both areas are far stronger in 2016 than in prior decades and a much broader set of products are subject to these protections. This section summarizes some of the key measures over this period.

Prior to 1995, patents in the United States extended for 17 years after the date of issuance. In 1995, Congress passed legislation that changed the length to 20 years from the date of filing to be in compliance with the TRIPS provisions of the Uruguay Round of the WTO.[1] This law also included provisions that allowed for the extension of the duration of patents in the event that delays extended the approval process beyond three years, the average length of the process. Patents issued prior to 1995 were extended to be the longer of 20 years from filling or 17 years from issuance. More recently the duration of design patents — patents that apply to the design of a product like furniture or appliances — was extended from 14 years to 15 years from the date of issuance in 2015.[2]

In the case of copyrights, the extensions were considerably longer. Prior to 1976, copyrights were extended for 28 years from the date they were secured, with the possibility of an extension for another 28 years.[3] The 1976 Copyright Act increased the length of the extension to 47 years for a total duration of 75 years. The 1998 Copyright Term Extension Act increased the length of the extension to 67 years for a total duration of 95 years. In both cases, the extensions were applied retroactively to works that had already been produced with copyrights still in effect. In 1992, Congress changed the law to make renewal of copyrights automatic for work copyrighted after 1964. This is noteworthy because in the U.S. copyright holders do not have to be formally registered. As a result, it may be difficult and time-consuming for someone seeking to make use of copyrighted material to track down the copyright holder in order to negotiate terms of use. In fact, in many cases they would have no way of even knowing the material was copyrighted.

The scope of patents has been extended substantially over this period. In the 1980s, patents were extended to cover DNA sequences and life-forms. In the 1990s, it became possible to patent software and business methods. The Bayh-Dole Act, which became law in 1980, allowed for

1 U.S. Patent and Trademark Office (2015).
2 U.S. Government Publishing Office (2012).
3 U.S. Copyright Office (2011).

universities, research institutions, private companies and individuals operating on government contracts to gain control of patents derived from their work. This law created the opportunity for universities to earn large rents from patents and for many researchers to form their own companies, relying on knowledge and expertise they had obtained on government contracts. In 1982, Congress created a designated court to hear patent appeals cases, the United States Court of Appeals for the Federal Circuit. This new court has been substantially more patent friendly than prior appellate court panels. In cases where a patent's validity was in question, the new court has ruled in favor of the patent holder in two-thirds of the cases, while the prior appellate panels only ruled in favor of the patent holder in one-third of the cases.[4]

Copyright law has been similarly extended to accommodate digital technology. The most important development in this area was the Digital Millennial Copyright Act of 1998 (DMCA), which applied explicit rules for digital reproduction and transmission of copyrighted work. The Act allows for large fines and extensive prison sentences for willful violation.[5] While it is reasonable to have rules for digital reproductions if the point is to preserve copyright in the digital age, the point is that a decision was made to preserve this institution rather than allowing it to fall victim to changing technology, as was the case, for example, with Kodak film. Even with the passage of the DMCA, the entertainment industry remains unhappy over the extent to which unauthorized versions of copyrighted material are reproduced. They have repeatedly sought measures in Congress, such as the Stop On-Line Piracy Act (SOPA) and Protect Intellectual Property Act (PIPA), and in trade agreements which would strengthen rules of copyright enforcement. These measures would require Internet intermediaries, like Google or Facebook and millions of smaller sites, to proactively police postings by third parties to prevent copyright violations. This would take the responsibility and cost of enforcement away from the copyright holder and shift it to third parties.

As a simple logical point, as technology increases the ease of reproducing and transferring copyrighted material, copyright enforcement becomes more costly and difficult. In this context, efforts to increase enforcement inevitably impose greater costs on society.

Administrations from both political parties have also placed a high priority on extending patent and copyright protection to other countries through trade agreements and political pressure. The most important item in this area was the inclusion of the Trade Related Aspects of Intellectual Property (TRIPS) in the Uruguay Round of the WTO. This required developing countries to adopt U.S.-style patent and copyright laws, albeit with a substantial phase-in period (which has been repeatedly extended) for the poorest countries. Other trade deals, like NAFTA, CAFTA, and the Trans-Pacific

4 Scherer (2009).
5 U.S. Copyright Office (1998).

Partnership (TPP), have included "TRIPS-Plus" provisions, such as periods of data and marketing exclusivity, which prohibit generic drug manufacturers from using test data submitted by brand manufacturers to establish the safety and effectiveness of their drugs. Marketing exclusivity prohibits generic competitors from competing during the period of exclusivity even if they did their own clinical trials. These treaties have also broadened the scope of patentable items, for example the TPP requires patents be issued for combination drugs and also new uses of existing compounds.

The U.S. has also explicitly pursued stronger and longer patent and copyright protections in bilateral negotiations. For example, the Obama administration has been quite public about its efforts to force the Indian government to allow patents for combination drugs. Many widely used new drugs involve new combinations of existing molecules, rather than the development of a new chemical entity. It also has sought to discourage countries from using their right to require compulsory licenses for drugs, as explicitly allowed under the TRIPS provisions.

The goal of stronger patent protections in developing countries serves two purposes. The first is the obvious one of directly increasing the profits of drug companies by allowing them to charge higher prices. This can be important, especially in the larger markets. However, the industry also is concerned about the large gap in the price of patent protected brand drugs in the U.S. and generic equivalents in developing countries. For example, Sovaldi has a list price of $84,000 for a three-month course of treatment. High-quality generic versions are available in India for $300 to $500 for a three month course of treatment.[6] With new cancer drugs often selling for over $100,000 per year, the gap with generic prices could be even larger. These enormous differences in price create a large incentive for patients to seek out the generic version, whether by finding a way to bring the drugs into the U.S. or by traveling to a country where the generic is available.[7] If the pharmaceutical industry can succeed in taking away the low-cost generic option, it will eliminate a major threat to its marketing model.

Table 1 — Legal Changes Affecting Patent and Copyrights Since 1970

In short, we have seen considerable strengthening of intellectual property rules in the last four decades, as summarized in **Table 1**. The result has been a sharp increase in the size of rents for the protected items. This is most notable in prescription drugs and medical equipment, which went

6 Ketaki (2015). http://www.bloomberg.com/news/articles/2015-12-29/the-price-keeps-falling-for-a-superstar-gilead-drug-in-india.

7 The pharmaceutical companies have sought to place extraordinary restrictions on the use of low-cost drugs in developing countries. For example, Gilead Sciences, the patent holder on Sovaldi, authorized a generic version for Egypt. However, a condition of this license is that the government carefully polices the distribution of the generic. The patient is supposed to pick up the drug herself, and open the container and take the first pill in the presence of the pharmacist selling the drug. See McNeil (2015).

from 0.4 percent and 0.17 percent of GDP in 1975, respectively, to 2.3 percent and 0.51 percent of GDP in 2015. The increase in the economic importance of patents also led to a sharp increase in patenting and in patent suits, as the growing value of these rents provided more incentive companies and individuals to pursue and contest patents. These costs would be justified if the incentives also led to more innovation and creative work. However, it is questionable that this has been the outcome. The next section reviews some of the recent literature in this area.

Before examining the literature, it is worth briefly describing the nature of the possible rents in these areas. In the case of patents and copyrights, the issues are reasonably straightforward. With both patents and copyrights, the government grants individuals or corporations a monopoly for a period of time as an incentive to innovate or produce creative work. The question of rents comes up in the context of whether such monopolies are the most efficient way to provide incentives and whether the system as currently structured is optimal. The rents would be the additional cost that society incurs as a result of this system compared with an alternative structure. As the literature shows, this question does not have a simple answer because it can't be known whether alternative mechanisms will be as effective in promoting innovation and creative work. However, it is possible to get good estimates of the extent to which these monopolies raise costs compared with a competitive market in the protected items. And, there is some basis for assessing the efficiency of alternative funding mechanisms for innovation and creative work. These calculations can provide a basis for assessing whether alternative mechanisms are likely to be more efficient.

Rents from Patents and Copyrights: What the Literature Shows

At this point there is a vast literature on both the benefits and the costs of patent and copyright protection to the economy. The case against such protections is best summarized in a series of papers and a book authored or co-authored by David Levine and Michele Boldrin, along with a number of other researchers. They note the explosion of patents and patent litigation in the U.S. in the last three decades, with the number of patent approvals having more than quadrupled between 1983 and 2010. However, this increase in patents is not associated with obvious benefits in the former of either expenditures on research and development or total factor productivity growth. They note the former has been near 2.5 percent of GDP since the 1970s, with no upward trend associated with the proliferation of patents.

The same is the case with total factor productivity growth. It averaged 1.2 percent from 1970−1979, while falling below 1.0 percent in the decade from 2000−2009. (It has been even lower in the last six years.) Their work also includes more detailed analyses of multifactor productivity growth by sector. They find little relationship between the number of patents in a sector and the rate of productivity growth.[8] The fit is little improved when measures like frequency of patent citations are used instead of the number of patents. In short, they find little evidence in this work of the positive benefits of patents.

They cite a wide range of evidence that patents can be a major source of waste and a hindrance to productivity growth. For example, the vast majority of patents are never used. Old established companies often stockpile patents to use as competitive weapons against smaller upstarts. Hall and Ziedonas (2001) examined the upsurge of patents in the semi-conductor industry in the 1980 and 1990s. They found that the main motivation was to use patents as a weapon in lawsuits against competitors, as well as bargaining chip to be used in a settlement in cases in which they were the defendant. Because litigation involves large costs, an established firm is much better situated to contest a patent than an upstart with few resources. As a result, a patent can be used to force the upstart to share much of the benefits of its technology, even if there is no actual dependence on the patent of the established firm.

This sort of reasoning was commonly cited as the main explanation for Google's decision to buy the Mobility division of Motorola in 2011 for $12.5 billion. At the time, as a relatively new company, Google did not have a large portfolio of patents which could be used as a retaliatory weapon when it was sued. The purchase of Motorola's Mobility division gave Google a large portfolio of patents that could be used in retaliatory suits against competitors.

The extreme case of using patents for legal harassment is that of an actual patent troll, a company that only exists to push claims to patent rights against profitable companies. Boldrin and Levine (2013) note the case of NTP, a patent troll that won a patent infringement case against Research in Motion (RIM) over the Blackberry. In order to avoid having its system shut down at a point where its service was expanding rapidly, RIM agreed to pay NTP $612.5 million to license the use of the patent. On appeal, the original ruling was overturned; however, RIM did not get its money back. The implication is that more than $600 million was taken from, what as at the time a thriving and innovative company, due to a mistaken judicial ruling. Of course, this ruling provided an enormous incentive for other companies to try to follow NTP's example.

8 Boldrin et al. (2011).

One recent study by Bessen and Meurer, which relied on a survey of corporate executives, put the direct cost to firms of litigation with patent trolls (including settlements) at $29 billion for the year 2011.[9] An earlier study involving the same authors, which looked at the impact on stock prices, put the cost at $80 billion a year.[10] Most of the cost in these estimates stems from payments made to the patent trolls or the need to alter their business plan in response to a patent suit. Insofar as these payments reflect compensation for legitimate innovations (a claim disputed by Bessen and Meurer), they would not constitute rents associated with the patent system, they would simply be redistributions among patent holders. But even with this generous interpretation, Bessen and Meurer still attribute more than $5 billion of their $29 billion estimate to direct litigation costs.

These litigation costs are pure waste from an economic standpoint. The actual waste to the economy would have to be several times this size, because the patent trolls undoubtedly spent a comparable amount on litigation. In addition, this study is only looking at suits with patent trolls (formally, non-practicing entities (NPEs)). These suits account for roughly 60 percent of all patent suits. While suits brought by companies that actually use the technology may be more meritorious on average, the legal expenses are still a cost to the economy. Extrapolating from the $5 billion costs estimate of litigation costs, total litigation costs related to patent for 2011 could have easily been close to $17 billion or 7.3 percent of total R&D spending for the year.[11] And this does not even account for the extent to which payments resulting from these suits may not be merited, as was the case with the NTP suit and which Bessen and Meurer argue is the case with most suits involving NPEs.

Boldrin and Levine (2013) also note the substantial legal costs associated with patent protection. It points out almost 250,000 patents were filed in 2010. It puts average legal costs at more than $7,000 per patent, implying that firms spent almost $2 billion in legal fees in 2010 just to file patents. Furthermore, with the ratio of litigation to patents remaining roughly constant, while the ratio of patents to R&D spending has risen considerably over the last three decades, the ratio of litigation to R&D spending has clearly increased. From the standpoint of the economy, these additional legal costs are a pure deadweight loss.

The legal issues surrounding the proliferation of patents can obstruct innovation in a variety of ways. Shapiro (2001) notes the problem of "patent thickets," situations where innovations often involve the use of a large set of patents. This can result in large transactions costs, which may stifle innovation. The problem can be even more serious if inadvertent infringement can result in major penalties. The paper notes that the problem of patent thickets has become especially serious in

9 Bessen and Meurer (2012).
10 Bessen et al. (2012).
11 This calculation assumes that the patent trolls' litigation costs are equal to the defendants ($5 billion). It then assumes that the $10 billion in litigation costs involving trolls accounts for 60 percent of total litigation costs.

several important sectors, such as semiconductors, biotechnology, computer software, and the Internet, since all have seen a proliferation of patents in recent years. In the same vein, patents on research tools, such as transgenic animals and biological receptors, have become increasing common in the last three decades. The royalty payments and transactions costs associated with these tools can make the research to develop new drugs and medical diagnostic products considerably more expensive and thereby slow the process.

Recent research has also found considerable evidence that the threat of patent litigation distorts the direction of research and is a powerful weapon of larger firms against smaller firms and start-ups. Lerner (1995) examined the patenting behavior of biotech firms. It found that firms facing higher legal costs, due to their small size, are less likely to patent in subclasses where there are many other patents. This is especially likely if the firms holding the other patents in the subclass are larger firms with substantial legal resources.

Similarly, Lanjouw and Schankerman (2001a) found evidence of a strong reputation effect where patent holders are more likely to file suits in areas where many new patents are being issued. This presumably means that companies want to show their willingness to contest patents to intimidate competitors. Suits were also more likely in patents with fewer backward citations. It takes this as evidence that in new areas where the bounds of existing patents are less well-established there will be a larger basis for contesting claims.

Both of these findings are troubling from the standpoint of promoting innovation. Insofar as a reputation effect is important for being able to protect a claim, it means that larger firms will be better situated than smaller ones who may have difficulty covering the cost of litigation. The finding that patent suits are more likely in new areas implies that litigation will more frequently be needed to protect patents that are opening new ground. Here also the implication is that patents will be of less value to smaller upstarts than well-established firms.

Lanjouw and Schankerman (2001b) found that smaller firms and individual holders are far more likely to be involved in patent suits than large firms. The disproportionate negative effect on start-ups is made worse by the fact that large patent portfolios seem to provide protection from suits. Firms with large patent portfolios are less likely to be involved in patent suits even when controlling for size. The study finds that the probability of a suit going to trial or the settlement size is not affected by firm size. The conclusion of this analysis is that litigation costs are greater to smaller firms because they are less well-situated to pursue litigation avoidance strategies. This means that patents are a less valuable asset to smaller firms because they are more costly on average for them to enforce.

Lanjouw and Lerner (2001) found that larger firms were 16 to 25 percent more likely to gain a preliminary injunction in a patent suit than smaller firms. This figure likely understates the bias in favor of large firms because lower litigation costs would mean that they would be more likely to pursue weak patent claims than smaller firms. This indicates a substantial tilting towards large firms because a preliminary injunction is an important weapon in a suit, granting the plaintiff the opportunity to effectively maintain a monopoly in the market for the duration of the injunction, while preventing the defendant from receiving a return on its investment.

There is considerable research on the importance of patents as a subsidy for research. Most of the research finds that in most areas the subsidy provided by patents is in the range of five to 15 percent of expenditures on research (e.g. Jaffe (2000), Schankerman and Pakes (1986), Lanjouw (1998), and Schankerman (1998)). The major exception is in pharmaceuticals, where the subsidy could be in the range of 30 percent. This research finds a tremendous skewing of patents, with a relatively small share accounting for the vast majority of the value of patents. Also, the value of most patents seems to dissipate quickly. In several European countries in the 1970s and 1980s, patents were subject to renewal after five years. The vast majority of patents were not renewed, indicating that companies usually did not consider it worth the renewal fees and associated expenses to keep a patent in force after the first five years.

Cohen at al. (2000) surveyed a large number of R&D labs in the U.S. to gain insights on the relative importance of patents as mechanism to support research. It found that patents were viewed as a relatively unimportant mechanism in allowing them to profit from their research. The respondents cited lead time advantages, secrecy, and the use of complementary manufacturing and marketing as more important than patents. The survey also found substantial differences in answers by firm size, with large firms most frequently citing patents as a major way to protect their investment in R&D.

Patents can also raise the cost of R&D by making the use of research tools costly. This is a growing problem in areas like biotechnology, where many of the tests, tools, and biological materials used by researchers are themselves subject to patents. The costs stem not only from the compensation paid to patent holders, but also the transactions costs associated with making all the necessary agreements. The same sort of problem can comes up with the development of new drugs or software, where several patents may be involved in the finished product. The innovator must then negotiate with a number of patent holders in order to market their product. This process may prevent many products from ever being marketing. Also, in cases where joint licensing agreements are the outcome, Lerner and Merges (1998) shows that the larger firm is most likely left in control of

the marketing. This means that newer firms are less likely to be able to reap the full benefit of their innovation.

There is also evidence that the publication of patents does not serve the intended purpose of diffusing knowledge. Boldrin and Levine (2013) argue that firms deliberately write up their patents in ways that make them as unintelligible as possible precisely to avoid giving their competitors any advantage. This is certainly what would be predicted as profit-maximizing behavior. As a practical matter, there is no real downside to a firm for writing its patent in a way that makes it difficult to understand. It's unlikely that a patent will be rejected for poor writing. In addition, competitors often deliberately avoid having their researchers review patents in order to protect themselves from infringement suits.[12] For these reasons, the publication of patents under current intellectual property rules may do far less for the diffusion of knowledge than would be hoped.

Summing up this literature, there is evidence that patents and their enforcement impose considerable costs on the economy. There are substantial legal expenses associated with patents, as they are increasingly used as weapons in a competitive strategy. They are less often used to protect innovation, than as a tool to harass competitors. The legal expenses are themselves a substantial drain on the economy, but the larger drain is the extent to which they distort the innovation process causing companies to abandon promising areas of research and instead look for segments of the market where they are less likely to confront a deep-pocketed competitor. This is likely to be an especially serious problem for smaller companies and start-ups that are less well positioned to engage in costly patent litigation.

The research shows that the effective research subsidy provided by patents in most sectors is limited, usually in the range of five to 15 percent of research expenditures. The major exception is with biomedical research, where the subsidy has been estimated at 30 percent. The evidence from this research raises serious questions as to whether patents are a net positive for innovation and productivity growth.

Levine and Boldrin also question the extent to which patents are necessary as a mechanism for supporting research and development from a theoretical perspective. They demonstrate how the assumption of a substantial first-mover advantage in a simple monopolistically competitive model can eliminate the need for patent protection to support innovation. On an empirical level, they cite a survey of company managers on the key to earning a return on innovation. The survey showed that

12 Gallini (2002).

among managers outside of the pharmaceutical and medical equipment sectors, 50 percent of managers cited lead time as being key to earning a return. Only 35 percent cited patent protection.

The body of work produced and compiled by Levine and Boldrin and their collaborators presents an impressive list of the problems associated with the patent system. They argue for weakening or eliminating patents in most areas. Assuming that the patent system is not eliminated in its entirety they argue for tailoring patent length to the specifics of competition in a sector as a necessary reform.[13] They do note the need for some public mechanism for funding the research and development of pharmaceuticals, because a free market system is not likely to support the cost of this work.

Copyright

Handke (2011) reviews some of the empirical research on the cost and benefits of the copyright system. It begins by noting that claims of the industry group on the importance of copyright to the economy are grossly exaggerated. The industry group lists the size of the core copyright industries at $890 billion in 2007 (6.4 percent of GDP). However, this is not a measure of the value of copyrights themselves — for example the computer software and newspaper industry are not completely dependent on copyright for their existence — but rather the size of the industries that make substantial use of copyright protection. Measures of growth are also exaggerated because they assume a constant price on products that are in fact rapidly falling in price (e.g. software).

Handke notes that the evidence with copyrights, like the evidence with patents, is ambiguous as to whether they are a net economic positive. It cites examples of creative work, such as open source software, that does not depend on copyright protection. It also points out that copyrights can impede creative work by raising the cost of using copyrighted material in derivative work. This can be an especially large problem in the case of copyright, because there is no official registry. It is incumbent on the user to first determine if a copyright protects material, to find the person or corporation in possession of the copyright, and then to make arrangements for non-infringing use of the material.

These transaction costs can be prohibitive in the case of limited uses of copyrighted material in books or movies, leading in many cases to a decision to simply avoid using the work in question. This issue has often been a problem for musicians doing live performances. In principle, the venue where the performance is taking place (typically a restaurant or bar) should be paying a licensing fee

13 It is worth noting that this goes directly counter to the thrust of recent trade agreements, which have sought to create uniformity in patent duration and enforcement across sectors.

for use of songs to the relevant licensing organizations. However, many smaller places with only occasional performances may not want to incur this expense. To avoid potential liability on their part, they would have to ask performers not to include copyrighted material in their sets. This could be difficult for singers or musicians who typically use some amount of copyrighted material in a standard set. As a result, these musicians may find themselves excluded from some of the venues that would otherwise be available to them. Because the vast majority of performing artists will receive far more money from live performances than the sale of recorded music, copyright is more likely to be a hindrance than a support to their work.[14]

To get an idea of the magnitude of some of the expenses associated with copyright, many companies find it necessary to buy Digital Assessment Management systems, at costs in the range of $20,000, just to keep track of the items to which they have purchased access.[15] Legal fees from even inadvertent infringements can easily run into the tens of thousands of dollars.[16]

These costs are in addition to the deadweight losses, which are definitionally associated with copyright monopolies, that raise the price above the marginal cost. These are likely to be substantial relative to the amount paid to the performers, writers, songwriters and other creative workers. A recent analysis of the impact of the Trans-Pacific Partnership's copyright provisions on New Zealand placed the elasticty of demand for books at -1.77 and the elasticity of demand for recorded music at -1.41 based on its analysis of recent research.[17] These estimates imply that for every dollar that copyright raises the price of books and recorded music, the effective cost to consumers in higher prices and deadweight loss is $1.39 in the case of books and $1.22 in the case of recorded music. If creative workers gets 70 percent of the copyright margin in the case of recorded music (in other words, 70 percent of the mark-up associated with copyright goes to creative workers as opposed to promoters, marketing, and profits), this implies that the cost to consumers is $1.74 for every dollar that goes to creative workers. If share going to creative workers is 50 percent, then the cost to consumers is almost $2.00 for every dollar going to creative workers.

At least in the case of recorded music it is clear that the development of digital technology has had a substantial negative effect on the revenue from recorded music. Arguably, this has been a positive development from the standpoint of the economy as a whole. Two studies that examined the welfare effects of unauthorized copying of recorded music, Rob and Waldfogel (2004) and Waldfogel (2010), both find net short-run welfare gains from unauthorized file sharing. While this

14 In an extreme case, ASCAP, the recording rights organization, once requested that the Girl Scouts pay fees for singing copyrighted songs at their campfires. See Bumiller (1996).
15 See, for example, https://www.thirdlight.com/articles/dam-cost.
16 See, for example, https://webdam.com/blog/true-costs-of-copyright-infringement/.
17 New Zealand Ministry of Business, Innovation, and Employment (2015).

may seem obvious, Handke also cites several studies showing that the supply of recorded material actually increased following the widespread practice of file sharing. In another study, Waldfogel (2011) found no evidence of deterioration in quality as a result of widespread file sharing, by looking at measures of "greatest hits."

Another key question with copyrights is the appropriate duration. Most analysis seems to find that older works have relatively little value. Rappaport (1998) found that most copyright works were of little commercial value when they expired, but a minority do still generate considerable revenue. Landes and Posner (2004) find that most copyright holders did not file to extend their copyright.

Arguing in the opposite direction Liebowitz and Margolis (2005) found that 41 percent of 236 bestselling titles from the 1920s were still in print after 58 years. (This is not inconsistent with Landes and Posner's finding that in 2001 only 1.7 percent of the books published in 1930 were still in print. Clearly a very popular book is likely to have more longevity than the average book.) The piece notes several studies that found that the various copyright extensions of the last four decades had no impact on the number of copyrights or renewals.

Handke also notes some unintended effects of copyright. For example, copyright restrictions may slow the spread of new hardware that would be complementary to recorded material. Also, copyrights may affect the mix of work that people consume in ways that favor more established performers. It cites several studies that found evidence that less well-known musicians had better sales after file sharing became common and more attendance at live performances. These studies are far from conclusive, but such an effect is plausible. At a more theoretical level, Salganik et al. (2006) found that in an experimental analysis, people listened more frequently to music that they were told was popular. The implication is that marketing certain songs or musicians will increase the extent to which the public listens to them at the expense of musicians that are not favored. Insofar as copyright may give entertainment companies an incentive to promote certain performers, it will be skewing the public's choice in music towards a more narrow group of musical performers.

Copyright protection in the digital age has also required more punitive law enforcement measures and extraordinary effects to inculcate respect for copyright monopolies. A Minnesota woman was fined $222,000 in 2007 for allowing 24 songs to be downloaded off her hard drive with a peer to peer file-sharing system.[18] Another person was fined $675,000 for the same offense. One of the provisions in the Trans-Pacific Partnership requires countries to have criminal penalties for

18 See: http://abcnews.go.com/US/supreme-court-lets-verdict-stand-recording-industry-case/story?id=18765909.

copyright infringement. In order to promote respect for copyright laws, the industry even created a patch for Girl Scouts and a merit badge on copyrights for Boy Scouts.[19]

Both patent and copyrights are often used to protect software. Lerner and Tirole (2000) and Bessen (2005) analyze the success of open source software. The Lerner and Tirole paper focuses on the motivations of the individual developers. It notes that many innovators are prepared to devote large amounts of their time without any direct monetary reward. In some cases, this is done out of intellectual curiosity. In other cases, working on open source software is a way for a programmer to advance her reputation, which presumably can lead to higher paying jobs in the future.

Bessen focuses on the willingness of many companies to support open source systems. The paper argues that this can be an efficient way to gain a number of programmers' insights into difficult problems that would not be addressed by standardized software. In this way, open source software may be a useful complement to proprietary software and other services provided by the company. These insights are useful in assessing how technology may be usefully shaped in the absence of patent or copyright protection.

In short, there are clearly substantial costs associated with copyright protection. These costs have increased substantially as a result of digital technology. The response of the U.S. government has been to have stronger and more punitive laws and to require third parties to share in enforcement costs.

Patents and GDP Growth: A Cross Country Comparison

In order to assess the extent to which patents are associated with growth, we ran a series of cross-country regressions using data for 19 OECD countries over the years from 1965 to 2010. We used average values for five year periods for both the dependent and independent variables. The Ginarte-Park index was used as the measure of patent strength. We used a variety of independent variables to test for the effects of stronger patent protection, including changes in GDP per capita, changes in GDP per worker, changes in GDP per hour worked, changes in multifactor productivity, and changes in total factor productivity.[20] Each set of regressions included changes in the working age population, changes in the openness of the economy, and inflation as a control variables. We also

19 See: http://www.ipoef.org/?page_id=30 and http://arstechnica.com/gadgets/2006/10/8044/.

20 The measure of multifactor productivity was taken from the OECD while the measure of total factor productivity was taken from United Nations Industrial Development Organization. A full explanation of the sources is in the Appendix.

ran regressions with country control variables, year control variables, and both country and year control variables.

Table Patent-2 shows the set of regressions with per capita GDP as the dependent variable. In the regression without year or country controls the coefficients for the Ginarte-Park index is negative and significant, which would imply that stronger patents were actually associated slower per capita GDP growth. In the regressions with country controls only and year controls only, the coefficients on the Ginarte-Park index variable are negative, but not statistically significant. In the regression with both year and country controls, the coefficient turns trivially positive, but it is nowhere close to being statistically significant.

Table Patent-2 — Changes in per capita GDP, 1965–2010

Table Patent-3 shows a set of regressions with changes in GDP per worker as the dependent variable. In this case the coefficient of the Ginarte-Park index is negative in all four cases. It is highly significant in the regression without year or country controls and marginally significant in the regression with only country controls. The coefficient is not close to being statistically significant in the other two regressions.

Table Patent-3 — Changes in GDP per worker, 1965–2010

Table Patent-4 shows the regressions that used changes in GDP per worker hour as the independent variable. In this case, also the coefficients on the Ginarte-Park index are negative for all four regressions. In the regression without country or year controls, the coefficient is highly significant. The negative coefficient in the regression that only uses country controls is significant at the 10 percent level. It is worth noting that the coefficient for the trade openness variable in this regression is also negative and significant, which does undermine confidence in its meaningfulness.

Table Patent-4 — Changes in GDP per hour worked, 1965–2010

Table Patent-5 shows the set of regressions with total factor productivity as the dependent variable. In this case, two of the four regressions do have a positive coefficient for the Ginarte-Park index variable, although none of them are significant at even 10 percent level.

Table Patent-5 — Changes in Total Factor Productivity, 1965–2010

Table Patent-6 shows the set of regressions with multi-factor productivity as the dependent variable. In this case, the coefficient on the Ginarte-Park index is negative in all four regressions. In the regression without period controls only, the negative coefficient is significant at the 10 percent level. In the other three regressions, the coefficient is negative and significant at the 1.0 percent level.

Table Patent-6 — Changes in Multi-Factor Productivity, 1965–2010

While the results shown in the five tables above are hardly conclusive evidence on the impact of patents on GDP and productivity, they certainly do not support the contention that patents are on net supportive of growth. While there is no doubt that the lure of patent rents provides an incentive for innovation, this benefit is offset by the costs associated with patent monopolies noted in the prior discussion. Just to summarize these costs, patents most immediately lead to deadweight losses associated with items selling for prices that are often far above their marginal cost of production. In addition, there is the waste that stems from rent-seeking activity associated with protecting and maximizing the returns from patents. This includes advertising and marketing, legal fees, and political lobbying. Furthermore, there are also important ways in which patents slow and/or distort research. The incentive for secrecy would imply slower progress compared to a scenario in which all research findings were fully open. And, the pursuit of patent rents can lead researchers to duplicate research to innovate around a patent, rather than to pursue qualitatively new research.

It is entirely possible that these costs collectively could exceed the benefits that stronger patent protection provides in the form of increased incentive to innovate. The results shown above do not prove this is the case, but they do certainly provide evidence in support of that view. The results are also hard to reconcile with the argument that the strengthening of patent protection over the last four decades has been a net benefit from the standpoint of economic growth. In this context, it is reasonable to consider whether different systems for fostering innovation and creative work could lead to better outcomes.

Alternatives to the Current Patent System

The prior sections provide solid grounds for questioning the extent to which patent and copyright protection are efficient mechanisms for supporting innovation and creative work. While some research suggests that there is no need for any form of explicit government intervention to support innovation and creative work, it is likely that the market would undersupply both in the absence of

some form of government support. This is especially likely to be the case in the areas where patents were found to provide the greatest subsidy for research: pharmaceuticals and medical equipment.[21] In these areas, survey results typically found that patents provided an effective subsidy in the range of 30 percent of the cost of research. By contrast, research on the value of patents in other sectors suggested that the subsidy provided by patents was generally in the range of five to 15 percent.

The large gap in the size of the implicit subsidy found for the pharmaceutical and medical supply industries, and for patents more generally, argues for using different mechanisms to support research and innovation in these sectors. In these two industries, the patent is typically responsible for the bulk of the price of the product, often creating a large gap between the patent protected price and the cost of production. The discussion below outlines a mechanism for direct public funding of research in the first two industries. It later describes a modified patent system with much shorter effective patent terms, coupled with an enhanced R&D tax credit, to replace the current patent system in other sectors.

Public Financing for the Research and Development of Pharmaceuticals and Medical Equipment

The importance of patents in the pharmaceutical and medical equipment industry is reflected in the large gap between patent protected prices and the cost of production. As noted earlier, patent protected drugs can sell at prices that are over one hundred times as high as their generic equivalents. There is a similar story with medical equipment. The cost of manufacturing even the most complex scanning devices or other cutting edge equipment will rarely be more than a few thousand dollars, yet patent protection can allow these products to sell for hundreds of thousands or even millions of dollars. This cost is then recouped in high prices paid by patients (or their insurers) for procedures that may have a trivial marginal cost.

The large gap between price and marginal cost has exactly the sort of consequences that economic theory predicts. The first and most obvious is that many people are forced to get by without drugs that are produced at a low marginal cost because they cannot afford the patent-protected price. In many cases, going without high-priced drugs can impose large health risks and even be life-threatening. While this is more commonly a problem in developing countries, in the U.S. there are many people who do not take drugs that would be useful for them due to the cost.[22] Patients will

21 Some of the studies had also found large implicit subsidies for patents in the chemical industry. This would be an argument for treating it in the same way as the pharmaceutical and medical equipment industry. However, because chemicals are mostly sold as an intermediate good, it does not raise the same set of issues as pharmaceuticals and medical equipment.

22 Patients often don't take drugs due to their costs, with substantial health outcomes. A recent study found substantial negative health effects among older people associated with drug copayments in Canada, even though the expected payments were relatively limited compared to what most patients would face in the U.S. See Anis, Aslam H. et al. (2005).

also often take less than the recommended dosage, or skip days or cut pills in half, in order to reduce the cost of their drugs.

A simple calculation of the deadweight loss associated patent protection of drugs indicates that patients incur substantial costs as a result of not paying free market prices. **Table 7** below shows the deadweight loss based on 2016 expenditures of $440 billion, assuming alternatively that drugs would sell for 10 percent and 20 percent of their current prices if there were no patent or related protections.[23] The table applies elasticities of 15 percent, 25 percent, and 50 percent.

TABLE 7 — Annual Deadweight Loss Due Patent Protected Drugs

In the case where the elimination of patent protections reduce average drug prices by 80 percent, and elasticity is just -0.15, the deadweight loss from current protection would still be over $60 billion given 2016 demand and prices. In the case of a 90 percent drop in prices in a freely competitive market and -0.15 elasticity the deadweight loss would be $90.8 billion. In the case of a 90 percent drop in prices and demand elasticity of -0.25 the deadweight loss from current protections would be $171.2 billion.[24] These are substantial losses by any measure. The $90.8 billion loss would be almost 0.5 percent of 2016 GDP and the $171.2 billion loss would be more than 0.9 percent of 2016 GDP.

In addition to the deadweight losses, patent protection also imposes substantial costs in the form of time and resources that are wasted as a result of patent protected prices. These costs take a variety of forms.

First, even where patients have insurance that largely covers the cost of expensive drugs, the high price often will lead the insurer to demand additional proof that the patient actually needs the drug in question. Insurers may require additional tests or a second opinion before agreeing to pay for expensive drugs. When the government is the payer, which is to some extent the case in the U.S., the willingness to pay for a particular drug can often be the outcome of a political battle, with the drug's producer working with patients to pressure the government to pay for a drug of questionable

23 The $450 billion is taken from Bureau of Economic Analysis (2016), Table 2.4.5U, Line 120. It increases the 2015 figure by 9.5 percent, the same increase as occurred between 2014 and 2015. The calculations assume a constant elasticity of substitution consumption function.

24 These calculations would understate the loss substantially insofar as the price declines are uneven. In effect, the assumption in the calculations is that the price of all drugs decline by 80 percent or 90 percent. The FDA (2015) puts the reduction in the price of brand drug in a mature generic market at more than 90 percent. While many drugs are already available as generics, even these would often see large price declines in a free market. Some generics have the benefit of the six-month period of exclusivity as the first generic in the market. Also, in many cases generic manufacturers will still be facing licensing fees of various types, even if the main patent on a drug is no longer applicable. On the other side, the price decline for the most expensive drugs may be in excess of 99 percent. Using averages would understate the loss. Taking these differences into account would almost certainly lead to a larger measure of deadweight loss.

value.[25] The fact that patent-protected drugs are expensive has created a whole industry of intermediaries — pharmacy benefit managers — who negotiate with drug companies on behalf of insurers, hospitals, or other institutions. There would be no purpose for this industry if drugs sold at free market prices.

Because the government is often the payer for drugs through Medicare, Medicaid, and other government health care programs, and can set standards that effectively require private insurers to pay for drugs, the pharmaceutical industry has reason to be heavily involved in the political process. According to Center for Responsive Politics, the pharmaceutical industry ranked 5th in campaign contributions to members of Congress in 2016.[26] The broader category of health related industries ranked second, behind only finance, insurance, and real estate in total contributions to politicians.[27]

Because this involves decisions on public health, the victory of drug companies is not just a question of getting more money at the expense of competitors or the general public. They may lobby for policies that are detrimental to public health in order to boost their profits. For example, pharmaceutical companies that produce pain relief medication have been leading the fight against medical marijuana. It turns out that marijuana is an effective substitute in many cases for prescription pain medications, so in order to protect its market share, the industry is trying to keep a major potential competitor off the market.[28] There can be major consequences for public health as patients take stronger and more addictive medications when marijuana may be an effective treatment. Similarly, the industry uses its ties to disease groups to try to keep generic competitors from being covered by the government or insurers.[29] This is precisely the sort of corruption that would be expected in a situation where there is such a huge gap between the monopoly price and the cost of production.

The fact that there is so much money as stake with patent protection in pharmaceuticals means that the sector is also a primary target for litigation. Pharmaceutical companies routinely bring suits to harass competitors, discourage generic competition, or to gain a slice of the patent rents associated with a highly profitable drug. The pharmaceutical and medical equipment industries together accounted for almost a quarter of the patent-related lawsuits over the years 1995−2014. The suits in

25 Pharmaceutical companies are often major funders of organizations established as support groups for victims of specific diseases and their families. These support groups are often encouraged to lobby insurers and the government to pay for expensive drugs sold by the sponsoring pharmaceutical company. See, for example, Nuñez (2006).
26 Center for Responsive Politics (2016a).
27 Center for Responsive Politics (2016b).
28 Ingraham (2016).
29 Pollack (2016).

the pharmaceutical sector also had the highest median damage settlement, with medical equipment coming in a close third just behind the telecommunication industry.[30]

In any legal battle, there is a fundamental asymmetry between the situation of brand drug manufacturers, which has the right to sell a drug at monopoly prices for the duration of its patent protection, and potential generic entrants, who are looking to have the right to sell a drug in a competitive market. This means that the brand manufacturer stands much more to lose than the generic producer stands to gain. As a result, the brand producer has an incentive to spend much more on legal expenses than a potential generic competitor if doing so can block, or at least delay, generic competition. The brand producer also may attempt side payments as a way to discourage the entry by a generic competitor. While this collusion is illegal, it can be hard to detect, especially if the payment takes the form of a contract (e.g. the generic is paid to manufacture one of the brand manufacturer's drugs) which could have been reached without any collusion. A 2010 study by the Federal Trade Commission estimated the annual cost to consumers of these "pay to delay" agreements at $3.5 billion.[31]

The large gap between price and marginal cost also provides an enormous incentive for drug companies to conceal evidence that reflects poorly on its drugs. If they find evidence that their drug may not be as effective as claimed or possibly even harmful for some patients, the enormous gap between price and marginal cost gives them an incentive not to disclose this information. This was the allegation in the case of the arthritis drug Vioxx, where the manufacturer allegedly concealed evidence the drug increased the risk of heart attack and stroke among patients with heart conditions. Drug companies also have an incentive to promote the use of their drug in situations where it may not be appropriate. Efforts to promote drugs for "off-label" use are a regular source of scandal in the business press.

A recent analysis that looked at five prominent instances in which it was alleged that either drug companies concealed information about their drugs or marketed them for inappropriate uses, found that the cost born by patients was in the range of $27 billion annually over the years 1994−2008.[32] While this estimate is far from precise, it suggests that the cost associated with improper drug use due to deliberate misrepresentations and mis-marketing is substantial, quite likely in the range of the amount spent by the industry on drug research. Also, it is worth repeating that these costs, in terms of bad health outcomes, are the result of deliberate actions stemming from the perverse incentives

30 PricewaterhouseCoopers (2015).
31 Federal Trade Commission (2010). The Public Interest Research Group compiled a list of 20 of the most important cases of this sort of pay for delay, see
32 Katari and Baker (2015).

created by patent monopolies, not costs from the sort of mistakes that are an inevitable part of the research process.

Patent monopolies also distort the research process itself. Most obviously they encourage drug companies to pursue patent rents rather than finding drugs that meet the most urgent health needs. This means that if a pharmaceutical company produces a drug for a particular condition that earns large amounts of revenue, its competitors have a strong incentive to try to produce similar drugs for the same condition to capture a share of the rents.

For example, in the case of Sovaldi, Merck and AbbVie, along with several smaller drug manufacturers, are rushing to market alternatives to Sovaldi as treatments for Hepatitis C.[33] In a context where Gilead Sciences, the maker of Sovaldi, has a monopoly on effective treatments for Hepatitis C, this sort of competition is highly desirable because it will lead to lower prices. However, if Sovaldi was being sold in a free market at $500 to $1,000 for a course of treatment, there would be little reason to waste valuable research dollars finding additional treatments for a condition where an effective drug already exists. If drugs were sold without protection, research would usually be better devoted to developing a drug for a condition where no effective treatment exists than developing duplicative drugs for a condition that can be well-treated by an existing drug.

Patent protection also is likely to slow and/or distort the research process by encouraging secrecy. Research advances most quickly when it is open. However, companies seeking profits through patent monopolies have incentive to disclose as little information as possible in order to avoid helping competitors. This forces researchers to work around rather than build upon research findings. Williams (2013) found that the patenting of DNA sequences in the human genome project slowed future innovation and product development by between 20 to 30 percent.[34]

Finally, relying on patent incentives to support medical research encourages drug companies to direct research toward finding a patentable product. This means that if evidence suggests that a condition can be most effectively treated through diet, exercise, environmental factors, or even old off-patent drugs, a pharmaceutical manufacturer would have no incentive to pursue this research.[35] Ideally, the manufacturer would make this evidence publicly available so that researchers supported by the government, universities, or other non-profit organizations could pursue it, but there is little

33 See, for example, http://www.investopedia.com/ask/answers/052215/who-are-gilead-sciences-gild-main-competitors.asp.
34 Williams (2010).
35 The U.S. and many other countries now allow for the patenting of a new use for an existing drug; however, there are still likely to be limits to the extent to which this might provide incentives for researching new uses of an old drug. If it turned out that a common drug, like aspirin, was an effective treatment for some other condition, it would be very difficult to keep people from using the cheap generic versions for the newly discovered treatment, even if it violated the patent.

incentive for them to go this route. In fact, if they are concerned that such research could lead to an alternative to a patentable product that they might develop or be in the process of developing, their incentive is to conceal the research.

For all of these reasons, patent-supported research is particularly ill-suited for the pharmaceutical sector, as well as the medical equipment sector.[36] It is likely that a system of directly funded research, paid for by the government, would be considerably more efficient for the development of new drugs and medical equipment. Such a system is outlined in the next section.[37]

A System of Publicly Financed Medical Research

The basic logic of a system of publicly financed medical research would be that the government expand its current funding for biomedical research, which now goes primarily through NIH, by an amount that is roughly equal to the patent supported funding currently being conducted by the pharmaceutical industry. Pharma, the industry trade group, puts this funding level at roughly $50 billion or 0.3 percent of GDP, a figure that is also consistent with data from the National Science Foundation. That would be a reasonable target, with the idea that the public funding would eventually replace the patent-supported funding.[38] Adding in research on medical equipment and tests would increase this figure by $12–15 billion.[39]

In order to minimize the risk of political interference and also the risk that excessive bureaucracy could impede innovation, it would be desirable that the bulk of this funding would be committed to private firms under long-term contracts (e.g. 10–15 years).[40] This would allow for the imposition of

36 All the arguments made above on pharmaceuticals would apply to the research for the development of new medical equipment as well.

37 This discussion pursues the logic of directly funded research. There have been several proposals for creating a fund for prizes which would be used to buy out patents and place them in the public domain. While a prize system would have enormous advantages over the current system, most importantly because drugs would be available at their free market price, it shares some of the major drawbacks with the current patent system. Mainly, it would still encourage secrecy in the research process, because companies would have the same incentive as they do now to prevent their competitors from gaining the benefit of their research findings. The awarding of prizes may also prove problematic. The company that manages to patent a drug may not be the one responsible for the key scientific breakthroughs responsible for its development. In principle, prizes could be awarded for important intermediate steps, and not just achieving a final endpoint, but this is likely to make the prize process complicated and contentious.

38 It would be necessary to have some system of international coordination so that the U.S. was not funding research for the whole world. This would presumably involve some payments scaled to GDP, with richer countries paying a larger share of their income. While there would undoubtedly be some problems working through such a system, the current system of imposing patent and related protections on U.S. trading partners has not been quite contentious.

39 National Science Foundation (2012).

40 The use of private drug companies also a potentially valuable benefit from a political economy standpoint. There is no reason that the existing pharmaceutical companies could not bid for public research money, as long as they are prepared to abide by the conditions placed on this funding. This means that insofar as they are efficient in their conduct of research, they would be able to continue to exist and profit on this sort of system. This should reduce their political opposition to an alternative funding mechanism. Insofar as their expertise is primarily in marketing rather than developing drugs, they would run into difficulties under this proposed alternative system.

clear rules that apply to all research directly or indirectly funded by the public sector, without a need for micro-management. The contracts would be subject to regular oversight for their duration, but the contractors would be free to set priorities for which lines of research to support. The contractors could also freely subcontract, just as the major pharmaceutical companies do now. They could also use their funds to buy research produced by other companies, just as the pharmaceutical industry does at present. As the period for a contract approached its end, the contractor could attempt to gain a new long-term contract. It would argue its case based on its track record with the prior contract.

The basic rules governing these contracts would be that all the results stemming from publicly financed research would be placed in the public domain, subject to copyleft-type restrictions.[41] This means that any patents for drugs, research tools, or other intermediate steps developed by contractors or subcontractors, would be freely available for anyone to use, subject to the condition that they also would place any subsequent patents in the public domain. Similarly, test results used to get approval for a drug from Food and Drug Administration would be available for any generic producer to use to gain acceptance for their own product.

In addition to requiring that patents be placed in the public domain, there would also be a requirement that all research findings be made available to the public as quickly as practical. This means, for example, that results from pre-clinical testing be made available as soon as they are known, so that other researchers could benefit from the findings. This should prevent unnecessary duplication and allow for more rapid progress in research. These restrictions would apply to both direct contractors and any sub-contractors that were hired.[42]

This disclosure requirement would not be a negative for participants in the context of this sort of open-source contract system. Because the goal is to generate useful innovations rather than procure a patent, a contractor would be able to make an effective case for the usefulness of their work even if competitors were the ones that ultimately used it to develop a useful drug or medical device. The incentive in this system is to disseminate any interesting findings as widely as possible in the hope that other researchers will be able to build upon them.

41 Copyleft is a type of copyright developed by the Free Software Movement, under which a copyrighted software can be freely used as long as any derivative software is also put in the public domain subject to the same condition. See https://www.gnu.org/licenses/copyleft.en.html.

42 This would be the sort of issue that would be examined in periodic reviews of contractors. If a contractor had excessive delays in posting findings on an ongoing basis, this would be grounds for revoking the contract. Contractors would also be held responsible for the behavior of any subcontractors, who would also be bound by the requirement to post findings in a timely manner.

The contracting system in the Defense Department can be seen as a loose model for contracting in pharmaceutical research. When the Defense Department is planning a major project, such as a new fighter plane or submarine, it will typically sign a contract with a major corporation like General Electric or Lockheed. The contractor will generally subcontract much of the project, because it is not prepared to do all the work in-house. The same would be the case with a contractor doing research developing pharmaceuticals or medical equipment, although the expected results will be somewhat less clearly specified. While that is a disadvantage of contracting with medical research, because the outcomes will be less well-defined, a major advantage is that there would be no excuse for secrecy in the medical research process. There is a clear justification for secrecy in military research, because it wouldn't make sense to allow potential enemies to have access to the latest military technology. By contrast, biomedical research will be advanced more quickly by allowing the greatest possible access.

Secrecy has often been an important factor allowing military contractors to conceal waste or fraud, because only a very select group of people would be able to have access to the specific terms of a contract and the nature of the work a company is doing. In the case of bio-medical research, there is no reason that the terms of the contract would not be fully public. And, all research findings would have to be posted in a timely manner. With such rules, it should be possible to quickly identify any contractor whose output clearly did not correspond to the money they were receiving from the government. For all the instances of waste and fraud in military contracting, it is important to remember that it has been effective in giving the U.S. the most technologically advanced military in the world.

Because the system of patent protection and rules on data exclusivity is now enshrined in a large number of international agreements that would be difficult to circumvent, it is important that an alternative system work around this structure. As proposed here, patent protection under current rules would still be available to drug companies conducting research with their own funds. However, they would run the risk that at the point where they have an FDA-approved drug, there is a new drug available at generic prices that is comparably effective. This sort of competition would likely force the company to sell its drug at a price comparable to the generic, leaving it little margin for recouping its research costs.

Simply the risk of this sort of generic competition should make the current system of patent-financed drug development unprofitable, especially if the industry's claims about its research costs are anywhere close to being accurate. In this way, the existing rules on patents can be left in place, even as a new system of publicly financed research comes to dominate the process of drug development.

The Cost-Benefit Arithmetic of an Alternative System

The simple arithmetic summing the extra costs, deadweight losses, and wasteful rent-seeking behavior associated with patents, and comparing it to the amount of actual research that is funded, suggests the opportunity for large gains through an alternative system. The first and most obvious advantage is that all the drugs and medical equipment developed through this process would be immediately available at free market prices. Instead of costing hundreds of thousands of dollar a year, breakthrough cancer drugs might cost $1,000 a year, or even less. The cost would be the price of safely manufacturing these drugs and with very few exceptions, that cost would be quite low. With drugs selling at prices that even middle-income families could readily afford, the whole industry of middle-men that has grown up around mediating between the drug companies and insurers, hospitals, and patients would disappear. There would be no need for it.

This would also end the horror stories that many patients must now endure as they struggle to find ways to pay for expensive drugs even as they suffer from debilitating or potentially fatal diseases. Doctors also would not be forced to compromise in prescribing a drug they consider inferior because it will be covered by a patient's insurance when the preferred drug is not. Also, doctors would likely make better informed prescribing decisions because no one would stand to profit by having them prescribe a drug that may not provide the best treatment for their patient.

A similar story would apply to the use of medical equipment. In almost all cases, the cost of manufacturing the most modern medical equipment is relatively cheap. The cost of usage is even less. For example, the most modern screening equipment only involves a small amount of electricity a limited amount of a skilled technician's time, and the time of a doctor to review the scan. Instead of a scan costing thousands of dollars, the cost would likely be no more than $200−$300. Here also, the price would then be a minor factor in deciding how best to treat a patient. A doctor would naturally recommend the device that best meets the patient's needs. And in a context where no one has an incentive to mislead about the quality of the equipment, the doctor is likely to make better choices. The same would be the case with various lab tests, all of which would be available at their free market price. With few exceptions, this would be a trivial expense compared to the current system.

Table 8 below shows the potential gains from replacing patent supported research with direct public funding under three alternative sets of assumptions.

Table 8 — Gains from Ending Patent Protection for Pharmaceuticals and Medical Equipment

The most optimistic, shown in column 1, assumes that 75 cents of public spending on research is roughly equivalent to one dollar of spending financed by patent monopolies. The greater efficiency would be based on the idea that increased openness and the elimination of unnecessary duplication led to more effective research. It also assumes that prescription drugs would sell for 10 percent of their current price without any patent or related protections.[43] In this case, the implied annual savings would be $349.5 billion. Adding in the reduction in deadweight loss from the high elasticity case shown in Table 7 brings the total benefits to more than $800 billion a year.

Column 2 shows an intermediate scenario in which it $1.00 of public money for research is needed to replace $1.00 of patent supported research. This case assumes that prescription drugs would cost 15 percent as much to produce as they do today if all patent and related protections were eliminated. In this case the savings would be $315.5 billion. Adding in the reduction in deadweight loss brings the total net benefit to more than $450 billion a year.

Column 3 shows a scenario in which it takes $1.50 of public money is needed to replace $1.00 of patent supported research. This implies that because money is going through the government, the research process becomes hugely less efficient than is currently the case. This is in spite of the fact that the research is now fully open so that all researchers can benefit quickly from new findings and a main motivation for unnecessary duplicative research has been eliminated. This scenario assumes that it would cost 20 percent as much to manufacture drugs in a world without patent and related protections as is the case at present. In this scenario, the savings would still be $269 billion annually or 1.5 percent of GDP. Adding in the reduction in deadweight loss in the most inelastic scenario would put the total net benefit at $329 billion annually.

The next set of rows shows the additional benefits from publicly funded research for medical equipment. The assumption in all three cases is that the cost of buying and using this equipment would fall by 70 percent if it was sold in a free market. The 2016 spending level is a projection from the Center for Medicare and Medicaid Services. The estimate for current research spending is taken from data for 2012 from the National Science Foundation and increased by 20 percent to account growth between 2012 and 2016. The optimistic scenario assumes that 75 cents in publicly funded research is equivalent to a dollar of patent-supported research. The middle scenario assumes that

43 It is worth noting that with some drugs the price may be high currently not because the compound itself is subject to patent protection, but rather one of the inputs. The implicit assumption in this discussion is that the inputs would also be in the public domain because they would have been produced with public funding.

they are equally effective, and pessimistic scenario assumes that $1.50 in publicly funded research is needed to replace $1.00 in patent supported research. In these cases, the net annual savings in optimistic, middle, and pessimistic scenarios would be $24.1 billion, $20.4 billion, and $12.9 billion, respectively.[44]

While publicly financed research would require the government directly commits funding for research, it should not be necessary to secure additional tax revenue. The government already directly or indirectly pays for a large portion of prescription drug expenditures through Medicare, Medicaid and various other health care programs. In addition, it effectively subsidizes private spending on drugs as a result of the tax-deductible status of employer provided health insurance and various other tax deductions. **Table 9** shows the Centers for Medicare and Medicaid Services (CMS) projections for 2016 spending on prescription drugs and medical equipment by source.[45] It also shows the assumed savings in each case.

Table 9 — Savings to the Government from Publicly Supported Research for Pharmaceuticals and Medical Equipment

For Medicaid and other government programs, the assumed savings are 50 percent on both drugs and medical equipment, based on the fact that these programs typically pay substantially lower prices for drugs than private insurers. In the case of Medicare, the assumed savings are 70 percent on drugs and 50 percent on medical equipment, under the assumption that insurers within the program pay somewhat lower prices drugs than insurers not connected with Medicare. In the case of private insurers and the out-of-pocket payments, it is assumed that the savings to the government will be equal to 16 percent of current payments for drugs 14 percent for medical equipment. This uses the assumption that drug prices will fall 80 percent if not subject to patent protection and the price of medical equipment will fall by 70 percent. The calculation further assumes that 20 percent of this saving accrues to the government in the form of higher tax revenue, because less money will be deducted for health care expenditures.

44 Even these calculations don't fully capture the potential benefits from having drugs sold in a free market. CMS projects that private insurers will pay just over $150 billion for prescription drugs and medical equipment in 2016. With insurance expenses averaging more than 20 percent of benefits paid out, if these combined payments fell by $100 billion, it would imply savings of more than $20 billion in the administrative costs of insurers.

45 Centers for Medicare and Medicaid Services (2014). https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/Proj2015Tables.zip

Even with these relatively conservative assumptions the savings to the government based on the 2016 projections would still be over $139 billion.[46] This substantially exceeds the amount of public funding that would be needed to replace patent supported research in even the most pessimistic scenario described above. This means that the savings to the government from having drugs sold in a free market without patent or related protections should be more than enough to support a system of publicly funded drug development. There would be no need for additional tax revenue even in a relatively pessimistic scenario.

It is possible that there could be some short-term need for additional funding due to the lag between research spending and the development of new drugs. At least initially, there would be no savings from publicly funded research because all the drugs being sold would still be subject to the same protections as they are today. The savings would only accrue over time as new drugs were produced through the public system and being sold at free market prices. For this reason, a switch to direct public funding of research may at least initially increase budget deficits, even if it led to substantial savings over a longer time frame.

Publicly Funded Clinical Trials

Switching all at once to a system of fully funded research would likely be a difficult step both politically and practically. This would involve a radical transformation of a massive industry of a sort that is rarely seen in the U.S. or anywhere else. Fortunately, there is an intermediate step that can be used to advance toward a system of fully funded research which would offer enormous benefits in its own right.

There is a simple and basic divide in the research process between the pre-clinical phase of drug development and the clinical phase. The pre-clinical phase involves the development of new drugs or new uses of existing drugs and preliminary tests on lab animals. The clinical phase involves testing on humans and eventually proceeding to the FDA approval process if the earlier phases of testing are successful. The clinical testing phase accounts for more than 60 percent of spending on research, although this number is reduced if a return is imputed on the pre-clinical testing phase, because there is a considerably longer lag between pre-clinical expenditures and an approved drug than with clinical tests.

The clinical testing process involves a standard set of procedures, and is therefore far more routinized than the pre-clinical portion of drug development. For this reason, the clinical testing

46 These calculations are based on CMS projections of spending on prescription drugs. Data from the Bureau of Economic Analysis show spending levels that are more than 30 percent higher. A calculation of savings based on the Bureau of Economic Analysis spending levels would therefore be correspondingly higher.

portion of the drug development process could be more easily adapted to a program of direct public funding. The model could be the same as discussed earlier, with the government contracting on a long-term basis with existing or new drug companies. However, the contracts would specify the testing of drugs in particular areas. As was the case described earlier, all results would be fully public, and all patent and related rights associated with the testing process would be put in the public domain subject to copyleft type rules. This would likely mean that in many cases the contracting companies would have to buy up rights to a compound(s) before they initiated testing, because another company held a patent on it.

There are many advantages to separating out the clinical testing portion of drug development rather than attempting to fully replace patent supported research all at once. First, it would be much easier to slice off particular areas to experiment with public funding. For example, it should be possible to set aside a certain amount of funding for clinical trials for new cancer or heart drugs without worrying about fully replacing private support for research in these areas. Also, it should be possible to obtain dividends much more quickly in the form of new drugs being available at generic prices. The time lag between the beginning of preclinical research and an approved drug can be as long as 20 years. The clinical testing process typically takes less than eight years and can be considerably shorter if a drug's benefits become quickly evident in trials.

Another important early dividend from the public funding of clinical trials is that the results of these trials would be posted as soon as they are available. This means that researchers and doctors would not only have access to the summary statistics showing the success rates in the treatment group relative to the control group, but they would also have access to the data on specific individuals in the trial.[47] This would allow them to independently analyze the data to determine if there were differences in outcomes based on age, gender, or other factors. It would also allow for researchers to determine the extent to which interactions with other drugs affected the effectiveness of a new drug.

In addition, the public disclosure of test results may put pressure on the pharmaceutical industry to change its practices. The problem of misreporting or concealing results in order to promote a drug is one that arises in the process of clinical testing. While misrepresented results can be a problem at any stage in the drug development process, misrepresentations at the pre-clinical phase are unlikely to have health consequences because they will be uncovered in clinical testing. The problem of patients being prescribed drugs that are less effective than claimed or possible harmful to certain patients due to misrepresentations is entirely an issue with clinical testing. If experiments with a

47 Some information on individuals may have to be put into categories (e.g. between the age of 25 and 34, rather than a specific age) in order to preserve the anonymity of particular patients. With rare diseases, these categories may have to be fairly broad, but it will still be possible to disclose car more information than is currently available.

limited number of publicly funded clinical trials can change the norms on disclosure of test results, they will have made an enormous contribution to public health.

Potential Benefits from Marginal Cost Pricing

While the savings shown in Table 8 are substantial, these may not even be the most important benefit from shifting to a system of upfront research funding and marginal cost pricing. The current system leads to a situation in which drugs, scans, and tests which are important to patients' health can be enormously expensive. As a result many patients are left struggling to find ways to pay for medical care that may be necessary for their health or even their life. Even in cases where patients are insured they may still be faced with large co-payments or have an insurer that refuses to pay for a particular drug or procedure. If drugs, scans, and tests were all being sold in a free market, they would almost invariably be relatively cheap. As a result, all but the lowest income households should be able to afford the drugs and tests that are considered beneficial to their health. Because families have the need for these products and services at a time when they have a family member struggling with bad health, the elimination of this potential financial burden should be an enormous benefit.

In addition, there is good reason to believe that a switch to a system of marginal cost pricing with fully open research will lead to better health outcomes. There are two main reasons why this could be the case. First, the current system of patent monopolies provides drug companies, manufacturers of medical equipment, and proprietary tests with an enormous incentive to misrepresent the benefits of their products and conceal potential negatives. If all of these items were sold in a free market where competition had pushed profits down to normal levels, there would be little incentive to misrepresent the safety and/or effectiveness of a product in order to boost sales. The additional profit from increased sales in a competitive market does not provide the same sort of incentive for corruption as the opportunity to sell more of a product at monopoly prices.

The other reason why an alternative system of open research should lead to better outcomes is that doctors and researchers would have the ability to directly assess the evidence for effectiveness of a drug or procedure rather than it being proprietary information held in secret by a drug company or medical equipment manufacturer. This should allow doctors to make decisions that focus on the specific situation of their patients. If more than one drug is available for treating a condition, a doctor will have access to evidence that could indicate that one of the drugs is more effective for men than women, or for overweight people, or people with other health conditions. This should allow her to make more-informed decisions for treating her patients.

There is also the possibility that there will be better drugs and equipment available if openness allows research to advance more quickly. If open research turns out to advance more quickly, as some studies have indicated, the move away from patent-supported research may hasten the invention of treatments and cures for a wide variety of conditions.

In addition to the benefits to the patients, there will be substantial savings to the economy beyond just paying lower prices for drugs. The massive marketing industry that has developed to promote sales of drugs would quickly disappear, because there would be little point in spending tens of billions of dollars each year promoting drugs being sold at generic prices. The resources being devoted to this purpose could instead be committed to productive uses.

There would also be less need for lawyers and lobbyists in these industries because there would be much less at issue to contest in court or reason to lobby politicians. This could free up a considerably amount of resources. At present, lawyers specializing in intellectual property tend to be among the most highly paid members of the profession. If the demand for lawyers to press or defend patent suits in prescription drugs it would free up a substantial share of these lawyers to pursue other lines of work.

Marginal cost pricing of drugs, medical equipment, and medical tests also would substantially reduce the amount of money flowing through health care insurance industry. On average, insurers take over 24 percent of the money paid to providers to cover administrative costs and provide their profit.[48] If spending on drugs and medical equipment was reduced by $100 billion annually, this would imply savings on administrative expenses of more than $20 billion a year.

Non-Patent Supported Research Outside of the Health Care Sector

While the abuses and inefficiencies of the patent system have the greatest consequence in the prescription drug industry and other health-related sectors, similar problems arise in other sectors as well. In most other sectors, patents are less important for supporting research and innovation, because factors such as a first-mover advantage and complementary services tend to far more important in giving companies an edge on their competitors that allows them to profit from

48 This calculation comes from taking the $194.6 billion estimate for the net cost of administering health insurance in 2014 from the Center for Medicare and Medicaid Services (CMS), National Health Expenditures data for 2014 (Table 2) and dividing it by $796.4 billion, the CMS estimate for 2014 payments by insurance companies after subtracting administrative expenses (Table 3).

innovation. In this context, it might be desirable to preserve the patent system but reduce its importance to limit abuses of the system.

As noted earlier, the U.S. is committed by a number of trade agreements to a set of rules, including a 20-year patent duration, which would prevent it from simply altering the basic structure of the patent system. However, the government can provide firms with a strong incentive to accept weaker patent rules. Because some of the worst abuses stem from patent trolls who make dubious legal claims based on older patents, a major reform would be to radically reduce the period of patent duration.[49] A patent length of three to five years would allow firms to protect their use of new technologies for a limited period of time, while giving patent trolls little opportunity to dredge up old patents with the purpose of extorting payments from successful innovators.

Because firms have the right to a 20-year patent, they would have to be given incentive to accept a shorter duration. An expanded research and development (R&D) tax credit could provide this sort of incentive.[50] The current tax credit is constructed as a marginal tax credit. It gives firms a credit of between 14−20 percent on R&D expenditures in excess of spending over a prior base period. The tax as it is currently structured costs $18 billion annually, as of 2016, or 0.1 percent of GDP.[51] This general credit could be eliminated and replaced with a credit of 10−15 percent of all R&D expenditures. However, the condition of getting this credit would be that all patents claimed by the company are open to the public under the copyleft rules after an initial three to five year period. This means that after this initial period, anyone would be able to make full use of the patent, if they also agree to the shorter three to five year patent duration period. Such rules would still allow corporations to have the full 20-year patent term required under trade agreements, but they would then be foregoing both the R&D tax credit also free access to material subject to copyleft patents.

Table 10 — Non-Medical R& D Expenditures

This set of incentives should provide a mix that is roughly comparable to the incentive provided by the current patent system and tax credit. **Table 10** shows the National Science Foundation's estimates of research and development spending by sector for 2012, the most recent year available. Total spending in its breakdown came to 1.9 percent of GDP. If spending in the pharmaceutical industry and other health related industries is removed, this amount fell to 1.45 percent of GDP.[52] A

49 Love (2013).

50 Dechezlepretre et al. (2016) provides evidence on the effectiveness of the R&D tax credit as currently structured in promoting research spending.

51 The structure of the tax, as well as the estimate of the cost can be found in CBO (2015).

52 This calculation counts 50 percent of the spending in the category "Navigational, measuring, electromedical, and control instruments" as being health related.

tax credit of 10−15 percent would cost between 0.15 percent and 0.22 percent of GDP if the take-up was 100 percent. Clearly, this would not be the case; more likely somewhere between 60−80 percent of spending would be covered by this system. That would imply a cost of between 0.09 percent of GDP and 0.18 percent of GDP, or between $16 billion and $29 billion in the 2016 economy. At the low end, this would be roughly equal to the cost of the current R&D tax credit, at the high end the cost would be approximately 50 percent more than the cost of the tax credit. If this system led to a comparable amount of research, then the benefits to the economy should easily exceed the additional expense to the government.

Figure 1 shows the additional spending implied in these scenarios from this alternative tax credit compared to expenses from the current patent system. The expenses shown are the annual costs of patent applications, the litigation costs of defending patent suits, the annual cost of settlements as estimated by Bessen and Meurer.[53] (All numbers are scaled to 2016 GDP.)

Figure 1 — Expenses Associated with Patents and Cost of Tax Credit

In the low-end estimate, the tax credit as described would actually imply a very modest savings compared to the current credit.[54] At the high end, the additional cost of the credit would be $11 billion in the 2016 economy. Working off of the Levine and Boldrin calculation, companies would spend more than one fifth of this amount just on the filing of patents. While firms would certainly still have motivation to apply for patents under this alternative system, the incentive would be considerably less, so the number of patent applications would likely fall sharply. The cost of litigation derived from Bessen and Meurer (2012) in the 2016 economy is $20.3 billion — almost twice as much as the high end net cost of the tax credit. The cost of settlements with non-practicing entities derived from Bessen and Meuer is $28.6 billion, which is two-and-a-half times as much as the high end cost of the tax credit.

These calculations suggest that the economy would hugely better off a system that relied more on tax credits and less on patent protection to support research. Of course, the costs from patent litigation would not fall to zero even in a scenario where tax credit support became the dominant mode for financing research. There would still be some litigation even associated with the shorter patents and the government would have to be prepared to protect its patents for the duration of the

53 The $5 billion litigation cost estimate is doubled to include the costs incurred by NPEs and then multiplied by 1.66, as described earlier, to account for lawsuits that do not stem from NPE.

54 The savings would actually be somewhat larger than indicated, because a portion of the current credit goes to firms in the health care sector.

copyleft period. In addition, there would almost certainly be some firms that opted to remain outside the tax credit system.

But on the other side, the increased competition from having fewer items subject to patent protection is likely to mean lower prices in a wide range of areas. And, having more research freely available to innovators is likely to hasten the pace of innovation. This is likely to be especially important for smaller firms and start-ups that would see negotiating for the rights to use patented research as a major expense. Also, if they could count on supporting more of their research through a tax credit, rather than relying on patent protection, they would have less fear that a competitor would expose them to costly litigation.

This sort of dual track system would require provisions to prevent gaming. Naturally, companies would like to take advantage of free access to technology and the R&D tax credit and then also get a full 20-year patent. Some of the protective measures are obvious. The receipt of the tax credit and free access to copyleft material by any subsidiary of a firm should prevent the whole firm from having access to 20-year patent protection. It would be all but impossible to police the separation whereby some parts of a firm are getting the tax credit and access, but other parts are ostensibly fully funding their own research and thereby entitled to long patents. Similarly, the rules on short patents would have to apply to companies and patents purchased by a firm that was within the tax credit/copyleft system.

On the other hand, if the incentives are structured properly, few large firms would find it advantageous to stay outside the system. The access to the tax credit and the free use of copylefted material should far exceed the potential benefits of additional years of patent protection. As a result, it would be difficult to envision a company like Google or General Electric remaining outside the system. Also, because larger companies are in a position to benefit from the network effect of having their technology widely adopted, they would have a further incentive to go with the tax credit/copyleft system.

Small firms are likely to find the tax credit system even more advantageous relative to the current system. As noted earlier, small firms and start-ups seem to be more disadvantaged under the current system. It is often expensive for them to effectively defend a patent and, relative to their size, they are more likely to be in a patent suit than larger firms. One result is that smaller firms tend to patent in areas that are less crowded, effectively ceding large areas of research to larger more established firms. If these firms could instead count on a tax credit to subsidize their research and have less need for a lengthy patent, then it could help to level the playing field between small and large firms.

The additional competition from more entrants in key areas of research should help to boost the pace of innovation and lead to more rapid productivity growth.

If the tax credit/copyleft system did become widely adopted, it should have the desired effect of drastically reducing the number of patent suits and sharply reducing the space of operation for patent trolls. The simple arithmetic is striking. If the short patent associated with the tax credit system was five years, and everyone was in the system, then the number of patents in force at a point in time would drop by 75 percent.[55] If it was three years, then the reduction in the number of patents still in effect would fall by 85 percent. This is before taking into account what is likely to be a collapse in the number of patents in the pharmaceutical and medical equipment sector, with direct public funding largely replacing patent monopolies as a source of financing for R&D in these sectors.

In fact, the actual decline in the number of patents in effect is likely to be even larger than these 75-85 percent calculations. Because the life of the patent will have been shortened, patents will be of less value. Therefore many companies may opt not to patent inventions that they would patent under the current system. The net result of this change would be far fewer resources getting wasted in filing patents and patent suits and far less concern on the part of innovative companies and individual inventors over the risk of being sued for patent infringement.

It will be necessary for the government to be vigilant in protecting the patents subject to copyleft rules, both in the case of patents that grew out of research supported by the tax credit and also patents that resulted from direct public funding in the health care sector. Enforcement of these patents would be a great activity to be contracted out to private law firms paid largely on commission. This would minimize the risk that corporations could use their power to stay outside of the public funding and tax credit system and still gain free access to the technology developed through these systems.[56]

While the shortening of patent durations in most sectors is not likely to lead to the same collapse of prices that the ending of patent monopolies would cause in the health care sector, it should result in more competition and innovation, along with some drop in prices. There would be more pressure on larger established companies to constantly innovate and improve their products, because they could not count on a lengthy period of patent monopolies to protect them from competitors. In

55 This calculation assumes that the number of patents issued each year is constant.

56 There is risk that law firms given the responsibility for enforcing copyleft patents for the government could act like patent trolls. Presumably, the opportunities for public accountability and the option of non-renewal of contracts would limit this risk.

addition, the free access to a vast amount of technology on a copyleft basis to both large firms and smaller start-ups should accelerate the process of innovation.

This system is likely to disproportionately benefit smaller firms because they would not need the legal resources to protect their patents nor to protect themselves against infringement suits.[57] Also, the free access to copylefted technology is likely to be more of an asset to smaller firms that don't have the in house capacity to negotiate contracts allowing for the use of patents held by other firms. While it may be a relatively simple matter for an Amazon or an Apple to work out a licensing arrangement to gain access to patented technology, this is likely to be a much more difficult process for a small start-up without a sophisticated legal department. For this reason, having ready access to the technology that is copylefted should be a major advantage.

An Alternative to Copyright Monopolies

The clear path on copyright policy over the last four decades has been longer and stronger protection. Not only has the duration of copyright protection been repeatedly extended, but the rules for enforcement have been strengthened in order to prevent protection from being undermined by digital technology. The law has been repeatedly adjusted to make it more difficult to use digital technologies and the web to reproduce material subject to copyright protection. This has meant in some cases blocking certain technologies until effective locks could be developed to prevent unauthorized reproductions of protected material.[58]

It has also meant imposing responsibilities for enforcing copyright protections on third parties. There have been a series of laws passed that require intermediaries to remove copyrighted material from their sites when they have been alerted by the copyright holders. An aspect of this law that is striking is that intermediary is liable if they are notified by the copyright holder and do not promptly remove the material in question. This forces the intermediary to side with the individual or corporation making the copyright claim against their customer. There have also been efforts by the entertainment industry to push measures that would require intermediaries to proactively search their sites for unauthorized versions of copyrighted material.

57 As was noted in Lerner (1995), there was a clear tendency for smaller biotech firms to patent in areas in which there were relatively few patents. This was taken as evidence that these companies feared infringement suits from larger competitors.

58 There was a major debate in the 1990s around the introduction of digital audio recorders. There were several lawsuits filed with the major manufacturers agreeing to include locks to prevent duplication of copyrighted material. See, for example, https://partners.nytimes.com/library/tech/98/10/cyber/cyberlaw/16law.html.

This strengthening of copyright law and altering its structure to adjust to digital technology and the Internet is interesting not only because of the costs involved for the larger economy, but also because it shows alternative ways in which society adapts to technological change. In many instances, technological change has destroyed sectors of the economy. For example, the spread of digital cameras essentially destroyed the traditional film industry, causing the collapse of two major U.S. corporations, Kodak and Polaroid, and leading to the loss of tens of thousands of jobs. While the collapse of these companies and the resulting job loss were unfortunate, no one would have considered it a reasonable strategy to try to block the spread of digital cameras.

On the other hand, when the development of digital technologies and the Internet threatened the business model of the entertainment industry, the response was to pass laws to contain these technologies to preserve the sector's mode of doing business. This is a great example to show that it is not technology itself that is determining the distribution of income, but rather how various interest groups are able to write the laws governing the use of technology.

Like patents, copyright terms are also protected by international agreements. However, it is possible to develop a comparable system or alternative funding to work around the copyright system. In this case, it is important that the system be set up in a way that respects individuals' choices in supporting music, books, movies and other types of creative work rather than having a government agency deciding which work should be supported. For this purpose, an individual tax credit would be appropriate.

The model for a tax credit to support creative work would be the tax deduction for charitable giving. This allows for individuals to make tax-deductible contributions to religious, educational, social assistance, and cultural organizations with a minimum of interference from the government. In effect, the government is subsidizing the contribution by the taxpayer's marginal tax rate, which is 39.6 percent in the case of the highest income taxpayers. Because the deduction is not capped, it is limited only by the size of the taxpayer's tax liability (i.e. it is not refundable).

In order to qualify to get tax-deductible contributions an organization need only file with the Internal Revenue Service (I.R.S.) and indicate the sort of tax-deductible activity in which it is engaged. There is no effort by the I.R.S to determine whether an organization is "good" as a religious organization or as a provider of food to the poor; that is left for the taxpayer making the contribution to determine. The only concern for the I.R.S. is that the organization is in fact engaged in the activity that provides the basis for its tax-deductible status and that it is not engaged in prohibited activities such as political campaigns or profit-making ventures.

Registration to be eligible to receive funds through a creative work tax credit would be along similar lines. Individuals or organizations would register to be eligible to receive funds by indicating the type of creative work in which they engaged as individuals or supported as organizations. This means that individuals would indicate that they are writers, musicians, video producers or engaged in some other type of creative work. The only issue from the standpoint of the I.R.S. (or any comparable enforcement agency) would be whether the person in fact engaged in the activity that they claimed. For an organization, the question would be whether they in fact used their funding to support the type of creative work they claimed to support. In other words, if an organization claimed to support the writing of mystery novels or jazz music, then the concern would be whether they had actually used their funds for this purpose.

Because this system is intended to be an alternative to the copyright system, the condition for getting funding, for both individuals and organizations is that they would not be eligible for copyright protection. In effect, creative workers would be given the option of relying on one or the other system of support. They could choose to rely on copyrights to support their work or they could opt to join the tax credit system, but they could not do both. In order to ensure that the tax credit system did not become a farm system for the copyright system, in which people established their reputation in the tax credit system and then cashed in with the copyright system, there should be a substantial gap (e.g. five years) between the last time a creative worker received funding through the tax credit system and when they could first receive copyright protection.

A convenient feature of this system is that it is largely self-enforcing. A person who attempted to cheat the system by getting a copyright on material when they were clearly not eligible due to receiving support through the tax credit system would have the burden of suing the alleged infringer. Because there would be a registry of everyone in the tax credit system it would be a simple matter to show that the creative worker had been in the system too recently to qualify for copyright protection, therefore their copyright would not be valid. In this case, there is no need for the government to do anything — it protects the integrity of the tax credit system by doing nothing; the person does not have an enforceable copyright.

From the standpoint of the individual taxpayer, the tax credit system would provide a limited sum (e.g. $100) that they could give to any individual(s) or organization that is registered as an eligible recipient. This means they could give their tax credit directly to a writer, singer, musician, or other creative worker that is in the system or they could contribute to organizations that are within the system and are committed to supporting particular types of creative work. Individual taxpayers would have the option to give the tax credit to a single individual or organization or divide the sum among as many individuals as they choose. One major difference with the tax deduction for

charitable contributions is that the tax credit would be refundable. This means that every person would have the option to support creative work of their choosing, even if they had no tax liability.

There would be some risk of fraud with this system, just as there is with the charitable tax deduction. However, the risks are likely to be considerably smaller in the tax credit system than with charitable deduction, because the sums involved per person are much smaller. If a high-income person contributed $1 million to a bogus charity, there would be an effective tax subsidy of $396,000 that the charity and the individual could in principle split between them. If the tax credit is set at $100, it would be necessary to involve almost 40,000 people to scam the government for the same amount of money. Needless to say, this would be a difficult thing to do without being detected.

One mechanism for preventing simple frauds would be to require a modest minimum payment for a person or an organization to be eligible to receive any funds through the tax credit system. If an individual had to receive at least $3,000 through the tax credit system to be eligible to get any money and an organization had a floor of $10,000, it would largely prevent simple trade off arrangements where people agree to give each other their credits. It might still be possible to coordinate tax credit swapping, but it would require a consider amount of coordination, and therefore risk, for a relatively small payout.

This system would generate an enormous sum of money, compared to what is presently available, to support creative work. If the credit were set at $100 and 90 percent of the adult population opted to take advantage of it (this is free money), it would generate more than $22 billion a year to support books, movies, recorded music and other forms of creative work. This would vastly exceed the amount of money that currently goes to creative workers through the copyright system, although it would be far smaller than the subsidy for charitable contributions through the tax system. The Congressional Budget Office estimated the size of this subsidy at $40.9 billion for 2006.[59] Adjusting for the growth of the economy would put the subsidy at $54 billion in 2016. This is likely an understatement, because the tax rate for high-income taxpayers rose from 35 percent to 39.6 percent in 2013. As a result, a contribution of the same dollar amount would imply a substantially larger tax subsidy in 2016 than it did prior to 2013.

One of the issues that would naturally arise with this system is its borders. For example, should journalism be included as a type of creative work to be supported through this system? [60] Similarly,

59 Congressional Budget Office (2011).

60 The Bureau of Labor Statistics gave the number of people employed as reporters in 2015 in print, broadcast, and Internet as 44,360. The average annual pay was $50,700. (The median was $37,700.) (Bureau of Labor Statistics (2016)). This means that if their pay was fully supported by the creative work tax credit it would require roughly $2.2 billion of revenue from the tax credit. Of course, newspaper and broadcast outlets require other support personal as well. However, even in the absence of copyright

should video games also be included? Software is also often protected by copyright in addition to patents.

The logic of the system would suggest that the boundaries be drawn broadly for two reasons. First, it would be difficult, if not impossible to police the boundaries. If a person was being supported for writing non-fiction books, but they also posted weekly or daily pieces on the web on political events, would this be a violation of the rules if the system was not intended to support journalism? There would be a similar situation with video games. At what point would interactive art become a video game, and do we want the I.R.S. making this assessment?

The other reason why it would be desirable to have the boundaries of the system drawn broadly is to minimize the need for copyright protection. The goal of creative work tax credit is to make a large amount of material available to the public which can be transferred at zero cost. Putting more material in the public domain in different areas is a positive benefit, as long as people value this work. The ultimate check on the boundaries of the system is what people are prepared to support with their tax credits. If few people opted to support journalism or video games then these industries would remain largely dependent on copyright protection.

Textbooks

Textbooks are an enormous expense for college students. Households are on a path to spend more than $10.5 billion on textbooks in 2016.[61] With a bit more than 20 million students, this comes to $500 per student. The figure would undoubtedly be considerably higher if we just looked at full-time students. As with prescription drugs, the vast majority of the cost of a textbook is attributable to the copyright monopoly. A single textbook can cost several hundred dollars to buy. Even renting a textbook, which is an increasingly common practice, can often cost $50−$100 for a semester.

Textbooks would be a great area where a system of public funding could produce a large number of textbooks that are not subject to copyright protection. The arithmetic on textbook funding is striking. If the federal government were to appropriate $500 million a year to finance textbook writing and production (at 0.01 percent of federal spending), it would allow for the production of 500 textbooks a year, assuming an annual cost of $1 million per textbook. After 10 years, this would

protection it would still be possible to charge for print versions of newspapers or other publications and to charge for advertising, even if the fees would be considerably lower for material that could be immediately duplicated.

61 Bureau of Economic Analysis (2016), Table 2.4.5U, Line 67. This spending does not correspond exactly to college textbooks because it refers to "educational books," a category that can include some other books that are not college texts.

mean that 5000 textbooks were available in the public domain to be downloaded at zero cost, or printed out in hard copy for the cost of the paper.[62]

In addition to offering enormous cost-savings to students, this sort of system would offer considerably more flexibility to professors. They could freely combine chapters from different textbooks, in order to customize their class for students. Under the copyright system, this sort of mixing of textbooks would likely involve time-consuming and possibly costly permission requests. It would also be a much simpler matter to update a textbook because there would no need to have a complete new edition to add one or two additional topics.

This is an area where long-term contracts with private publishers could work quite well. The contracts in this case, unlike prescription drugs, could be well defined. Publishers could specify how many books they intended to produce and the timeline on which they expected to produce them. Their ability to get subsequent contracts would depend on the quality of the work and the timeliness of the production. Because all of this information would be fully public (the contract, the publication dates, and the books themselves), the problem of political favoritism should be minimized.

Furthermore, this system would not prevent anyone from producing textbooks under the copyright system. If the texts produced through a system of public financing proved to be inferior, few professors would use them, in spite of the potential cost-savings for students. This competition would provide a clear market test of the quality of the publicly financed work.

Conclusion: Savings from Alternatives to Patents and Copyrights

The prior sections suggested alternative mechanisms to patents and copyrights for supporting innovation and creative work in a variety of areas. While prescription drugs and medical equipment are almost certainly the most important area for alternatives to the existing system, there are many other areas in which the current patent and copyright system is likely posing a drag on growth. Switching to a system that relies on alternative mechanisms for supporting patents and copyrights could lead to substantial savings for households and businesses.

62 Because the funding might also be used to finance updates of existing texts, the number of discrete books published through this system might be somewhat less than the simple calculation would indicate.

Table 11 — Total Savings from Patent/Copyright Alternatives

Table 11 shows projected 2016 spending and potential savings in areas where the costs of these monopolies are likely to be largest. For recorded music and video material, as well as recreational books, it is assumed that the savings would be close to 50 percent if there was a fully phased in tax credit system, under the assumption that this would make available a vast amount of free writing, as well as recorded and video material. The savings on educational books is assumed to be 70 percent under the assumption that the bulk of the textbooks used by students would be produced through the publicly funded system. The savings for prescription drugs is based on the calculation in Table 8. It is assumed that the savings in newspapers and periodicals, motion pictures, and cable television would each be 20 percent of total spending, with the assumption that there would be a large amount of free material available leading to less spending in all three areas. (With cable, many people may opt to rely on material received over the Internet and cancel cable subscriptions.) The figure for medical equipment is loosely derived from the earlier calculation in Table 8. The spending figure shown in this table is considerably higher than the one in that table because the number in Table 11 reflects spending to purchase the equipment in 2016 rather than the fees charged to patients. The total potential savings in Table 11 is $434 billion or 2.4 percent of GDP.

The calculations shown in Table 11 must ultimately be speculative because there is no way to determine in advance the effectiveness of an alternative funding mechanism to replace patents and copyrights. As argued in the prior sections, there are good reasons for believing that an alternative would be at least as effective, especially in the case of patents. The prospect of having fully open research, where the incentive is for dissemination rather than secrecy, would almost certainly lead to more rapid progress than the current patent system.

More importantly, the gains from having prices brought in line with production costs would offer enormous gains, especially in the case of drugs and medical equipment. It is difficult to understand the logic of paying for innovation at the point where a patient needs a drug or access to medical equipment. The imposition of monopoly pricing imposes an enormous burden on people at precisely at the time when they are least able to bear it. A payment system should be structured to allow patients and their families to focus on getting well, not paying for their health care. No one would propose determining payments for firefighters at the point where they show up at a burning house with people inside. This effectively what we are doing with patent monopolies in the medical sector. The absurdity is heightened by the fact that the ultimate payment almost always ends up being a political decision, not a matter of consumer choice, so proponents of the patent system can't even use the classic justification for market outcomes.

Weakening or eliminating patent and copyright support for innovation and creative work would radically reduce the enormous waste associated with these systems. The economic system should be structured so that the best way to make profits is to produce better products, not run to court to win awards from profitable companies. Unfortunately, the patent system is increasingly supporting this second path to profits.

Economists have been quite successful in getting the general public to have at least some appreciation of marginal cost pricing. The idea that consumers and the economy benefit from eliminating tariffs and other trade barriers is widely recognized even if not universally accepted. However, there is less public awareness of the much greater gap between prices and the cost of production as a result of patent and copyright monopolies. The costs associated with this gap are enormously larger than the costs associated with the traditional trade barriers that remain, as economic theory predicts. There is little reason to believe that the gain from the innovation and creative work that is induced is remotely comparable, especially when compared with the potential benefits of alternative systems.

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Appendix

Data Sources for Regressions

The regression analysis shown in the third section of this paper used data on total factor productivity from the United Nations Industrial Development Organization. The data on multifactor productivity came from the OECD. Data on labor productivity was taken from the Conference Board (2015). This is also the source for data on GDP per person. The data on the working age population was taken from the OECD. Data on inflation uses the CPI measure of inflation from the OECD. Trade openness was taken as the sum of imports and exports over GDP, as calculated in the World Bank's World Development Indicators. The patent index used is the Ginarte-Park Index of Patent Protection.[63] All regressions used five year averages for changes or levels, as indicated.

63 See: http://fs2.american.edu/wgp/www/res_policy08.pdf.

Tables and Figures

TABLE 1

Legal Changes Affecting Patent and Copyrights Since 1970	
Year	**Legal Changes**
1976	Copyright duration extended to 75 years from 47 years (applied retroactively). End of registration requirement for copyright protection.
1980	Bayh-Dole Act allows universities, research institutions, private companies and individuals operating on government contracts to gain control of patents derived from their work.
1980	Diamond v. Chakrabarty, Supreme Court rules that life forms are patentable.
1981	Diamond v. Diehr, Supreme Court sets rules under which computer software can be patented, formalized by U.S. Patent and Trademark Office in 1996.
1982	Congress creates the United States Court of Appeals for the Federal Circuit to handle patent claims, proves to be more patent-friendly.
1995	TRIPS provisions of the WTO require member countries to adopt U.S.-style patent law. Also extends duration to 20 years from date of issuance, with automatic extensions in cases where approval process was delayed.
1998	Copyright duration extended to 95 years (applied retroactively).
1998	Digital Millennial Copyright Act extended copyright to digital materials. Also established liability for third party intermediaries.
1998	State Street Bank & Trust Co. v. Signature Financial Group Inc., Supreme Court rules that business methods are patentable.
2006	Central America Free Trade Agreement and Dominican Republic — includes "TRIPS Plus" provisions requiring countries to have lengthy periods of data exclusivity when a drug is approved by licensing authority. This excludes generics from the market even when no patents are applicable.
Source and notes: Various sources, see text.	

TABLE PATENT-2

Changes in per capita GDP, 1965–2010

	Coefficients (t-statistics)			
	Model 1: Neither country nor period controls	**Model 2: Country controls, no period controls**	**Model 3: Period controls, no country controls**	**Model 4: Country and period controls**
constant	0.2037707	0.3487479	0.1002102	-0.2429303
	(2.94)***	(2.85)***	(1.29)	(-1.63)
ln patent index	-0.1032489	-0.0827649	-0.0396183	0.0013845
	(-2.91)	(-1.60)	(-1.05)	(0.02)
ln work-age population	0.464919	0.3132187	0.521174	0.3511356
	(1.38)	(1.23)	(1.56)	(1.81)*
ln trade	0.0043149	-0.0538985	0.021499	0.1135512
	(0.44)	(-1.46)	(1.81)*	(2.85)***
ln inflation	-0.0407303	-0.0264452	-0.0366391	-0.0548818
	(-1.06)	(-0.51)	(-0.96)	(-1.05)
N	200	200	200	200
R^2	0.1531	0.4063	0.3820	0.6412

Source and notes: Author's analysis of data, see appendix for sources. Regression coefficients are displayed with t-statistics in parentheses below. All models include controls for the size of the working-age population, trade openness measure, and inflation. Model 1 does not include country nor period controls. Model 2 includes country dummy variables. Model 3 includes period dummy variables. Model 4 includes both country and period dummy variables. * = significant at the 10 percent level; ** = significant at the five percent level; *** = significant at the one percent level.

TABLE PATENT-3

Changes in GDP per worker, 1965–2010

	Coefficients (t-statistics)			
	Model 1: Neither country nor period controls	**Model 2: Country controls, no period controls**	**Model 3: Period controls, no country controls**	**Model 4: Country and period controls**
constant	0.4754902	0.7544953	0.3343841	0.4373479
	(5.56)***	(3.68)***	(4.64)***	(1.83)*
ln patent index	-0.1678423	-0.1061523	-0.0541722	-0.0103371
	(-4.92)	(-1.76)	(-1.51)	(-0.17)
ln work-age population	0.0505526	0.0467049	-0.0093685	-0.0302923
	(0.19)	(0.16)	(-0.03)	(-0.11)
ln trade	-0.0377847	-0.1573356	-0.0137835	-0.068123
	(-2.42)	(-2.32)	(-0.94)	(-0.91)
ln inflation	-0.088317	-0.0732306	-0.0055037	-0.0087448
	(-2.46)	(-1.41)	(-0.20)	(-0.21)
N	237	237	237	237
R^2	0.3368	0.5781	0.4650	0.6505

Source and notes: Author's analysis of data, see appendix for sources.. Regression coefficients are displayed with t-statistics in parentheses below. All models include controls for the size of the working-age population, trade openness measure, and inflation. Model 1 does not include country nor period controls. Model 2 includes country dummy variables. Model 3 includes period dummy variables. Model 4 includes both country and period dummy variables. * = significant at the 10 percent level; ** = significant at the five percent level; *** = significant at the one percent level.

TABLE PATENT-4

Changes in GDP per hour worked, 1965–2010

	Coefficients (t-statistics)			
	Model 1: Neither country nor period controls	**Model 2: Country controls, no period controls**	**Model 3: Period controls, no country controls**	**Model 4: Country and period controls**
constant	0.5054132. (5.64)***	0.8055112 (4.34)***	0.329431 (4.23)***	0.4168739 (1.97)*
ln patent index	-0.1802488 (-4.98)	-0.1211325 (-2.02)	-0.0492493 (-1.25)	-0.0062487 (-0.09)
ln work-age population	-0.002509 (-0.01)	-0.0080342 (-0.03)	-0.0809899 (-0.29)	-0.1555253 (-0.53)
ln trade	-0.0360497 (-2.18)	-0.1627005 (-2.67)	-0.0071119 (-0.43)	-0.0539841 (-0.82)
ln inflation	-0.0842519 (-2.05)	-0.0658873 (-1.23)	-0.0101699 (-0.31)	-0.0134718 (-0.30)
N	237	237	237	237
R^2	0.328	0.5880	0.4715	0.6669

Source and notes: Author's analysis of data, see appendix for sources.. Regression coefficients are displayed with t-statistics in parentheses below. All models include controls for the size of the working-age population, trade openness measure, and inflation. Model 1 does not include country nor period controls. Model 2 includes country dummy variables. Model 3 includes period dummy variables. Model 4 includes both country and period dummy variables. * = significant at the 10 percent level; ** = significant at the five percent level; *** = significant at the one percent level.

TABLE PATENT-5

Changes in Total Factor Productivity, 1965–2010

	Coefficients (t-statistics)			
	Model 1: Neither country nor period controls	**Model 2: Country controls, no period controls**	**Model 3: Period controls, no country controls**	**Model 4: Country and period controls**
constant	0.0225566 (0.41)	0.0269104 (0.25)	-0.07422 (-1.78)	-0.2859386 (-2.01)
ln patent index	-0.0228611 (-1.00)	-0.0357066 (-0.74)	0.0301576 (1.41)	0.086029 (1.49)
ln work-age population	-0.0023232 (-0.02)	0.1863348 (0.69)	0.0310196 (0.20)	0.2477053 (0.89)
ln trade	0.0146855 (1.55)	0.0138754 (0.39)	0.0268298 (3.58)	0.0801022 (1.80)*
ln inflation	-0.0157252 (-0.49)	-0.0164143 (-0.35)	0.0055617 (0.14)	-0.0028974 (-0.05)
N	169	169	169	169
R^2	0.0189	0.1559	0.1701	0.3077

Source and notes: Author's analysis of data, see appendix for sources. Regression coefficients are displayed with t-statistics in parentheses below. All models include controls for the size of the working-age population, trade openness measure, and inflation. Model 1 does not include country nor period controls. Model 2 includes country dummy variables. Model 3 includes period dummy variables. Model 4 includes both country and period dummy variables. * = significant at the 10 percent level; ** = significant at the five percent level; *** = significant at the one percent level.

TABLE PATENT-6

Changes in Multi-Factor Productivity, 1965–2010

	Coefficients (t-statistics)			
	Model 1: Neither country nor period controls	**Model 2: Country controls, no period controls**	**Model 3: Period controls, no country controls**	**Model 4: Country and period controls**
constant	0.1502024 (2.11)**	0.4412658 (3.61)***	0.0983856 (1.31)*	0.1939591 (1.15)
ln patent index	-0.0907325 (-2.58)**	-0.0863463 (-3.37)	-0.0590842 (-1.67)	-0.0909634 (-3.58)
ln work-age population	0.322345 (1.63)	0.2203941 (1.32)	0.319049 (1.65)	0.2197336 (1.84)*
ln trade	0.0038518 (0.38)	-0.0813291 (-2.38)	0.0116108 (1.00)	-0.0082691 (-0.17)
ln inflation	-0.0103441 (-0.10)	-0.0599158 (-0.59)	-0.0247659 (-0.21)	-0.0478406 (-0.50)
N	109	109	109	109
R^2	0.1876	0.6262	0.3114	0.7030

Source and notes: Author's analysis of data, see appendix for sources.. Regression coefficients are displayed with t-statistics in parentheses below. All models include controls for the size of the working-age population, trade openness measure, and inflation. Model 1 does not include country nor period controls. Model 2 includes country dummy variables. Model 3 includes period dummy variables. Model 4 includes both country and period dummy variables. * = significant at the 10 percent level; ** = significant at the five percent level; *** = significant at the one percent level.

TABLE 7

Annual Deadweight Loss Due Patent Protected Drugs

(billions of 2016 dollars)

	Elasticities		
	0.15	0.25	0.5
Free Market Price = 10 percent of current prices	$90.8	$171.2	$475.7
Free Market Price = 20 percent of current prices	$60.1	$109.0	$271.9

Source and notes: Bureau of Economic Analysis (2016) and author's calculations, see text.

TABLE 8

Gains from Ending Patent Protection for Pharmaceuticals and Medical Equipment

(billions of 2016 dollars)

	High Saving	**Middle Saving**	**Low Savings**
Drugs			
Current spending	$430.0	$430.0	$430.0
Patent free cost	$43.0	$64.5	$86.0
Additional research	$37.5	$50.0	$75.0
Net saving	**$349.5**	**$315.5**	**$269.0**
Reduction in Deadweight Loss	$475.70	$140.10	60.1
Total Savings	$825.20	$455.60	$329.10
Medical Equipment			
Current spending	$50.40	$50.40	$50.40
Patent free cost	$15.12	$15.12	$15.12
Additional research	$11.2	14.9	$22.4
Net saving	**$24.1**	**$20.4**	**$12.9**

Source and notes: Bureau of Economic Analysis (2016) and author's calculations, see text.

TABLE 9

Savings to the Government from Publicly Supported Research for Pharmaceuticals and Medical Equipment

(billions of 2016 dollars)

Year	Total	Out-of-Pocket Payments	Health Insurance					Other Third Party Payers
			Total	Private Health Insurance	Medicare	Medicaid	Other Health Insurance Programs	
Projected								
Spending	$342.1	$48.3	$291.8	$142.0	$105.2	$33.8	$10.8	$2.0
Savings	$126.4	$7.7		$22.7	$73.6	$16.9	$5.4	
Medical equipment								
Spending	$50.4	$24.7	$25.0	$8.9	$8.5	$7.4	$0.1	$0.6
Savings	$12.7	$3.5		$1.2	$4.3	$3.7	$0.1	
Total Savings	**$139.1**							

Source and notes: Centers for Medicare and Medicaid Services (2014) and author's calculations, see text.

TABLE 10

Non-Medical R& D Expenditures

(billions of 2012 dollars)

	2012	GDP shares	Tax Credit	
			10%	15%
GDP	$16,155.3			
Total	$302.3	1.87%		
Pharmaceuticals and Medicines	$48.1	0.30%		
Navigational, measuring, electromedical, and control instruments (50%)	$7.975	0.05%		
Electromedical, electricotherapeutic, and other irradiation apparatus	$4.4	0.03%		
Biotechnology research and development	$7.4	0.05%		
All Other	$234.425	1.45%	0.15%	0.22%

Source and notes: National Science Foundation (2012).

TABLE 11

Total Savings from Patent/Copyright Alternatives

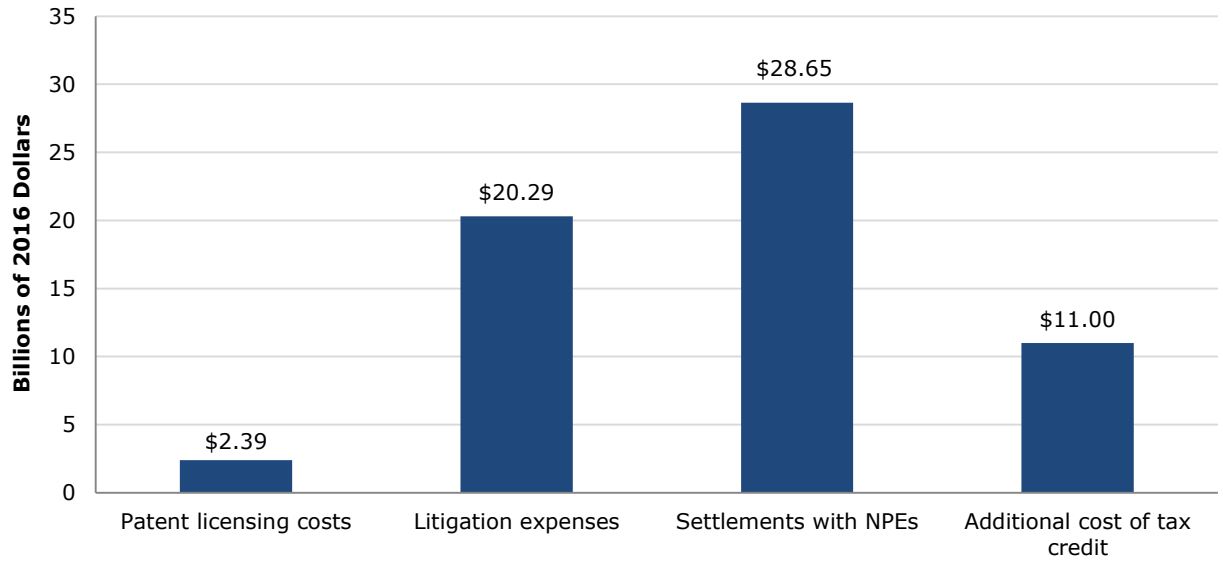
(billions of 2016 dollars)

	Current spending	Potential savings
Recorded music and video material (line 42)	$30.80	$15.40
Educational Books (line 67)	$10.50	7.35
Recreational books (part of 90)	30.2	$15.10
Prescription drugs (line 131)	$430	$315.50
Newspapers and periodicals (line 141)	$61.20	$12.24
Motion Pictures (line 210)	$15.00	$3.00
Cable and satellite television and radio services (line 215)	$95.00	$19.00
Medical Equipment and Instruments (Line 6)	$94.0	$47.00
Total		**$434.59**

Source and notes: Bureau of Economic Analysis (2016), Tables 2.4.5U and 5.5.5U and author's calculations, see text.

FIGURE 1

Expenses Associated with Patents and Cost of Tax Credit



Source and notes: Bessen and Meurer (2012), Levine and Boldrin (2013) and author's calculations, see text.