The Impact of Intellectual Property Protections on Research and Development in India and on the Growth and Wages of Key Indian Industries

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I. Introduction

For most developing countries, modernization requires years of public investments in infrastructure, health and education; difficult reforms to encourage the creation of new businesses; and politically-painful measures to open up their markets to foreign producers, often by cutting tariffs and quotas. With globalization, a nation intent on accelerating its modernization can also get access to advanced technologies and business methods, mainly through foreign direct investments (FDI); and more ambitious developing countries then focus on fostering native industries capable of developing innovations. Yet in both developing and more advanced nations, firms pursue the research and development (R&D) required to come up with new technologies only if they are certain that their intellectual property (IP) rights will be respected.

This study examines the economic impact of India's current IP regime on levels of R&D in India's most advanced industries and the economic benefits that should follow if India strengthens its IP rights and protections. We begin by reviewing the economic impact of IP rights on the development of innovations. While most innovations require costly and risky R&D, nations that invest more in R&D usually experience faster growth and larger productivity gains. One measure of India's prospects for rapid progress, therefore, is the R&D intensity of its key industries, usually defined as the share of an industry's sales or output devoted to R&D.

Next, we examine the extent to which a nation's IP regime determines the R&D intensity of its industries. In recent decades, nations as disparate as the United States and India, Germany and China, Japan and Mexico have upgraded their IP rights and protections. In new research, we found clear relationships over time and across many countries between improvements in the IP regimes and the increasing R&D intensity of their leading industries and their overall economies. We also found significant variations across industries within each country, as well as across nations, in how strongly they responded to improvements in IP rights. On balance, we show that R&D intensity increases as IP protections improve over time; and at any particular time, the R&D intensity of industries is greater where IP rights are more strictly protected.

The United States has the world's strictest IP regime, based on the leading measure of IP rights and enforcement, the Ginarte-Park (G-P) Index. Therefore, we conducted a case study of the United States, analyzing the R&D intensity of its industries and how it affects their growth, employment and wages. We identified those U.S. manufacturing industries with above-average R&D intensity -- including computer and electronic products, pharmaceuticals and chemicals, automobile and aerospace, and electronic equipment and components – and found that from 2000 to 2013, their real value-added increased at more than twice the rate of all U.S. manufacturing. In fact, the value-added of manufacturing industries with below-average R&D intensity actually

[1] We gratefully acknowledge the Pharmaceutical Research and Manufacturing Association for its support for the research for this project. The views and analysis are solely those of the authors.

contracted over this period. We also found that while overall U.S. manufacturing employment also contracted sharply over this period, the average rate of job loss in non-R&D intensive industries, on average, was more than 50 percent greater than the average rate of job loss in R&D intensive industries. Finally, we found that compensation increased some 65 percent faster in R&D intensive industries than in non-R&D intensive industries.

Next, we turned to the R&D intensity of Indian industries. Using Indian Government data, we identified those industries with above-average R&D intensity -- pharmaceuticals and drugs; biotechnology; information technologies; scientific instruments; telecommunications; transportation; and medical and surgical appliances. In fact, the list closely resembles the roster of R&D intensive industries in the United States. We then measured the sensitivity or elasticity of the R&D intensity of these industries to the improvements in India's IP regime from 2000 to 2010, measured by its G-P Index score. The IT, scientific instruments, and transportation industries substantially increased their R&D intensity as India's IP protections strengthened, while the response of drugs and pharmaceutical companies was more moderate. The data also showed that India's medical and surgical instrument firms, biotech companies and telecommunications industry did not respond to the IP improvements by increasing their R&D.

Using these findings, we estimated the extent to which India's most IP-sensitive industries would increase their R&D investments, if India upgraded its IP regime. We posit two scenarios. First, India upgrades its IP rights and enforcement, as measured by the G-P Index, to the level of China, the world's other very large nation at roughly the same stage of development as India. Second, India upgrades its IP regime to the level of the United States, at the top of the G-P Index. Under the China scenario, we estimate that the share of industry output devoted to R&D would rise from 4.9 to 8.8 percent among Indian IT companies, or by 79.8 percent; from 2.8 percent to 3.4 percent in the scientific instruments industry, or by 21.4 percent; from 1.4 percent to 1.5 percent in the transportation sector, or by 7.1 percent; and from 3.2 percent to 3.5 percent across Indian drugs and pharmaceuticals companies (9.4 percent).

Similarly, U.S.-level IP protections would lead to substantially greater R&D commitments in four key Indian industries. We estimate that the share of industry output devoted to R&D would increase from 4.9 percent to 14.6 percent in IT, or by 198.0 percent; from 2.8 percent to 4.1 percent in scientific instruments, or 46.4 percent; from 1.4 percent to 1.8 percent in transportation, or by 28.6 percent; and from 3.2 percent to 3.8 percent in drugs and pharmaceuticals, or 12.5 percent.

We also know from a long line of research that nations with weak IP protections attract little FDI in R&D from multinational companies, so we investigated whether upgrading India's IP regime could increase inflows of FDI in R&D. We found that as India strengthened its IP protections from 2003 to 2009, foreign firms in three industries increased their R&D operations there – automobiles, drugs and pharmaceuticals, and aerospace. We analyzed the elasticity of these increases in FDI in R&D to the improvements in India's G-P Index rating in this period, and applied the findings to our two scenarios for further improvements in India's IP regime. On this basis, we estimate that if India upgraded its IP protections to China's level, inflows of FDI in R&D would increase in the automobile sector from 2.1 percent of its output to 3.0 percent, or by 42.9 percent; and from 1.2 percent to 1.6 percent in the drugs and pharmaceutical sector, or one-third. The response by foreign firms in the aerospace industry was marginal.

Similarly, if India adopted U.S. IP rights and enforcement, inflows of FDI in R&D would increase substantially in the two industries: We estimate that the inflows of FDI in R&D would rise from 2.1 percent to 4.3 percent of the output of foreign automobile producers in India sector, or by nearly 105 percent, and from 1.2 percent to 2.2 percent of the output among foreign drugs and pharmaceuticals companies, or 83.3 percent.

Finally, we analyzed how increases in R&D affect growth and wages in key Indian industries. This analysis relied on different industry groupings than the preceding analyses, because Indian statistics on value-added, employment and wages by industry are organized differently. Here, we focused on four R&D intensive industries that broadly corresponded to the classifications used earlier: drugs, pharmaceuticals and biotechnology; computers and electronics (IT), machinery and equipment (scientific instruments); and transport equipment (transportation).

First, we tracked changes in value-added, employment and wages in those four industries over the period of 2001 to 2007, as India's IP regime improved. We tested the proposition that increases in R&D intensity associated with improvements in IP protections also boost growth and wages, by calculating the sensitivity or elasticity of value-added per employee and wages per employee in each industry to their increases in R&D intensity. We found that among Indian transportation companies, scientific instrument firms, and Indian drugs, pharmaceuticals and biotechnology companies, increases in R&D intensity were accompanied by significant gains in value-added per employee and moderate gains in wages per employee. The value-added response by IT companies was weaker, but their response on wages was stronger.

Using this analysis, we estimated the impact of further improvements in India's IP regime on the value-added and wages per employee of the four industries. Under the first scenario, in which India upgrades its IP protections to China's level, we estimate that over five-to-ten years, value-added per employee would increase about 22 percent in the transportation industry, 13 percent in the scientific instruments industry, more than 10 percent in the drugs, pharmaceuticals and biotech industry, and just under 4 percent in the IT sector. All of these increases would come on top of each industry's current rising trend of value-added. Such additional improvements in India's IP regime also should boost wages per employee, over time and on top of each industry's current trend of wage increases: We estimated those additional wage gains at nearly 4 percent in the IT industry, 2.4 percent in both the scientific instruments industry and the drugs, pharmaceuticals and biotechnology industry, and 1.6 percent in the transportation sector.

As expected, the projected gains are considerably large under the second scenario, in which India adopts U.S.-level IP rights and protections. Under these conditions, we estimate that over five-to-ten years, value-added per employee would increase 55.5 percent in the transportation industry, almost 33 percent in the scientific instruments industry, about 26 percent in the drugs, pharmaceuticals and biotech industry, and more than 9 percent in the IT sector. Again, all of these increases would come on top of each industry's current trend of increases in value-added per employee. Under this scenario, we also would expect to see increases in wages per employee, over time and on top of each industry's current wage trends, of nearly 10 percent in the IT industry, about 6 percent in both the scientific instruments and the drugs, pharmaceuticals and biotechnology industries, and 4 percent in the transportation sector.

We also estimated the impact on value-added and wages of increases in inflows of FDI in R&D. Based on our analysis of the impact of India's IP regime on those inflows, we focused on the automobile and aerospace industries, combined here into a transportation industry grouping, and on the drugs, pharmaceuticals and biotechnology industry group. We calculated the elasticity of each industry grouping's value-added and wages per employee, over time, to the its foreign R&D intensity, and found that value-added responded strongly to increases in FDI in R&D in the transportation sector, and responded more moderately in the drugs, pharmaceuticals and biotech industry. As with native companies, the wage responses to more FDI in R&D were weaker.

Finally, we applied those elasticity results to estimate how additional improvements in India's IP regime could affect value-added and wages in these industries. If India adopts IP protections equivalent to China, FDI in R&D should increase sufficiently to lift value-added per employee, over time, by about 16 percent in the transportation sector and by more than 7 percent in the drugs, pharmaceuticals and biotechnology sector. In both cases, these increases would come on top of the industries' existing rates of growth in value-added per employee. As before, the impact on wages is smaller: We estimate that the IP improvements would boost FDI in R&D sufficiently to increase wages per employee, over time, by about 2 percent in the transportation sector and nearly 3 percent in drugs, pharmaceuticals and biotechnology, on top of each industry's current path of wage increases. The second scenario, in which India's adopts the IP regime of the United States, naturally produced larger results. We estimate that under those conditions, value-added per employee would increase, over time, by as much as 40 percent in the transportation industry and by more than 18 percent in drugs, pharmaceuticals and biotech; and wages per employee would also increase, over time, by about 5 percent in the transportation sector and by just under 7 percent in the drugs, pharmaceuticals and biotech industry.

In summary, the research and analysis presented in this study establish the importance of IP rights in determining how much firms and industries invest in R&D and, as a consequence, how fast an industry grows and the wages it pays. The degree of importance varies from nation to nation and from industry to industry. However, most R&D intensive industries respond to improvements in a nation's IP regime by increasing R&D investment. The analysis shows that India's capacity to foster and promote advanced industries capable of meaningful innovation will depend on India's willingness to improve its IP regime. If it does so, the R&D intensity of many key Indian industries should increase substantially, and their value-added and wages per employee also should rise.

II. The Economic Significance of Intellectual Property Rights

Since the early-19th century, economists have investigated the roles and importance of various factors that influence economic development and growth. In recent decades, a general consensus emerged that how fast an economy grows at any given time depends on how many people work, how much capital equipment they have to work with, and how the political and social environment promotes or impedes economic activity.[2] There is also broad agreement that an economy's capacity to *increase* its growth and productivity depends mainly on its capacity for innovation – its pace in developing new technologies and ways of conducting business; how well its businesses adopt innovations; how effectively its workers deal with innovations, and whether the political and economic environment promotes or impedes these developments.[3]

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[2] Ramsey (1928); Solow (1956); and Koopmans (1965).
[3] Romer (1986); Lucas (1988); Rebelo (1991); and Barro (1996).

Once economists established the factors that determine how fast an economy grows, they faced new questions about why various nations grow at such disparate rates. It was clear that most successful advanced economies grow more slowly than most successful developing economies; and this pattern led to new theories of "convergence." These theories posited that over time, the practices and income levels of economies tend to converge, especially across nations with generally free markets, comparable legal protections for contracts and property rights, and similar behavior with regard to saving, work, and fertility.[4] One reason is that firms in developing economies can adopt the innovations developed by firms in more advanced countries without bearing the costs to develop them. It also was clear that some developing economies grow more rapidly than others, as some advanced economies grow faster than others. Much of those differences depend on the quality of a country's institutions: The United States has grown faster than Germany or Japan in recent decades, and China has grown faster than India, in large part because their political and social environments more effectively support and promote economic activity generally and the spread and application of innovations in particular.

In this study, we focus on the dynamics that support or impede such innovation, particularly through R&D investments. Most innovations require substantial R&D, and countries that invest more in R&D, along with education and training, tend to experience faster growth. One measure of an economy's capacity for development and progress, therefore, is the "R&D intensity" of its industries, which is usually defined as the share of an industry's sales or output devoted to R&D. Since R&D is costly and risky, the only economic justification for most firms for bearing its costs – and forgoing more certain returns by using resources in more typical ways -- is the prospect of much larger returns in the future.[5]

Many studies have established that most firms undertake costly R&D if they are confident of earning above-normal profits on any innovations which result.[6] Moreover, it is axiomatic that such profits are hard to achieve if other companies can copy the innovations of other firms at will and without compensation. Strict IP rights and enforcement, therefore, are usually needed to protect those returns.

The link between innovation and IP rights and protections has been well-established in modern economics. In 1997, economists from the World Bank and American University constructed an index of patent rights, the Ginarte-Park (G-P) Index, to help them study the relationships between patent rights in 60 countries and R&D, investment and growth.[7] They found strong, positive relationships, especially in higher-income countries. A subsequent study by Park found that over the period 1980 to 1995, R&D and productivity across 21 OECD countries increased with improvements in patents rights.[8] Similarly, another study of 32 countries between 1981 and 1990 found that the countries with stronger IP rights were more R&D intensive, as measured by R&D expenditures as a share of GDP.[9] Yet another analysis found that improvements in patent protections were strongly associated with higher rates of scientific

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[4] Barro (1996).
[5] For a literature review of the links between innovation and IP protections, see Kanwar and Evenson (2001).
[6] Romer (1990); Aghion and Howitt (1992); and Grossman and Helpman (1991).
[7] Ginarte and Park (1997).
[8] Park (2008).
[9] Kanwar and Evenson (2003).

discovery, inventions and innovations.[10] Finally, a study of 54 manufacturing industries in 72 countries from 1981 to 2000 found that in countries with strong IP protections, patent-intensive industries grow substantially faster than less R&D/patent-intensive industries.[11]

While the preponderance of evidence confirms the economic view that IP rights are vital to the development process for innovative technologies, which in turn help drive growth and economic progress, some critics continue to insist that developing nations with weak IP protections benefit by appropriating the IP of companies from more advanced nations. In fact, numerous researchers have found that the costs to a developing nation of ignoring the IP rights of foreign companies exceed the benefits. In one study, researchers confirmed that innovating firms care about the strength of their patents not only in the place where they develop their innovations, but also in other countries.[12] Moreover, the economic logic linking the development of new technologies and patent protections in foreign markets pivots on R&D: The prospect that an innovator can earn profits in a larger market directly stimulates R&D spending by expanding the potential customer base and raising the potential rate of return on the R&D.[13]

Furthermore, studies also have established that developing economies benefit from respecting IP rights at least as much as advanced economies. One major investigation examined 95 countries from 1960 to 1988 and found that patent rights affect growth in all cases, with the greatest impact in both the high-income countries where most innovations are developed and low-income countries where strong IP rights encourage imports of innovations.[14] These results were confirmed by another study of 80 countries over four time periods covering 1975 to 1994.[15] Its' authors found that strong IP protections stimulated growth to an even greater degree in countries with relatively low *per capita* incomes than in places with high *per capita* incomes, by encouraging imports and FDI from advanced countries and by promoting native innovation.[16]

Other studies have shown that countries with weak IP rights attract less FDI, especially FDI in R&D, and that the investments they attract are technologically less sophisticated.[17] One recent analysis found that in countries with weak IP protections, foreign companies focus on developing distribution channels for their products, versus countries with stronger IP protections where foreign firms focus on shifting their technologies and sometimes their R&D.[18] A number of researchers also have found that countries that fail to aggressively respect IP rights have more difficulties achieving economic growth through technology transfers. One study looked at how reforms in IP rights in 16 countries over the period 1982 to 1999 affected technology transfers by U.S. multinational firms to their foreign affiliates.[19] The research showed that royalty payments to parent companies for the use or sale of technologies transferred to their affiliates increased at times of IP reforms, as did R&D carried out by their foreign affiliates as a complement to the

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[10] Chen and Dahlman (2004).
[11] Hu and Png (2012).
[12] Diwan and Rodrik (1991).
[13] Cadot and Desruelle (1998); Rivera-Batiz and Oliva (2003).
[14] Gould and Gruben (1996).
[15] Falvey, Greenaway and Foster (2004).
[16] *Ibid.* In some middle-income countries, the positive effects of patents on growth from imports and FDI were offset by the potential costs for domestic imitators, slowing their production and the diffusion of new knowledge.
[17] Lee and Mansfield (1996).
[18] Smarzynska (2002).
[19] Branstetter, Fishman and Foley (2005).

technology imports from parent companies.[20] These dynamics also inform a World Bank study which found that during periods of IP reforms, the share of global trade comprised of knowledge-intensive or high technology products rose sharply.

As these studies suggest, foreign-based firms that expect to have their patents respected in other countries are more likely to invest in research that would be particularly beneficial to those countries.[21] More generally, foreign firms often shift some of their R&D to developing countries that respect their IP rights, directly increasing the IP-intensity of those industries in those countries. Such transfers benefit domestic industries in other ways: A 2000 study of investment flows to a number of developing countries found that as a country's IP protections increase and foreign R&D operations expand, domestic firms also focus more on R&D and developing other new intangible assets, with significant positive effects on economic growth.[22] These findings suggest a clear virtuous circle. Countries that respect IP rights encourage both native companies to undertake R&D and foreign firms to undertake FDI in R&D as well as transfer their advanced technologies; and these developments lead to higher growth, which encourages more R&D and FDI.

III. The Impact of Intellectual Property Rights on an Industry's R&D Intensity

Since intellectual property has value, and the recognition and enforcement of the IP rights of a firm or individual protect that value, we should expect to observe a relationship between the provision and enforcement of IP rights and an industry's IP or R&D intensity. In particular, IP rights and enforcement allow a firm or industry to earn greater revenues from the goods or services which embody their IP, which in turn justify the costs entailed to develop the IP and produce the goods or services. Without the rights protected by patents and copyrights, a competitor can reproduce the IP and sell the goods or services which embody it at much lower prices, based on their marginal costs of production without taking account of the R&D investments required to develop the underlying IP.

As expected, IP rights and enforcement vary widely across nations; and while most countries have improved their IP protections in recent years, there are countries in which those protections have deteriorated. The G-P Index of patent rights is the most widely used measure of IP protections across nations. A nation's index score is the un-weighted sum of its scores in five areas –, the coverage of its patents, patent direction, patent enforcement, special restrictions on patents, and a country's membership in international treaties protecting IP rights. The G-P Index tracked patent rights in various countries from 1960 to 2005 and in 2010 issued a new version to take account of developments such as the arbitration process created by the World Trade Organization (WTO) and the standards for IP protection established by the "Agreement on Trade-Related Aspects of Intellectual Property Rights" (TRIPS), changes in patent operations to conform with agreements such as NAFTA and the European patent convention, and new standards to protect software, biotechnology and other emerging technologies. The G-P Index has consistently found that the United States has the strongest patent rights and protections. Among the countries listed below, patent protections improved in 13 countries from 1960 to 2005, from the United States to India and Mexico, and deteriorated in only three nations (Brazil, Burma and Malaysia).

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[20] The countries include Argentina, Brazil, China, Indonesia, Japan, South Korea, Mexico, Spain, Thailand, Turkey.
[21] Lanjouw and Cockburn (2000).
[22] Claessens and Laeven (2002).

Table 1: Ginarte-Park Index Ratings, Selected Countries, 1960-2010[23]

Country	2010	Average 1960-2005	Change from 1960-2005 Average
USA	4.88	4.36	+ 0.52 (11.9%)
Chile	4.68	2.72	+ 1.96 (72.1%)
Japan	4.67	3.43	+ 1.24 (36.2%)
France	4.67	3.66	+ 1.01 (27.6%)
Netherlands	4.67	3.72	+ 0.95 (25.5%)
Germany	4.67	3.72	+ 0.95 (25.5%)
Singapore	4.21	2.36	+ 1.85 (78.4%)
China	4.21	2.39	+ 1.82 (76.2%)
India	3.76	1.45	+ 2.31 (159.3%)
Mexico	3.75	1.53	+ 2.22 (145.1%)
Colombia	3.43	3.43	0 (0.0%)
Indonesia	2.77	0.82	+1.95 (237.8%)
Pakistan	2.23	1.28	+ 1.28 (74.2%)
Malaysia	2.11	3.68	- 1.57 (- 42.7%)
Brazil	1.68	3.43	- 1.75 (- 51.0%)
Burma	0.06	0.20	- 0.14 (- 70.0%)

The economic weight or importance of IP varies across industries as well as across nations. This weight is referred to as "IP or R&D intensity." IP or R&D intensity can be measured in various ways, such as the number of patents in an industry as a fraction of the number of employees or, more commonly, an industry or nation's R&D spending as a share of total sales or business revenues. There has been relatively little analysis of R&D intensity across industries and nations; but a recent report by the Congressional Research Service (CRS) compared R&D spending as a fraction of sales across high-tech manufacturing industries in selected OECD countries.[24] The CRS focused on these industries, because economists have found that they also can produce substantial, positive spillovers for other industries. The OECD defines this sector to include pharmaceuticals; office, accounting, and computing machinery; radio, television and communications equipment; medical, precision and optical instruments; and aircraft and spacecraft. CRS found that in 2006, U.S. manufacturers were more R&D intensive in certain industries, such as electronic instruments; Japanese manufacturers, in office, accounting and computing machinery; and Italian manufacturers, in aircraft and aerospace.

To analyze the relationship between a country's IP protection and the IP or R&D intensity of its industries, we first collected data from the OECD's STAN database on the R&D intensity of different industries, as measured by total R&D expenditures as a share of sales, for different countries.[25] The OECD countries do not include a representative sample of developing and emerging economies, but they include countries with a wide range of IP protections, as measured by the G-P Index. These data allow us to derive a relationship between R&D intensity and the

[23] Park (2008).
[24] Levinson (2014).
[25] OECD, STAN Indicators.

levels of IP protection for the industries highlighted in the 2014 CRS report. For comparison purposes, we also analyze the R&D intensity of certain other manufacturing industries such as motor vehicles, and for manufacturing as a whole.

The countries examined here include Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, and the United States. Our data cover 1995 to 2009, although the sample size varies from country to country and from industry to industry. First, we calculated the relationship over time between changes in R&D spending as a share of sales for each industry and changes in a country's score on the G-P index, which provides a measure of the long-term elasticity of an industry's IP protection.

To obtain the relationship between the R&D intensity of these industries and a country's G-P Index score, we calculated the relationship or elasticity between changes in a country's IP protections and changes in the R&D intensity for each industry in the country. For example, the R&D intensity of manufacturing in Austria increased 42 percent from 1998 to 2009, and Austria's score on the G-P Index improved by nearly 3 percent over the same years, producing an elasticity value of 14.1. (We could not include the United States and United Kingdom here, because their very high G-P Index scores did not change from 1995 to 2010; their omission does not affect the correlations for countries which did improve their G-P Index rating.) The results for the other countries, by industry, are provided in the Appendix, Table 1. We can also gauge the relative R&D responsiveness of each industry to changes in IP protections by averaging the elasticity values for each industry across the countries. Those results are provided in Table 2, below. The results are very similar to what we find by conducting regressions of the R&D intensity of each industry in each country on the country's G-P Index score in each year.

Table 2: Average Elasticity of IP-Intensity to IP Protections, By Industry, Across Countries

Industry	Elasticity
Manufacturing	4.84
Chemicals, Plastics, Rubber, Fuels	1.47
Pharmaceuticals	4.98
Office, Accounting, and Computing Machinery	9.88
Electrical Machinery	7.61
Radio, TV and Communications Equipment	4.43
Medical, Precision, and Optical Instruments	8.19
Motor Vehicles	4.47
Aircraft and Spacecraft	6.19
High Technology Manufactures	1.24

These positive elasticity values show clearly that R&D investments respond to improvements in IP protections, across industries and countries. (For more detailed results, see Appendix, Table 1). The results also show variations across industries in the degree of responsiveness: When countries improve their IP protections, R&D investments as a share of sales increase the most, on average and across countries, in industries that include computers and peripherals (office, accounting and computing machinery), electrical machinery, and medical, precision and optical instruments. A more average response is evident in manufacturing, pharmaceuticals, telecommunications, aircraft and spacecraft, and motor vehicles. The analysis also found below-average elasticity values for some commodity industries (chemicals, plastics, rubber and fuels) and, surprisingly, for high-technology manufacturing. These results also are subject to certain caveats. As noted earlier, the analysis did not include the United States and United Kingdom, because their G-P Index scores did not change over this period. The United States accounts for substantial shares of worldwide R&D in certain industries, including pharmaceuticals and telecommunications; and its exclusion from the analysis may bias the elasticity results for those industries. In addition, declining R&D intensity in manufacturing and high-technology manufacturing in countries such as Norway and Sweden may reflect a secular decline in those industries in those countries rather than the changes in their G-P index scores.

Elasticity analysis depends on time-series changes. However, we also can explore these questions by performing cross-sectional regressions to test how in a given year variations in the G-P Index score result in differences in R&D intensity, by industries and across countries. (This approach allows us to include the U.S. and U.K.) Once again, the results for each country are provided in the Appendix, Table 2: U.S., U.K., Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Mexico, Netherland, Norway, Poland, Portugal, Spain and Sweden. Here, we present the average cross-sectional correlation value for each industry across countries. (Table 3, below)

Table 3: Average Cross-Sectional Correlation, Across Countries, between An Industry's IP-Intensity and a Country's IP Protections

Industry	Elasticity
Manufacturing	0.44
Chemicals, Plastics, Rubber, Fuels	- 0.06
Pharmaceuticals	0.19
Office, Accounting, and Computing Machinery	0.41
Electrical Machinery	0.26
Radio, TV and Communications Equipment	0.33
Medical, Precision, and Optical Instruments	0.05
Motor Vehicles	0.38
Aircraft and Spacecraft	0.48
High Technology Manufactures	0.68
Average	0.32

The results establish a high, positive correlation between the R&D intensity of an industry and the strength of the IP protections of the country where it is located.

IV. The R&D Intensity of Industries When IP Rights are Strictly Enforced: A Case Study of the United States

The preceding analysis establishes a clear relationship or link between the R&D intensity of particular industries and levels of IP protections across countries and over the last two decades. We found that countries' investments in R&D across industries are highly and positively correlated with improvements in those countries' IP protections, as measured by the G-P Index. As IP protections improve over time, R&D intensity increases; and at any particular time, the R&D intensity of industries is greater in countries with stricter IP protections. Here, we will focus on the relationship between IP protections and R&D intensity in the United States, a country with consistently strict IP protections. We will analyze how American R&D intensive industries have affected U.S. growth relative to other less R&D intensive industries, and how an industry's R&D intensity affects its employment and wages. Since value-added is a better measure of the contribution of IP to a firm or industry than its share of GDP, we will examine the growth in real value-added for U.S R&D-intensive industries, versus its non-R&D-intensive industries. In this way, we can better understand how IP protections affect the development of certain industries and the related consequences for their employment and wages.

We begin with data from the OECD STAN database discussed earlier. One drawback of that database is its focus on manufacturing. Many service industries are very R&D intensive, especially in developed economies such as the United States; nevertheless, this database aggregates all service industries and sub-industries into one "Total Services" category. This drawback, however, should not significantly affect our analysis, since our goal is to assess the impact of stricter IP protections on the R&D intensity of Indian industries, and data on R&D in Indian service industries also are unavailable.

According to the OECD data, the most R&D-intensive U.S. manufacturing industries are pharmaceuticals; medical, precision and optical instruments; radio, TV and communications equipment; aircraft and spacecraft; and other high-technology manufacturing. (Table 4, below) We note that the OECD classifies pharmaceuticals separately from basic chemicals, while U.S. industry classifications combine them.[26]

Table 4: R&D Intensity in Selected U.S. Manufacturing Industries (OECD), 2007-2008

Industry	R&D Intensity
Overall Manufacturing	3.35
R&D Intensive Industries	
Pharmaceuticals	24.47
Radio, TV and Communications Equipment	18.76
Medical, Precision, and Optical Instruments	18.34
High Technology Manufactures	16.89
Aircraft and Spacecraft	15.35
Office, Accounting, and Computing Machinery	13.57
Average	17.90
Non-R&D Intensive Industries	
Chemicals, Plastic, Rubber, and Fuels	4.01
Motor Vehicles	3.25
Electrical Machinery	2.45
Average	3.27

[26] The data presented here are from 2008 for all industries except high-tech manufacturing and chemicals, plastics, rubber and fuels, for which the STAN database provides only 2007 data.

The National Science Foundation (NSF) has issued more recent (2011) and detailed data on the R&D intensity of U.S. manufacturing industries.[27] Across all manufacturing, the ratio of R&D to domestic sales was 3.9 or moderately higher than the OECD estimate. Table 5 presents data for five R&D intensive industries (R&D intensity of more than 3.9, averaging 5.3) and nine less R&D intensive industries (R&D intensity of less than 3.9, averaging 1.2).

Table 5. R&D Intensity in Selected U.S. Manufacturing Industries (NSF), 2011

Industry	R&D Intensity
All Industries	3.2
All Manufacturing	3.9
IP-Intensive Industries	
Computer and Electronic Products	9.9
Chemicals (including Pharmaceuticals)	4.8
Transportation Equipment	4.8
Machinery	3.8
Electrical Equipment, Appliances & Components	3.3
Simple Average	5.3
Non-IP-Intensive Industries	
Non-Metallic Mineral Products	2.3
Fabricated Metal Products	1.6
Plastics and Rubber	1.4
Paper	1.3
Textiles, Apparel and Leather Products	1.2
Furniture and Related Products	1.0
Food and Beverage Products	0.8
Wood Products	0.8
Primary Metals	0.4
Simple Average	1.2

Next, we use this classification to explore whether the R&D intensity of these American industries affects its growth rate: In an environment where IP is strictly protected, do R&D intensive industries grow faster than average or faster than non-IP intensive industries? To answer this question, we analyze changes in the relationship between an industry's R&D intensity and rates of change in the real value-added each industry produced from 2000 to 2013.[28] The analysis found significant differences between those industries with above-average R&D intensity and those with below-average R&D intensity.

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[27] National Science Foundation (2011).
[28] Bureau of Economic Analysis (2015-A).

Table 6: Change in Real Value-Added for IP-Intensive and Non-IP-Intensive Industries, 2000-2013 (Chained 2009 Dollars)

Industry	2000 ($ billions)	2013 ($ billions)	Average Annual Growth
All Industries	**10826.2**	**13482.8**	**1.70%**
All Manufacturing	**1603.3**	**1862.6**	**1.16%**
R&D Intensive Industries			
Computer and Electronic Products	91.8	273.3	8.75%
Chemicals (including Pharmaceuticals)	263.4	297.2	0.93%
Transportation Equipment (Autos & Aerospace)	199.2	266.2	2.26%
Machinery	130.2	140.5	0.59%
Elec. Equipment, Appliances & Components	53.6	48.7	-0.73%
Average	**147.6**	**205.2**	**2.36%**
Non-R&D Intensive Industries			
Non-Metallic Mineral Products	51.2	39.2	- 2.03%
Fabricated Metal Products	162.1	139.5	- 1.15%
Plastics and Rubber	78.5	67.8	- 1.12%
Paper	72.5	47.7	- 3.17%
Textiles, Apparel and Leather Products	49.3	26	- 4.80%
Furniture and Related Products	40.7	24.8	- 3.74%
Food and Beverage Products	209.9	220	0.36%
Wood Products	25.1	22.1	- 0.97%
Primary Metals	46.9	56.8	1.48%
Average	**81.8**	**71.5**	**-1.68%**

This analysis suggests a general relationship between relative R&D intensity and growth in value-added for U.S. manufacturing industries over this period. The real value-added of industries with above average R&D intensity increased, on average, at more than twice the rate (2.36 percent per-year)[29] of all manufacturing (1.16 percent per-year) and nearly 40 percent more than all industries (1.7 percent per-year). Computers and electronic products dominated this result: Excluding that industry, the real value-added of the other four R&D intensive industries grew on average 0.76 per year. Nevertheless, the value-added of R&D intensive manufacturing grew faster than the value-added of non-R&D intensive manufacturing, which *contracted* at an average annual rate of 1.68 percent in this period. Only two of the nine non-R&D intensive industries – food and beverage products, and primary metals -- experienced net increases in real value-added from 2000 to 2013, and that largely reflected rising commodity prices.

These findings are in line with a 2007 study that analyzed the impact of R&D intensity on GDP using NSF data for 2000 to 2004.[30] The authors defined R&D intensity as the ratio of R&D expenditures to employment and identified four industries as R&D intensive: petroleum and coal products; chemicals (including pharmaceuticals); computers and electronic products; and transportation equipment. Using the ratio of R&D to employment explains why this study found petroleum and coal products to be R&D intensive: From 2000 to 2013, as energy prices generally

[29] If we exclude electrical equipment, appliances and components, we get an annualized growth rate of 2.59 percent.
[30] Shapiro and Pham (2007).

rose, the real value-added of the petroleum and coal products industry rose at a 1.33 percent average annual rate, consistent with industries classified as R&D intensive.[31]

We also find significant differences in job and compensation rates among U.S. manufacturing industries based on their R&D intensity. (Table 7, below) U.S. manufacturing employment contracted sharply from 2000 to 2013, with average annual losses of nearly 2.8 percent per-year. However, R&D intensive manufacturing industries shed jobs at an average rate of less than 2.3 percent per-year, compared to losses averaging 3.6 percent per-year among non-R&D intensive industries. Therefore, the annual rate of job losses was 57 percent greater in non-R&D intensive manufacturing than in R&D intensive manufacturing. This period also saw wage stagnation across much of the U.S. economy. Nevertheless, compensation in R&D intensive manufacturing grew at an average annual rate of 0.77 percent, versus 0.47 percent across all industries and 0.46 percent among non-R&D intensive manufacturing. Based on these data, the average annual rate of compensation growth across R&D intensive manufacturing was more than 67 percent greater than for non-R&D intensive manufacturing.

Table 7: Average Annual Gains in Manufacturing Employment and Wages, IP-Intensive and Non-IP Intensive U.S. Industries, 2000-2013[32]

Industry	Average Annual Employment Gains	Average Annual Gains in Compensation
All Industries	0.19%	0.47%
All Manufacturing	-2.78%	0.62%
IP-Intensive Industries		
Computer and Electronic Products	-1.58%	0.59%
Chemicals (including Pharmaceuticals)	-3.98%	0.95%
Transportation Equipment (Autos & Aerospace)	-2.35%	0.24%
Machinery	-2.08%	0.51%
Elec. Equipment, Appliances & Components	-3.52%	1.56%
Average	-2.28%	0.77%
Non-IP-Intensive Industries		
Non-Metallic Mineral Products	-0.60%	0.25%
Fabricated Metal Products	-7.82%	0.32%
Plastics and Rubber	-4.23%	0.52%
Paper	-3.69%	0.50%
Textiles, Apparel and Leather Products	-2.85%	1.14%
Furniture and Related Products	-3.09%	0.43%
Food and Beverage Products	-3.32%	0.37%
Wood Products	-1.64%	0.28%
Primary Metals	-4.86%	0.30%
Average	-3.57%	0.46%

[31] A recent study by Hassett and Shapiro (2011) defines intellectual capital more broadly, covering the value of patents, copyrights, databases, software and business methods. This broader definition procures a larger set of industries dominated by intellectual capital.

[32] Bureau of Economic Analysis (2015-B).

V. The R&D Intensity of Indian Industries

Our preceding analysis established relationships between IP protections and an industry's R&D intensity over time within a country and across countries at a given time. The analysis also established a relationship across the American economy between an industry's R&D intensity and the rate of growth of its value-added, employment, and wages. Here, we will explore whether the Indian economy supports or accommodates similar relationships.

Our investigation begins with data on R&D by industry in India, issued in the annual reports of India's Department of Science and Technology (DS&T).[33] These data allow us to track the R&D intensity of Indian industries, defined as an industry's R&D as a share of that industry's output. We focus here on the period from 2000/2001 to 2009/2010, during which India became compliant with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and its G-P Index score for IP rights increased from 2.27 to 3.76, or 65.8 percent.[34] We also focus on those industries with above-average R&D intensity in 2010 – biotechnology,[35] pharmaceuticals and drugs, information technology, scientific instruments, telecommunications, transportation, and medical and surgical appliances. Using these data, we measure the sensitivity or elasticity of each industry's R&D intensity to India's improvements in its IP regime.

The data show a range of sensitivity or elasticity of the R&D intensity of Indian industries to India's improved IP regime. To begin, the most R&D-intensive Indian industries at the beginning of this period were not the most responsive to the improvements in IP protections. Over this period, the R&D intensity of the drugs and pharmaceutical industry increased from 2.32 to 3.22, a substantial increase of nearly 40 percent.[36] (Table 7 below) However, several industries with significantly lower R&D intensity in 2000/2001 increased their R&D spending as a share of revenues to a greater degree. From 2000 to 2010, the information technology industry raised its R&D intensity more than four-fold, the scientific instruments sector more than doubled its R&D intensity, and the transportation industry increased its R&D intensity by nearly 70 percent. In addition, Indian medical and surgical appliance companies, the least R&D-intensive of the seven industries with above average R&D intensity in 2000/2001, raised its R&D intensity level by more than 22 percent. Finally, biotechnology and telecommunications, the remaining two R&D-intensive industries, did not respond to India's IP improvements by increasing R&D spending as a share of output. There are no grounds to hold that India's IP improvements in some way led to this result, and we believe that the stagnation or decline in the R&D-intensity of Indian biotechnology and telecommunication firms was unrelated to India's IP upgrades. In this regard, some analysts have noted that India's biotechnology firms have been largely unable to discover and commercialize new products for some time,[37] and Indian domestic telecommunications companies often focus on innovations for internal use rather than as products for the market.[38]

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[33] Government of India (2013-A)

[34] The data are available starting in 1994/1995, but due to changes in the industry classification system, a consistent series of these data is available only from 2000/2001 on. For analysis of earlier periods, see Bagchi (2013) and Sheeja (2013).

[35] Indian industry analysts define biotechnology firms as those which use "living organisms or parts thereof to make or modify products, improve plant or animal productivity or develop micro-organisms for specific uses." Visalakshi *(2008)*

[36] For a more detailed analysis of trends in the Indian pharmaceutical industry, see Joseph (2011).

[37] Nayak (2001).

[38] Malik and Ilavarasan (2011).

Table 8: The R&D-Intensity of Indian Industries and Improvements in IP Rights in India, 2000/2001 and 2009/2010

	2000/2001	2009/2010	Change	Elasticity: R&D Intensity and the G-P Index
G-P Index Rating	**2.27**	**3.76**	**65.8%**	**--**
R&D Intensity				
All Private Industries	0.61	0.82	34.4%	0.52
IP/R&D-Intensive Industries				
Information Technology	0.90	4.87	441.1%	6.70
Scientific Instruments	1.41	2.83	100.7%	1.53
Transportation	0.81	1.37	69.1%	1.05
Drugs & Pharmaceuticals	2.32	3.22	38.8%	0.59
Medical & Surgical Appliances	0.76	0.93	22.4%	0.34
Biotechnology	1.81	1.81	0.0%	0.00
Telecommunications	1.25	1.24	- 0.8%	- 0.01

The Impact of Improvements in India IP Regime on R&D by India's IP-Intensive Industries

Next, we assume that most Indian industries would respond to further improvements in the nation's IP regime in much the same way as they responded to the improvements from 2000/2001 to 2009/2010, with respect to their R&D investments and consequent R&D intensity. In this regard, we examine two scenarios. The first scenario assumes that India undertakes reforms that upgrade its IP regime to the level of China and its 4.21 score on the G-P Index. The second scenario assumes that India upgrades its IP regime to the level of the United States with a G-P Index score of 4.88. The India-China scenario assumes a 12 percent improvement in India's IP regime, and the India-U.S. scenario assumes a 29.8 percent improvement.

To see how such improvements could affect the incentives for Indian companies in various industries to increase their R&D investments, we apply the elasticity values developed above (Table 8 above) and project the consequent changes in the R&D intensity of those industries. The projected changes equal the elasticity times the percent-changes in the G-P Index, and the results are presented in Tables 9-A and 9-B. Since there is no empirical evidence of a relationship between India's IP improvements and the declining rates of R&D investment by the Indian biotechnology and telecommunications industries, we focus here on the five Indian industries with positive elasticity and above-average R&D intensity.

This analysis suggests that based on their response to India's improvements in its IP regime from 2000 to 2010, additional improvement should have significant effects on R&D investments by leading, domestic high-technology industries. Upgrading India's IP protections to China's level would increase the R&D intensity of India's domestic information technology firms, over time, by more than 80 percent, the R&D intensity of Indian scientific instrument companies by more than 18 percent, and the R&D intensity of transportation companies by nearly 13 percent. (Table 9-A below) As a result, the share of revenues dedicated to R&D by domestic Indian IT companies would rise from 4.9 percent to 8.8 percent, and the share dedicated to R&D in the scientific instruments industry would rise from 2.8 percent to 3.4 percent. (Table 9-B) The increases in other industries are less marked: The share of revenues invested in R&D by domestic drugs and pharmaceutical firms would rise from 3.2 percent to nearly 3.5 percent, the share dedicated to

R&D by Indian transportation firms would increase from less than 1.4 percent to more than 1.5 percent, and the share of revenues going to R&D in the medical and surgical instrument industry would edge up from 0.93 percent to 0.97 percent.

Similarly, if India upgraded its IP protections to the level of the United States, we estimate that over time, R&D intensity would double in India's IT industry, increase 46 percent among Indian scientific instrument companies and rise more than 31 percent in the transportation industry. (Table 9-A) R&D intensity would also increase by nearly 18 percent in India's drugs and pharmaceutical industry and by more than 10 percent among domestic medical and surgical instrument firms. As a result, the share of revenues dedicated to R&D by Indian IT firms would rise from 4.9 percent to an estimated 14.6 percent, and the share going to R&D in the scientific instruments industry would rise from 2.8 percent to 4.1 percent. (Table 9-B) Increases in other industries are smaller. The share of revenues invested in R&D by domestic Indian drugs and pharmaceutical firms would rise from 3.2 percent to 3.8 percent, the share dedicated to R&D by transportation firms would increase from 1.4 percent to 1.8 percent, and the share going to R&D in the medical and surgical instrument industry would rise from 0.93 percent to 1.02 percent.

Table 9-A: Impact of Improvements in IP Rights on the R&D Intensity of Indian Industries

Industry	Elasticity	Change in R&D-Intensity with China's IP Rights	Change in R&D Intensity with U.S. IP Rights
Improvement in India G-P Index		**12.0%**	**29.8%**
All Indian Private Industry	0.52	6.3%	15.7%
Information Technology	6.70	80.5%	201.1%
Scientific Instruments	1.53	18.4%	45.9%
Transportation	1.05	12.6%	31.5%
Drugs and Pharmaceuticals	0.59	7.1%	17.7%
Medical and Surgical Instruments	0.34	4.1%	10.2%

Table 9-B: The Impact of Improvements in IP Rights on the R&D Intensity of Indian Industries, As a Share of Industry Revenues

Industry	R&D Intensity 2009	R&D Intensity with China's IP Rights	R&D Intensity with U.S. IP Rights
All Indian Private Industry	0.82%	0.87%	0.95%
Information Technology	4.87%	8.79%	14.6%
Scientific Instruments	2.83%	3.35%	4.12%
Transportation	1.37%	1.54%	1.80%
Drugs and Pharmaceuticals	3.22%	3.45%	3.79%
Medical and Surgical Instruments	0.93%	0.97%	1.02%

As we noted, we could not find such effects for India's biotechnology and telecommunications industries. In principle, however, substantial additional improvements in India's IP regime should increase competitive pressures on the firms in those industries, which in turn could induce them to increase their R&D.

Impact of Upgrading India's IP Regime on R&D by Foreign-Based Companies in India

Improvements in India's IP protections should promote greater R&D and innovation by foreign firms operating there, as well as domestic Indian companies – and both effects should lead to stronger growth, employment and wages in certain industries. A long line of research has established that lax IP protections discourage foreign direct investments (FDI) generally, and especially FDI in R&D.[39] This research is confirmed in India's case by a 2011 report from the Center for Scientific Research in India (CSIR). With the improvements in India's R&D regime, FDI in R&D to India increased substantially, totaling $29.2 billion over the period from 2003 to 2009.[40] However, the data also show that relatively few multinational corporations perform meaningful R&D in India. From 2003 to 2009, 706 foreign-based companies invested in R&D in India; and most of those investments were modest (less than $50 million). Moreover, only 74 of the 706 companies went on to register patents in India; and the 1,166 patents they received in India accounted for less than one-half of one percent of their total worldwide patents. This suggests that the R&D undertaken by foreign firms in India has not been highly innovative.

As with domestic Indian firms and industries, we can estimate the impact of stricter IP rights in India on the volume of R&D investments by foreign-based firms there. The CSIR analysis includes data on FDI in R&D by industry; and using those data and industry sales data, we can estimate the R&D intensity of foreign firms in India by industry. To carry out these estimates, we must rely as well on data from India's Department of Science and Technology on the sales of foreign firms by industry.[41] The DS&T industry classifications do not correspond precisely to the industry classifications in our analysis of domestic Indian firms, so we use the closest approximations available from the DS&T.[42] In addition, the R&D data are expressed in rupees, which we convert to U.S. dollars at historical exchange rates.[43] Table 10, below, presents our R&D intensity calculations based on FDI in R&D by industry.

Table 10: FDI in R&D to India, by Industry, and R&D Intensity by Industry, 2003 and 2009 ($ billion)

Industry	R&D 2003	R&D 2009	Sales 2003	Sales 2009	R&D Intensity 2003	R&D Intensity 2009
Software and IT	1.43	0.40	0.02	0.10	73.92	4.06
Automobiles	0.08	0.76	0.12	0.36	0.65	2.11
Drugs & Pharmaceuticals	0.04	0.35	0.10	0.30	0.39	1.15
Machinery & Equipment	0.11	0.10	0.01	0.13	20.69	0.79
Electronic Equipment	0.33	0.15	0.11	0.36	3.08	0.42
Aerospace	0.02	0.1	0.12	0.36	0.16	0.28
Engines & Turbines	0.02	0.03	0.01	0.13	3.76	0.24

[39] Shapiro and Mathur (2014).
[40] Mrinalini, Nath and Sandhya (2013).
[41] Government of India (2008); Government of India (2011).
[42] Aerospace and Autos become Transportation; Machinery and Equipment, and Engines and Turbines, become Industrial Machinery.
[43] Board of Governors of the Federal Reserve System (2015).

These calculations confirm that the improvements in IP rights in India were followed by an increase in the R&D intensity of foreign firms in three key industries -- automobiles, drugs and pharmaceuticals, and aerospace. As we saw in our preceding analysis of domestic Indian industries, the R&D intensity of foreign firms in certain other industries actually declined during the period in which India upgraded its IP regime, including IT and software, machinery and equipment, electronic equipment, and engines and turbines. A large literature has established that many factors affect FDI decisions, both generally and with regard to FDI in R&D. These results, therefore, tell us that other factors in the multinational operations of these firms had greater impact on their R&D investments in India than the improvements in India's IP protections, or that those improvements were insufficient.

As with our preceding analysis of domestic Indian industries, we focus here on the industries of the foreign firms which increased their R&D investments in India as IP protections improved – automobiles, drugs and pharmaceuticals, and aerospace. Over this period, India's G-P Index score rose from 2.27 (2003) to 3.76 (2009), an increase of 65.8 percent.[44] Using that data and the data on FDI in R&D by industry, we can estimate the sensitivity or elasticity of the three industries' R&D intensity to the improvements in India's IP regime. As before, we will apply those elasticity values to calculate how much the R&D intensity of foreign firms in the three industries might further increase, if India further upgraded its IP regime to the level of China or the level of the United States.

Based on the data presented in Table 10, we estimate that as India upgraded its IP regime from 2003 to 2009, the R&D intensity of foreign firms increased 227 percent in India's automobile industry, 198 percent in the drug and pharmaceutical industry, and 72 percent in India's aerospace industry. (Table 11 below) From this analysis, we also calculated the elasticity of FDI in R&D in the three industries over the same period. Applying those elasticity values, we estimate that the R&D intensity of foreign firms in these industries would increase by between 13 percent and 41 percent if India upgraded its IP regime to the levels of China. Similarly, the R&D intensity of foreign firms in these industries would increase by between 33 percent and more than 100 percent if India upgraded its IP regime to the level of the United States.

Table 11: Estimated Effects on the R&D Intensity of Foreign Firms in India In Response to Improvements in India's IP Regime, by Industry (Percent Change)

Industry	Change in R&D Intensity, 2003-2009	Elasticity	Change in R&D-Intensity	Change in R&D-Intensity
	--	--	China IP Level	U.S. IP Level
Improvement in India's G-P Score	65.8%		12.0%	29.8%
Automobiles	226.8%	3.45	41.4%	103.4%
Drugs & Pharmaceuticals	197.7%	3.01	36.1%	90.2%
Aerospace	72.0%	1.09	13.1%	32.8%

Based on this analysis, we estimate that if India upgraded its IP regime to the level of China, R&D by foreign companies in the automobile industry would increase from 2.1 percent of

[44] India's G-P Index score increased in 2005 when its transition period to TRIPS-compliance ended.

their output to 3.0 percent; R&D investments by foreign firms in the drug and pharmaceutical industry would increase from 1.2 percent to 1.6 percent of their output; and R&D by foreign aerospace companies in India would edge up from 0.28 percent of output to 0.31 percent. (Table 12 below) Similarly, if India adopted an IP regime as strict as the United States, R&D investments in India by foreign automobile firms would increase from 2.1 percent of their output to 4.3 percent; R&D by foreign drug and pharmaceutical firms in India would increase from 1.2 percent of output to 2.2 percent; and R&D by foreign aerospace firms in India would edge up from 0.28 percent of their output to 0.37 percent.

Table 12: Estimated Effects on the R&D Intensity of Foreign Firms in India In Response to Improvements in India's IP Regime, by Industry (Levels)

Industry	R&D Intensity 2009	Upgrade to China 's Level	Upgrade to U.S. Level
Automobiles	2.11	2.98	4.29
Drugs & Pharmaceuticals	1.15	1.57	2.19
Aerospace	0.28	0.31	0.37

These analyses also suggest, as expected, that Indian domestic and foreign firms in the same industry respond in different ways to improvements in the country's IP regime. For example, while domestic and foreign drug and pharmaceutical companies operating in India both increased their R&D intensity as India upgraded its IP regime, the foreign pharmaceutical firms increased their R&D investments, relative to output, to a greater extent than their domestic Indian counterparts. Moreover, while domestic Indian firms in the IT and scientific instruments industries substantially increased their R&D investments in this period, as a share of their output, foreign firms in the IT and electronic equipment industries sharply reduced their R&D investments in India as a share of output over the same period. Finally, while industry classifications of foreign and domestic companies in the transportation sector are not uniform, the analysis found that foreign automobile companies substantially increased their R&D intensity as India improved its IP regime, while domestic "transportation" companies raised their R&D intensity to a more modest degree.

VI. The Impact of Greater R&D Intensity on the Value-Added, Employment and Wages of Indian Industries

Finally, we will explore how changes in the R&D intensity of Indian industries, from increased investments in R&D by domestic and foreign companies in India, affect the growth of the value-added produced by these industries, along with their employment and wages. We first consider the impact of increased R&D intensity on the value-added, employment and wages of domestic Indian companies in selected industries; and then we will examine the impact of increased FDI in R&D in selected Indian industries.

The Impact of R&D Intensity on the Growth, Employment and Wages of Indian Industries

The data on the value-added, employment and wages of Indian industries is issued by the Ministry of Statistics and Programme Implementation in the "Annual Survey of Industries" (ASI).[45] Once again, we confront challenges involving the classification of certain industries,

[45] Government of India (2013-B)

because the broad industry groups defined in the ASI do not match the industry groups defined in the reports on R&D from the DS&T. For example, the ASI data for the drugs and pharmaceutical industry includes the biotechnology industry, combined into "Pharmaceuticals, Medicinal Chemical and Botanical Products." Similarly, the IT industry in the DST analysis is part of ASI's "Computers, Electronics and Optical Products" category, the scientific instruments industry is part of ASI's "Machinery and Equipment" category, telecommunications is part of the "Printing and Reproduction of Recorded Media" category, the transportation industry is part of "Transport Equipment," and the medical and surgical appliances industry is part of "Machinery and Equipment." Therefore, the results of our analysis of the impact of greater R&D intensity on an industry's value-added, jobs and wages should be considered to be approximations.

With this stipulation, we begin with the recent economic record of the five broad industry groups described above. Table 13, below, presents the value-added, employment and total wages of those industry groups in 2001-2002 and 2006-2007. We focus on the 2001-2007 period and do not include more recent data, because changes in 2008 in ASI's industry classifications render problematic analysis covering both periods. The 2001-2007 period includes the 2005 improvement in India's G-P Index score, which will allow us to explore the relationship between changes in the R&D intensity of the industry groups and the changes in India's IP regime.

Table 13: Value Added, Employment and Total Wages in R&D-Intensive Indian Industries, 2001-2007

Industry	Value-Added 2001-2002 (100,000 Rs)	Value Added 2006-2007 (100,000 Rs)	Employment 2001-2002	Employment 2006-2007	Total Wages 2001-2002 (100,000 Rs)	Total Wages 2006-2007 (100,000 Rs)
Drugs, Pharma. & Biotechnology	2,915,352	5,333,935	509,812	593,264	322,239	424,533
IT: Computers, Electronics	98,132	174,842	12,394	18,293	6,729	12,073
Science Instruments: Machinery & Equip.	966,237	2,258,768	265,931	362,093	190,610	293,537
Transportation: Transport Equip.	591,883	2,287,265	181,495	316,225	153,836	291,578
Medical, Surgical Appliances	177,028	327,186	37,989	54,366	26,449	39,894

The data show that in 2001, the industry group comprised of drugs, pharmaceuticals and biotechnology was substantially larger than the other four R&D-intensive industries, and the computers and electronics industry (IT) was significantly smaller than the other four industry groups. Over the next six years, the transportation industry (transport equipment), followed by scientific instruments (machinery and equipment), expanded at much higher rates than the other three industries. Table 14 below presents the six-year rates of growth in the employment, value-added per employee, and wages per employee of these five R&D-intensive industries.

Table 14: Increases in Employment and Value-Added Per employee and Wages Per employee, R&D Intensive Indian Industries, 2001-2007

Industry	Employment	Value Added Per employee	Wages Per employee
Drugs, Pharmaceuticals, Biotechnology	16.4%	57.2%	13.2%
IT: Computers, Electronics	47.6%	20.7%	21.6%
Scientific Instruments: Machinery & Equipment	36.2%	71.7%	13.1%
Transportation: Transport Equipment	43.1%	121.8%	8.8%
Medical and Surgical Appliances	16.4%	29.2%	5.4%

Next, we measure the R&D intensity of these five industries over the years 2001 to 2007. While the R&D intensity of all private industry in India increased by nearly 30 percent over this period, five of the six R&D-intensive industries evidenced much larger increases. (Table 15 below) R&D intensity increased by nearly 49 percent among Indian drugs and pharmaceutical companies, by nearly 56 percent in the transportation industry, by nearly 89 percent in scientific instruments companies, by almost 113 percent in the biotechnology industry, and by more than 500 percent in information technologies. The outlier is the medical and surgical appliance industry, with the lowest R&D intensity in 2001 and virtually the same R&D intensity in 2007. In fact, by 2007, that industry's R&D intensity was lower than the average for all Indian private industry.

Table 15: Changes in the R&D Intensity of R&D-Intensive Industries, 2001-2007

Industry	R&D Intensity 2001/2002	R&D Intensity 2006/2007	Change
All Private Industry	0.61	0.79	29.5%
Biotechnology	1.81	3.85	112.7%
Drugs & Pharmaceuticals,	2.32	3.45	48.7%
Information Technology	0.90	5.47	507.8%
Scientific Instruments	1.41	2.66	88.7%
Transportation	0.81	1.26	55.6%
Medical and Surgical Appliances	0.76	0.75	-1.3%

Next, we explore the relationship between the increases in the R&D intensity of the five industries from 2001 to 2007 and increases in the value added per employee and wages per employee. In technical terms, we calculated the elasticity of these two variables for each industry with respect to the increases in the R&D intensity of each industry. As before, we combined the biotechnology industry and the drugs and pharmaceutical industry. For the reasons noted earlier, we focus on the industries which increased their R&D intensity over this period. The results are presented in Table 16, below.

Table 16: Sensitivity of the Value Added and Wages, Per Employee, To the R&D Intensity of Indian Industries, By Industry

Industry	Value Added Per employee	Wages Per employee
Drugs, Pharmaceuticals, Biotechnology	1.17	0.27
Information Technology	0.04	0.04
Scientific Instruments	0.81	0.15
Transportation	2.19	0.16

The results show that among Indian transportation companies, scientific instrument firms and drugs, pharmaceutical and biotechnology companies, the increases in R&D intensity were accompanied by significant increases in value-added per employee, and by moderate increases in wages per employee. The response by IT companies was much weaker in both cases. Using these values, we can estimate broadly the dimensions of response of value added and wages in these industries to further improvements in India's IP regime.

First, we present the elasticity of the R&D intensity of the selected Indian industries to the improvements in India's IP regime, as measured by increases in the country's G-P Index score from 2002 to 2007. While we found that value-added and wages in the IT industry were relatively unresponsive to increases in the industry's R&D intensity, the R&D intensity of the IT industry is highly responsive to improvements in India's IP regime, with an elasticity value of 7.72. (Table 17 below) The response by the other three industries was considerably more moderate. These elasticity values correspond generally to those derived earlier using the industry classifications of the DS&T and covering the period 2000 to 2010. For this analysis, the data issues described earlier limit the time period to 2000 to 2007, and we adopt the ASI industry classifications in order to use ASI data on value added, employment and wages.

This analysis shows that if India upgraded its IP regime to the level of China, industry R&D investments as a share of industry sales would increase nearly 93 percent in India's IT industry, by more than 16 percent among Indian scientific instruments companies, by about 10 percent among Indian transportation companies, and by about 9 percent in India's drugs, pharmaceuticals and biotechnology industry. (Table 17 below) As expected, the R&D intensity of these industries would increase more dramatically in every case if India upgraded its IP protections to the level of the United States, with increases ranging from more than 22 percent to nearly 232 percent.

Table 17: Estimated Effects on the R&D Intensity of Indian Industries In Response to Improvements in India's IP Regime, By Industry

Industry	Elasticity of R&D Intensity to Changes in the GP Index, 2000-2007	Increase in R&D Intensity with China's IP Regime	Increase in R&D Intensity with U.S. IP Regime
Drugs, Pharmaceuticals & Biotech	0.74	8.9%	22.2%
Information Technology	7.72	92.6%	231.5%
Scientific Instruments	1.35	16.2%	40.4%
Transportation	0.84	10.1%	25.3%

Based on our analysis of the responsiveness of each industry's R&D intensity to improvements in India's IP regime and the responsiveness of each industry's value-added and wages, per employee, to increases in its R&D intensity, we can project how improvements in India's IP regime could affect each industry's value-added and wages, per employee. These effects unfold over time, and we estimate that improvements in India's IP regime would be followed by the higher production and wages per employee over a five-to-ten year period.

Table 18 presents our estimates of the impact on value-added and wages, per employee, on four R&D intensive Indian industries, if India upgraded its IP regime to the level of China's arrangements (a 12 percent increase in India's G-P Index score). The largest effects on the value-added of production if India upgraded its IP regime to the level of China's should occur in India's transportation sector, where value-added per employee would increase by about 22 percent on top of the industry's current trend of rising value-added. Similarly, value-added per employee would increase by more than 13 percent among Indian scientific instrument companies and by more than 10 percent in India's drugs, pharmaceuticals and biotechnology industry, on top of those industries' current rate of rising production per employee. The impact is less dramatic for Indian IT companies: We estimate that their value-added per employee would rise by about 4 percent more than their current rate of increase. This level of improvement in India's IP regime also should boost wages per employee in these four industries, although to lesser degrees. The largest wage increases would occur in India's IT sector, where wages per employee would rise by nearly 4 percent on top of the industry's current rate of wage increase. We estimate that wages per employee also would increase by about 2.4 percent in India's drugs, pharmaceutical and biotechnology industry and among Indian scientific instrument companies, on top of their current trends of wage increases. Finally, wages per employee in India's transportation sector would rise by 1.6 percent on top of that industry's current rates of wage increases.

Table 18: Estimated Effects on the Value Added and Wages, Per Employee, of Indian Industries If India Upgraded Its IP Regime to China's Level

Industry	Increase in R&D Intensity	Increase in Value Added Per employee	Increase in Wages Per employee
Drugs, Pharmaceuticals & Biotech	8.9%	10.4%	2.4%
Information Technology	92.6%	3.8%	3.9%
Scientific Instruments	16.2%	13.1%	2.4%
Transportation	10.1%	22.2%	1.6%

The effects on the value-added of production and wages per employee would be substantially greater if India upgraded its IP regime to the level of United States, an increase of 29.8 percent in India's G-P Index score. (Table 19 below) In India's transportation sector, we estimate that value-added per employee would increase by more than 55 percent on top of the industry's current trend of rising value-added. Similarly, under an IP regime comparable to the United States, we estimate that value-added per employee would increase by nearly 33 percent among Indian scientific instrument companies and by more than 26 percent in India's drugs, pharmaceuticals and biotechnology industry, on top of those industries' current rate of rising value-added per employee. We further estimate that Indian IT companies would see their value-added per employee rise by more than 9 percent on top of their current rate of increase. Again, this level of improvement in India's IP regime also should lead to higher wages in these industries. The largest wage increases would occur in India's IT sector, where wages per employee would rise by nearly 10 percent on top of the industry's current rate of wage hikes. We estimate that wages per employee also would rise by more than 6 percent in India's drugs, pharmaceutical and biotechnology industry and by 6 percent among Indian scientific instrument companies, on top of their current trends of wage increases. Finally, wages per employee in India's transportation sector should increase by an estimated 4 percent on top of that industry's current rates of wage increases.

Table 19: Estimated Effects on the Value Added and Wages, Per Employee of Indian Industries If India Upgraded Its IP Regime to the U.S. Level

Industry	Increase in R&D Intensity	Increase in Value Added Per employee	Increase in Wages Per employee
Drugs, Pharmaceuticals & Biotech	22.2%	26.1%	6.1%
Information Technology	231.5%	9.4%	9.8%
Scientific Instruments	40.4%	32.7%	6.0%
Transportation	25.3%	55.5%	4.0%

The analysis establishes clearly that among India's more innovative industries, which depend upon IP protections much as other innovative firms do everywhere in the world, a significant upgrade in India's IP regime would, over time, lead to significant increases in R&D. The analysis also found that the estimated increases in R&D investments, in turn, would lead to expanded production and higher wages across Indian transportation companies, the scientific instruments industry, IT firms, and the rugs, pharmaceuticals and biotechnology sector.

The Impact of Increased R&D Intensity from Increases in FDI in R&D on the Production and Wages of Indian Industries

Earlier, we assessed the impact of improvements in India's IP regime on flows of FDI in R&D to India by foreign companies. The data on the value-added and wages of foreign companies in India, by industry, is less detailed and less complete than data on domestic Indian companies. Thus, our analysis of the impact of improvements in India's IP regime on the value-added and wages of foreign companies in India, by industry, will be more tentative than our analysis of domestic Indian companies. Nevertheless, based on the analysis of domestic companies and the economic literature, increased inflows of foreign R&D investments should strengthen the affected industries, since sustained R&D generally leads to higher value-added and productivity.

In our earlier assessment of the impact of improvements in India's IP regime on the R&D intensity of foreign companies in India, using DS&T data for 2003 to 2009, we found that the most responsive industries were aerospace, automobiles, and drugs and pharmaceuticals. For this analysis of the impact on value added and wages, we must again rely instead on ASI data for the period 2002 to 2007. We begin by analyzing the change in the R&D intensity of foreign firms over that period, as India's G-P Index score rose from 2.27 to 3.76. For example, FDI in R&D increased in the drugs and pharmaceuticals industry from $40 million in 2002 to $310 million in 2007, from $80 million to $660 million in the automobile industry, and was unchanged at $20 million in aerospace. Table 20 below presents the large increases in FDI in R&D among automobile companies and drugs and pharmaceutical firms, and strong elasticity values for both.

Table 20: R&D Intensity of Foreign Firms in India, by Industry, and The Response to Improvements in India's IP Regime, 2002 – 2007

Industry	2002/2003	2006/2007	Change	Elasticity: Foreign R&D Intensity and the G-P Index
Aerospace	0.16	0.06	- 62.5%	- 0.95
Drugs & Pharmaceuticals	0.39	1.36	248.7%	3.78
Automobiles	0.65	2.02	210.8%	3.20

To make these industries compatible with ASI data, we classify automobiles and aerospace as transportation; and since FDI in R&D to the aerospace industry did not respond to India's improvements in IP rights, we will apply the elasticity value for automobile to transportation as a whole. We also apply the elasticity for drugs and pharmaceuticals to biotechnology, as that also corresponds to the ASI industry group. Table 21 presents ASI data on value-added, employment and wages for the two sectors, covering 2002/2003 and 2006/2007.

Table 21: Value Added, Employment and Total Wages In Two Major Indian Receiving FDI in R&D, 2002-2007

Industry	Value-Added 2002-2003 (100,000 Rs)	Value Added 2006-2007 (100,000 Rs)	Employment 2002-2003	Employment 2006-2007	Total Wages 2002-2003 (100,000 Rs)	Total Wages 2006-2007 (100,000 Rs)
Drugs, Pharma. & Biotechnology	3,311,724	5,333,935	512,365	593,264	317,359	424,533
Transportation	763,870	2,287,265	198,411	316,225	165,778	291,578

Using these data on changes in value-added and wages per employee in these industries and the preceding analysis of the elasticity of foreign R&D intensity in these industries to changes in the G-P Index (Table 20, above), we can analyze the elasticity of value-added per employee and wages per employee to foreign R&D intensity. (Table 22 below) It shows that value-added per employee in India's transportation industry responds strongly to significant increases in foreign R&D in that sector; value-added per employee in India's drugs, pharmaceuticals and biotechnology industry also increases with inflows of foreign R&D to the industry, but to a lesser degree. As we saw with increases in the R&D intensity of domestic Indian companies, the impact of increases in R&D intensity arising from FDI in R&D on wages per employee is more moderate in both industries.

Table 22: Changes in the Value-Added and Wages per Employee of Two Indian Industries Receiving FDI in R&D, and the Elasticity of those Changes With Respect to the Foreign R&D Intensity of Those Industries, 2002-2007

Industry	Change in Value-Added Per Employee	Elasticity: Value-Added Per Employee & Foreign R&D Intensity	Change in Wages Per Employee	Elasticity: Wages Per Employee & Foreign R&D Intensity
Drugs, Pharma. & Biotechnology	39.1%	0.16	15.5%	0.06
Transportation	87.9%	0.42	10.4%	0.05

Finally, we apply these elasticity values to estimate how further improvements in India's IP regime would affect the value-added and wages per employee of these two industries, based on the impact of FDI in R&D on those industries. As previously, we present two scenarios, based on upgrading India's IP regime to the level of China and to the level of the United States. The results of reforms which upgrade India's IP protections to China's level – a 12 percent improvement in India's G-P Index score – are presented in Table 23, below. We estimate that such improvements would lead to increases in value-added per employee, on top of the industries' current trend of increases and over time, of more than 16 percent in Indian transportation companies and more than 7 percent in India's drugs, pharmaceuticals and biotechnology industry. As before, the impact on wages is more modest: We estimate that upgrading India's IP regime to China's level would lead to increases in wages per employee, again on top of the current trend of rising wages in these industries and over time, of nearly 3 percent in the drugs, pharmaceuticals and biotechnology industry and nearly 2 percent in India's transportation industry.

Table 23: Estimated Effects on the Value Added and Wages, Per Employee, Of Industries Receiving FDI in R&D, If India Upgraded Its IP Regime to China's Level

Industry	Increase in R&D Intensity	Increase in Value Added Per employee	Increase in Wages Per employee
Drugs, Pharmaceuticals & Biotechnology	45.4%	7.3%	2.7%
Transportation	38.4%	16.1%	1.9%

As expected, the results of reforms that could upgrade India's IP protections to the level of the United States – a 29.8 percent improvement in India's G-P Index score – are substantially greater. (Table 24 below) We estimate that such large improvements would lead to increases in value-added per employee, on top of the industries' current level of increases and over time, of more than 40 percent in Indian transportation companies and more than 18 percent in India's drugs, pharmaceuticals and biotechnology industry. The impact on wages is more modest but significant: We estimate that upgrading India's IP regime to the U.S. level would lead to increases in wages per employee, over time and on top of the current trend of rising wages in these industries, of nearly 7 percent in the drugs, pharmaceuticals and biotechnology industry and nearly 5 percent in India's transportation industry.

Table 24: Estimated Effects on the Value Added and Wages, Per Employee, Of Industries Receiving FDI in R&D, If India Upgraded Its IP Regime to U.S. Level

Industry	Increase in R&D Intensity	Increase in Value Added Per employee	Increase in Wages Per employee
Drugs, Pharmaceuticals & Biotechnology	113.4%	18.1%	6.8%
Transportation	96.0%	40.3%	4.8%

VII. Conclusion

India is building a number of advanced industries to compete with companies from world's most developed nations in both the Indian and global markets. Their success will depend in large part on their capacity for innovation. Economists have long established, however, that such innovation depends on effective investments in R&D, and those investments in turn depend on the strength of a country's IP regime. This study has investigated the impact of India's current IP regime on the R&D intensity of India's advanced industries, how improvements in India's IP rights and protections would affect the R&D intensity of those industries, and how increased R&D intensity would affect their value-added and wages per employee.

We found that the R&D intensity of India's IT industry, its scientific instruments firms, Indian transportation companies, and its drugs and pharmaceuticals sector increased as India improved its IP rights, albeit to different degrees. We also found that if India further upgrades its IP regime, it would stimulate much greater investments in R&D by those industries. If India provided IP rights and protections equivalent to China, the share of industry output devoted to R&D would increase, over time, by an estimated almost 80 percent in India's IT industry, 21 percent in its scientific instruments industry, about 7 percent in the Indian transportation sector, and just under 10 percent among Indian drugs and pharmaceutical companies. If India upgrades its IP rights and protections to the level of the United States, we estimate that the share of industry output devoted to R&D would increase almost 200 percent in India's IT industry, by more than 46 percent among its scientific instruments companies, by almost 30 percent in the Indian transportation sector, and by nearly 20 percent among Indian drugs and pharmaceutical firms.

Such improvements in India's IP regime also would attract additional FDI in R&D, especially in India's automobile industry and drugs and pharmaceuticals sector. If India upgrades its IP regime to the level of China, we estimate that inflows of FDI in R&D, over time, would increase almost 43 percent in the automobile sector and 33 percent in the drugs and pharmaceutical industry. If India adopts U.S. IP rights and protections, inflows of FDI in R&D would increase almost 105 percent in the automobile sector and more than 83 percent in the drugs and pharmaceutical industry.

In many industries, enhanced R&D intensity is also associated with higher value-added and higher wages, per employee. Our analysis of the impact of recent improvements in India's IP regime on value-added and wages found such effects in India's transportation sector, its scientific instruments industry, its drugs, pharmaceutical and biotechnology companies, and its IT industry. Therefore, we projected how further improvements would affect the value-added and wages, per employee, of those industries. We found that if India provides IP rights and protections equivalent to China, value-added per employee would increase, over time, by more than 55 percent in Indian transportation companies, by almost 33 percent in the scientific instruments sector, by 26 percent in the drugs, pharmaceuticals and biotechnology industry, and by more than 9 percent in the IT sector – all on top of each industry's current trend of rising value-added. Such an additional upgrade in India's IP regime also should boost wages per employee, over time and on top of each industry's current trend of wages increases, by about 4 percent in the IT industry, 2.4 percent in both the scientific instruments and the drugs, pharmaceuticals and biotechnology sectors, and 1.6 percent in the transportation sector.

Similarly, if India upgrades its IP regime to the level of the United States, we estimate that over time, value-added per employee would increase more than 55 percent in the transportation industry, almost 33 percent in the scientific instruments industry, about 26 percent in the drugs, pharmaceuticals and biotechnology industry, and more than 9 percent in the IT sector. Again, these projected increases would come on top of each industry's current trend of rising value-added per employee. Under this scenario, we also would expect to see increases in wages per employee, over time and on top of each industry's current wage trends, of an estimated 10 percent in the IT industry, about 6 percent in both the scientific instruments and the drugs, pharmaceuticals and biotechnology industries, and 4 percent in the transportation sector.

The greater FDI in R&D which we found would follow from improvements in India's IP regime also would affect value-added and wages, per employee, in the transportation industry and the drugs, pharmaceuticals and biotechnology sector. If India adopts IP protections equivalent to China, inflows of FDI in R&D would increase sufficiently to increase value-added per employee, over time, by about 16 percent in the transportation sector and more than 7 percent in the drugs, pharmaceuticals and biotech sector. Again, these increases would come on top the industries' current rates of growth in value-added per employee. The increase in FDI in R&D also would, over time, raise wages per employee by about 2 percent in the transportation sector and nearly 3 percent in the drugs, pharmaceuticals and biotechnology industry, on top of each industry's current path of wage increases. Finally, if India adopts an IP regime equivalent to the United States, value-added per employee would increase, over time, by an estimated 40 percent in the transportation industry and more than 18 percent in drugs, pharmaceuticals and biotechnology; and wages per employee would increase, over time, by an estimated 5 percent in the transportation sector and by nearly 7 percent in the drugs, pharmaceuticals and biotech industry.

This analysis shows that India's ambitions to foster globally-competitive advanced industries – in IT, transportation, scientific instruments, and drugs and pharmaceuticals -- depend on upgrading its IP regime. IP rights and protections directly affect how much the companies in those industries will invest in R&D, even as the dimensions of those effects vary from industry to industry. If India strengthens its IP rights and protections, the R&D intensity of those industries will increase, as will their value-added and wages per employee.

Appendix

Table 1: Elasticity of Changes in IP Protection and IP-Intensity, By Industry and Country, 1995-2009

	Austria	Belgium	Canada	Czech Rep.	Denmark
Manufacturing	14.10	6.88	0.19	0.48	26.12
Chemicals, plastics, rubber & fuels	1.60	-2.04	0.02	0.24	27.53
Pharmaceuticals	12.06	11.16	0.39	3.73	7.51
Office, accounting, computing machinery	122.80	16.35	1.40	-1.86	-4.82
Electrical Machinery	79.59	22.76	-0.03	1.65	46.06
Radio, TV & communication equipment	5.32	-7.94	0.29	-1.39	19.46
Medical, precision & optical instruments	25.77	29.59	-	14.50	15.84
Motor Vehicles	14.97	10.76	1.43	-1.06	-
Aircraft and Spacecraft	-21.57	-6.76	-0.35	-0.94	-
High Technology Manufactures	-0.97	5.54	0.22	-1.12	-

	Finland	France	Germany	Greece	Hungary
Manufacturing	21.36	0.22	-0.27	1.88	7.08
Chemicals, plastics, Rubber, Fuels	-3.97	-3.61	-2.13	1.85	2.58
Pharmaceuticals	9.97	-2.90	1.70	8.83	-
Office, accounting, computing machinery	-4.40	23.69	-4.69	-	-5.56
Electrical Machinery	4.07	8.55	-6.58	-3.22	17.08
Radio, TV & communication equipment	4.51	6.14	-4.54	2.13	-0.57
Medical, precision & optical instruments	-2.08	-12.84	0.46	-3.07	24.96
Motor Vehicles	-11.23	7.62	1.90	1.45	35.27
Aircraft and Spacecraft	187.21	-22.03	-9.23	-	-
High Technology Manufactures	7.08	-8.78	-4.67	-	-

	Ireland	Italy	Japan	Korea	Mexico
Manufacturing	1.26	3.69	6.99	1.92	6.57
Chemicals, plastics, rubber, fuels	1.82	-1.66	-1.30	-1.43	6.34
Pharmaceuticals	0.03	-6.25	12.08	13.20	9.02
Office, accounting, computing machinery	-0.09	-9.92	-1.45	0.83	-
Electrical Machinery	3.23	-4.78	2.63	0.85	-
Radio, TV & communication equipment	2.26	-4.26	6.37	2.45	-
Medical, precision & optical instruments	0.04	12.24	17.82	25.38	-
Motor Vehicles	4.62	-0.70	8.24	-3.08	9.27
Aircraft and Spacecraft	-	5.16	-11.45	-4.18	-
High Technology Manufactures	1.17	-2.68	6.66	4.13	-

Table 1 (cont): Elasticity of Changes in IP Protection and IP-Intensity
By Industry and Country, 1995-2009

	Norway	Poland	Portugal	Spain	Sweden
Manufacturing	-0.79	-2.21	4.75	4.33	-0.03
Chemicals, plastics, rubber, fuels	-2.95	-1.84	4.54	4.61	-9.12
Pharmaceuticals	-2.83	-1.53	15.32	9.04	-10.76
Office, accounting, computing machinery	-5.85	20.19	36.40	27.80	1.68
Electrical Machinery	2.48	-2.86	-1.42	1.53	10.00
Radio, TV & communication equipment	-3.02	-3.67	3.75	-1.96	4.79
Medical, precision & optical instruments	0.07	-0.07	0.31	5.45	-4.68
Motor Vehicles	10.96	-2.44	1.66	4.77	-1.98
Aircraft and Spacecraft	-1.03	-0.26	-	-4.31	-10.62
High Technology Manufactures	-2.09	-1.97	-	3.63	-2.83

Table 2: Cross-Sectional Correlations of IP-Intensity, by Industry, and G-P Index Value

Country	US	UK	Austria	Belgium.	Canada
IP Index (Year)	**4.88 (2008)**	**4.54 (2006)**	**4.33 (2009)**	**4.67 (2008)**	**4.54 (2006)**
Industry	R&D Intensity				
Manufacturing	3.35	2.44	2.56	1.49	1.40
Chemicals, plastics, rubber & fuels	..	5.16	2.49	2.29	1.18
Pharmaceuticals	24.47	24.92	..	..	11.88
Office, accounting, computing machinery	13.57	0.38	12.04	4.30	10.92
Electrical Machinery	2.45	3.29	7.99	3.70	1.32
Radio, TV & communication equipment	18.76	7.56	13.80	9.71	14.52
Medical, precision & optical instruments	..	3.63	5.97	12.10	..
Motor Vehicles	3.25	1.91	3.95	0.42	0.59
Aircraft and Spacecraft	15.35	10.70	..	..	6.27
High Technology Manufactures	..	11.10	..	..	11.50

Country	Czech Rep	Denmark	Finland	France	Germany
IP Index (Year)	**4.33 (2009)**	**4.67 (2006)**	**4.67 (2007)**	**4.67 (2006)**	**4.67 (2008)**
Industry	R&D Intensity				
Manufacturing	0.67	2.89	2.77	2.48	2.41
Chemicals, plastics, rubber & fuels	0.65	7.71	1.85	2.95	2.54
Pharmaceuticals	..	18.40	24.50	8.69	..
Office, accounting, computing machinery	0.03	5.09	2.34	7.94	5.77
Electrical Machinery	0.76	2.87	5.00	3.47	1.42
Radio, TV & communication equipment	0.45	11.49	11.76	12.24	8.11
Medical, precision & optical instruments	4.37	8.32	4.91	7.08	6.84
Motor Vehicles	1.55	0.80	0.62	4.70	5.01
Aircraft and Spacecraft	..	..	4.81	5.20	..
High Technology Manufactures	..	..	11.50	7.74	..

Table 2 (cont): Cross-Sectional Correlations of IP-Intensity by Industry and G-P Index Value

Country	Greece	Hungary	Iceland	Ireland	Italy
IP Index (Year)	**4.47 (2007)**	**4.33 (2009)**	**3.88 (2009)**	**2.37 (2005)**	**4.67 (2008)**
Industry	R&D Intensity				
Manufacturing	0.28	0.62	1.76	0.81	0.72
Chemicals, plastics, rubber & fuels	0.38	1.75	22.33	1.02	0.62
Pharmaceuticals	1.34	..	47.23	4.55	..
Office, accounting, computing machinery	0.00	0.09	0.00	0.40	1.16
Electrical Machinery	0.10	0.34	3.33	1.02	0.64
Radio, TV & communication equipment	8.86	0.37	19.27	4.73	4.64
Medical, precision & optical instruments	1.12	2.70	36.43	1.90	2.52
Motor Vehicles	0.77	0.59	0.00	0.50	2.31
Aircraft and Spacecraft	..	..	..	..	..
High Technology Manufactures	..	..	..	1.81	..

Country	Japan	Korea	Mexico	Netherlands	Norway
IP Index (Year)	**4.67 (2008)**	**4.33 (2009)**	**3.75 (2007)**	**4.67 (2007)**	**4.42 (2007)**
Industry	R&D Intensity				
Manufacturing	3.43	1.81	0.22	1.44	1.15
Chemicals, plastics, rubber & fuels	3.44	0.90	0.29	1.49	1.18
Pharmaceuticals	16.40	2.72	0.79	8.05	5.48
Office, accounting, computing machinery	7.61	2.41	0.09	5.07	0.85
Electrical Machinery	7.98	1.33	0.19	1.44	3.03
Radio, TV & communication equipment	8.90	6.26	0.06	12.16	7.51
Medical, precision & optical instruments	16.98	4.40	0.02	3.68	5.91
Motor Vehicles	4.39	2.67	0.27	1.32	3.50
Aircraft and Spacecraft	2.90	..	..	..	1.09
High Technology Manufactures	10.50	..	..	..	

Country	Poland	Portugal	Spain	Sweden
IP Index (Year)	**4.00 (2007)**	**4.33 (2005)**	**4.33 (2007)**	**4.54 (2007)**
Industry	R&D Intensity			
Manufacturing	0.15	0.29	0.75	3.60
Chemicals, plastics, rubber & fuels	0.24	0.54	1.20	4.52
Pharmaceuticals	2.08	3.95	6.25	13.44
Office, accounting, computing machinery	0.27	1.10	3.80	13.92
Electrical Machinery	0.35	0.12	0.89	3.24
Radio, TV & communication equipment	0.26	2.67	3.85	14.73
Medical, precision & optical instruments	0.37	0.41	3.24	8.99
Motor Vehicles	0.22	0.19	0.89	5.16
Aircraft and Spacecraft	4.55	..	6.87	12.91
High Technology Manufactures	0.94	..	5.22	13.18

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