

Patent Rights and Economic Growth: Evidence from Cross-Country Panels of Manufacturing Industries

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Abstract

The objective of patent rights is to foster innovation and economic growth. However, to date, there is little robust evidence that patents “work” as intended.

Here, we apply a difference-in-differences strategy to study the impact of changes in effective patent rights within panels of up to 54 manufacturing industries in up to 72 countries between 1981-2000. We find that more patent-intensive industries respond to stronger patent laws with higher growth. This effect was stronger in more advanced economies.

During 1991-1995, when the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) was completed, a one standard deviation increase in effective patent rights (equivalent to an increase from Hong Kong to Australia) would have raised the average growth of the leather industry by 1/18 but that of other chemicals industry by about 1/5.

The growth-inducing effect of patents worked through both factor accumulation and increasing productivity. Our findings were robust to alternative measures of patent rights and patent intensity, specification of the growth equation and sample, controls for various possible confounds, including financial development, trade openness, and human capital, as well as instrumental variables estimation for patent rights and patent intensity.

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1. Introduction

In modern thinking on economic growth, a central tenet is that growth is endogenously sustained by technological change, which is a result of the conscious efforts of economic agents, lured by the monopoly rents that their innovations generate (Aghion and Howitt 1998: Chapters 2-3; Eaton and Kortum 1999; Barro and Sala-i-Martin 2004: Chapters 6-7; Zeira 2011). Unlike private goods, however, the use of innovation is nonrival and possibly nonexcludable, rendering it inherently susceptible to misappropriation. Thus, the incentive to innovate, and hence the rate of economic growth, depends on the extent to which innovators can reap the benefits from their creative efforts. An important institution that regulates the incentive to innovate is intellectual property (IP) rights.

The relationship between economic growth, innovation, and IP rights involves a complex tradeoff. Stronger IP rights raise the returns to innovation, but impede the diffusion of technology and subsequent innovations. Thus the net effect can be either more or less innovation, and thus slower or faster economic growth in the aggregate. Previous scholarship on both endogenous growth (cited above) and optimal patent policy (Nordhaus 1969; Scherer 1972) have recognized this complexity.¹

However, the empirical evidence on the effect of IP rights, particularly patent laws, on economic growth is scanty. With few exceptions, cross-country studies and studies of particular countries, industries, and historical episodes have provided only limited results on the impact of stronger patent rights (Lerner 2002; Hall 2007; Hu and Jaffe 2007). Indeed, Arora et al. (2008) concluded: “[S]tudies analyzing the impact of IPRs [IP rights] on innovation and growth have yielded mixed and, at times, difficult-to-interpret results.”

This lack of empirical evidence for the growth-inducing effect of strong IP rights has not hindered efforts to strengthen global IP protection. In 1994, members of the General Agreement on Tariffs and Trade concluded the Uruguay round of international trade

¹ A particular parallel between the macro and micro literatures is the possibility of patent races. In an analysis of endogenous growth, Jones and Williams (2000) showed that duplication externality and redistribution of rents from past innovators to current innovators could result in R&D exceeding the socially optimal level. Zeira (2011) showed that patent races could result in duplicative research, which negatively affects economic growth. For the micro patent race literature that preceded these, see Loury (1979), Lee and Wilde (1980), and Dasgupta and Stiglitz (1980).

negotiations, including the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). In 2000, members of the World Intellectual Property Organization agreed the Patent Law Treaty. TRIPS reformed substantive law and the Patent Law Treaty focused on harmonizing and streamlining procedures. Whether this wave of legal reforms has affected economic growth remains unproved and thus is the primary motivation of our research.

We focus on patents and investigate whether stronger patent rights have led to faster economic growth in a diverse sample of countries in terms of economic development. Our empirical strategy is to exploit inter-industry differences in the importance of patents in protecting proprietary knowledge. As patent rights strengthen at the national level, we ask whether more patent-intensive industries grow faster than less patent-intensive industries in response to the change. For example, the pharmaceutical industry, which relies heavily on patent protection, might exhibit faster growth in response to stronger patent protection than the leather industry, where patents are less important.

Another contribution of our study is that we construct, for the first time, a measure of national patent protection that accounts for both the coverage of patent laws, or patent protection on paper, and the degree to which laws in general are enforced, a proxy for patent enforcement.

Using four panels of up to 54 three-digit ISIC manufacturing industries in up to 71 developed and developing countries, we find that more patent intensive industries experienced faster growth as a result of stronger effective patent rights, and that this effect was stronger in higher income economies. For instance, a one standard deviation increase in effective patent rights (equivalent to an increase from Hong Kong to Australia) in 1990 would have raised the average growth of the leather industry by about 1/18 but that of other chemicals industry (which includes pharmaceuticals) by about 1/5 over the subsequent 5-year period.

Further, we find that patent rights affected economic growth through both factor accumulation and increases in productivity. Our findings are robust to multiple checks, including alternative measures of patent rights and patent intensity, specification of the

growth equation and sample, controls for various possible confounds, including financial development, human capital, and trade openness, as well as estimation using instruments for effective patent rights and patent intensity.

Our results have important implications for public policy. One is that patent laws and their enforcement matter for economic growth. However, our findings also suggest that the impact of patent rights varies by country and industry. We show that patent rights have a smaller impact on economic growth in poorer countries and in less patent-intensive industries. Since patent-intensive industries account for a smaller share of the economies of the poorer countries, our results imply that the welfare gain in terms of economic growth for these countries is more likely to be outweighed by the welfare loss due to lower end-usage, and hence, tip the balance towards weaker rights being socially optimal.

The rest of the paper is organized as follows. Section 2 reviews the previous literature. We set up the empirical model and discuss estimation issues in Section 3, and describe the sources of data and construction of variables in Section 4. Then, we report and discuss estimates of the baseline model and various robustness tests in Section 5. Section 6 concludes.

2. Previous Literature

The empirical investigation of whether stronger patent rights lead to faster economic growth is predicated on two structural premises -- stronger patent rights give rise to more innovation, and the latter, in turn, generates faster economic growth, through cost saving technologies and new products and services. In this review, we focus on cross-country studies of advanced and developing economies, as these are the most closely related to our work.²

In an important contribution, Ginarte and Park (GP) (1997) compiled an index of patent laws for 60 countries between 1960-90. The GP index focused only on patent laws, as published, with no attention to actual enforcement. Park and Ginarte (1997) used the index to study the relation of economic growth, investment, and R&D expenditure to patent laws. They found no relationship between stronger patent laws and economic growth. However,

² See Jaffe (2001) and Jaffe and Lerner (2004) for critical assessments of U.S. patent policies and their consequences, and Maskus (2000) and Hall (2007) for recent academic scholarship on patents.

among richer countries (with above median income), stronger patent laws were positively related to investment and R&D. There was no such relation among poorer countries.

Focusing on 18 manufacturing industries in 21 OECD countries between 1980-95, Park (2003) found that both labor productivity and R&D expenditure increased with the GP index. In a larger sample of countries, R&D expenditure did increase with patent laws, but labor productivity did not. Among 32 countries between 1981-90, Kanwar and Evenson (2003) found that stronger patent laws, as measured by the GP index, were associated with higher R&D intensity (ratio of R&D expenditure to GDP). Applying Generalized Method of Moments methods to panels of up to 72 countries over the period 1975-2003, Kim, Lee, and Park (2008) found that stronger patent laws, as measured by the GP index, had no significant effect on economic growth. A higher GP index was associated with higher R&D intensity, but only in high-income countries.

The relatively limited results from the analyses of Park and Ginarte (1997), Park (2003), Kanwar and Evenson (2003), and Kim, Lee, and Park (2008) might possibly be explained by the aggregation involved in analyses at the country level. The impact of patent laws may vary with the industry – being stronger in patent-intensive industries such as pharmaceuticals and weaker in less patent-intensive industries such as leather. In a country-level analysis, the measured impact of patent laws on the aggregation of the entire spectrum of industries might be very small, and turn out to be statistically insignificant.

Two studies focused on the relation between the national stock of patents and economic growth. In cross-sections of up to 86 countries in the year 2000, Lederman and Saenz (2005) showed that GDP per capita increased in the stock of patents, as instrumented by the GP index. Applying Generalized Method of Moments methods to a panel of 58 countries over 1980-2003, Hasan and Tucci (2010) found that economic growth increased with R&D expenditure and the stock of patents. These studies relate growth to patenting and R&D expenditure rather than patent laws.

For developing economies, to the extent that they engage in relatively less innovation, their trade-off is between imitation and technology transfer. Among foreign affiliates of U.S. multinational companies between 1982-99, royalty payments for intangible assets to parent

companies, R&D expenditure, and the level and growth rate of patenting increased with patent reforms in the host country (Branstetter et al. 2006). Further, in a sub-sample of 16 countries, the patent reforms led to an increase in industry-level value added, suggesting that reductions in value-added associated with imitation were outweighed by increases in value-added due to technology transfer by multinational companies (Branstetter et al. 2011).

In independent work closest to ours, Vichyanond (2009) studied the impact of patent laws, as characterized by the GP index, on national exports from 24 three-digit SIC manufacturing industries. Using the NBER Patent Database Database (Hall, Jaffe, and Trajtenberg 2001), he constructed a measure of patent intensity for each industry as the number of U.S. patents weighted by citations divided by the average value of U.S. production. He then regressed exports by industry-country on the interaction between the GP index and patent intensity. The analysis revealed a non-monotone relationship between exports and patent laws. Below a threshold, exports increased with stronger patent laws, while beyond the threshold, exports fell with stronger patent laws.

Several studies have focused on the impact of patent laws on innovative activity, as distinct from economic growth. Using propensity scoring, Qian (2007) considered 26 countries which expanded the scope of patent law to pharmaceuticals between 1978 and 2002. Stronger patent protection was associated with higher domestic R&D only among economically advanced countries.³ Moser (2005) studied innovations exhibited at 19th century World Fairs. Countries without patent laws focused innovations on industries where patents were less important, suggesting that patent laws significantly affected the direction of technological innovation.

Among 15 Western countries over several centuries, enactment of patent law was associated with higher rates of scientific discoveries, inventions, and innovations (Chen 2008). Lerner (2009) identified 177 major changes in the patent system in 51 of 60 countries over a period of 150 years. Surprisingly, he found that increases in patent protection were associated with *fewer* patent applications.

³ In her main sample, including both developed and developing countries, Qian (2007) used U.S. patents granted and pharmaceutical exports to the U.S. as proxies for R&D expenditure in the absence of data on R&D itself. The dependent variable was R&D expenditure only for a sub-sample of OECD countries.

To summarize, various studies limited to particular countries, industries, or historical episodes have shown that stronger patent rights were related to greater patenting or R&D, but not economic growth. Several cross-country studies have shown that patent stocks were related to economic growth, but are silent on the impact of *patent laws*. Some of the studies that related patent laws to economic growth found only weak results, which were possibly due to the aggregate nature of the investigation. Only Branstetter et al. (2011), focusing on developing countries, found strong results linking patent laws to economic growth.⁴

3. Empirical Strategy

Our research question is whether stronger patent rights promote economic growth. In order to sharpen the analysis, we followed Rajan and Zingales (1998) and drilled down to the level of industry-country and conditioned the impact of national differences in effective patent rights on the patent intensity of the industry,

$$\Delta \log(VA_{ic}) = \alpha_0 + \alpha_1 \log(VA_{ic,0}) + \alpha_2 \text{Effective Patent Rights}_{c,0} \times \text{Patent Intensity}_i + \beta_c D_c + \beta_i D_i + \varepsilon_{ic}, \quad (1)$$

where i represented industry and c represented country. The dependent variable, $\Delta \log(VA_{ic})$, was the growth of value added in industry i of country c over a period of time; Effective Patent Rights $_{c,0}$ represented the strength of the country's patent rights at the beginning of the period; Patent Intensity $_i$ characterized the importance of patents to industry i , relative to other industries, in appropriating the returns from innovations, and D_c and D_i , were country and industry fixed effects. We assumed that the relative patent intensity of industries was the same across all countries.⁵ We also included the initial level of value added, $\log(VA_{ic,0})$, as a control for time-invariant industry-country characteristics that might be correlated with the interaction of effective patent rights and patent intensity.^{6 7}

⁴ In addition, Vichyanond (2009) showed that patent laws affected exports. This would have implications for economic growth to the extent that exports are related to economic growth.

⁵ While equation (1) specifies patent intensity as varying by industry only, the specification does accommodate an additive country-specific element in patent intensity which is common across all industries in the country. In any estimation, this country-specific element in patent intensity would be absorbed by the country fixed effect.

⁶ Since our specification included country and industry fixed effects, we could not include patent intensity (which varied with industry but not country) or effective patent rights (which varied with country but not industry) as separate explanatory variables, since these would not be identified.

The identification of the impact of effective patent rights on economic growth as specified in equation (1) drew on variation in effective patent rights across countries and the assumption that the impact varied across industries within a country. By organizing the data as country-industry panels, we could control for both country- and industry- specific effects. This identification strategy distinguishes our study from much of the previous work.

Our primary interest was in the sign and magnitude of the coefficient of the interaction between patent rights and patent intensity, specifically, whether $\alpha_2 > 0$, i.e., whether, and the extent to which, more patent-intensive industries grew relatively faster in response to stronger effective patent rights in the country.

We emphasize that stronger effective patent rights, by providing inventors with greater exclusivity, need not necessarily imply faster industry growth. Among advanced economies, stronger effective patent rights could stimulate the *prospective* invention of new products and processes, but, by limiting the usage of *existing* inventions, would reduce usage and follow-on invention (Green and Scotchmer 1995, Bessen and Maskin 2009).⁸ Among developing economies, stronger effective patent rights would reduce imitation and free-riding on the technology of advanced economies, but might stimulate technology transfer by multinational companies.

We should note that our identification strategy does depend on the assumption that country-industry specific shocks are not correlated with the choice of effective patent rights at the national level. In particular, it might be possible that, in countries where patent-intensive industries are growing relatively faster, these industries would lobby for stronger

⁷ We did not pool the data from the four periods into a single industry-country-year panel because the industry mix in the countries varied substantially over time. To cope with this variation, it would be necessary to include separate country fixed effects for each time period, which would be equivalent to our procedure of estimating separate industry-country panels for each of the four periods.

⁸ It might be asked why national patent laws should matter at all for production and value-added. One possible view is that patent laws should matter only in major world markets, with the location of production being determined by comparative advantage. By this argument, if China produces electronics for the U.S. market, only U.S. patent laws matter – to prevent the sale of infringing products in the U.S. However, this reasoning ignores patents that provide exclusivity over processes. If China does not enforce patents on processes, an interloper could copy a manufacturer's processes and produce in China and then export similar (but not infringing) products to the U.S.

effective patent rights.⁹ We addressed this concern by specifying effective patent rights as at the beginning of each period, which would precede any industry specific shocks during the period. Further, in a robustness check, we applied instrumental variables estimation, using measures of legal origin that have been widely used as deep determinants of national institutions.

4. Data and measurement issues

4.1. Industry value added

We used the World Bank Trade, Production and Protection database (Nicita and Olarreaga 2007) to compile data on the value added, employment, and gross capital formation by 3-digit manufacturing industry (ISIC (International Standard Industrial Classification, rev. 3), 151-372) for up to 100 countries between 1976-2004. The original source of the data was an annual survey by the United Nations Industrial Development Organization (Yamada 2005). However, data coverage varied by country and year. The industry value added was deflated using the corresponding U.S. value added deflator.¹⁰ In the absence of a more appropriate deflator for capital goods, we also deflated the gross capital formation series using the value added deflator.

4.2. Effective patent rights

A major measurement challenge that we faced was how to quantify the strength of a country's legal infrastructure in enforcing patent rights so that we could track its changes over time and assess the strength of the national patent regime. Previous studies used the index of patent laws compiled by Ginarte and Park (1997) and Park (2008), hereafter "GP index". The GP index assigns each country a score between 0 and 1 for each of five components: the extent of coverage of patent protection, membership in international patent agreements, provisions for protection against loss, enforcement mechanisms, and duration of

⁹ Singapore provides a counter-example to this reverse causation theory. In the early stages of economic development, the government deliberately set intellectual property rights to be weak, so as to benefit from imitation of foreign innovations. In later stages of development, the government changed its policy and strengthened intellectual property rights, in part to attract foreign pharmaceutical investment into Singapore.

¹⁰ The deflator was taken from the Groningen Growth and Development Centre, 60-Industry Database, September 2006, <http://www.ggdc.net>. This database is comparable to the OECD STAN database.

protection. The GP index is the unweighted sum of these individual scores and ranges from 0 to 5. The index covers up to 119 countries at five-year intervals from 1960 to 2005.

In essence, the GP index measures the completeness of laws *de jure*. For instance, it measures enforcement only to the extent that the legal system provides for preliminary injunctions, pleadings of contributory infringement, and reversal of the burden of proof. As constituted, the GP index results in obvious anomalies. For instance, among developing countries, the 1990 index rated Malawi (3.24) and Nigeria (3.05) substantially ahead of Hong Kong (2.57) and Singapore (2.57). Evidently, the GP index did not reflect the actual state of patent rights, *de facto*. Economic research into the enforcement of law (Becker 1968; Mookherjee and Png 1992) emphasizes that effective penalties depend on both the legal penalty and the enforcement rate.

To our knowledge, no systematic, cross-country metric of enforcement of patent rights is available for the period of study. The closest is the Fraser Institute's index of legal system and property rights, which was reported on a scale of 0 to 10 for up to 141 countries at 5-year intervals from 1970 to 2000. From 1980 onward, the index was compiled from subjective measures of three aspects of the legal system and property rights: legal security of private ownership rights (risk of confiscation); viability of contracts (risk of government repudiation of contract); and rule of law (Gwartney et al. 2000). These subjective measures were compiled from surveys of international business executives as published in the *International Country Risk Guide*.¹¹

Drawing on the GP and Fraser indexes, we propose a new index of *effective* patent rights that accounts for both the state of patent laws and their enforcement. We constructed the new index as the product of the GP and Fraser indexes:

$$\text{Effective patent rights index} = \text{GP index} \times \text{Fraser index.} \quad (2)$$

For an innovator, a situation of complete patent laws with zero enforcement seems little different from a situation of no patent laws at all. Laws and enforcement are complements

¹¹ The Fraser index was based on subjective measures from Business Environment Risk Intelligence and covered the rule of law only from 1980 onward, and, so, we limited our study accordingly.

(Becker 1968; Mookherjee and Png 1992), and hence, it is reasonable to construct the index of effective patent rights as the product of the GP and Fraser indexes.

By construction, the components for coverage and loss protection in the GP index measure the scope of the patent law. For instance, the score for coverage ranges from 0 to 1 depending on how many of the categories – pharmaceuticals, chemicals, food, plant and animal varieties, surgical products, microorganisms, and utility models – that the law covers. So, any increase in enforcement would raise protection on all of the products covered, and likewise for loss protection. The GP component for duration of protection is simply the number of years of exclusivity divided by the international norm. Any increase in enforcement would linearly increase the expected length of exclusivity. Accordingly, it seems reasonable to construct the index of effective patent rights according to (2).

Our index of effective patent rights depended on an assumption that enforcement of patent rights was correlated with enforcement of property rights in general, as measured by the Fraser index. While this crude approximation was necessitated by the limited data, we could not think of strong reasons or systematic evidence against it.

In Figure 1, we plotted the Fraser index against the GP index scaled up by a factor of two.¹² The two indices were correlated. Further, the pattern among OECD countries was markedly different from the non-OECD countries. The correlation between the two indices appeared to be weaker for the non-OECD countries, the correlation coefficients being 0.59, 0.65, 0.59 and 0.81 for 1980, 1985, 1990 and 1995 respectively. For OECD countries, the corresponding coefficients were 0.91, 0.90, 0.93 and 0.84. Towards the end of the sample, the correspondence between the two indices tended to converge among OECD and non-OECD countries. This is consistent with the thinking that the published law is much better enforced in economically advanced countries than in developing countries, and that the gap has narrowed.

Figure 1 also depicts a 45 degree line. A larger proportion of non-OECD countries fell below the line, which indicated that, in these countries, enforcement of laws lagged

¹² The Fraser index was produced on a 10-point scale of 10, while the GP was on a 5-point scale. Accordingly, for easier visualization in Figure 1, we scaled up the GP index by a factor of 2.

formal patent legislation. However, among non-OECD countries, Brazil, Hong Kong, Singapore and Taiwan were placed consistently above the 45 degree line. Within the OECD, France, Italy, the U.K. and the U.S. placed below the 45 degree line.

[Insert Figure 1 here]

[Insert Figure 2 here]

Figure 2 presents a box chart of the effective patent rights index for each of the four years. The top of each box represents the 75th percentile, the solid line within the box represents the median, while the bottom of the box represents the 25th percentile of the patent rights index. The cross-country distribution of effective patent rights in 1985 stood out in two ways – it was less dispersed and it appeared to disrupt a general upward trend. The distribution sharply shifted upward and became much less skewed in 1995, compared to that in 1985 and 1990.

Table 1 presents the top and bottom five countries by our effective patent rights index.¹³ The U.S. was ranked highest in all four years, while the Netherlands always placed among the top five countries. By contrast, Guatemala was consistently among the bottom five countries on the patent rights index.

[Insert Table 1 here]

We also decomposed the variance of the effective patent rights index into three components: between OECD and non-OECD, within OECD, and within non-OECD variations. These are plotted in Figure 3 along with the coefficient of variation of the index (plotted against the right axis). Clearly, the variation in the index shrunk towards the end of the sample. While there was more variation among non-OECD countries than OECD countries, both variations were dominated by that between the two groups, which consistently accounted for over 60% of the total variation in the patent rights index.

[Insert Figure 3 here]

¹³ Owing to data limitations, not all of these countries were included in our sample.

In our main specification, the index of effective patent rights was constructed as the product of the GP and Fraser indexes. In robustness checks, we used two alternative constructions of effective patent rights. One was the geometric mean:

$$\text{Effective patent rights index} = (\text{GP index} \times \text{Fraser index})^{1/2}. \quad (3)$$

This construction is also based on complementarity between patent law and enforcement, but subject to constant returns to scale.

The other alternative index is constructed as an average, based on the assumption that law and enforcement are independent,

$$\text{Effective patent rights index} = [\text{GP index} + 0.5 \times \text{Fraser index}]. \quad (4)$$

Since the GP index ranged from 0 to 5, while the Fraser index ranged from 0 to 10, we divided the Fraser index by 2 in order to give equal weight to patent laws and their enforcement. The ranking of countries by our main and alternative indexes of effective patent rights was quite similar.

4.3. Patent intensity

For each industry, we measured patent intensity by the ratio of the number of patents awarded to an industry to the industry's total sales. To implement our identification strategy, we used U.S. data to construct this measure of patent intensity by industry and assumed that this measure reflected the relative patent intensity across industries in all other countries.¹⁴

While equation (1) specifies patent intensity as varying by industry only, the specification does accommodate an additive country-specific element in patent intensity which is common across all industries in the country. This country-specific element in patent intensity would be absorbed by the country fixed effects. Hence, our assumption reduced to assuming that the *relative* patent intensity across industries was the same in all countries.

¹⁴ In a subtle critique, Ciccone and Papaioannou (2010) show that the use of U.S. benchmarks in Rajan and Zingales (1998) style cross-country cross-industry studies might cause the estimated coefficients to be attenuated owing to measurement error, or amplified if U.S. industry characteristics are closer to those of some countries than others. Below, we report a robustness check applying the instrumental variables method suggested by Ciccone and Papaioannou (2010).

We compiled industry-level data using company-level data from the Compustat database. Sales of individual companies were aggregated to the 3-digit ISIC (rev. 3) industry level, and deflated by the value added deflator, in the absence of an appropriate industry sales deflator.¹⁵ We then used the NBER Patent Database (Hall, Jaffe, and Trajtenberg 2001) and the Compustat identification numbers to link the Compustat companies to patents granted by the U.S. Patent and Trademark Office (USPTO).¹⁶ Individual companies' patent grants were then aggregated to the same 3-digit ISIC level. Finally, we computed patent intensity as the ratio of aggregate industry patent grants to total deflated industry sales.^{17 18}

A major issue was the time over which to measure the patent intensity. The ratio of patents granted to sales would increase with the propensity to patent. In the early 1980s, USPTO patent applications and grants surged for several reasons: passage of the Bayh-Dole Act; establishment of the Court of Appeals for the Federal Circuit; and expansion of the scope of patentability to include biotechnology, software, and business methods. All these had arguably strengthened the rights of patent owners and increased the propensity to patent (Martinez and Guellec 2004; Henry and Turner 2006; Hall 2007).¹⁹ Subsequently, in the early 1990s, the USPTO adopted an incentive structure that might have compromised the standards of patent examination, leading to more frivolous and strategic patenting, and thus greater propensity to patent (Jaffe and Lerner 2004).

¹⁵ Compustat identified industries by North America Industry Classification System (NAICS). We mapped ISIC (rev. 3) to NAICS using the concordance provided by the U.S. Census Bureau: <http://www.census.gov/epcd/naics/concordances/index.html>

¹⁶ The NBER Patent Database (<http://www.nber.org/patents/>) matched patent assignees to companies in the Compustat database by the CUSIP number in the year 1989.

¹⁷ Compustat covers only publicly-listed U.S. companies. Our procedure omitted patents granted to companies not covered by the NBER Patent Database match, and any assignee which was not a U.S. listed company – individuals, unlisted businesses, non-profit organizations and foreign entities. However, the denominator in our measure of patent intensity was consistent with the numerator in the sense that both pertained to the same set of listed U.S. companies.

¹⁸ Our procedure matched 298,000 patents granted to U.S. manufacturing businesses from 1979 to 2000. Over the same period, the USPTO granted around 1.11 million patents to “U.S. non-government organizations”, which category is the closest to U.S. manufacturing businesses but was clearly over-inclusive. Hence, our procedure successfully matched at least 26% of patents issued to U.S. manufacturing businesses.

¹⁹ By contrast, Kortum and Lerner (1998) concluded that rising R&D productivity could be a major driving force behind the patenting surge.

Figure 4 plots the patent intensity as measured over the periods 1979-82, 1979-2000, and 1997-2000. Apparently, changes in patent law and procedure might have had disproportionate effects on patenting *across industries*. For instance, in 1979-82, the patent intensity of “other chemicals” (ISIC 242), which category includes pharmaceuticals, was 0.0384. By contrast, the patent intensity of “office, accounting, and computing machinery” (ISIC 300) was far lower at 0.0001. However, by 1997-2000, the relative position was reversed, with the patent intensity of “other chemicals” having declined to 0.0204, and that of “office, accounting, and computing machinery” exploded to 0.2566. A major reason for the disparity would have been the expansion of patentability to software (Bessen and Hunt 2007).

[Insert Figure 4 here]

While striking, these apparent changes in patent intensity due to idiosyncrasies in U.S. patent law and procedure might not be directly relevant to productivity and growth in other countries. Accordingly, we specified patent intensity as the average over the entire sample period, 1979-2000, and hence, constant over time. Table 2 presents the average patent intensities for various industries. The measure seems to be intuitively reasonable: the patent intensity of ISIC 242 (Other chemicals), which includes pharmaceuticals, was 0.0240, an order of magnitude larger than that of ISIC 15 (Food and beverages), which was 0.0012. The patent intensity was 0.0513 for ISIC 30 (Office, accounting, computing machinery), as compared with 0.0072 for ISIC 21 (Paper products). To avoid any bias due to the use of U.S. data to calculate patent intensity, we excluded the U.S. from all estimates.

[Insert Table 2 here]

Countries differed in their mix of industries, and this mix varied over time. Referring to Figure 5, we see that patent intensity was correlated with effective patent rights. Interestingly, countries which were dominated by patent intensive industries tended to have stronger patent rights. This correlation would not pose any challenge to our empirical strategy as our strategy was to test whether more patent-intensive industries grew relatively *faster* in countries where patent rights were stronger, as distinct from the question of whether more patent-intensive industries were relatively *larger* in countries where patent rights were

stronger. Indeed, to the extent of diminishing returns or mean reversion, where patent-intensive industries were relatively larger, they would tend to grow relatively more slowly.

[Insert Figure 5 here]

However, as an alternative to the patent intensity measure and constructed in a similar way, we used the average R&D to sales ratio over the period 1979-2000 in robustness tests. This was computed as the ratio of R&D to sales for each industry using the Compustat database. Patent intensity and R&D intensity were highly correlated: the unconditional correlation coefficient was 0.50; regressing patent intensity on R&D intensity yielded a statistically significant coefficient of 0.48 and an R^2 of 0.25. If a company's proprietary knowledge is largely an outcome of R&D, then the high correlation suggests that patent intensity captures well the inter-industry variation in the production of proprietary knowledge.²⁰

4.4. Other data and measurement issues

In robustness tests, we investigated the impact of patent rights on total factor productivity (TFP). To construct TFP, we used the gross capital formation series from the World Bank Trade and Production Database to compute a capital stock measure and so to estimate an industry production function. The capital stock was constructed using the perpetual inventory model (Jorgenson, Gollop, and Fraumeni 1987). We assumed an investment growth rate of 5% and a depreciation rate of 10%, and to check robustness, also explored alternative rates.²¹

Finally, the intersection of the coverage of the effective patent rights index (5-yearly from 1980) and the NBER Patent Database (up to 1999, extended by Bronwyn Hall to 2002), limited our analysis to four 5-year intervals, viz., 1981-85, 1986-90, 1991-95, and 1996-2000. For each of these 5-year periods, we computed the average growth of value added by industry and regressed the average growth on the interaction of the effective patent rights index in the

²⁰ Arora, Ceccagnoli and Cohen (2008), for example, showed that R&D and patenting are highly correlated. In a recent study, Ilyina and Samaniego (2011) showed that R&D-intensive industries grow relatively faster in countries with more developed financial systems.

²¹ Capital, k , was assumed to evolve according to the perpetual inventory model:

$k_t = (1 - \delta)k_{t-1} + I_t$, where δ was the depreciation rate of capital and I_t was gross investment. Initial capital stock was constructed as $k_0 = I_1 / (\delta + \gamma)$, where γ was the constant past growth rate of gross investment.

year preceding the interval and the industry patent intensity, e.g., we regressed the average growth of value added between 1981-85 on the interaction of the effective patent rights index in 1980 and the industry patent intensity.

Table 3 presents summary statistics of the major variables used in our analysis.

[Insert Table 3 here]

5. Results

Table 4 presents least squares estimates of our baseline specification, (1). The coefficient of the interaction between national effective patent rights and industry patent intensity was positive in all periods and statistically significant in the periods 1991-95 and 1996-2000, and marginally significant in the other periods. The reason why the coefficient was not significant during 1986-90 was possibly that effective patent rights did not vary across countries during that period so much as in the other periods (see Figure 2).²²

[Insert Table 4 here]

The coefficient of the interaction of effective patent rights with patent intensity exhibited a trend of growing economic significance over time, increasing from 0.0129 and 0.0128 in the 1980s to 0.0442 and 0.0191 in the 1990s. It is also notable that the impact of patent rights appeared to be the strongest during 1991-95, when the Uruguay round of trade negotiations and the TRIPS agreement were concluded.

The model also included the initial value added (value added at the beginning of the period) as a further control for country-industry heterogeneity. In all four periods, the coefficient of the initial value added was robustly negative, implying that smaller industries had been catching up with bigger ones. The model fitted the data reasonably well, explaining between 46-58% of the variation in industry growth.²³

²² In all of the estimates, we excluded five outliers – one for Thailand (THA) in 1986-1990, one for Nigeria (NGA) in 1991-95, and three for Algeria (DZA) in 1996-2000.

²³ In each regression, the dependent variable was the average of the growth of the logarithm of industry value added over the 5-year period and the sub-sample comprised one observation per industry-country for the 5-year period. Hence, each “industry-country” cluster was a singleton. We checked and obtained similar results with standard errors clustered by country.

To appreciate the economic significance of our results, it is useful to conduct counterfactual experiments. In 1990, for an industry with the overall average patent intensity of 0.018, an increase in effective patent rights by one standard deviation, 9.71, or the equivalent of raising the index from the level of Hong Kong (16.04) to that of Australia (25.78), would have contributed to an increase of the growth rate of value added by $0.0442 \times 0.018 \times 9.71 = 0.77\%$ points. Compared with the average industry growth rate of 3.6% in 1991-1995, the effect of strengthening patent rights on economic growth was substantial in economic terms. For the 1986-90 period, a one-standard-deviation increase in effective patent rights would have led to the annual growth rates of industry value added being higher by 0.19% points or 1.6% of the average industry growth rate in the period. (We do not discuss counterfactuals for the 1981-85 and 1991-95 periods as, on average, industry value added contracted during those periods.)

[Insert Table 5 here]

Table 5 presents counterfactuals with respect to the effect of a one standard deviation increase in effective patent rights on the growth rate for each industry during the respective time period. Evidently, the impact was larger among more patent-intensive industries – office, accounting, and computing machinery (ISIC 30, patent intensity 0.0513) as compared with less patent-intensive industries – wood products (ISIC 20, patent intensity 0.025) and other chemicals (ISIC 242, patent intensity 0.024) as compared with even less patent-intensive industries – leather (ISIC 18, patent intensity 0.0105). In the 1991-95 period, a one standard deviation, 9.71, increase in effective patent rights would have raised the annual growth rate of the leather industry by 0.47%, or about one eighteenth of the industry's average growth rate of 8.18%, and that of other chemicals by 1.07% or almost one fifth of the average growth rate of 5.9%.

5.1. Level of economic development

The impact of patents on industry growth possibly differs between advanced and developing economies. Indeed, several of the previous cross-country studies of patents and patent laws found effects among advanced economies but not poorer economies. These results suggest that the impact of patent laws might vary with the nation's stage of economic development.

To explore this issue, we estimated a revised specification with growth of industry value-added regressed on the interaction of industry patent intensity, national effective patent rights, and GDP per capita. As reported in Table 6, the coefficient of the interaction was positive and statistically significant in all periods. As with the main estimates, the impact of patent rights appeared to be strongest during 1991-95, at the time of the TRIPS agreement.

[Insert Table 6 here]

These results suggest that the impact of patent rights on economic growth was stronger in more economically advanced countries. They also provide assurance that stronger patent rights increased economic growth in all four periods of study.

5.2. Factor accumulation and productivity growth

Stronger patent rights could lead to innovation that results in higher productivity growth. With higher returns, factor accumulation would also accelerate. Thus the growth-promoting effect of patent rights we have identified also encompasses the contribution of factor accumulation. In the next specification, we aimed to isolate the effect of patent rights on productivity vis-à-vis factor accumulation by estimating a Cobb-Douglas production function:

$$\Delta \log(VA_{ic}) = \alpha_0 + \alpha_2 \text{Effective Patent Rights}_{c,0} \times \text{Patent Intensity}_i + \alpha_3 \Delta \log K_{ic} + \alpha_4 \Delta \log L_{ic} + \beta_c D_c + \beta_i D_i + \varepsilon_{ic}, \quad (5)$$

where K_{ic} represents services of capital and L_{ic} represents labor input in industry i in country c . This specification assumes that the interaction of effective patent rights and patent intensity affected only the growth of total factor productivity.

Owing to the limited availability of data on capital and labor, the sample size was reduced by up to half, so reducing the power of the statistical tests. Table 7 reports estimates of equation (5). The production function seems to have been properly identified: all but one of the elasticities of capital and labor were precisely estimated, of reasonable magnitude, and were not far from indicating constant returns to scale. Controlling for the contribution of factor accumulation, the growth of industry-level total factor productivity was positively and significantly associated with the interaction between effective patent rights and patent intensity in the periods, 1981-85 and 1996-2000.

[Insert Table 7 here]

These results suggest that, in 1981-85 and 1996-2000, the growth promoting effect of stronger patent rights was channeled through higher productivity growth, as well as factor accumulation. Put differently, stronger patent rights had induced faster technical progress and/or better management and organization. By contrast, during 1986-90 and 1991-95, our earlier finding that stronger patent rights promoted growth had largely worked through more rapid factor accumulation rather than faster growth of productivity.^{24 25}

6. Robustness checks

We subjected our findings to a battery of robustness checks, focusing on the baseline specification. The checks included alternative measures of effective patent rights and patent intensity, specification of the growth equation and sample, controls for various possible confounds, including financial development, human capital, and trade openness, and estimation using instrumental variables for effective patent rights and patent intensity.

6.1. Effective patent rights

Our baseline index of effective patent rights measured variations in the completeness of patent laws and their enforcement as the product of the GP and Fraser indexes. This measure was based on patent laws and enforcement being complements. In the first set of robustness checks, we studied the robustness of our findings to the measure of effective patent rights.

[Insert Table 8 here]

Table 8 reports estimates of equation (1), using alternative measures of effective patent rights. For brevity, we report only the coefficient of the interaction of effective patent rights with patent intensity. The first panel reports the estimates with the effective patent

²⁴ Our research design did not allow us to identify whether the technical progress was achieved through indigenous innovation or technology diffusion from abroad, which could take the form of knowledge spillover from foreign direct investment in the host country. However, it was encouraging to find that stronger patent rights had increased productivity growth. Also, we could not distinguish whether the increase in factor accumulation was due to domestic or foreign direct investment.

²⁵ In unreported estimates, we also estimated equation (5) with the capital stock constructed using other rates of depreciation of capital goods and past investment growth. All coefficient estimates were similar to those reported in Table 7. Apparently, the estimates were not sensitive to assumptions on the depreciation rate and investment growth rate.

rights constructed as the geometric mean of the GP and Fraser indexes, as specified in (3). The results were similar to those with the baseline index of effective patent rights, but less precisely estimated. The coefficient of the interaction between patent rights and industry patent intensity was positive in all four periods and was statistically significant in 1991-95, and marginally significant in 1981-85 and 1996-2000. Consistent with the results applying the baseline index of effective patent rights index, patent rights had a larger effect in the 1990s as compared with the 1980s.

Likewise, with the additive measure of effective patent rights, constructed as the GP index plus half the Fraser index, as specified in (4), the results were similar to those with the baseline index of effective patent rights, but less precisely estimated. Further, with effective patent rights being simply measured by the Fraser index alone, the results were similar to those with the baseline index of effective patent rights. The results were weakest with effective patent rights being simply measured by the GP index alone, which further underscores the thinking that *de jure* law is of little effect without enforcement.

Contrasting the results using the composite indexes of effective patent rights (whether the product, geometric mean, or additive) with those from Fraser and GP indexes alone, it appears that the impact on growth during 1981-85 and 1996-2000 was contributed by enforcement, while that during 1991-95 was contributed by both law and enforcement. Overall, our results were quite robust to the construction of the index of effective patent rights. Accordingly, our focus on the baseline index, as specified in (1), appeared to be a reasonable assumption.

6.2. Patent intensity

Our baseline measure of industry patent intensity was the ratio of patents granted to sales over the entire period 1979-2000. This smoothed out shifts in patenting due to changes in patent law and system over the period. In the next set of robustness checks, we studied the robustness of our findings to the measure of patent intensity.

[Insert Table 9 here]

Table 9 reports estimates of equation (1), using two alternative measures of patent intensity. Again, for brevity, we report only the coefficient of the interaction of patent rights

with patent intensity and the corresponding estimated standard error. The first panel reports the estimates with patent intensity computed as the ratio of patent applications to sales by industry for the sample period of 1979-2000 as the measure of patent intensity. The pattern of results was very close to the baseline estimates reported in Table 4. This is not surprising as patent applications are closely correlated with patents granted.²⁶

By incorporating a general enforcement component, our patent rights index might also represent protection of other forms of intellectual property. Accordingly, in another robustness check, we used the ratio of R&D to sales in place of patent intensity. To the extent that proprietary knowledge, including that protected by patents, is an outcome of R&D, the R&D to sales ratio provides a more comprehensive measure of the importance of intellectual property to an industry. As reported in Table 9, second panel, the results were very close to the baseline specification. The coefficient of the interaction between patent rights and R&D intensity was positive in all four periods and was statistically significant in 1981-85, 1991-95, and 1996-2000, and patent rights had a larger effect in the 1990s as compared with the 1980s.²⁷

6.3. Potential confounds

In our next set of robustness checks, we sought to rule out effective patent rights being a proxy for other factors – financial development, openness to trade, and accumulation of human capital – which are known to influence economic growth. Table 10 reports estimates of equation (1), including an additional explanatory variable to account for the possible confound. For brevity, we report only the coefficients of the interaction of patent rights with patent intensity and the additional variable, and the estimated standard errors.

²⁶ Yet another way to construct the benchmark for patent intensity would be to use patent data from the European Patent Office (EPO) or Japan Patent Office (JPO). However, the EPO or JPO patent profile across industries would not necessarily be more representative than the U.S. profile as both European countries and Japan revised patent law and procedure in the 1980s and 1990s (Martinez and Guellec 2004). Moreover, like the USPTO, the EPO and JPO classifies patents by patent class rather than industry, so, we would also face the challenge of matching patents with industry.

²⁷ In another check of robustness, unreported for brevity, we estimated the baseline specification, (1), with patent intensity replaced by Cohen et al.'s (2000) measure of patent importance for product innovation. The results were consistent with our findings using patent intensity. However, Cohen et al.'s (2000) industry coverage was much more limited than ours, and so, the power of the estimates was weaker.

[Insert Table 10 here]

Rajan and Zingales (1998) showed that financial development facilitated economic growth. Suppose that patent-intensive industries are also more dependent on external finance. So, if financial development was correlated with the strengthening of effective patent rights, our estimates might be subject to omitted variable bias. To check this possible bias, we obtained a measure of financial development (ratio of stock market capitalization to GDP) from Demirguc-Kunt and Levine (2001). We then estimated an augmented version of the baseline model including the interaction of financial development with patent intensity as an additional explanatory variable.²⁸ Owing to the limited availability of data on financial development, the sample was reduced by one-third or more. As reported in Table 10, panel A, the interaction of effective patent rights with patent intensity was positive and significant in three of the four periods, 1981-85, 1991-95, and 1996-2000. The inclusion of financial development interacted with patent intensity had the interesting effect of causing the estimates of the interaction of effective patent rights with patent intensity to converge to between 0.0227-0.0263 in the three periods.

Economic growth is correlated with liberalization of trade (Sachs and Warner 1995; Wacziarg and Welch 2008). Historically, many patent reforms were implemented together with trade liberalization, particularly among developing countries that acceded to the TRIPs agreement of the Uruguay Round of trade negotiations. To distinguish the effect of trade liberalization from stronger patent rights on industry growth, we included trade openness (Sachs and Warner 1995; Wacziarg and Welch 2008) interacted with patent intensity as an additional explanatory variable.²⁹ As reported in Table 10, panel B, the results were very close to those including financial development. There was little evidence that patent intensive industries benefited more from trade openness than less patent intensive industries. Indeed, the interaction between openness and patent intensity was negative and significant during 1996-2000.

²⁸ An econometrically equivalent approach would be to regress the patent rights index on financial development, recover the residuals, and then in a second stage, include the interaction of the residual with patent intensity as an additional explanatory variable in equation (1).

²⁹ The original Sachs and Warner (1995) measure of trade openness has been criticized for the collinearity between protectionist policies and other growth-retarding policies (Rodriguez and Rodrik 2000).

The last potentially omitted factor that we considered was human capital. Patent-intensive industries would benefit relatively more from human capital accumulation. To distinguish the effect of increases in human capital from stronger patent rights, we included the average years of male secondary and higher schooling (Barro and Lee 2001; Barro and Sala-i-Martin 2004: 524) interacted with patent intensity as an additional explanatory variable. As reported in Table 10, panel C, with the inclusion of human capital, the coefficients of the interaction of effective patent rights with patent intensity tended to converge and were similar to the coefficients with the inclusion of financial development. However, all but the coefficient for 1996-2000 were imprecisely estimated. On the other hand, the interaction of human capital with effective patent rights was negative in two periods and not significant in any period. Overall, the evidence supports the role of effective patent rights in industry growth, but overlapped to some extent with human capital accumulation.

Generally, our conclusion that patent intensive industries grew faster in countries with stronger patent protection and that the growth promoting effect of strong patent rights became stronger in the 1990s than in the 1980s, was robust to the inclusion of financial development, and trade openness, and, to a lesser extent, human capital.

6.4. Endogeneity

Our identification strategy was premised on the assumption that country-industry idiosyncratic shocks were not correlated with national effective patent rights. To address potential violation of this assumption, we specified effective patent rights as at the beginning of each period, which would precede any industry specific shocks during the period. In addition, we checked the robustness of our findings by estimating (1) with effective patent rights instrumented by measures of legal origin that have been widely used as deep determinants of national institutions (La Porta et al. 2008; Kangur 2008). As reported in Table 11, panel A, the instrumental variables (IV) coefficients of the interaction between effective patent rights and patent intensity were all positive, and broadly similar to those in the OLS estimates, as reported in Table 4.^{30 31}

³⁰ The first-stage regressions, unreported for brevity, were quite reasonable: all the instruments were highly statistically significant. The Cragg-Donald Wald statistic exceeded the critical values suggested by Stock and Yogo (2005). In none of the cases did the Sargan test statistic suggest rejection of the null hypothesis that the instruments were valid.

[Insert Table 11 here]

Our identification strategy also depended on the U.S. patent intensities across industries differing from the patent intensities in other countries by at most an additive country-specific element. In a recent critique, Ciccone and Papaioannou (2010) show that, in Rajan and Zingales (1998) style cross-country cross-industry analyses that rely on U.S. benchmarks for industry characteristics, the estimated coefficients would be attenuated due to measurement error, or amplified if U.S. industry characteristics are closer to the characteristics of some countries than others.

Table 11, panel B, reports a robustness check applying the instrumental variables (IV) method suggested by Ciccone and Papaioannou (2010). Specifically, using the robust regression procedure in STATA, the first stage regressed growth of industry value-added by country-industry on industry and country fixed effects, and the index of effective patent rights, while allowing the coefficient of the index to vary with industry. In the second stage, the U.S. industry patent intensity was instrumented by the industry-varying coefficient of the index of effective patent rights from the first stage.^{32 33}

The estimated IV coefficients of the interaction between effective patent rights and patent intensity in the periods 1986-90, 1991-95, and 1996-2000 were positive and precisely identified. The estimated IV coefficients were much larger than the OLS estimates reported in Table 4. Hence, our inference based on the OLS estimates would be on the conservative, and accordingly, we prefer the OLS estimates.

³¹ In another robustness check, unreported for brevity, we organized the data as two 10-year country-industry panels rather than four 5-year country-industry panels. The longer panels would further mitigate the effect of any pre-existing trend in effective patent rights. The results were similar, showing an increasing trend in the impact of national patent rights, but less precisely estimated than in the 5-year panels. We prefer the 5-year panels as they track the differences in effective patent rights more closely.

³² The first-stage regression could not identify industry-varying coefficients of effective patent rights for all industries, as one would be collinear with the country fixed effects. We excluded ISIC 151 (Production, processing and preservation of meat, fish, fruit, vegetables, oils and fats).

³³ In the first-stage regressions, unreported for brevity, the instrument was highly significant in all four subsamples. The *F*-statistic of the weak identification test was 96, 70, 86 and 165 respectively, all of which are well above the critical values suggested by Stock and Yogo (2005).

Overall, we conclude that our estimates were robust to endogeneity of effective patent rights and misspecification of patent intensity.

7. Concluding Remarks

We investigated whether stronger patent rights achieved their intended objective of stimulating economic growth. Despite its importance in the debate on the global harmonization of IP protection, there has been little conclusive empirical evidence to support the claim that stronger patent rights indeed stimulate growth.

Using an ISIC 3-digit industry level database that spanned 54 manufacturing industries in over 72 countries between 1981-2000, we found evidence that stronger patent rights were associated with faster industrial growth measured by value added. The impact of the stronger effective patent rights was economically significant, and became stronger in the 1990s compared to the 1980s. Further, the impact was stronger in advanced economies than in developing economies. Stronger patent rights promoted industry growth through productivity increases in the 1981-85 and 1996-2000 periods and through more rapid factor accumulation in the 1986-90 and 1991-95 periods.

Our results bear upon the public policy debate regarding the role of intellectual property rights in economic growth and development. We found that patent laws and their enforcement do matter for economic growth. However, we also found that stronger patent rights have less impact on economic growth in poorer economies and in less patent-intensive industries. Hence, in poorer economies where less patent-intensive industries account for a larger share of the economy, the welfare gain in terms of economic growth from stronger patent rights is more likely to be outweighed by the welfare loss due to less end-usage. Our findings lend empirical support to arguments that patent laws be tailored to the particular circumstances of country and industry (Burk and Lemley 2009).

In executing the empirical investigation, we had to deal with a number of challenging measurement issues. The GP index focuses on the completeness of patent laws but ignores the actual enforcement of such laws. We constructed an index of effective patent rights that combined both elements. However, in the absence of a measure of the enforcement of patent

laws, we had to use an index of general law and property rights enforcement and assumed that this reflected the enforcement of patents. In future work, it would be good to refine the measure and so to more closely measure the economic impact of enforcement.

The other major issue was our application, in common with the various studies applying the Rajan and Zingales (1998) cross-industry, cross-country method, of U.S. patent intensities as a benchmark for all other countries, subject to an additive country-specific element. While we did check the robustness of the estimates using the method suggested by Ciccone and Papaioannou (2010), future work should do more to measure industry-level patent intensities in advanced and developing economies. This would then provide the basis of more accurate estimates of the economic impact of patent rights.

References

- Aghion, Philippe, and Peter Howitt, *Endogenous Growth Theory*, Cambridge, MA: MIT Press, 1998.
- Arora, Ashish, Marco Ceccagnoli and Wesley M. Cohen, “R&D and the Patent Premium”, *International Journal of Industrial Organization*, Vol. 26 No. 5, September 2008, 1153-1179.
- Barro, Robert J., and Jong-Wha Lee, “International Data on Educational Attainment: Updates and Implications”, *Oxford Economic Papers*, 53, July 2001, 541-563.
- Barro, Robert J., and Xavier Sala-i-Martin, *Economic Growth*, 2nd edition, Cambridge, MA: MIT Press, 2004.
- Becker, Gary S. “Crime and Punishment: An Economic Approach”, *Journal of Political Economy*, Vol. 76, March/April 1968, 169-217.
- Bessen, James, and Robert M. Hunt, “An Empirical Look at Software Patents”, *Journal of Economics & Management Strategy*, Vol. 16 No. 1, Spring 2007, 157-189.
- Bessen, James, and Eric Maskin, “Sequential Innovation, Patents, and Imitation”, *RAND Journal of Economics*, Vol. 40 No. 4, 2009, 611-635.
- Branstetter, Lee, Raymond Fisman, and Fritz Foley, “Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Data”, *Quarterly Journal of Economics*, Vol. 121 No. 1, 2006, 321-349.
- Branstetter, Lee, Ray Fisman, C. Fritz Foley, and Kamal Saggi, “Does intellectual property rights reform spur industrial development?”, *Journal of International Economics*, Vol 83 No 1, January 2011, 27-36.
- Burk, Dan L., and Mark A. Lemley, *The Patent Crisis and How the Courts Can Solve It*, Chicago, IL: University of Chicago Press, 2009.
- Chen, Qiang, “The Effect of Patent Laws on Invention Rates: Evidence from Cross Country Panels”, *Journal of Comparative Economics*, Vol. 36 No. 4, 2008, 694-704.
- Ciccone, Antonio, and Elias Papaioannou, “Estimating Cross-Industry Cross-Country Models Using Benchmark Industry Characteristics”, DP8056, Centre for Economic Policy Research, September 2010.
- Cohen, Wesley M., Richard R. Nelson, and John P. Walsh, “Protecting Their Intellectual Assets: Appropriability Conditions and Why US Manufacturing Firms Patent (or Not),” *NBER Working Paper 7552*, 2000.
- Dasgupta, Partha, and Joseph Stiglitz, “Industrial structure and the nature of innovative activity”, *Economic Journal*, Vol. 90 No. 358, June 1980, 266–293.
- Demirguc-Kunt, Asli, and Ross Levine, *Financial Structure and Economic Growth: A Cross-Country Comparison of Banks, Markets, and Development*, Cambridge, MA: MIT Press, December 2001.
- Eaton, Jonathan, and Samuel Kortum, “International Technology Diffusion: Theory and Measurement”, *International Economic Review*, Vol. 40 No. 3, August 1999, 537-570.

- Ginarte, Juan Carlos, and Walter G. Park, "Determinants of Patent Rights: A Cross-National Study", *Research Policy*, Vol. 26 No. 3, October 1997, 283-301.
- Green, J.R. and Suzane Scotchmer, "On the Division of Profit in Sequential Innovation", *Rand Journal of Economics*, Vol. 26, 1995, 20-33.
- Gwartney, James, Robert Lawson, and Dexter Samida, *Economic Freedom of the World: 2000 Annual Report*, Fraser Institute, Vancouver, BC, 2000.
- Hall, Bronwyn H., "Patents and Patent Policy", *Oxford Review of Economic Policy*, Vol. 23 No. 4, Winter 2007, 568-587.
- Hall, Bronwyn H., Adam B. Jaffe, and Manuel Trajtenberg, "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools", Working Paper 8498, National Bureau of Economic Research, Cambridge, MA, October 2001.
- Hasan, Iftekhar, and Christopher L. Tucci, "Innovation and Economic Growth", *Research Policy*, forthcoming 2010.
- Henry, Matthew D., and John L. Turner, "The Court of Appeals for the Federal Circuit's Impact on Patent Litigation", *Journal of Legal Studies*, Vol. 35, 2006, 85-117.
- Hu, Albert G.Z., and Adam B. Jaffe, "IPR, innovation, economic growth and development", Department of Economics, National University of Singapore, October 2007.
- Ilyina, Anna, and Roberto Samaniego, "Technology and Financial Development", *Journal of Money, Credit and Banking*, Vol. 43 No. 5, August 2011, 899-921.
- Jaffe, Adam B. "The U.S. Patent System in Transition: Policy Innovation and the Innovation Process", *Research Policy*, Vol. 29, 2000, 531-557.
- Jaffe, Adam B., and Josh Lerner, *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What To Do About It*, Princeton, NJ: Princeton University Press, 2004.
- Jones, Charles I., and John C. Williams, "Too Much of a Good Thing? The Economics of Investment in R&D", *Journal of Economic Growth*, Vol. 5 No. 1, March 2000, 65-85.
- Jorgenson, Dale W., Frank M. Gollop, and Barbara M. Fraumeni, *Productivity and U.S. Economic Growth*, Cambridge, MA: Harvard University Press, 1987.
- Kangur, Alvar, "What Rules in the 'Deep' Determinants of Comparative Development?" Department of Economics, University of Oxford, Discussion Paper No. 386, February 2008.
- Kanwar, Sunil, and Robert Evenson, "Does Intellectual Property Protection Spur Technical Change?" *Oxford Economic Papers*, Vol. 55 No. 2, April 2003, 235-264.
- Kim, Yee Kyoung, Kuen Lee, and Walter G. Park, "Appropriate Intellectual Property Protection and Economic Growth in Countries at Different Levels of Development", *3d Annual Conference of the EPIP Association*, Bern, Switzerland, October 3-4, 2008.

- Kortum, S. and Lerner, J. “Stronger Protection or Technological Revolution: What is Behind the Recent Surge in Patenting?” *Carnegie-Rochester Series on Public Policy*. 48: 247-304. 1998.
- La Porta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer, “The Economic Consequences of Legal Origins”, *Journal of Economic Literature*, Vol. 46 No. 2, 2008, 285–332.
- Lederman, Daniel, and Laura Saenz, “Innovation and Development around the World, 1960-2000”, World Bank Policy Research Working Paper 3774, November 2005.
- Lee, Tom, and Louis L. Wilde, “Market structure and innovations: A reformulation”, *Quarterly Journal of Economics*, Vol. 94 No. 2, March 1980, 429–436.
- Lerner, Joshua, “Patent policy shifts and innovation over 150 years”, *American Economic Review: Papers and Proceedings of the American Economic Association*, Vol. 92 No. 2, May 2002, 221–5.
- Lerner, Josh, “The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues”, *American Economic Review: Papers and Proceedings of the American Economic Association*, Vol. 99 No. 2, May 2009, 343–8.
- Loury, Glenn. C., “Market structure and innovation”, *Quarterly Journal of Economics*, Vol. 93 No. 3, August 1979, 395–410.
- Martinez, Catalina, and Dominique Guellec, “Overview of Recent Changes and Comparison of Patent Regimes in the United States, Japan and Europe”, Chapter 7 in *Patents, Innovation and Economic Performance*, Paris, France: OECD Publishing, 2004.
- Maskus, Keith, *Intellectual Property Rights in the Global Economy*, Institute for International Economics, Washington, DC, 2000.
- Mookherjee, Dilip, and I.P.L. Png, “Marginal Deterrence in Enforcement of Law”, *Journal of Political Economy*, Vol. 102 No. 5, 1992, 1039-1066.
- Moser, Petra, “How do patent laws influence innovation? Evidence from nineteenth-century world fairs”, *American Economic Review*, Vol. 95 No. 4, September 2005, 1214–36.
- Nicita, Alessandro, and Marcelo Olarreaga, “Trade, Production and Protection 1976-2004”, *World Bank Economic Review*, Vol 21 No. 1, 2007, 165-171.
- Nordhaus, William D., *Invention, growth and welfare: A theoretical treatment of technological change*, Cambridge, MA: MIT Press, 1969.
- Park, Walter G., “Do Intellectual Property Rights Stimulate R&D and Productivity Growth? Evidence from Cross-National and Manufacturing Industry Data”, in Jon Putnam, ed., *Intellectual Property Rights and Innovation in the Knowledge-Based Economy*, Calgary: University of Calgary Press, 2003.
- Park, Walter, “International Patent Protection: 1960-2005”, *Research Policy*, Vol. 37 No. 4, May 2008, 761-766.
- Park, Walter, and Juan Carlos Ginarte, “Intellectual Property Rights and Economic Growth”, *Contemporary Economic Policy*, Vol.15 No. 3, July 1997, 51-61.

- Rajan, Raghuram G., and Luigi Zingales, “Financial Dependence and Growth”, *American Economic Review*, Vol. 88 No. 3, June 1998, 559-86.
- Rodriguez, Francisco, and Dani Rodrik, “Trade Policy and Economic Growth: A Skeptic’s Guide to the Cross-National Evidence”, In Ben Bernanke and Kenneth Rogoff, eds., *NBER Macroeconomics Annual 2000*, Cambridge, MA: MIT Press.
- Qian, Yi, “Do Additional National Patent Laws Stimulate Domestic Innovation in a Global Patenting Environment: A Cross-Country Analysis of Pharmaceutical Patent Protection, 1978–2002”, *Review of Economics and Statistics*, Vol. 89, No. 3, August 2007, 436-453.
- Sachs, Jeffrey D and Andrew Warner, “Economic Reform and the Process of Global Integration”, *Brookings Papers on Economic Activity*, Vol 1, 1995, 1-118.
- Scherer, F. M., “Nordhaus’ Theory of Optimal Patent Life: A Geometric Reinterpretation”, *American Economic Review*, Vol 62, 1972, 422-427.
- Stock, James, and Motohiro Yogo, “Testing for Weak Instruments in Linear IV Regression”, Chapter 5 in Donald W.K. Andrews, eds, *Identification and Inference for Econometric Models*, New York: Cambridge University Press, 2005, 80-108.
- Vichyanond, Jade, “Intellectual Property Protection and Patterns of Trade”, Department of Economics, Princeton University, November 2009.
- Wacziarg, Romain, and Karen Horn Welch, “Trade Liberalization and Growth: New Evidence”, *World Bank Economic Review*, Vol 22, No. 2, 2008, 187-231.
- Yamada, Tetsuo, “Relevance and Applicability of the UNIDO Industrial Statistics Database for Research Purposes”, UNIDO ESA/STAT/AC.105/21, Vienna, 2005.
- Zeira, Joseph, “Innovations, patent races and endogenous growth”, *Journal of Economic Growth*, Vol 16, No. 2, June 2011, 135-156.

Figure 1. Fraser index vs. Ginarte-Park index

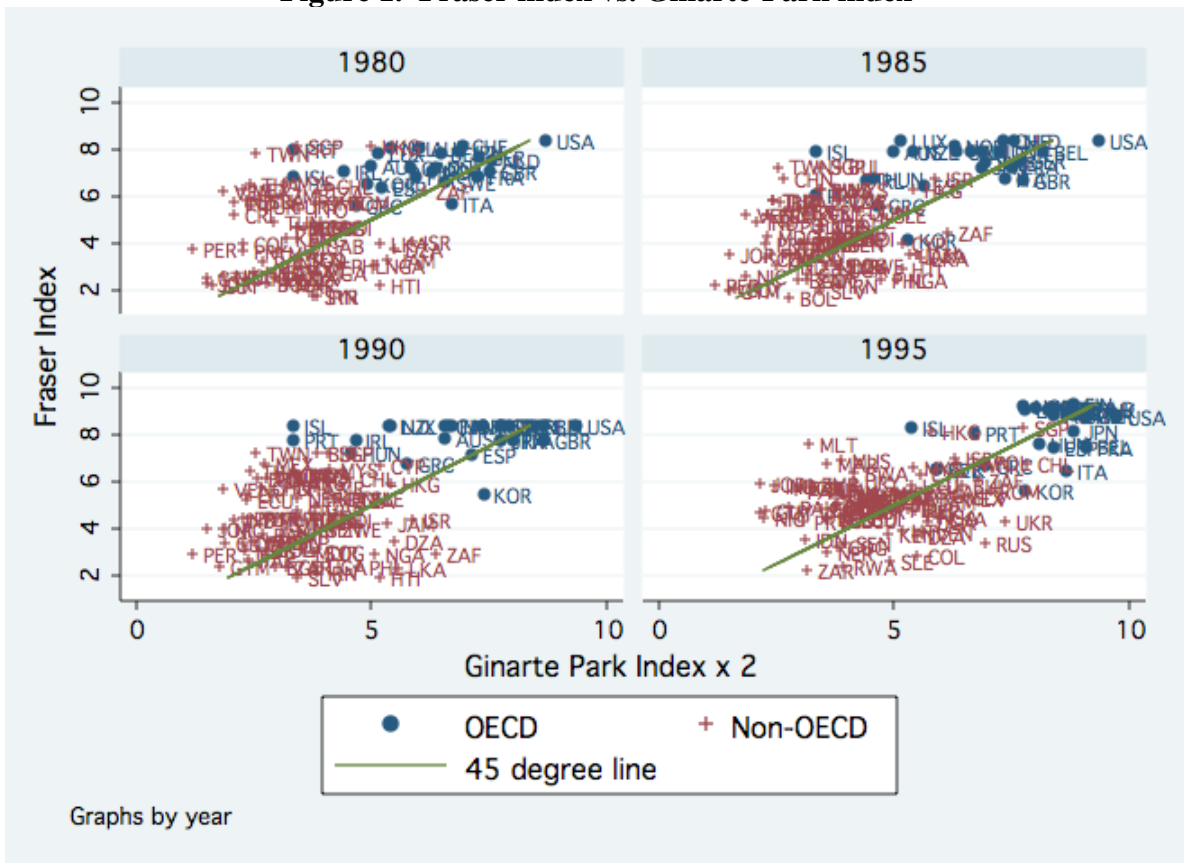


Figure 2. Effective patent rights index: Box plot

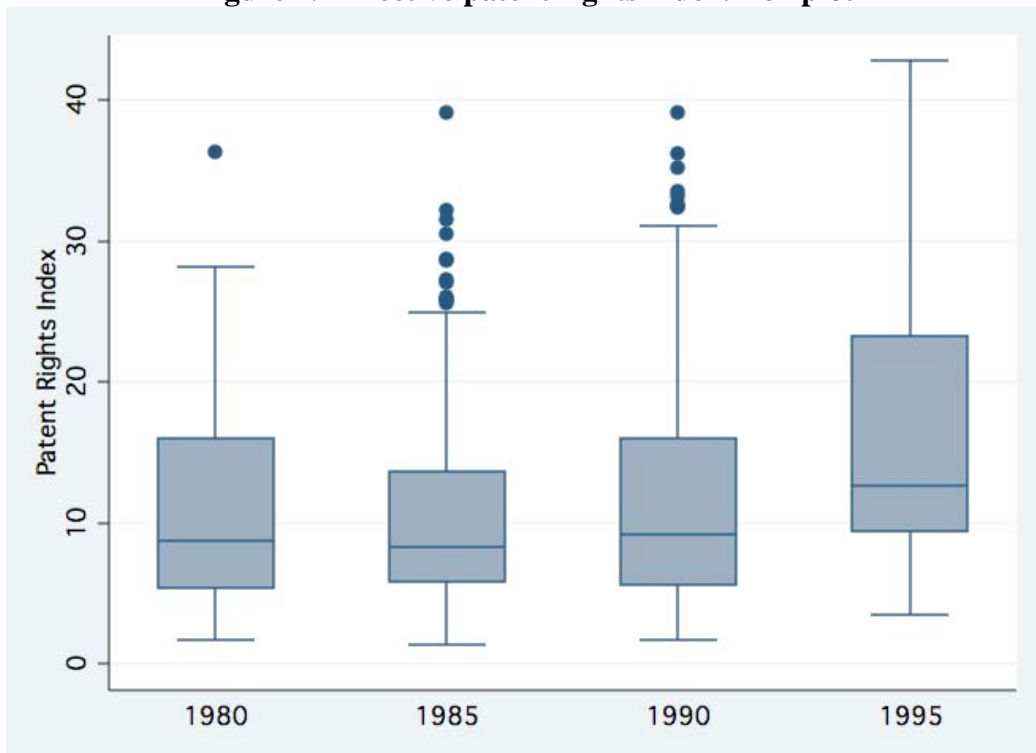


Figure 3. Effective patent rights index: Variance decomposition

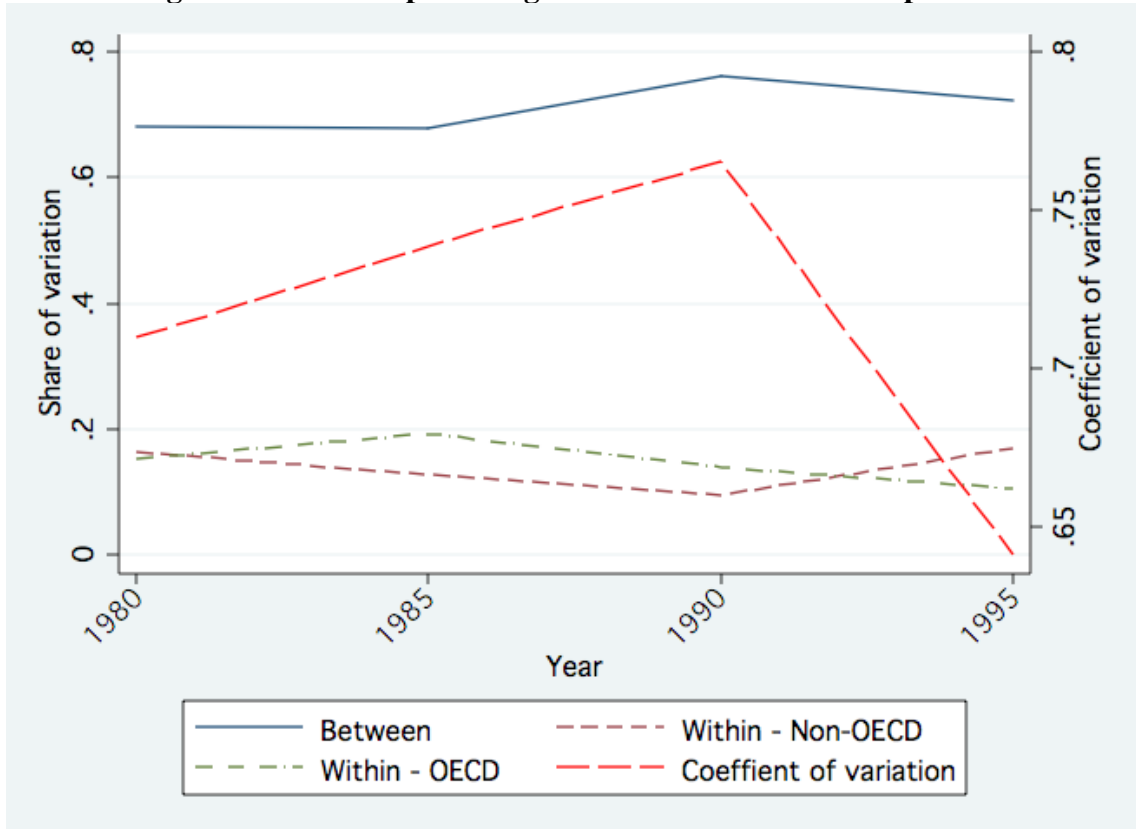


Figure 4. Patent intensity, by industry

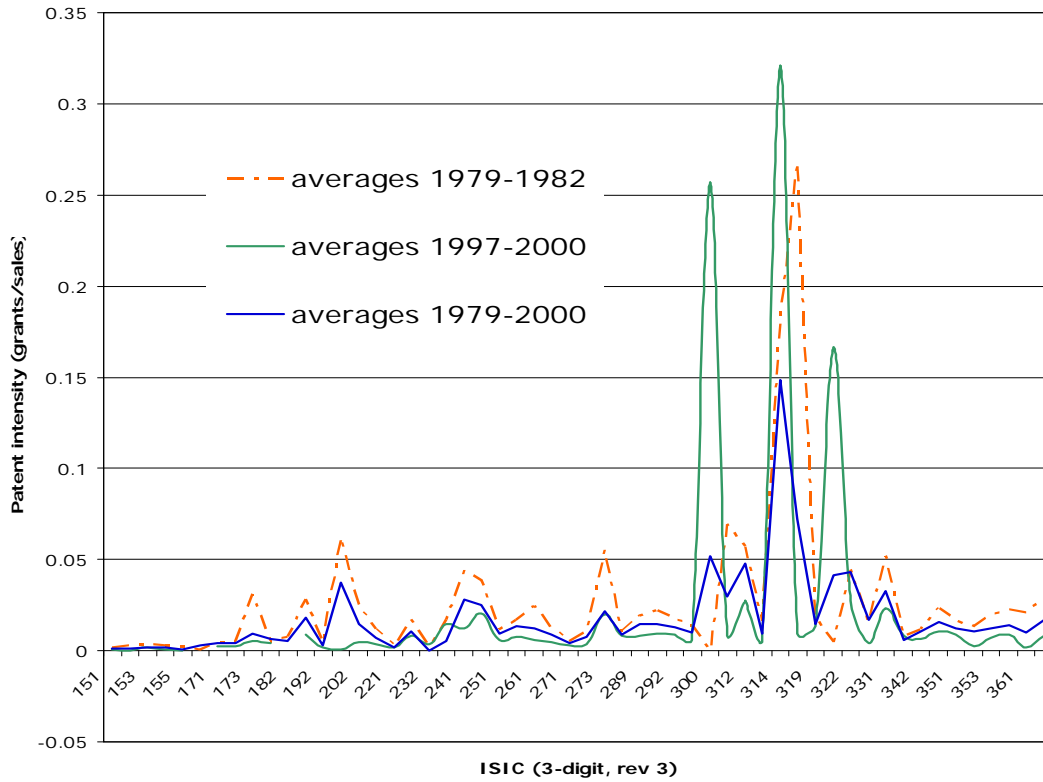


Figure 5: Patent intensity and effective patent rights

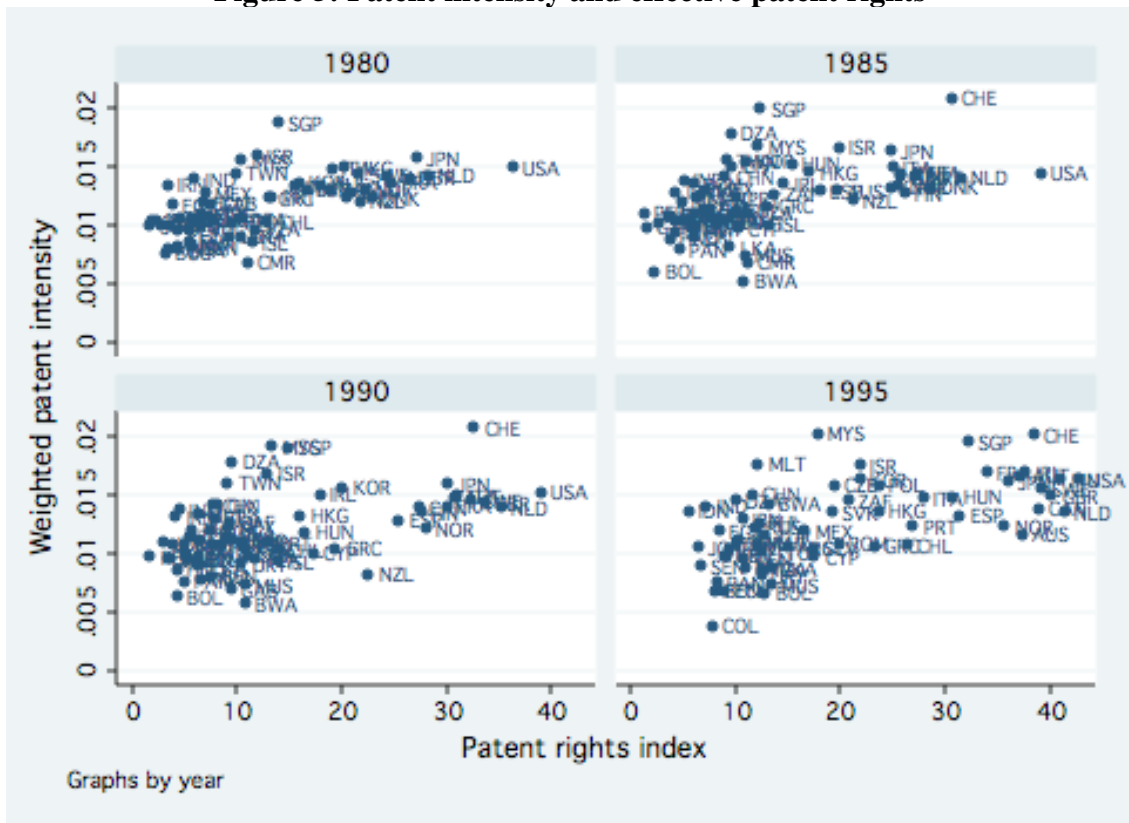


Table 1. Effective patent rights index: Top and bottom countries

1980		1985		1990		1995	
Top countries							
U.S.A.	39.30	U.S.A.	39.06	U.S.A.	39.06	U.S.A.	42.75
Netherlands	28.20	Belgium	32.23	Belgium	36.22	Netherlands	41.36
Switzerland	28.12	Netherlands	31.47	Netherlands	35.22	Denmark	41.26
Germany	28.01	Switzerland	30.55	U.K.	33.57	Finland	41.01
Japan	27.14	Germany	28.73	Germany	33.14	U.K.	40.15
Bottom countries							
Nicaragua	2.38	Nicaragua	2.38	Guyana	3.17	Niger	5.38
Peru	2.22	Bolivia	2.30	Pakistan	3.17	Guatemala	5.10
Guatemala	1.90	Guyana	1.69	Jordan	2.95	Nicaragua	5.00
Guyana	1.78	Guatemala	1.50	Guatemala	2.15	Rwanda	4.64
Jordan	1.72	Peru	1.31	Peru	1.73	Zaire	3.51

Table 2. Patent intensity

Industry (ISIC3 rev 3)	
Food and beverages (15)	0.0012
Tobacco (16)	0.0045
Textiles (17)	0.0058
Apparel (18)	0.0058
Leather (19)	0.0105
Wood products (20)	0.0250
Paper products (21)	0.0072
Publishing, printing (22)	0.0063
Coke and petroleum products (23)	0.0108
Basic chemicals (241)	0.0272
Other chemicals (242) (incl. pharmaceuticals)	0.0240
Rubber and plastics (25)	0.0110
Other non-metal (26)	0.0106
Basic metals (27)	0.0107
Fabricated metals (28)	0.0114
Machinery and equipment (29)	0.0122
Office, accounting, and computing machinery (30)	0.0513
Electric motors, generators and transformers (311)	0.0290
Electricity distribution and control apparatus (312)	0.0463
Insulated wire and cable (313)	0.0095
Accumulators, primary cells and primary batteries (314)	0.1420
Electric lamps and lighting equipment (315)	0.0695
Electronic valves, tubes and other electronic components (321)	0.0425
TV and radio transmitters (322)	0.0423
TV and radio receivers (323)	0.0163
Medical appliances and instruments (331)	0.0323
Motor vehicles, trailers and semi-trailers (34)	0.0105
Other transport equipment (35)	0.0123
Furniture and other manufactures (36)	0.0130

Notes: Patent intensity calculated as ratio of patents granted to sales during 1979-2000. For industries with low ratios of patents to sales, we aggregated the 3-digit industries to the 2-digit level. We exhibited more of the 3-digit industries with high ratios of patents to sales or of particular interest.

Table 3. Descriptive statistics

VA growth	Fraser Index	GP index	Effective patent rights index	Patent rights index (average)	Patent intensity 79-00	R&D/Sales 79-00	Capital (\$ mill.)	Labor
1981-85								
-0.005	5.35	2.07	11.853	4.745	0.018	0.023	781	18,229
(0.153)	(1.923)	(0.833)	(7.490)	(1.548)	(0.022)	(0.023)	(8,551)	(43,172)
2962	2962	2962	2962	2962	2962	2962	1,688	2,918
1986-90								
0.126	5.475	2.061	12.322	4.798	0.018	0.023	588	30,195
(0.197)	(1.827)	(0.909)	(8.412)	(1.643)	(0.022)	(0.023)	(2,032)	(108,727)
3185	3185	3185	3185	3185	3185	3185	1,844	3,157
1991-95								
0.036	5.624	2.176	13.218	4.988	0.018	0.023	954	34,845
(0.224)	(1.921)	(0.984)	(9.400)	(1.694)	(0.022)	(0.023)	(2,823)	(152,166)
3244	3244	3244	3244	3244	3244	3244	1,691	3,232
1996-2000								
-0.007	6.349	2.952	19.854	6.126	0.018	0.023	1,564	40,664
(0.224)	(1.672)	(1.034)	(11.177)	(1.698)	(0.022)	(0.023)	(4,348)	(168,115)
2837	2837	2837	2837	2837	2837	2837	1,396	2,781

Notes: Each panel reports means in the first row, standard deviations in the second row and numbers of observations in the third row.

Table 4. Main estimates

VARIABLES	(1) 1981-1985	(2) 1986-1990	(3) 1991-1995	(4) 1996-2000
Initial value added	-0.0154*** (0.00427)	-0.0496*** (0.00619)	-0.0382*** (0.00906)	-0.0117* (0.00599)
Effective patent rights x patent intensity	0.0129* (0.00707)	0.0128* (0.00708)	0.0442*** (0.0101)	0.0191** (0.00941)
Observations	2962	3185	3244	2837
R-squared	0.549	0.577	0.464	0.459

Notes: Dependent variable was the average of the growth of ln industry value added over 5-year period. Effective patent rights specified as product of GP index and Fraser index; patent intensity was computed over 1979-2000. All regressions included country and industry fixed effects. Robust standard errors in parentheses (***) p<0.01, ** p<0.05, * p<0.1).

INDUSTRY	Patent	(1)	(2)	(3)	(4)
	intensity	1981-1985	1986-1990	1991-1995	1996-2000
ISIC 19 (Leather)	0.0105	0.0011 (0.0006)	0.0014 (0.0006)	0.0047 (0.0010)	0.0025 (0.0011)
ISIC 20 (Wood products)	0.0250	0.0027 (0.0013)	0.0034 (0.0015)	0.0111 (0.0024)	0.0060 (0.0026)
ISIC 242 (Other chemicals)	0.0240	0.0026 (0.0013)	0.0033 (0.0015)	0.0107 (0.0023)	0.0057 (0.0025)
ISIC 30 (Office, accounting & computing machinery)	0.0513	0.0056 (0.0027)	0.0070 (0.0031)	0.0228 (0.0050)	0.0122 (0.0054)

Notes: Each panel presents, for the industry and 5-year period: change in the average growth of ln industry value added associated with one standard deviation increase in effective patent rights, standard error (in parentheses), and average growth rate of industry value added for the corresponding period. Counterfactual calculations are based on estimated coefficients from Table 4.

VARIABLES	(1)	(2)	(3)	(4)
	1981-1985	1986-1990	1991-1995	1996-2000
Initial value added	-0.0154*** (0.00427)	-0.0497*** (0.00619)	-0.0383*** (0.00906)	-0.0117* (0.00600)
Effective patent rights x patent intensity x GDP per capita	0.00137** (0.000691)	0.00157** (0.000723)	0.00419*** (0.000982)	0.00181** (0.000851)
Observations	2962	3185	3244	2837
R-squared	0.549	0.577	0.464	0.459

Notes: Dependent variable was the average of the growth of ln industry value added over 5-year period. Effective patent rights specified as product of GP index and Fraser index; patent intensity was computed over 1979-2000. All regressions included country and industry fixed effects. Robust standard errors in parentheses (***) p<0.01, ** p<0.05, * p<0.1).

Table 7. Factor accumulation and productivity growth

VARIABLES	(1)	(2)	(3)	(4)
	1981-1985	1986-1990	1991-1995	1996-2000
Change in	0.0553	0.182***	0.255***	0.291***
log of capital services	(0.0523)	(0.0567)	(0.0627)	(0.0813)
Change in	0.888***	0.788***	0.626***	0.892***
log of labor	(0.0541)	(0.103)	(0.0713)	(0.0631)
Effective patent rights	0.0120**	-0.00695	0.00423	0.0442**
x patent intensity	(0.00525)	(0.00607)	(0.00588)	(0.0181)
Observations	1598	1856	1638	1419
R-squared	0.828	0.652	0.599	0.780

Notes: Estimated equation specified in (4). Dependent variable was the average of the growth of ln industry value added over 5-year period. Depreciation rate, $\delta = 0.1$, growth rate of capital, $\gamma = 0.05$. Effective patent rights specified as product of GP index and Fraser index; patent intensity was computed over 1979-2000. All regressions included country and industry fixed effects. Robust standard errors in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$).

Table 8. Effective patent rights

VARIABLES	(1)	(2)	(3)	(4)
	1981-1985	1986-1990	1991-1995	1996-2000
Geometric mean:	0.0967*	0.0754	0.371***	0.163*
(Fraser x GP) ^{1/2}	(0.0500)	(0.0514)	(0.0798)	(0.0901)
Average: (GP +	0.0757**	0.0614	0.284***	0.123*
0.5 x Fraser)	(0.0373)	(0.0374)	(0.0601)	(0.0675)
Fraser index	0.0776**	0.0545	0.261***	0.186**
	(0.0342)	(0.0359)	(0.0636)	(0.0920)
GP index	0.0530	0.0908	0.347***	0.0885
	(0.0630)	(0.0683)	(0.0834)	(0.0818)

Notes: Each panel reports the coefficient of the interaction of patent rights with patent intensity in a regression of the growth of ln industry value added on initial value added and patent rights x patent intensity with country and industry fixed effects over the 5-year period. Patent intensity was computed over 1979-2000. Panels differ in construction of the index of effective patent rights. Robust standard errors in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$).

Table 9. Patent intensity

VARIABLES	(1)	(2)	(3)	(4)
	1981-1985	1986-1990	1991-1995	1996-2000
Patent applications	0.0153*	0.0131	0.0605***	0.0216**
- sales ratio	(0.00815)	(0.00870)	(0.0119)	(0.0104)
R&D-sales	0.0172**	0.0115	0.0638***	0.0210**
ratio	(0.00860)	(0.0102)	(0.0125)	(0.00991)

Notes: Each panel reports the coefficient of the interaction of patent rights with patent intensity in a regression of the growth of ln industry value added on initial value added and patent rights x patent intensity with country and industry fixed effects over the 5-year period. Effective patent rights were specified as the product of GP index and Fraser index. Panels differ in construction of patent intensity. Robust standard errors in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$).

Table 10. Confounds

VARIABLES	(1)	(2)	(3)	(4)
	1981-1985	1986-1990	1991-1995	1996-2000
<u>A. Financial development</u>				
Effective patent rights	0.0227***	-0.00317	0.0261***	0.0263***
x patent intensity	(0.00686)	(0.00819)	(0.0101)	(0.00861)
Financial development	-0.661***	0.0551	1.202***	-0.117
x patent intensity	(0.209)	(0.281)	(0.378)	(0.198)
<u>B. Trade openness</u>				
Effective patent rights	0.0173*	-0.000451	0.0364***	0.0304***
x patent intensity	(0.00981)	(0.00949)	(0.0105)	(0.00973)
Trade openness	-0.107	0.541**	0.604*	-1.124**
x patent intensity	(0.176)	(0.244)	(0.340)	(0.443)
<u>C. Human capital</u>				
Effective patent rights	0.0166	0.00585	0.0227	0.0244**
x patent intensity	(0.0108)	(0.00960)	(0.0162)	(0.0110)
Human capital	-0.0366	0.0540	0.0774	-0.0557
x patent intensity	(0.0686)	(0.0742)	(0.175)	(0.122)

Notes: Each panel reports the coefficients of the interaction of effective patent rights with patent intensity and the interaction of the confound with patent intensity in a regression of the growth of ln industry value added on initial value added, effective patent rights x patent intensity, confound x patent intensity, and country and industry fixed effects over the 5-year period. Effective patent rights were specified as the product of GP index and Fraser index, and patent intensity was computed over 1979-2000. Confounds were, respectively, financial development, trade openness, and human capital. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 11. Instrumental variables estimates

VARIABLES	(1)	(2)	(3)	(4)
	1981-1985	1986-1990	1991-1995	1996-2000
<u>A. Instruments for effective patent rights</u>				
Effective patent rights	0.0178*	0.0211**	0.0601***	0.0235
x patent intensity	(0.0107)	(0.00903)	(0.0157)	(0.0151)
<u>B. Instruments for patent intensity</u>				
Effective patent rights	0.219	0.229***	0.230***	0.128***
x patent intensity	(0.139)	(0.0795)	(0.0709)	(0.0337)

Notes: Each panel reports the coefficient of the interaction of effective patent rights with patent intensity in a regression of the growth of ln industry value added on initial value added, effective patent rights x patent intensity, and country and industry fixed effects over the 5-year period. Panel A: Effective patent rights specified as product of GP index and Fraser index, and instrumented by legal origin (La Porta et al. 2008). Panel B: Patent intensity computed over 1979-2000, and instrumented by the Ciccone and Papaioannou (2010) method. Specifically, using the robust regression (rreg) procedure in STATA, the first stage regressed growth of industry value-added on industry and country fixed effects, and the index of effective patent rights, while allowing the coefficient of the index to vary with industry, excluding ISIC 151. In the second stage, the industry patent intensity was instrumented by the industry-varying coefficient of the index of effective patent rights from the first stage. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).