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Determinants of patent rights: A cross-national study

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Abstract

This paper presents an index of patent rights for 110 countries for the period 1960–1990. The index is used to examine what factors or characteristics of economies determine how strongly patent rights will be protected. The evidence does indicate that more developed economies tend to provide stronger protection. But the underlying factors which influence patent protection levels are the country's level of research and development (R&D) activity, market environment, and international integration, which are correlated with its level of development. The results qualify, however, that R&D activity influences patent protection levels after a nation's research sector reaches a *critical* size. An implication of this is that to raise patent protection levels in weakly protecting countries, it is important to foster a significant research base in those countries and thereby create incentives for protecting patent rights. © 1997 Elsevier Science B.V.

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1. Introduction

What types of countries provide strong patent rights protection? The World Trade Organization (WTO) has drawn increased attention to international patent issues and to the divergent levels of protection worldwide. In order to facilitate comparisons of patent regimes across countries, this paper develops an *index* of patent rights (PR) for 110 countries for the period 1960–1990. After constructing the index, the paper analyzes country characteristics which predict how strongly a country will provide patent protection. The paper asks, for example, whether richer countries provide stronger protection, whether countries provide stronger protection as they develop, and whether such rights are better protected in democracies, freer markets, educated societies, in countries exposed to international trade, or in regions with higher levels of innovative activity.

In addition to quantifying the levels of patent protection across countries and investigating their determinants, this study has significance for a variety of applications. The index can be used to investigate the impact of patent rights on innovation, trade, direct foreign investment, and technology diffusion,

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and to address normative issues such as the optimal level of protection. [1]

Surprisingly, there are numerous studies on patent systems but few have gauged the overall strength of the system in each country. The few available studies are based either on a 'dummy variables' approach or on surveys of firms. Examples of the 'dummy variables' approach are Bosworth (1980) and Ferrantino (1993). Their approach is to develop various indicators of whether certain features of patent laws exist. They do not, however, provide a composite index of those indicators. Rapp and Rozek (1990), on the other hand, do aggregate their indicators (which too are dummy variables: 1 if a feature exists, 0 otherwise). An example of the survey approach is Mansfield (1994), which samples the views of 94 U.S. multinationals on the adequacy of patent rights in 16 countries during 1991.

The index developed in this paper differs from previous measures in a number of ways. First, it provides information about national patent rights for more countries and periods than do the surveys, which otherwise offer many insights. Secondly, broader categories of the patent system are considered, particularly the treatment of foreigners. Thirdly, the measures obtained in the dummy variable approaches exhibit little variability across countries. For example in the Rapp–Rozek index, one cannot distinguish the levels of patent protection between the USA and Denmark since they both earn the same value. In this paper, indicators describing the patent system are more finely defined so that the measures of patent rights exhibit greater variability across countries.

Moreover, none of these studies use their measures to examine why and which type of countries provide strong levels of patent protection. Studying the determinants of patent rights would be useful for understanding the political economy of global intellectual property law reform. The analysis would help explain, for example, why certain countries resist (or favor) the strengthening of intellectual property rights. However, in one previous work, Frame (1987) does explore what types of countries have weak commitments to intellectual property (IP) protection, but does not rely on any IP index but on surveys to identify which countries have low commitments. While Frame's study is broader than that of this paper in examining copyright and trademark protection in addition to patent protection, Frame's survey approach does not take into account, as does this paper, changes in levels of commitment and country characteristics over time.

The paper is organized as follows. The measurement of patent rights is discussed in Section 2, and the determinants of patent rights analyzed in Section 3. Conclusions are in Section 4.

2. Measurement of patent rights

2.1. Construction of the index

The index was constructed for each of the 110 countries in the sample, quinquennially from 1960 to 1990, using a coding scheme applied to national patent laws. Five categories of the patent laws were examined: (1) extent of coverage, (2) membership in international patent agreements, (3) provisions for loss of protection, (4) enforcement mechanisms, and (5) duration of protection. Each of these categories (per country, per time period) was scored a value ranging from 0 to 1, as discussed below. The unweighted sum of these five values constitutes the overall value of the patent rights index. [2] The index, therefore, ranges in value from zero to five. Higher values of the index indicate stronger levels of protection. Table 1 summarizes the index values by country and year.

It is important to note at the outset that higher levels of protection are not necessarily 'better' (from a social welfare point of view). As the model of Section 3 shows, the optimal level of protection is one which balances the dynamic benefits and costs of protection. It should also be noted that the patent

[1] On the impact of patent rights on trade, see Maskus and Penubarti (1995); on foreign direct investment, see Mansfield (1994); on economic development, see United Nations Conference on Trade and Development (1975), Siebeck (1990), and Sherwood (1990); and on North–South normative issues, see Chin and Grossman (1990) and Helpman (1993).

[2] Later, in this section, the sensitivity of the patent rights index to alternative weighting schemes is discussed.

Table 1
Index of patent rights, 1960–90

Country	1960	1965	1970	1975	1980	1985	1990
Algeria	3.05	3.05	3.38	3.38	3.38	3.38	3.38
Angola	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Argentina	1.93	1.93	2.26	2.26	2.26	2.26	2.26
Australia	2.90	2.90	2.90	2.90	3.23	3.23	3.32
Austria	3.38	3.38	3.48	3.48	3.81	3.81	4.24
Bangladesh	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Belgium	3.05	3.38	3.38	3.38	3.38	4.05	3.90
Benin	2.05	2.05	2.52	2.52	2.52	2.52	2.86
Bolivia	2.12	2.12	1.98	1.98	1.98	1.98	1.98
Botswana	1.70	1.70	1.70	1.70	1.90	1.90	1.90
Brazil	1.64	1.64	1.64	1.51	1.85	1.85	1.85
Burkina Faso	1.76	2.10	2.24	2.24	2.24	2.24	2.24
Burma	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burundi	2.52	2.52	2.52	2.52	2.86	2.86	2.86
Cameroon	1.76	2.10	2.24	2.24	2.57	2.57	2.57
Canada	2.76	2.76	2.76	2.76	2.76	2.76	2.76
Central African Republic	1.76	2.10	2.24	2.24	2.57	2.57	2.57
Chad	2.05	2.38	2.38	2.38	2.71	2.71	2.71
Chile	1.98	1.98	2.41	2.41	2.41	2.41	2.41
Colombia	2.08	2.08	1.62	1.80	1.12	1.12	1.12
Congo	1.76	2.10	2.24	2.24	2.57	2.57	2.57
Costa Rica	2.19	2.19	1.76	1.76	1.94	1.47	1.47
Cyprus	1.90	1.90	2.24	2.24	2.24	2.24	2.24
Denmark	2.33	2.66	2.80	2.80	3.62	3.76	3.90
Dominican Republic	2.26	2.26	2.41	2.41	2.41	2.41	2.41
Ecuador	1.94	1.94	1.66	1.66	1.54	1.54	1.54
Egypt	1.99	1.99	1.99	1.99	1.99	1.99	1.99
El Salvador	2.19	2.19	2.19	2.19	2.19	2.19	2.19
Ethiopia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fiji	2.01	2.01	2.01	2.01	2.01	2.01	2.61
Finland	1.99	1.99	2.14	2.14	2.95	2.95	2.95
France	2.76	3.10	3.24	3.24	3.90	3.90	3.90
Gabon	1.76	2.10	2.24	2.24	2.57	2.57	2.57
Germany	2.33	2.66	3.09	3.09	3.86	3.71	3.71
Ghana	2.23	2.23	2.37	2.37	2.90	2.90	2.90
Greece	2.46	2.46	2.46	2.46	2.46	2.46	2.32
Grenada	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Guatemala	1.94	1.94	1.08	1.08	1.08	0.75	1.08
Guyana	1.42	1.42	1.42	1.42	1.42	1.42	1.42
Hong Kong	2.04	2.04	2.04	2.04	2.24	2.57	2.57
Haiti	3.19	3.19	3.19	3.19	3.19	3.19	3.19
Honduras	2.05	2.05	2.05	2.05	1.76	1.76	1.76
Iceland	2.12	2.12	2.12	2.12	2.12	2.12	2.12
India	1.85	1.85	1.42	1.62	1.62	1.62	1.48
Indonesia	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Iran	2.38	2.38	2.38	2.38	2.38	2.38	2.38
Iraq	2.13	2.13	2.13	2.13	2.46	2.46	2.46
Ireland	2.23	2.56	2.99	2.99	2.99	2.99	2.99
Israel	3.04	3.37	3.57	3.57	3.57	3.57	3.57
Italy	2.99	3.32	3.32	3.46	3.71	4.05	4.05
Ivory Coast	2.05	2.38	2.52	2.52	2.52	2.52	2.52

Table 1
(continued)

Country	1960	1965	1970	1975	1980	1985	1990
Jamaica	3.09	2.86	2.86	2.86	2.86	2.86	2.86
Japan	2.85	3.18	3.32	3.61	3.94	3.94	3.94
Jordan	1.52	1.52	1.52	1.86	1.86	1.86	1.86
Kenya	2.37	2.37	2.37	2.37	2.57	2.57	2.57
Korea	2.80	2.80	2.94	2.94	3.28	3.61	3.94
Liberia	2.19	2.19	2.19	2.19	2.19	2.19	2.19
Luxembourg	2.29	2.29	2.71	2.71	3.05	3.05	3.05
Madagascar	1.05	1.38	1.52	1.52	1.86	1.86	1.86
Malawi	2.37	2.70	2.70	2.70	3.04	3.24	3.24
Malaysia	2.37	2.37	2.37	2.37	2.57	2.90	2.37
Mali	1.90	1.90	1.90	1.90	1.90	2.57	2.57
Malta	1.56	1.56	1.89	1.89	1.89	1.89	1.89
Mauritania	1.76	2.10	2.24	2.24	2.24	2.57	2.57
Mauritius	2.56	2.56	2.56	2.56	2.89	2.89	2.89
Mexico	1.70	1.70	1.99	1.99	1.40	1.40	1.63
Morocco	2.38	2.38	2.38	2.38	2.38	2.38	2.38
Mozambique	0.00	0.00	0.00	0.00	0.00	0.00	0.00
New Zealand	2.85	3.18	3.18	3.18	3.32	3.32	3.32
Nepal	2.52	2.52	2.52	2.52	2.52	2.52	2.52
Netherlands	2.95	3.29	3.61	3.47	4.24	4.24	4.24
Nicaragua	1.78	1.78	0.92	0.92	0.92	0.92	0.92
Niger	1.76	2.10	2.24	2.24	2.24	2.24	2.24
Nigeria	2.71	3.05	3.05	3.05	3.05	3.05	3.05
Norway	2.66	2.66	2.80	2.80	3.29	3.29	3.29
Papua New Guinea	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pakistan	1.99	1.99	1.99	1.99	1.99	1.99	1.99
Panama	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Paraguay	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Peru	1.17	1.17	1.31	1.31	1.02	1.02	1.02
Philippines	2.19	2.52	2.67	2.67	2.67	2.67	2.67
Portugal	1.98	1.98	1.98	1.98	1.98	1.98	1.98
Rwanda	2.52	2.52	2.52	2.52	2.52	2.86	2.86
South Africa	3.04	3.37	3.37	3.37	3.57	3.57	3.57
Sierra Leone	2.52	2.52	2.52	2.52	2.52	2.52	2.52
Saudi Arabia	2.05	2.05	2.05	2.05	2.05	2.05	2.05
Senegal	1.76	2.10	2.24	2.24	2.24	2.57	2.57
Singapore	2.37	2.37	2.37	2.37	2.57	2.57	2.57
Somalia	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Spain	2.95	3.29	3.29	3.29	3.29	3.29	3.62
Sri Lanka	2.60	2.60	2.60	2.60	2.79	3.12	3.12
Sudan	2.86	2.86	2.86	2.86	2.86	3.52	3.52
Swaziland	2.19	2.19	2.19	2.19	2.19	2.19	2.19
Sweden	2.33	2.66	2.80	2.80	3.47	3.47	3.90
Switzerland	2.38	2.71	3.14	3.14	3.80	3.80	3.80
Syria	2.46	2.46	2.46	2.46	2.46	2.46	2.46
Tanzania	2.70	2.70	2.70	2.70	2.90	2.90	2.90
Thailand	1.51	1.51	1.51	1.51	1.85	1.85	1.85
Togo	1.90	1.90	2.24	2.24	2.24	2.24	2.24
Trinidad and Tobago	3.01	3.01	3.01	3.01	3.01	3.01	3.01
U.S.A.	3.86	3.86	3.86	3.86	4.19	4.52	4.52
Uganda	2.04	2.37	2.37	2.37	2.57	2.57	2.57

Table 1
(continued)

Country	1960	1965	1970	1975	1980	1985	1990
Uruguay	1.79	1.79	2.26	2.26	2.26	2.26	2.26
Venezuela	1.35	1.35	1.35	1.35	1.35	1.35	1.35
Zaire	2.52	2.52	2.52	2.86	2.86	2.86	2.86
Zambia	3.52	3.52	3.52	3.52	3.52	3.52	3.52
Zimbabwe	2.37	2.37	2.37	2.37	2.90	2.90	2.90
Max	3.86	3.86	3.86	3.86	4.24	4.52	4.52
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean	2.13	2.22	2.27	2.28	2.40	2.44	2.46
Standard deviation	0.71	0.74	0.79	0.79	0.90	0.94	0.95

rights (examined here) are not 'natural rights' but are rights created by the State. Like real property, some nations may not recognize rights to intellectual property. But like real property, ownership rights to intellectual property may be fundamental to a community's sense of values (i.e. morals or ethics).

Turn now to the determination (or scoring) of values in each category. Except for the duration category (which is elaborated on below), each category consists of several *conditions* which, if satisfied, indicate a strong level of protection in that category. Each condition is of a binary character: yes it is satisfied or no it is not. For example, if a country satisfies all three conditions required for strong enforcement, it scores 3 out of 3 and earns a value of 1 for enforcement; if it satisfies only 1 condition, it receives a score of 1/3 for enforcement.

In what follows, a description of these conditions in each category is provided. This is followed by a discussion of the duration category and of how duration levels are scored. The choice of conditions for consideration is based on: (a) which provisions of the patent law are indicative of strong protection, as identified in the economics and legal literature; (b) which combination of these provisions gives the maximum separation (i.e. variation) among countries. [3] Appendix A summarizes all the categories, conditions, and scoring technique.

[3] The sources of information on patent laws used in this study were Baxter (1968), Gadbaw and Richards (1988), Hemnes et al. (1992), Jacobs (1978), Kim (1993), Matip (1965), Meller (1990), Nelson (1975), Schade (1961), United Nations Conference on Trade and Development (1975), and World Intellectual Property Organization (1988).

2.1.1. Coverage

The patent laws were examined for the patentability of various kinds of inventions. While in general patents are granted for inventions that are novel, industrially applicable, and nonobvious, most countries have, over time, specified unpatentable inventions. In this category, the strength of protection has been measured by the patentability of the following seven items: pharmaceuticals, chemicals, food, plant and animal varieties, surgical products, microorganisms, and utility models. [4] The value of this category indicates the fraction of these seven elements that were specified as being patentable in the law or were not specifically declared unpatentable. [5]

2.1.2. Membership in international agreements

By participating in international patent treaties, signatories indicate a willingness to provide national, nondiscriminatory treatment to foreigners. The three major agreements are: (a) the Paris Convention of 1883 (and subsequent revisions); (b) the Patent Cooperation Treaty (PCT) of 1970; and (c) the International Convention for the Protection of New Varieties of Plants (UPOV) of 1961. Countries which are signatories to all three receive a value of 1 in this category; those which are signatories to just one receive a value of 1/3.

The Paris Convention provides for national treatment to foreign nationals in the provision of patent rights. The main objective of the PCT is to harmonize and simplify administrative procedures. It allows the filing of a single patent application that is

[4] In general, utility models constitute new arrangements or forms introduced or obtained in known objects. Usually, this kind of protection applies to such objects as tools. Protection is granted only to the new form or arrangement, provided that it results in an improved utilization of the object. Among developing countries where patent protection is generally weak and where most inventions are of the minor, incremental type, this type of protection helps to distinguish which of these countries provides relatively stronger protection.

[5] Many countries also have laws against granting patents to inventions which adversely affect public welfare, health, or morality. Other than inventions pertaining to certain biological processes or products, the laws are generally not detailed about what types of inventions would be restricted. As this could be a loophole in blocking patents, it would be useful as an extension to determine how this exception is applied or interpreted.

effective in any of the member country patent offices. The UPOV confers plant breeder's rights, a form of protection similar to a patent. Unlike the Paris Convention, this treaty requires signatories to adopt common standards and scope of protection as national law, helping to make application procedures and laws clear and non-discriminatory.

2.1.3. *Loss of protection*

Patent holders may also face risks of forfeiting their patent rights. This category measures protection against losses arising from three sources: (a) 'working' requirements; (b) compulsory licensing; and (c) revocation of patents. A country that protects against all three sources receives a value of 1 in this category.

Working requirements refer to the exploitation of inventions. The authorities may, for example, require that a good based on the patent be *manufactured* or, if the patent is granted to a foreigner, that a good be *imported* into the country. In the absence of such requirements, the patentee does not have to put the invention into practice in order to enjoy patent protection, an advantage when the patentee is not financially able to work the invention or if working is not at that point economically feasible. Hence if a country does not require working at any point during the patent term, it receives a value of 1/3. Compulsory licensing requires patentees to share exploitation of the invention with third parties, and reduces the returns to invention that the patentee can appropriate (especially if it is imposed within a short time after a patent is obtained). A country receives a 1/3 value if it does not impose compulsory licensing within 3 or 4 years from the date of patent grant or application (the time frame stipulated by the Paris Treaty (see World Intellectual Property Organization, 1988) and recommended by the U.S. Chamber of Commerce (see Gadbaw-Gwynn (1988)). Finally, countries that do not revoke patents for non-working receive a value of 1/3.

2.1.4. *Enforcement*

Laws require adequate mechanisms of enforcement. In this category, the pertinent conditions are the availability of: (a) preliminary injunctions, (b) contributory infringement pleadings, and (c) burden-of-proof reversals. A country that provides all three receives a value of 1 for this category. [6]

Preliminary injunctions are pre-trial actions that require individuals to cease an alleged infringement. Preliminary injunctions are a means of protecting the patentee from infringement until a final decision is made in a trial. Contributory infringement refers to actions that do not in themselves infringe a patent right but cause or otherwise result in infringement by others. Examples include the supplying of materials or machinery parts that are essential to the use of a patented invention. Thus, third-party participants can be liable as infringers. Burden-of-proof reversals are procedures that shift the burden of proof in process patent infringement cases from the patentee to the alleged infringer. Under a burden-of-proof reversal, if a certain product is produced by another party, it is assumed that it was produced with the patented process. Given the difficulty patentees have of proving that others are infringing on their patented processes (since there are often several ways of producing the same product), the shift in burden can be a powerful enforcement mechanism.

Note that 'discovery' could also have been included as a fourth condition of enforcement. [7] However, it is not part of patent laws but of civil (pre-trial) procedures; moreover, the benefits of including this are ambiguous. On the one hand, it is very helpful in preparing a case, especially in process patent infringement cases where access to the alleged infringer's plants or documents are needed. [8] On the other hand, discovery is very costly. [9] Yet, where

[6] Legal remedies (or punishments) were not incorporated here because they provide little separation among countries. Virtually all patent laws stipulate that damages be awarded for infringement. For further discussions, see Baxter (1968) and Meller (1990).

[7] Discovery refers to legal procedures which one party can use before a trial to obtain facts and information about the case from the other party.

[8] For product patents, proof of infringement is not too difficult (using analyses of the product, expert testimony, photographs, advertising brochures, and operating manuals)—see Meller (1990), (1994 supplement, p. 17).

[9] In the UK, discovery fees have been as high as US$2 million during the mid-1980s—see Meller (1990), (1996 supplement, p. 3).

discovery is absent, the *burden of proof* reversal can prove to be a useful substitute. For example, in process patent cases the onus is put on the infringer to prove otherwise and thereby *reveal* the underlying 'process.' Countries like Japan, Germany, France, and Italy, that otherwise have strong patent regimes, do not provide for discovery, yet allow for burden of proof reversals. [10]

2.1.5. Duration of protection

The length of the patent term is important for ensuring adequate returns to innovative activity. Due to cross-country variation in the definition of starting points of patent terms, two scales were established to measure the strength of protection. The scales differ according to whether the start of the patent term is set from the date of application or the date of grant. [11] For patent terms based on the date of application, the standard is 20 years of protection. [12] The processing of the application often takes as much as 3 or 4 years. [13] Countries that provide 20 years or more of protection receive a value of 1 for this category. Those that provide shorter terms receive a value equal to the fraction of the 20 years that are provided. For example, if a country provides 15 years of protection, it receives a value of 0.75 for this category. The same procedure is applied to patent terms established from the date of grant. The only difference is that in this case the duration of standard is 17 years.

In closing, the index focuses on five general aspects of patent laws. A limitation with this is that a number of special, country-unique practices of the laws are omitted. For example, Japan permits pre-grant oppositions, Europe post-grant oppositions, and the U.S. neither. Such oppositions make it difficult for inventors to obtain or keep protection. Some patent regimes have relatively few patent examiners and attorneys, causing delays in obtaining protection or in enforcing rights. Others like Japan with a narrower patent scope [14] tends to encourage 'patent flooding,' the practice of filing numerous patent applications, often representing minor, incremental changes around an existing patentee's core technology. Often this is done for strategic purposes: to force the existing patentee into cross-licensing (otherwise the latter faces threats of infringement suits based on those surrounding patents). Patent flooding not only 'clogs' the system but can take away the exclusiveness of protection to a patentee. Finally, there are also unique cultural factors to take into account. In Japan, for example, litigation is viewed with disfavor. [15] Infringement suits are often acts of last resort. This might explain some of the frustration foreign firms have in trying to enforce their patent rights through the 'system.' Incorporating these country-unique factors would require adjustments in the generalized index values and a need to address the issue of international comparability. These tasks are deferred to future extensions.

2.2. Sensitivity of the index to weighting

As mentioned earlier, the unweighted sum of the values of all five categories gives the overall index value. Before proceeding, it would be useful to know how sensitive the overall index value is to the assumption that the categories be unweighted (or equally weighted, as it is effectively here). Different weighting would be important to heterogeneous innovators, some of whom might weigh one category (enforcement) more than another (duration).

The following sensitivity test determines whether

[10] As a check, for 38 nations, discovery was added as a fourth condition to enforcement. The Spearman rank correlation (see Section 2.2 below) between the original index for 1990 and the modified index is 0.976. Thus the ranking of patent regimes among countries remains virtually the same.

[11] Patent terms often start from the date of publication of the patent application in an official patent gazette. This usually occurs within the first 18 months after the date of application. In this case, the scale based on the date of application was used.

[12] This standard has been recommended by the U.S. Chamber of Commerce's Intellectual Property Task Force (see Gadbaw-Gwynn, 1988). Note that the U.S. has recently adopted this standard.

[13] The appendix to Hemnes et al. (1992) specifies the average patent processing times for over forty countries. For some innovations, such as pharmaceuticals, the processing time could be considerably longer than the average, but such distinctions have not been incorporated in the index.

[14] Patent scope refers to the boundaries of the invention for which the patentee is seeking exclusive rights. The scope is defined by the patent examiner on an invention-by-invention basis. Unfortunately, few systematic cross-country studies exist upon which to compare how narrowly protection is granted.

[15] U.S. Government Accounting Office (1993), p. 66.

Table 2
Sensitivity of index

Version	Spearman correlation coefficient	Summary statistics			
		Min.	Max.	Mean	Standard deviation
PR Index	1.00	0.00	4.52	2.46	0.96
COV4O	0.99	0.00	4.67	2.51	1.00
COV6O	0.97	0.00	4.67	2.60	1.09
MEM4O	0.96	0.00	4.64	2.31	1.06
MEM6O	0.92	0.00	4.76	2.16	1.22
RIG4O	0.95	0.00	4.64	2.26	0.98
RIG6O	0.85	0.00	4.76	2.07	1.08
ENF4O	0.95	0.00	4.43	2.23	1.00
ENF6O	0.90	0.00	4.68	1.99	1.11
DUR4O	0.98	0.00	4.64	2.90	0.98
DUR6O	0.92	0.00	4.76	3.33	1.06

This table pertains to the 1990 values of the index. Correlations are between the version indicated and the original Patent Rights Index (PR Index).

The first three letters of an abbreviation denote the category of the index that is being examined. A category is indicated by the following three letter abbreviations: COV = coverage; MEM = membership in international agreements; RIG = potential loss of rights; ENF = enforcement; DUR = duration.

The numbers 4O and 6O indicate weights of 40 and 60%, respectively, for that category. When the weight is 40%, all other categories are each weighted by 15%; when the weight is 60%, all others are each weighted by 10%.

different weighting schemes produce substantial changes in the rank ordering of the 110 countries, for it is primarily this ranking that affects the qualitative conclusions in Section 3.

The idea of the test is to vary one at a time the weight assigned to each of the five categories of the index. In the original index, each category is practically given the same weight (of 20 percent). As alternatives, ten new versions of the index are created by weighing one of the categories once by 40% and weighing it a second time by 60%, while assigning the other four categories equal weight. For example, DUR40 in Table 2 denotes the version of the index when duration is given a weight of 40% while the other four categories are each given a weight of 15%. DUR60 denotes a version giving 60% weight to duration and 10% to each of the others, and so forth.

The ten new indices are then related to the original index using Spearman rank correlations. [16] The results in Table 2 indicate that, while substantial changes in the *absolute* values of the index do occur, the rank sensitivity is rather low: there is essentially the same ordering of countries by strength of patent rights. The Spearman rank correlation between the original patent rights index and each of the other ten versions of the index does not fall below 0.85. Thus, the ranking of countries by patent protection levels is not sensitive to the application of equal weighting (or unweighting) of categories.

2.3. A note on statutory versus actual protection

An important concern is whether 'laws on the books' are actually carried out. Thus, a related sensitivity issue is whether there any gaps between real and perceived (statutory) protection. Determining whether laws are actually enforced is difficult to determine for any legal statute, let alone patent laws. Nonetheless, some indirect evidence is worth considering. The concern should mostly be with the measured indexes of the OECD countries rather than those of the less-developed, since the main concern about the latter is the *absence* of laws. Hence if there is any overestimation of patent rights and protection, it should be the OECD's measures.

It would be ideal to examine the execution of laws by studying court case activities: the percentage of infringement cases that went to court; attitude of

[16] Spearman's rank correlation (or Spearman's rho) indicates how the ranks of objects in one sample differ from the ranks in another sample. Its values range from −1 to 1. A value of 1 indicates that the ranks are identical, while −1 indicates that they are exactly inverted.

judges and enforcement officials; damages awarded (as to whether they were commensurate with the offense). Unfortunately, no such international database of court records exists. A second-best approach to studying the execution of laws is to examine 'complaints' against the system (its courts, officials, and outcomes). The idea is that *numerous* complaints would be filed if the system is not working (relative to what the statutes provide). The nature of complaints would indicate whether there are any systematic problems with the execution of laws. It is important to note, for purposes here, that it is not the complaints per se that matter but whether they suggest deviations between the PR index and actual practice.

Table 3 lists the types of complaints made by U.S. firms in USTR and USITC reports regarding intellectual property protection abroad. If U.S. firms face these difficulties, it is likely that other foreign agents face similar treatment in those countries against which complaints are filed. Note, however, that the complaints are largely non-patent related (i.e. related to copyrights, trademarks, or trade secrets). Furthermore, the complaints are primarily statutory (rather than enforcement-related)—that is, with the lack of laws in the case of less developed countries, and with institutional differences in the case of developed nations (concerning coverage, exemptions, application procedures, and others). [17] Interestingly, there are relatively few complaints about the enforcement of patent rights. Non-OECD countries like Egypt, Pakistan, and Venezuela have received complaints about their *lack* of patent enforcement mechanisms (and their indexes reflect these inadequacies), while OECD countries have received no complaints about the execution of patent laws—except in the case of Japan (see below).

The complaints against actual execution arise in certain countries (for example, in Brazil, India, Korea, and Mexico) because the enforcement process is slow (e.g. lengthy court proceedings and police response), the system has inadequate resources, or certain officials were involved in corruption. In other countries (like Nigeria, Peru, and the Philippines), enforcement actions that are available under the law had failed to be executed.

In the case of Japan, some deviations between actual and statutory protection may arise because of non-patent related policies (such as strategic industrial or trade policies). For instance, firms have expressed that it is "difficult to isolate the effect of patent problems in Japan from other problems [that they] face in trying to penetrate the Japanese market." [18] It appeared to U.S. firms that the Japanese Patent Office (branch of MITI) did not provide broad protection for emerging technologies unless (i) Japanese industries for them were well-established, and (ii) no Japanese competitors existed.

Consider a few examples. In the case of Corning Glassworks (a U.S. firm) which owned U.S. patents on optical fibres, the NT&T (Nippon Telegraph & Telephone) vetoed a joint venture between it and Furukawa Electric on grounds that telecommunications were of 'national security' interest [19], and pressured Corning to license Furukawa instead, who in turn, under further pressure from NT&T, sublicensed to Sumitomo Electric (a Japanese firm), which then developed its own optical 'waveguide' guide fibres which U.S. courts had found to infringe on Corning's. In another case, Allied Signal (a U.S. firm) applied in Japan for a couple of patents on an amorphous metal technology. These applications were opposed by a consortium of Japanese companies (organized and subsidized by MITI) which at the time was also trying to develop the same technology. Eventually Allied did receive its patents, but many years after the dates of filing. These opposition battles resulted in a reduction in the effective duration of protection for Allied (to less than 10 years) since protection in Japan is from the date of filing.

Thus, in such cases, the patent rights indexes may not reflect what actually goes on. For example, in

[17] For example, a chief complaint against Australia has been its duration of protection of 16 yrs from the date of filing. A common complaint against Canada (until 1988 when its patent laws were amended) was its compulsory licensing of food and pharmaceutical products, and against New Zealand (until 1992 when its Patents Act was amended) was its lenient granting of compulsory licenses. There were also frequent complaints against Singapore, where government procurement is exempt from rules against buying products that infringe on existing patents. All of these 'aspects' are recorded in these countries' patent rights indexes.

[18] U.S. Government Accounting Office (1993), p. 4.

[19] *Economist*, 25th August 1984, vol. 292, p. 59.

Allied Signal's case, because of the delay in obtaining protection, the real duration is lower. If firms in their situation actually receive only 10 years of effective protection (or half of the statutory years), the real index value should be deducted by 1/2 a point. However, in the case of Corning, on whom compulsory licensing was imposed due to considerations of 'national security,' the index reflects the kind of difficulties such firms face, as Japan does not receive a score for protection against loss of rights due to compulsory licensing.

While the patent system can be an instrument of strategic industrial policy, its use in this manner appears to occur in particular situations [20], as "many U.S. patent attorneys and other patent experts do not believe that the Japanese patent system inherently discriminates against foreign applicants.... [Rather] certain cultural and structural aspects work together to make it difficult for non-Japanese firms to obtain effective patent protection." [21]

To summarize, the main complaints overall are not about the *execution* of patent laws, but of statutory and institutional differences which the PR indexes already reflect. Hence the gap between the measured and actual levels of patent protection is not very wide. When gaps between actual and statutory protection arise, they are due to slow enforcement and administrative processes or to some form of industrial targeting on the part of government branches.

2.4. Trends in patent protection levels

As shown in Table 1, the average value of the PR index increased by 15.5% from 1960 to 1990. However, as the standard deviations indicate, protection levels have not changed uniformly across countries. The increased spread in patent rights arises because countries that had high levels of protection in 1960 (e.g. the OECD countries) increased their levels while most countries that had low levels in 1960 either reduced or maintained them. Reasons behind this trend are explored in Section 3.

Note that African countries received relatively high scores. This is due to the similarity of their patent laws with those of France and the U.K., their former colonial ties. [22] In particular, it was the duration and coverage categories that were similar, and which sharply separated them from other developing countries.

A question of interest is whether nations strengthen their patent regimes as they transit to higher stages of development. A first look at this question is provided in Table 4. Using Table 1, all countries were sorted by the level of real GDP per capita in 1960 in descending order. The countries were then put into three groups: the top third (in terms of GDP per capita in 1960), middle third, and bottom third. Each group in turn was sorted by the average growth rate during 1960–90 (in descending order), and three further subgroups were formed within each group. Those whose average growth rate exceeded 3% were put in the Fast Growth category, those whose rate was less than 1% were put in the Slow Growth category, and all others were put in the Moderate Growth category.

As Table 4 indicates, the higher income group tends to provide stronger patent protection. However, while there is not a clear pattern by growth rates, it is interesting to note that the fast growing economies of the 1960 Low Income group increased their patent protection the most. This group consists of countries like South Korea and Botswana. During the 1970s, their index values grew at an average annual rate of 1.39% (the highest experienced among all subgroups). By the 1980s, their index values reached those of the industrialized countries. On the other hand, the slow and moderately growing economies of the Middle Income group have tended to provide weaker levels of protection over time. Thus the table suggests that as nations swap places in the international distribution of income, in some cases they switch from providing weak protection to strong protection, and vice versa. Interestingly, the fast and

[20] The complaints filed with the U.S. Trade Representative suggest that governments tend to use more direct means (e.g. subsidies, government procurement) when targeting industries, rather than indirect means like patent policy.

[21] U.S. Government Accounting Office (1993), p. 43.

[22] Some, such as Kenya and Ghana, merely provide for registration of United Kingdom patents. That is, to receive patent protection in these countries one must first patent in the United Kingdom. Thus, in constructing the index, the U.K. values of the coverage and duration components were assigned to these countries.

Table 3
U.S. firm/industry complaints of inadequacies in foreign intellectual property regimes, 1986–95

Country	Patent		Copyright, trademark, or trade secret	
	Statutory	Enforcement	Statutory	Enforcement
Argentina	2,3,4	5	2	
Australia	1,2			
Brazil	1,2,3	5,7	1,2	5,7
Canada	1,2,3		2	
Chile	1,2		2	
Colombia	2,3,4	7		5,7
Costa Rica	1,2			7
Dominican Republic	2,3		2	7
Ecuador	1,2,3		1,2	
Egypt	1,2,3	5	2,6	7
El Salvador	1,2,4		2,4	7
Finland	2			
Germany			2	
Guatemala	1,2,3,4		2,4	5,7
Honduras	1		2	5
India	1,2,3,4	5,7	2	7
Indonesia	1,3,6		2	7
Israel	2,3			
Italy				5,7
Japan	6		1,2	7
Korea	2,3,4	5,7	6	5,7
Malaysia	1,3		2	7
Mexico	1,2,3	5,7	2	7
New Zealand	2,3,6		6	
Nicaragua	1,2		2,6	
Nigeria		7	4	5,7
Pakistan	1,2,3,4	5	2	7
Paraguay	1,2,4		2,4	7
Peru	2,3	7		5,7
Philippines	3	7	1,2	7
Portugal	2,4		2	7
Saudi Arabia	4		1,2,4	
Singapore	6		2	7
South Africa	4		2	7
Spain	2			5,7
Thailand	2,3		2	7
Turkey	1,2,3			5,7
Venezuela	1,3,4	5	2	5,7

Codes for types of complaints registered:
A. Institutional Factors
1. Duration of protection too short.
2. Lack of coverage.
3. Loss of rights (due to compulsory licensing, working requirements, or other).
4. Lack of membership in major international conventions (e.g., Paris Convention or Berne Convention).
5. Inadequate enforcement mechanisms (e.g., court procedures, injunctive relief, seizure, impoundment).
6. Other (application process, government procurement).

B. Execution of Laws
7. Actual execution of the IP law (e.g., slow enforcement process, inadequate resources, corruption, politically biased courts).

Table 4
Patent rights and world distribution of income

	Average PR Index value per decade (and average annual percentage change)		
	1960–70	1970–80	1980–90
High income nations			
Fast growth	2.41 (0.79)	2.61 (0.66)	2.76 (0.2)
Moderate growth	2.82 (1.11)	3.07 (0.87)	3.32 (0.33)
Slow growth	1.99 (0.99)	2.15 (0.24)	2.19 (−0.00)
Middle income nations			
Fast growth	1.98 (0.39)	2.10 (0.72)	2.18 (−0.16)
Moderate growth	2.16 (−0.01)	2.17 (−0.02)	2.17 (−0.10)
Slow growth	1.63 (−0.12)	1.61 (−0.04)	1.63 (0.19)
Low income nations			
Fast growth	2.02 (0.17)	2.15 (1.39)	2.45 (0.61)
Moderate growth	1.94 (0.38)	2.01 (0.43)	2.08 (0.02)
Slow growth	2.12 (0.73)	2.23 (0.49)	2.35 (0.25)

Notes: Income grouping (by high, middle, and low) is based on GDP per capita as of 1960. Growth rates (GR) are based on the average during 1960–90. Fast growth refers to nations whose GR > 3%, moderate growth to 1% ≤ GR ≤ 3%, and slow growth to GR < 1%.

moderately growing economies of the High Income group have tended to increase their patent protection levels but at a diminishing rate. A reason might be that further increases (at high levels) are either inefficient, owing to increased market power, or more costly to provide (financially).

A weakness with the analysis above is that it overlooks the possibility of reverse causality. Countries may grow faster or be better developed because of the effect that greater patent protection has on stimulating innovative activity. On the other hand, richer countries may provide greater patent protection because they have the resources to create a legal infrastructure and enforce the laws.

3. Determinants of intellectual property rights

This section examines further the characteristics of nations which provide strong patent protection. First, some background theory is provided; secondly, a panel data set is described; and thirdly, the empirical results are presented.

3.1. Model

The purpose of the model is to motivate the regression analysis which follows. The model indicates what factors would affect a country's choice of level of patent protection. First, a choice-theoretic framework is outlined. Secondly, a derived decision rule is used to examine how the optimal level of protection varies in response to changes in exogenous variables.

A policymaker's choice of level of patent protection depends on weighing the benefits and costs. First, the benefits of patent protection are that it would stimulate innovation. Although, it is possible that if protection is excessive, innovators with market power may face less of an incentive to introduce new technologies which displace existing ones. Nevertheless, insofar as innovation is stimulated by increased patent protection, productivity growth can be enhanced, and the quality and variety of goods increased. Another potential benefit is that by providing patent protection, a nation develops better trade relations with other economies.

Note to Table 3:
Based on: National Trade Estimate Report on Foreign Trade Barriers, U.S. Trade Representative, 1987–95 (annual issues); Foreign Protection of Intellectual Property Rights..., U.S. International Trade Commission (1988), Tables G-6, G-8; U.S. Companies' Patent Experiences in Japan, GAO 1993, Appendix 1, GAO Survey on Patent Experience: Japan, Europe, and the United States.

Secondly, there are costs to providing patent protection. Under imitation, more of the newly invented goods (or processes) would be available, and at cheaper prices. Thus, there are burdens imposed on consumers and on intermediate goods producers who use the new innovations as inputs. Moreover, creating a patent system or 'infrastructure' (of courts, administrative offices, police, and so forth) entails *fixed* (setup) costs as well as *variable* costs in enforcing the laws and adjudicating disputes.

Consider the following indirect social welfare function:

$$V(p,Y),\ V_1 < 0, V_2 > 0, \tag{1}$$

where p is the long run equilibrium aggregate *price* level and Y the long run equilibrium aggregate *output* level (i.e. V is measured in steady-state). [23] This indirect welfare function can be derived from either a quality-ladders or an increasing variety growth model. [24] It captures, for example, the tradeoff typically faced in providing stronger patent protection. On the one hand, an increase in protection which stimulates innovation results in higher output Y, but in less diffusion of new goods, and hence higher p. On the other hand, under lax patent rights, imitation occurs which increases the availability of new goods, resulting in lower prices but at the cost of reduced long run output since innovators respond with reduced innovative activity due to their decreased ability to appropriate fully their rents.

The level of patent protection, θ, then is a determinant of p and Y, along with other determinants:

$$p = p(\theta, X_p) \tag{2}$$

$$Y = p(\theta, X_Y) \tag{3}$$

where X_p and X_Y are other general-equilibrium determinants of aggregate price and output, respectively. It is assumed that:

$$\partial p/\partial\theta > 0,\ \partial^2 p/\partial\theta^2 < 0,$$

$$\partial Y/\partial\theta > (<)\ 0,\ \partial^2 Y/\partial\theta^2 < 0,$$

that is, holding everything else constant, an increase in patent strength, θ, increases monopoly power, so that price p increases. But the price increases at a decreasing rate and approaches the monopoly price level as θ approaches its maximum level (i.e., perfect protection). X_p represents factors that affect the price level, such as factors affecting competition (for instance taxes, regulation, or openness to trade). In more highly distorted economies, the price level is expected to be higher.

Increases in θ have two effects on Y: on the one hand, improved protection increases the market share of owners of new goods (or processes). Hence, producers of new technologies would increase their production in order to exploit the larger market. on the other hand, increases in θ, by raising market power, induce producers to restrict output. Thus the effect on output Y is ambiguous. It is likely that the first effect dominates at lower levels of output (so that $\partial Y/\partial\theta > 0$) and the second at higher levels (so that $\partial Y/\partial\theta < 0$). For this reason, it is supposed that Y is concave downward in θ (hence $\partial^2 Y/\partial\theta^2 < 0$).

X_Y represents factors that determine per capita output, for example inputs like physical capital, human capital, labor, and R&D, and environmental variables that affect the technical efficiency of production like climate and political stability.

Let $G(\theta)$ be the present discounted (lifetime) value of the costs of developing and operating a patent law infrastructure. It is expected that the first derivative $G' > 0$; that is, the greater the level of enforcement, the more resources required. It will also be assumed that the second derivative $G'' > 0$. [25] This infrastructure cost explains why larger economies (with higher levels of GDP per capita) are more likely to develop patent systems, for they are

[23] V satisfies the following additional properties: $V_{11} < 0$, $V_{22} < 0$, $V_{12} = V_{21} < 0$, and $V_{11}V_{22} - V_{12}^2 > 0$.

[24] See Grossman and Helpman (1991).

[25] It is also plausible that $G'' < 0$. But this would mean that it is possible to approach an infinite (or perfect) level of protection by expending more resources at a diminishing rate. Here in contrast, it is assumed that it costs more to strengthen patent rights at higher levels than at lower; for example, to offset the more sophisticated methods of piracy and cheating which may arise or to offset the costs of congestion of court time and policing resources, since at higher levels of θ, more innovations may exist which need to be protected. Either assumption is plausible and can be incorporated into the model without major change in the results.

more likely to afford the cost G, or why economies with a large innovating sector provide patent rights, as they are more apt to produce benefits which exceed G. [26]

The optimizing policy authority thus chooses θ to maximize

$$W(\theta) = V\big(p(\theta, X_p), Y(\theta, X_Y)\big) - G(\theta) \qquad (4)$$

where W is the long run, steady-state value. The optimal level of protection, θ^*, solves $W'(\theta^*) = 0$ and $W''(\theta^*) < 0$. Of course, an *incentive* constraint is $W(\theta^*) \geq 0$, or else $\theta^* = 0$.

A few comparative statics will illustrate how θ varies across steady-states. By the Envelope Theorem,

$$\operatorname{sgn}(\partial\theta*/\partial Z) = \operatorname{sgn}(\partial W'(\theta*)/\partial Z) \qquad (5)$$

where Z is an exogenous variable. Thus,

$$\frac{\partial W'}{\partial X_p} = V_1 \frac{\partial^2 p}{\partial\theta\partial X_p} + V_{21} \frac{\partial p}{\partial X_p}\frac{\partial Y}{\partial\theta} + V_{11}\frac{\partial p}{\partial X_p}\frac{\partial p}{\partial\theta} < 0 \qquad (6a)$$

$$\frac{\partial W'}{\partial X_Y} = V_2 \frac{\partial^2 Y}{\partial\theta\partial X_Y} + V_{12}\frac{\partial Y}{\partial X_Y}\frac{\partial p}{\partial\theta} + V_{22}\frac{\partial Y}{\partial X_Y}\frac{\partial Y}{\partial\theta} > 0 \qquad (6b)$$

provided $\partial^2 p/\partial\theta\partial X_p$ and $\partial^2 Y/\partial\theta\partial X_Y$ are positive. These last two assumptions imply that larger X's increase the marginal effects of θ on price and output. [27] The second assumption holds provided the existing level of protection is not too excessive (i.e. $\partial Y/\partial\theta > 0$).

Returning to Eqs. (6a) and (6b), it is seen that each consists of two types of effects: direct and indirect. The direct effect is given by the first term in each, and the indirect effect by the last two terms in each. The *direct* effects are the effects of changes in price p and output Y on welfare. The *indirect* effects occur because the resulting changes in p or Y affect the marginal utility functions V_1 and V_2. For the 'signs' to be as stated, the direct effects have to dominate (which reinforces in Eq. (6a) the price effect on welfare $V_1 < 0$ and in Eq. (6b) the income effect, $V_2 > 0$).

To fix ideas, suppose X_p is a measure of market interventions. The higher X_p is, the less free markets are. A rise in X_p causes a rise in (long run) price, p, which according to Eq. (6a) directly lowers steady state welfare. But indirectly it decreases the marginal impact of a higher p on welfare (since $V_{11} < 0$), and thus offsets the decline in welfare. As long as the indirect effects are smaller than the direct, a decrease in market freedom lowers steady state welfare. In this case, an optimizing policy authority reduces the level of patent protection (tolerates some additional imitative activity) in order to offset the adverse price effects.

Next, suppose X_Y represents R&D intensity, and suppose an increase in X_Y results in an increase in Y. This directly increases welfare, but indirectly lowers it since a higher output level lowers the marginal gain in welfare from an increase in Y (since $V_{22} < 0$). As long as the direct effect dominates, an increase in R&D activity raises steady state welfare. At the existing level of protection, the marginal gain from an increase in protection, θ, exceeds the marginal cost; hence an optimizing policy authority is motivated to increase the level of patent protection.

To summarize, factors that reduce long run price or stimulate long run production should lead to a strengthening of patent protection. The influence of a nation's level of development on patent rights should be through G, the infrastructural costs. Richer countries are more able to afford these costs. In all of these cases, the effects on patent protection are empirical questions. The 'expected' effects depend on the direct effects dominating, which may not be the case if a variable has a small direct effect or no effect at all on welfare.

Based on this conceptual framework, the empirical analysis below relates patent rights to per capita

[26] Of course, the innovating sector may be large because of strong patent rights. This interdependence may be a reason why economies which protect patents weakly can be 'trapped' into providing weak patent rights. Authorities have weak incentives to strengthen those rights unless a significant innovation sector exists; but an innovating sector may not develop unless patent rights are strengthened.

[27] An analogy is where an increase in capital causes the marginal product of labor to be higher.

GDP, openness, political and market freedom, and investments in human and R&D capital.

3.2. Data

The data are from various sources: *Real GDP per-capita* are from Summers et al. (1995); *Research and Development* as a percentage of GDP from UNESCO; and the *Secondary School Enrollment Rate* and *Political Rights Index* from Barro and Lee (1994). [28] Political freedom includes the freedom to vote and run for office. The original index varies so that *lower* numbers reflect *greater* liberties. Here the index is converted to a scale from 5 (most free) to 1 (least free). This way, positive coefficients will be associated with positive influences on patent rights.

The *Market Freedom Index* is from Johnson and Sheehy (1995). Freer markets are defined, essentially, as involving lesser government intervention. The extent of government intervention is based on 10 indicators, including taxation, price controls, regulation, and private ownership rights (over tangible assets). This index is also converted to a scale from 5 (most free) to 1 (least free).

The *Openness Index* is from Sachs and Warner (1995). The variable equals one if the country in question meets all of the following four criteria: it must (a) not be socialist; (b) have a low black market exchange premium; (c) have a low coverage of quotas on imports of intermediate and capital goods; and (d) not have extreme trade distortions resulting from its export marketing board.

A panel data set is constructed for 48 countries and 4 periods: 1965, 1975, 1985, and 1990. A number of countries (particularly African) from Table 1 are dropped due to a lack of data, primarily on R&D. The dependent variable (PR index) takes on the values for those years (1965, 1975,...) while the independent variables (except for market freedom) are lagged five years (1960, 1970,...). Lagging the RHS variables helps to avoid potential simultaneity, especially between patent rights and R&D/GDP (or per capita GDP). [29] Unfortunately, the market freedom index is not time-varying; the index is a measure for the overall sample period. Given that market freedom is the more general measure of private property rights, it is likely that the causality is from market freedom to patent rights, rather than the reverse.

Table 5
Sample statistics (Average 1960–90)

	PR	*P*	*M*	*O*	*R*	*E*	*Y*
Mean	2.40	3.70	3.22	45	0.69	0.46	4623
Max	4.19	5.00	3.75	100	2.77	0.91	14330
Min	0.00	1.83	1.10	0	0.01	0.12	779
Standard deviation	0.80	0.96	0.58	42	0.76	0.22	3656
Correlation matrix							
PR	1.00						
P	0.53	1.00					
M	0.65	0.43	1.00				
O	0.58	0.45	0.70	1.00			
R	0.75	0.57	0.53	0.52	1.00		
E	0.71	0.64	0.62	0.68	0.66	1.00	
Y	0.70	0.71	0.67	0.67	0.80	0.83	1.00

PR, Patent rights index; *P*, Political rights index; *M*, Market freedom index; *O*, Openness index (% of sample period that country was open); *R*, R&D expenditures as a % of GDP; *E*, Secondary school enrollment rate; *Y*, Real GDP per capita.

Table 5 presents some sample statistics for the 48 countries in the panel. [30] Note that R&D is the only variable whose standard deviation to mean ratio exceeds one. It is the variable, in other words, with the greatest relative variability. Secondly, note the high correlation between the R&D variable and real GDP per capita. These two facts play an important role in the analysis below.

3.3. Empirical results

Table 6 contains estimates of the PR equation. All variables, except for the openness dummy, are logged. The first regression is a simple regression of the PR index on per capita GDP. The result confirms

[28] The authors in turn obtain the data from Gastil (1987).

[29] See Park and Ginarte (1997).

[30] Although *openness* is a dummy variable indicating whether a country was open during a given year, for purposes of presenting sample statistics, the percentage of the sample period during which countries were open was calculated. For example, the mean of 45% indicates that the average country was open for 45% of the period.

Table 6
Panel regressions

Dependent variable: PR Index					
	Full sample:			Split sample:	
	OLS (1)	OLS (2)	GLS (3)	GLS (4)	GLS (5)
Constant	−1.06 (0.203)	0.683 (0.33)	−0.12 (0.31)	0.19 (0.51)	0.35 (0.29)
GDP per capita	0.232 (0.025)	−0.031 (0.042)	0.06 (0.038)	0.05 (0.052)	−0.036 (0.062)
R&D/GDP		0.078 (0.018)	0.035 (0.019)	0.114 (0.031)	−0.003 (0.026)
Secondary enroll rate		0.057 (0.035)	−0.029 (0.022)	−0.011 (0.041)	−0.0006 (0.047)
Political freedom		0.071 (0.056)	−0.012 (0.033)	−0.061 (0.047)	0.006 (0.047)
Openness		0.096 (0.047)	0.114 (0.03)	0.005 (0.044)	0.164 (0.041)
Market freedom		0.52 (0.089)	0.55 (0.13)	0.54 (0.187)	0.47 (0.206)
Adj R^2	0.31	0.51	0.31	0.42	0.22
No. of obs.	192	192	192	96	96
F-indiv [p-value]	24.6 [0.00]	15.5 [0.00]			
F-time [p-value]	6.33 [0.00]	2.16 [0.095]			
$\chi^{2(6)}$ [p-value]			7.53 [0.27]	8.62 [0.19]	10.87 [0.093]

(i) Standard errors are in parentheses (). All variables are logged, except for openness. The PR Index is the value for 1965, 1975, 1985, and 1990. The RHS variables are averages of the preceding 5 yrs respectively. F-indiv (F-time) is the F-statistic for testing the significance of individual (time) effects. The $\chi^{2(6)}$ is the Chi-square statistic for testing the null of no correlation between the RHS variables and the individual specific error.

(ii) The full sample consists of 48 countries observed over the four time periods. The first-half of the split sample (column 4) consists of countries *above* the median sample income and the second-half (column 5) of countries *below* the median. The sample income measure is real GDP per capita (averaged 1960–90).

that the more developed economies provide stronger protection. However, as the second regression in column 2 reveals, it is not the level of development per se that influences the provision of patent rights but rather the determinants of economic development, such as research and development, market freedom, and openness. Once these are controlled for, the per capita GDP variable is no longer important. Thus, in regression 1, per capita GDP is likely to have proxied for the effects of these omitted relevant variables. Political freedom and human capital have positive influences on patent rights but are not statistically significant at conventional levels.

One problem with the pooled cross-section time-series regressions is that the error term may be nonspherical. Indeed an analysis of variance reveals the strong presence of an individual effect (the F-test results are indicated in Table 6). For the column 2 regression, the null of no time effect could not be rejected, but the null of no individual effect is rejected. Thus for the rest of the regressions, the PR equation is estimated by generalized least squares (GLS). The Hausman tests indicate that the null of no correlation between the RHS variables and the individual error cannot be rejected at the 5% significance level.

The re-estimation results are shown under column 3. [31] Once random variation due to individual country effects is accounted for, the R&D variable has a weaker influence on patent rights. Its significance level falls to about 7%. Thus, compared to GLS, OLS places greater weight on factors like R&D which varies considerably across countries, especially between rich and poor. This concern suggests dividing the sample into different income groups.

In fact, when the sample is split into two income groups, there are some noticeable differences in behavior. The first group consists of 24 countries whose sample average GDP per capita is above the median, and the second group of those whose average is below. Three points stand out: first, the model better explains the variation among the richer half (the goodness of fit is 42% for the richer half versus 22% for the poorer half). Secondly, R&D matters for the

[31] The explanatory power of additional lagged (5 yr averaged) RHS variables was also tested (i.e., one-period lags of all the RHS variables). The null hypothesis that the coefficients of all the additional lagged variables were zero could not be rejected (p-value of the F-statistic = 0.22).

richer half but not the poorer half. Thirdly, openness matters for the poorer half but not the richer half.

One reason why R&D matters less for the patent rights of poorer economies is that most of the latter's R&D is public (or government-sponsored). The output of this type of R&D is not likely to be subject to intellectual ownership claims, but rather to be public property. Secondly, some of their R&D, if not much of it, is likely to be of the imitative, adaptive type. The more of that type of R&D, the less stringent patent protection would be.

This finding (that R&D does not matter for the poorer economies) appears to be evidence against the hypothesis that countries have vested interests in providing patent rights *if* they engage in R&D, as they would then have something of interest to protect. The fact, however, that R&D is highly correlated with per capita GDP suggests a different story. Instead of dividing the sample between those above the median sample income and those below, the sample could have been divided between those above a certain R&D/GDP ratio and those below. In other words, what the results imply is that there is a *critical* size of a research sector, above which there is sufficient interest on the part of authorities to provide patent rights and below which there is not. This would be plausible if there were large fixed (set-up) costs to establishing a patent system, in which case it would take a large enough R&D sector to generate the amount of innovations (and social benefits) that would make the investment in the system worthwhile.

Indeed, as a check, the data set was sorted by the ratio of R&D to GDP, and two sub-samples were created: one where every country's R&D/GDP ratio exceeded 0.21% (of which there were 32 countries) and another where everyone's was below that (of which there were 16 countries). The results (not shown) indicated that R&D is an important determinant of patent rights for the larger R&D nations (with a coefficient (s.e.) of 0.076 (0.025)) but unimportant for the smaller R&D nations (with a coefficient (s.e.) of −0.032 (0.035)). Now, if the sample were divided at an R&D/GDP ratio lower than 0.21%, R&D is not significant (at conventional 32 levels) even for the larger R&D group. The cutoff R&D/GDP ratio of 0.21%, however, is by no means the 'critical' size of the research sector necessary to motivate strong IPRs. The critical size is likely to be country-specific (if not, time-specific), and its determination is beyond the scope of this paper. The main point to note is that the results in column 5 of Table 6 need not imply that R&D does not matter to the patent rights of the less developed region, only that it matters if R&D is large enough. [32]

This critical hurdle could in fact generate the increased spread in patent index values observed between the OECD and non-OECD, where R&D/GDP ratios increased in the former (during the sample period) but stayed low in the latter.

As for openness, one reason why the richer economies' patent rights are not sensitive to openness is that the richer economies are all fairly open, and hence there is not much variation in this variable among the richer half. On the other hand, openness is likely to be important to the poorer half because trade with the rest of world involves establishing good relations. The less developed economies have more to gain from a reputation for respecting international agreements, such as on patents. Openness is thus a good predictor of developing economies' patent rights.

The market freedom variable consistently has the predicted effect on the patent rights of both rich and poor alike. [33] The remaining explanatory variables are statistically insignificant.

Why is political freedom not an important determinant of patent rights? The key is to distinguish between political and market freedom. Barro (1996) finds that democracy is not an important determinant of growth but rather a luxury good, which richer countries can afford. Countries which have political freedom (but little market freedom) end up losing political freedom due to slow growth in living standards. Likewise, countries which have market free-

[32] The case of post-colonial America is an example of how an emerging nation can develop into a strong advocate of intellectual property rights. While U.S. patent rights are currently among the strongest, they were rather lax during the 19th century. One could argue that industrialization in the U.S. was partly aided by its ability to copy (or steal) vital foreign technology.

[33] It might seem contradictory that market freedom positively influences patent rights which create market power. But the fact is that in the absence of such rights, a market (for new knowledge) is 'missing.' It is therefore not surprising to find that more market-oriented economies tend to provide stronger patent rights.

dom (but little political freedom) end up acquiring greater political freedom due to a rise in living standards. Thus, it is market freedom, and not so much political freedom, that provides an environment conducive to innovation and production.

Another reason why political freedom does not contribute to patent rights may be that income distributional considerations weigh more heavily in social welfare. As Persson and Tabellini (1994) argue, populist governments who care more about distribution may not grant property, or intellectual property, rights protection. Stronger patent protection leads *ceterus paribus* to higher prices and limited diffusion. Democratic countries, *ceterus paribus*, tend more to favor income distribution, and thus would grant less patent protection if income groups below the median would be severely hurt by the higher prices and limited availability of important products, such as medical innovations.

Finally, some thoughts on why the human capital variable is not a significant determinant of patent rights. Both a high level of human capital and R&D activity characterize innovating economies. Yet it is not the stock of human capital per se that generates incentives to provide patent protection, but rather the investments or resources committed to knowledge creation. The stock of human capital per se does not indicate how much has been invested. Rather it is the amount of resources innovators invested in that matters for patent rights. Innovators have a stake in it, and thus seek protection to recoup their investments and appropriate the returns. The R&D variable better captures the resources committed.

4. Conclusion

This paper has constructed an index of patent rights for 110 countries for the period 1960–1990. The empirical analysis finds that market freedom is a strong determinant of patent protection levels across countries. It also finds that lagged R&D investment rates are an additional strong determinant of patent protection for developed economies and lagged openness an additional strong determinant for developing economies.

These results can be used to predict the kinds of nations that will provide stronger patent rights. The results can also be linked to policy issues. Consider, for example, the fact that R&D is not important to patent rights unless an economy reaches a sufficiently high level of development. This suggests some *threshold* effects at work; namely that a country requires a certain critical size of an innovating sector before it has an incentive to provide patent rights. There are large fixed costs of establishing a patent system as well as operating costs. [34] Thus, if the size of a research sector is small, inventors may not produce enough innovations to make the adoption of a patent system worthwhile. Hence, at an international level, cooperative efforts should be directed at fostering a significant research base in countries where patent protection levels are low. Countries that conduct significant innovative research are more likely to have vested interests in seeing patent rights respected. It is this fact that international negotiations should try to exploit. For example, in exchange for research collaboration or assistance, the weaker patent rights nations would strengthen their regimes. Current efforts to pressure them to strengthen their regimes are not likely to be successful unless their lack of motivation or incentives to strengthen is addressed.

For extensions, the index can be used to study the effects of patent protection on growth, trade, technology transfer, and market structure. Most studies of these have thus far been theoretical. Furthermore, the recently concluded Trade-Related Intellectual Property Rights (TRIPs) agreement contains essentially all of the categories of the patent rights index in this paper. Future work could therefore examine the rate at which countries strengthen their patent regimes by ratifying and implementing the new agreement.

5. Unlinked References

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[34] See Siebeck (1990), Chap. VII.

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Appendix A

The following is a summary of the categories of the PR index:

(1) Coverage	Yes	No
Patentability of pharmaceuticals	1	0
Patentability of chemicals	1	0
Patentability of food	1	0
Patentability of plant and animal varieties	1	0
Patentability of surgical products	1	0
Patentability of microorganisms	1	0
Patentability of utility models	1	0
(2) Membership in international treaties	Yes	No
Paris convention and revisions	1	0
Patent cooperation treaty	1	0
Protection of new varieties (UPOV)	1	0
(3) Loss of protection measures against losses	Yes	No
Working requirements	1	0
Compulsory licensing	1	0
Revocation of patents	1	0
(4) Enforcement	Yes	No
Preliminary injunctions	1	0
Contributory infringement	1	0
Burden-of-proof reversal	1	0
(5) Duration	Value	
Application-based standard:		
$x \geq 20$ years	1	
$0 \leq x < 20$	$x/20$	
Grant-based standard:		
$x' \geq 17$ years	1	
$0 \leq x' < 17$	$x'/17$	

where x = duration of protection (in years) under an application-based standard and x' = duration of protection under a grant-based standard.

The value of each category, other than duration, is j/k, where j is number of 1's received (or number of conditions satisfied) and k the number of conditions to be satisfied.

For example, in the U.S. in 1990, category (1) = 0.85, (2) = 1.00, (3) = 1.00, (4) = 0.67, and (5) = 1.00 (where the U.S. is under a grant-based standard). Thus the PR index value = 0.85 + 1.00 + 1.00 + 0.67 + 1.00 = 4.52.

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