INTELLECTUAL PROPERTY RIGHTS AND ECONOMIC GROWTH

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This paper studies the relationship between intellectual property rights (IPRs) and economic growth for a cross-section of countries for the period 1960–1990. The analysis focuses on effects of IPRs on growth using a quantitative index of IPRs. The paper finds that IPRs affect economic growth indirectly by stimulating the accumulation of factor inputs like R&D and physical capital. The positive effects of IPRs on factor accumulation, particularly of R&D capital, are present even when the analysis controls for a more general measure of property rights. (*JEL* O34, O40)

I. INTRODUCTION

Intellectual property protection has been an international policy concern. Owners of intellectual property face risks of imitation or piracy not only in domestic markets but also in foreign, particularly in less developed, markets. Recent global negotiations have called for higher levels of intellectual property protection and for the harmonization of standards. Advocates of these measures cite potential economic benefits ranging from greater world innovation to greater trade and direct foreign investment flows (see Butler, 1990, for a survey of issues).

This paper gauges the economic benefits of increased intellectual property protection. Specifically, it examines how patent protection affects long-run economic growth. Existing empirical and theoretical works study the importance of innovation and technology to growth, but few have empirically studied the effects of the institutions that motivate innovation and technological change, such as intellectual property laws. Studying the effects of intellectual property rights (IPRs) requires having a quantitative measure of the strength of intellectual property rights in a country. This paper constructs an index of the strength of patent protection in 60 countries and uses it to determine the role of IPRs in economic growth.

The key finding is that IPRs affect economic growth by stimulating the accumulation of factor inputs like research and development capital and physical capital. The institution of IPRs does not have any direct role in explaining international variations in growth. That is, the existence of intellectual property laws does not appear to affect directly the technical efficiency of production. Instead, the benefits to growth are from encouraging the research sector to invest and take risk.

This implies that countries not conducting innovative research or conducting a limited amount would enjoy few, if any, of the benefits of intellectual property protection because an innovation sector through which IPRs affect economic growth is absent. As an analogy, consider a town with few, if any, motor vehicles. If the town passes a law against lead emissions, the law is likely to have no appreciable effect on lowering pollution levels in

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ABBREVIATIONS

IPR: Intellectual property rights
PCT: Patent Cooperation Treaty
UPOV New Varieties of Plants of 1961
USCC: U.S. Chamber of Commerce
MRW: Mankiw, Romer, and Weil (1992)

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the region (pollution arising instead from other sources). Similarly, countries would not experience the growth effects of IPRs unless a significant domestic research base exists or unless foreign multinationals are present that transfer research knowledge into the country. Given the costs of creating an IPR system, the low returns to providing IPRs (owing to a lack of innovation) act as a disincentive to creating such a system.

Thus, countries without an innovative R&D sector (domestic or foreign-based) are likely to attach a low priority to developing an IPR infrastructure even though having an IPR system would help attract foreign research resources and possibly lead to the creation of a domestic research sector. Furthermore, countries without a domestic research base may find it difficult to justify providing IPR protection to foreigners, who seem to be the primary beneficiaries of protection, if in the short run the consequences of IPR protection are higher prices of new technologies and limited diffusion. The growth effects might appear later, but policymakers may, depending on their discount rate, perceive that the expected present discounted value of investing in a legal infrastructure is less than current costs of investing in the system plus the foregone benefits of imitation (assuming the ability to imitate foreign technologies).

While empirical growth studies emphasize the importance of knowledge accumulation (Mankiw et al., 1992; Lichtenberg, 1992; Park, 1995), none studies the importance of assigning proprietary rights to knowledge in the growth process. On the other hand, empirical analyses of intellectual property rights (Ferrantino, 1993; Mansfield, 1986, 1994) do focus on the effects of IPRs on innovation and foreign direct investment but have not linked these effects to long-run growth. Gould and Gruben (1996), however, study the link between growth and IPRs but differ from this paper in two respects: (i) their measure of IPRs is based on that of Rapp and Rozek (1990) whereas this paper constructs its own measure, one that exhibits more variability than that of Rapp-Rozek; (ii) this paper emphasizes how IPRs affect factor accumulation rather than long-run productivity directly.

Finally, a number of interesting studies examine the relationship between property rights in general and economic growth (Torstensson, 1994; Svensson, 1994; Sachs-Warner, 1995). These studies broadly define property rights while this paper focuses on the protection of intellectual property specifically. Nevertheless, the emphasis is similar, namely that growth is affected negatively by expropriation of private property and positively by the ability to appropriate investment returns. To ensure that the IPR variable is not picking up the effects of property rights in general, the empirical analysis controls for a market freedom variable that captures characteristics of a nation's overall level of property rights.

II. MEASUREMENT OF INTELLECTUAL PROPERTY RIGHTS

Information on quantifying intellectual property rights protection is from national patent laws and from legal background in Hemnes et al. (1992) and Gadbaw and Richards (1988). The index takes on values between zero and five, higher numbers reflecting stronger levels of protection. The index consists of five categories: (i) coverage, (ii) membership in international patent agreements, (iii) provisions for loss of protection, (iv) enforcement mechanisms, and (v) duration. Each category takes on a value between zero and one. The sum of these five values gives the overall value of the IPR index for a particular country. The index is computed for 60 countries for the period 1960–1990 (see table 1).

Except for the duration category, each category consists of three conditions that, if satisfied, indicate a strong level of protection in that category. For example, if a country receives a one for enforcement, it strongly enforces the laws; if it receives one-third, it weakly enforces them. Before getting to what those various conditions are, it is best to mention the "scoring technique." Given that there are three conditions per category, and given that each condition is of a binary character (yes it is satisfied or no it is not), the value assigned to this category is the fraction of conditions met. As an example, if the value of enforcement is two-thirds, this indicates that the country satisfies two of the three conditions needed for strong enforcement.

A. *Coverage*

The three conditions refer to whether the following are patentable: (i) utility models (i.e. improved utilization of objects, typically

TABLE 1
Intellectual Property Rights Index Values
(Average 1960–1990)

Algeria	3.24	Jordan	1.52
Argentina	2.06	Kenya	2.49
Australia	2.84	Korea	3.00
Austria	3.53	Mauritius	2.37
Belgium	3.48	Mexico	1.30
Bolivia	1.48	Netherlands	3.70
Brazil	1.52	New Zealand	2.98
Cameroon	2.04	Nicaragua	0.94
Canada	2.67	Norway	2.92
Cent Afr Rep	2.04	Pakistan	1.70
Chile	1.96	Panama	2.15
Colombia	1.13	Paraguay	1.29
Congo	2.04	Peru	0.65
Costa Rica	1.84	Philippines	2.52
Denmark	3.11	Portugal	1.82
Ecuador	1.60	Rwanda	2.43
El Salvador	1.97	Senegal	1.99
Finland	2.39	Singapore	2.16
France	3.48	South Africa	3.45
Germany	3.29	Spain	3.53
Greece	2.01	Sri Lanka	2.76
Guatemala	1.15	Sweden	2.99
India	1.39	Switzerland	3.23
Indonesia	0.33	Thailand	1.44
Iran	2.00	Trinidada	2.73
Ireland	2.46	Turkey	1.29
Israel	3.53	U.K.	3.26
Italy	3.50	U.S.A.	3.52
Jamaica	2.44	Uruguay	1.63
Japan	3.48	Venezuela	0.75

Source: Authors' Derivations based on National Patent Laws

minor inventions such as tools), (ii) pharmaceutical products, and (iii) chemical products. A country that provides patent protection for all three kinds of inventions receives a value of one, those that provide for two receive a value of two-thirds, and so on.

B. *Membership in International Agreements*

The three major agreements are: (i) the Paris Convention of 1883 (and subsequent revisions), (ii) Patent Cooperation Treaty of 1970 (PCT), and (iii) the International Convention for the Protection of New Varieties of Plants of 1961 (UPOV). Countries that are signatories to all three receive a value of one in this category; those that are signatories to just one receive a value of one-third.

The Paris Convention provides for national treatment to foreign nationals in the provision of patent rights—that is, for non-discriminatory treatment. The main objective of the Patent Cooperation Treaty is to facilitate administrative procedures in applications for patents. It allows the filing of a single patent application that is effective in any of the member country patent offices. The UPOV confers plant breeder's rights, a form of protection similar to a patent. This treaty obliges its signatories to adopt common standards and scope of protection as national law, helping to make application procedures and laws much more clear and non-discriminatory.

C. *Loss of Protection*

This category measures protection against losses arising from three sources: (i) "working" requirements, (ii) compulsory licensing, (iii) revocation of patents. A country that protects against all three receives a value of one in this category.

Working requirements refer to the exploitation of inventions (or utilization of patents).

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. Some countries impose conditions that inventions must be working by a certain period of time. Compulsory licensing requires patentees to share exploitation of the invention with third-parties and usually works to limit the capacity of the patent holder to appropriate the returns to his/her invention (particularly if compulsory licensing is imposed within a short time after a patent is granted). Finally, some countries may revoke patents entirely, usually if they are not working.

D. *Enforcement*

Laws are not effective without adequate mechanisms for their enforcement. In this category, the pertinent conditions were the availability of: (i) preliminary injunctions, (ii) contributory infringement pleadings, and (iii) burden-of-proof reversals. A country that provides all three receives a value of one for this category.

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 on a patent right but cause or otherwise result in infringement by others. In short, contributory infringement makes third-party participants 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. In light of the difficulty for patentees to prove that others are infringing on their patented processes (because there often are several means of producing the same product), the shift in burden can be a powerful enforcement mechanism.

E. *Duration*

The length of the patent term is important for ensuring adequate returns to innovative activity. Here, a country receives a one if it provides the minimum duration recommended by the U.S. Chamber of Commerce (USCC). The minimum duration is 17 years from the date of patent grant or 20 years from the date of patent application. Countries that give less than this minimum duration receive a value equal to the fraction of the minimum standard provided, and countries that give more than the minimum duration are assigned a value of one.

In summary, the overall index value is the sum of the values generated from the five categories; each category maps three conditions to a value in the range zero to one.

III. EMPIRICAL MODEL AND DATA

The following model augments Mankiw, Romer, and Weil (1992) (henceforth MRW) to incorporate the stock of domestic R&D capital. This extension of MRW resembles that of Lichtenberg (1992). The production function is given by:

$$Y = K^{\alpha} H^{\beta} R^{\gamma} (AL)^{1-\alpha-\beta-\gamma} \tag{1}$$

where Y is output, K physical capital, H human capital, R research and development capital, and L labour. The A term represents the level of labour-augmenting technology and depends on institutional, cultural, environmental, and related factors:

$$A = A(\mathit{Institutions},\ \mathit{Environment},\ \ldots) = \varepsilon\, I^{\varphi}$$

where I is an institutional variable (representing the state of laws, like intellectual property protection, or market freedom). ε is that part of A not specifically modelled (for example, political factors) and is treated as exogenous.

From (1), output per efficiency worker is given by:

$$y = a\, k^{\alpha} h^{\beta} h^{\gamma} \tag{2}$$

where $y = Y / \varepsilon L$, $K = K / \varepsilon L$, $r = R / \varepsilon L$, and $a = I^{\varphi(1-\alpha-\beta-\gamma)}$. The associated net investment rates are:

$$\dot{k} = s_k y - (n + g + \delta)k \tag{3a}$$

$$\dot{h} = s_h y - (n + g + \delta)h \tag{3b}$$

$$\dot{r} = s_r y - (n + g + \delta)r \tag{3c}$$

where $g = \dot{\varepsilon} / \varepsilon$, $n = \dot{L} / L$, and δ is the common depreciation rate. s_i is the fraction of output invested in factor $i = k$, h, and r. Linearizing the model around the transition path to steadystate gives the growth rate equation (4). The derivations follow from MRW. To simplify, however, $\dot{I}/I$ is assumed to be zero. This is innocuous given that institutions (of intellectual property protection and market freedom) changed slowly during the sample period. The growth rate equation is:

$$\Delta \ln y = \psi_0 + \psi_1 \ln y_0 + \psi_2 \ln s_k + \psi_3 \ln s_h + \psi_4 \ln s_r + \psi_5 \ln (n + g + \delta) + \psi_6 \ln I \tag{4}$$

where

$$\psi_1 = -(1 - \exp(-\lambda t)),$$

$$\psi_2 = \psi_1 \alpha / (1 - \alpha - \beta - \gamma)$$

$$\psi_3 = \psi_1 \beta / (1 - \alpha - \beta - \gamma),$$

$$\psi_4 = \psi_1 \gamma / (1 - \alpha - \beta - \gamma)$$

$$\psi_5 = \psi_1 (\alpha + \beta + \gamma) / (1 - \alpha - \beta - \gamma),$$

$$\psi_6 = \psi_1 \varphi (1 - \alpha - \beta - \gamma)$$

$$\lambda = (1 - \alpha - \beta - \gamma)(n + g + \delta)$$

Note that MRW treats the s_i as exogenous. In a more general setting, these gross investment rates would depend on the relevant rates of return (or relevant shadow price of capital); that is,

$$\ln s_k = f_k (R_k) \tag{5a}$$

$$\ln s_h = f_h (R_h) \tag{5b}$$

$$\ln s_r = f_r (R_r) \tag{5c}$$

where R_i denote the rates of return. The rates of return themselves are functions of other factors, such as institutional environment and government policies. Since rates of return data are not widely available, existing studies substitute in (5a-c) those various factors that affect the rates of the return. Thus, following Barro and Lee (1994), the gross investment rates will be functions of measures of market freedom, political stability, fiscal policy, and the initial stock of human and other capital. In addition, the IPR index will be included to measure the ability of investors to appropriate the returns to their investments.

To summarize, equations (4)–(5) are estimated as a system. Letting *INITIAL* denote the log of GDP per adult worker in 1960, *INVEST* ln s_k, *SCHOOL* ln s_h, *R&D* ln s_r, and *NGD* ln $(n + g + \delta)$, one can write the system more compactly as:

(6a) *GROWTH = G(INITIAL, INVEST, SCHOOL, R&D, NGD, IPR, MARKET)*

(6b) *INVEST = I(INITIAL, IPR, MARKET, REVOL, GOVT, EDUC)*

(6c) *SCHOOL = S(INITIAL, IPR, MARKET, REVOL, GOVT, EDUC)*

(6d) *R&D = R(INITIAL, IPR, MARKET, REVOL, GOVT, EDUC)*

where *IPR* denotes the log of the intellectual property rights index, *MARKET* the log of the market freedom index, *REVOL* the log of one plus the number of revolutions, *GOVT* the log of the ratio of government consumption to GDP, and *EDUC* the log of initial secondary school attainment (in years). Data on *INITIAL*, *GROWTH*, *NGD*, *INVEST*, and *GOVT* are from Summers et al. (1995). *GROWTH* is the difference between the log of 1990 GDP per adult worker and the log of 1960 GDP per adult worker. For *NGD*, n is the population growth rate, $g = 2\%$, and $\delta = 3\%$. These are the same values assumed in *MRW* and Lichtenberg (1992). *R&D* data are from *UNESCO*, *MARKET* data are from Gwartney et al. (1995), and *REVOL* and *EDUC* data are from Barro and Lee (1994).

A few remarks on expected signs: *INITIAL* should have a negative effect on the rate of growth if conditional convergence occurs, and *INVEST*, *SCHOOL*, and *R&D* should have a positive effect to the extent that they are important factors of production. A higher population growth rate, depreciation rate, or rate of labour efficiency growth has a negative effect because the available stocks of capital must be spread more thinly over the population. Since few studies exist on the role of institutions in economic growth, it is difficult to sign the market freedom and intellectual property rights variables. On the one hand, more liberalized markets and protection of legal rights should provide a positive environment for economic activity and thus be conducive to growth. On the other hand, command economies (with less free markets and rights) also have achieved (at times) high growth rates.

Regarding the accumulation equations (6b–d), two opposing effects of initial development influence investment rates. On the one hand, less developed countries have smaller amounts of reproducible assets and hence higher marginal productivities of those assets. This should make less developed countries have a higher rate of investment than the more developed. On the other hand, the market size is smaller and hence the less developed should have a lower rate of investment than the developed. The net effect is therefore ambiguous. *IPR*s are expected to contribute positively to investment to the extent that they raise the incentive to invest, but they may discourage investment in new plants and equipment (and new products and processes) to the extent that they grant excessive market power. Again, market freedom is difficult to sign given the present lack of empirical evidence about the role institutions play. The empirical analysis should shed light on how important "liberal" markets are to investment behavior. Political revolutions should have a negative effect on investment to the extent that they render investments riskier. The *GOVT* variable captures the size of government. Larger government sizes might capture the effects of distortionary taxation and/or financial and resource crowding out. Finally, *EDUC* proxies for the initial level of education. By raising the marginal productivities of factors, a higher level of *EDUC* should exert a positive influence on investments.

IV. EMPIRICAL RESULTS

The system (6a–d) is estimated by Seemingly Unrelated Regressions (SUR) in order to exploit the interrelationships among the equations. Tables 2 and 3 display the combined results. Table 2 reports the growth rate equation results, and table 3 the investment equation results. Each table contains four columns (1)–(4). Each column corresponds to one set of SUR estimation results. The first set of estimations considers the full sample of 60 countries but considers only the intellectual property rights variable as the measure of institutions. The second set of estimations includes other institutional and related factors (such as market freedom, political instability, government size, and initial education). Because *IPR*s might proxy for the effects of property rights in general, controlling for the broader measure (like *MARKET*) is important. Finally, in sets (3) and (4), the full sample is split in half, and separate SUR estimates are obtained for countries whose sample average GDP per worker is, respectively, above or below the median level. This allows one to examine whether *IPR*s matter differently for developed and developing regions.

First consider the growth regression results. Column (1) of table 2 presents the first set of results. Intellectual property rights have no statistically significant influence on growth. Thus, the model essentially reduces to a standard growth regression model, driven by reproducible factors of production. Yet, this does not preclude *IPR*s' having an indirect effect on *GROWTH* through their effect on some of these reproducible factors that do contribute to growth, like *R&D*.

The estimates of ψ_i can be used to derive estimates of the output elasticities (see equation (4) and the coefficient expressions). The estimates of column (1), table 2 yield an R&D output elasticity of $\gamma = 0.0904$, which is quite comparable to previous estimates. Park (1995) estimates the range of this elasticity as 0.07 – 0.11. Lichtenberg (1992), for a different sample, obtains 0.066. As for the estimates of α and β, the implied estimate of the output elasticity of physical capital is 0.4 (for which *MRW* obtained 0.44), and that of human capital is 0.15 (which is less than the 0.23 obtained by *MRW*). Thus, the presence of *R&D* takes away the measured impact of human capital.

The purpose of column (2) is to introduce another measure of institutions—namely market freedom. The *MARKET* index includes the strength of property rights more generally (over land, wealth, and earnings). The index covers 17 areas, including trade and monetary policy. Markets are freer to the extent that they are less restricted by the state. One drawback of *MARKET* is that is covers only half the sam-

TABLE 2
Growth Regressions

	Dependent Variable: *GROWTH RATE*, Average 1960–1990			
	(1)	(2)	(3)	(4)
CONSTANT	3.528 (1.20)	3.714 (1.15)	8.60 (1.28)	6.16 (2.82)
INITIAL	–0.483 (0.073)	–0.485 (0.069)	–0.841 (0.093)	–0.592 (0.14)
INVEST	0.537 (0.137)	0.657 (0.134)	0.26 (0.149)	0.71 (0.197)
SCHOOL	0.196 (0.086)	0.125 (0.087)	0.422 (0.129)	0.097 (0.119)
R&D	0.121 (0.042)	0.117 (0.041)	0.180 (0.066)	0.133 (0.053)
NGD	–1.144 (0.352)	–0.861 (0.356)	–0.402 (0.275)	–0.167 (0.918)
IPR	–0.045 (0.098)	–0.049 (0.094)	–0.042 (0.132)	–0.06 (0.114)
MARKET		0.343 (0.141)	0.334 (0.131)	0.47 (0.208)
Adj R^2	0.592	0.628	0.866	0.543
No. Obs.	60	60	30	30

Notes: Standard errors are in parentheses. Estimation is by *Seemingly Unrelated Regression* (equation in Column *x* is jointly estimated with equations corresponding to column *x*'s of table 2, where *x* = 1, 2, 3, 4). Column (3) represents the above-median income sample, and column (4) the below-median income sample.

INITIAL is the log of 1960 GDP per adult worker, *INVEST* the log of domestic investment to GDP ratio averaged 1960–1990; *SCHOOL* the log of secondary school enrollment per working-age population averaged 1960–1990; *R&D* the log of research and development expenditure to GDP ratio averaged 1960–1990; *NGD* the log of the sum of the rates of population growth, exogenous efficiency growth, and depreciation averaged 1960–1990; *IPR* the log of the index of intellectual property rights averaged 1960–1990; and *MARKET* the log of the index of economic freedom averaged 1975–1990.

ple period (1975–1990). However, the index changes very slowly (with most of the changes occurring in the late 1980s). Johnson and Sheehy (1995) offer another measure of market freedom that covers 1965–1990 but has fewer categories and covers fewer countries. The results are qualitatively similar if this latter measure is used in place of the *MARKET* variable.

The results show that the broader measure does contribute positively to economic growth while the narrower measure (intellectual property protection) does not. The interpretation is that *IPR*s do not augment the technical efficiency of factors of production in the act of production.

In the presence of the *MARKET* variable, the output elasticity of physical capital changes very little (estimated $\alpha = 0.47$), but those of human and *R&D* capital decline to 0.0903 and 0.085, respectively. Thus, controlling for the institution of freer markets reduces the impacts of intangible capital on growth.

Column (3) contains estimates for the top 30 countries (in terms of the average level of GDP per worker), and column (4) contains estimates for the bottom 30. The *IPR* variable remains insignificant while *MARKET* continues to be an important determinant of growth. A key difference is that *R&D* has a larger measured impact on growth among the richer half. For the top 30, whose average *R&D* to GDP ratio is 1.16%, the implied $\gamma = 0.11$, and for the bottom 30, whose average R&D/GDP ratio is 0.32%, the implied $\gamma = 0.087$. Another difference is that the market freedom measure has a larger impact for the poorer half. These economies, in other words, could benefit more from a given "liberalization" of markets. This also could suggest a type of diminishing returns to improving market freedom. Once quite liberalized, further liberalization does not yield as

TABLE 3
Accumulation Regressions, 1960–1990

	Dependent Variables:					
	(A) *INVEST*		(B) *SCHOOL*		(C) *R&D*	
	(1)	(2)	(1)	(2)	(1)	(2)
CONST	−3.32	−2.6	−6.65	−6.02	−11.6	−12.1
	(0.42)	(0.5)	(0.68)	(0.79)	(1.22)	(1.5)
INITIAL	0.19	0.064	0.49	0.29	0.7	0.68
	(0.06)	(0.07)	(0.09)	(0.11)	(0.16)	(0.21)
IPR	0.26	0.21	−0.04	−0.12	0.77	0.8
	(0.09)	(0.096)	(0.15)	(0.15)	(0.26)	(0.29)
MARKET		−0.2		0.245		0.51
		(0.16)		(0.25)		(0.48)
REVOL		−0.29		−0.25		−0.75
		(0.98)		(0.46)		(0.88)
GOVT		−0.17		−0.099		−0.09
		(0.13)		(0.202)		(0.38)
EDUC		0.15		0.203		−0.15
		(0.06)		(0.093)		(0.18)
Adj R^2	0.36	0.43	0.37	0.47	0.45	0.47
No. Obs	60	60	60	60	60	60
	(A) *INVEST*		(B) *SCHOOL*		(C) *R&D*	
	(3)	(4)	(3)	(4)	(3)	(4)
CONST	−0.64	−2.53	−2.46	−8.01	−12.5	−8.5
	(0.87)	(1.2)	(0.72)	(2.15)	(1.92)	(3.6)
INITIAL	−0.19	0.11	0.011	0.47	0.75	0.12
	(0.098)	(0.17)	(0.08)	(0.29)	(0.22)	(0.49)
IPR	0.43	0.043	0.036	−0.15	1.5	0.47
	(0.14)	(0.13)	(0.11)	(0.23)	(0.3)	(0.39)
MARKET	−0.04	−0.33	−0.03	0.45	0.62	−0.16
	(0.21)	(0.22)	(0.17)	(0.4)	(0.47)	(0.67)
REVOL	0.04	−0.31	−0.91	−0.16	0.51	−0.03
	(0.36)	(0.44)	(0.29)	(0.79)	(0.78)	(1.32)
GOVT	−0.13	−0.02	0.11	−0.17	0.65	−1.06
	(0.15)	(0.19)	(0.13)	(0.34)	(0.34)	(0.56)
EDUC	0.092	0.22	0.083	0.303	0.022	−0.27
	(0.066)	(0.095)	(0.054)	(0.17)	(0.14)	(0.29)
Adj R^2	0.39	0.34	0.46	0.43	0.75	0.14
No. Obs	30	30	30	30	30	30

Notes: Standard errors in parentheses. Estimation is by *SUR*, jointly with Growth Equation. Column (3) represents the above-median income countries and column (4) the below-median income countries.

REVOL is the log of (1 + Number of Revolutions Per Year) averaged 1960–1990, *GOVT* the log of government consumption to GDP ratio averaged 1960–1990, and *EDUC* the log of secondary education attainment in 1960. All other variables are as defined in table 2.

large a return (in terms of the impact on growth).

Another difference is that physical capital is less significant and human capital more important among the richer half. One possible explanation is that the richer half has accumulated larger stocks of tangible capital so that it faces greater diminishing returns to physical capital. As for schooling, in the poorer half, school enrollment rates are generally quite low. Thus, at lower levels of development and educational attainment, variations in enrollment rates are not a driving source of growth.

Table 3 presents the estimates of the investment equations. The underlying theme is that intellectual property protection is a significant determinant of physical and R&D capital accumulation, even after controlling for market freedom. Indeed, market freedom here does not help to explain investment behavior. This suggests that the broader measure of property rights protection does not focus in on capturing the importance of the ability of investors to appropriate the returns to their investments as well as does the intellectual property rights variable. However, neither the narrower nor broader measure of property protection helps explain investments in education. The reason might be that investments in basic, general education are hard to appropriate in the first place, and thus the ability to establish proprietary rights to knowledge is not a factor determining human capital accumulation.

In column 1, table 3, the other control variables are not considered. The results show that intellectual property rights do indirectly affect growth by stimulating the accumulation of physical and research capital. The positive influence of initial GDP per worker indicates that richer countries invest more in reproducible assets, and this certainly is a factor behind cross-country divergence. Since all the variables are in logs, the coefficients can be interpreted in percentage units. For example, a 1% increase in the intellectual property rights index (making laws stronger) raises the tangible capital investment rate by 0.26% and the research investment rate by 0.77%.

Column (2) introduces the other control factors affecting the rates of return to investment, including market freedom. The measured impact of *IPR* changes only slightly. A 1% increase in the index raises the R&D investment rate by 0.8% and the physical capital investment rate by 0.21%. Here, *MARKET* does not contribute to factor accumulation. This suggests that the effects of market freedom work through the "organization" of markets, exchange, and production so as to affect directly the technical efficiency of production. However, market freedom as a whole is likely to be too broad a measure to influence the relevant rates of return to investments.

The *REVOL* and *GOVT* variables have the right sign but are not statistically significant. A higher initial stock of education capital is important to the accumulation of physical and human capital, but not of *R&D* capital. One reason might be that *R&D* requires much more specialized knowledge (as embodied in, say, the stock of science and engineering education) and thus is insensitive to the initial level of basic education.

Columns (3) and (4) report estimates of the split sample. Even within-groups, market freedom does not affect investment (at conventional levels of significance). Intellectual property rights, however, explain only the physical and research capital investment behavior of the top 30 economies. *IPR*s are significant at only the 24% significance level for the lesser developed countries' *R&D* investment rates. Two possible reasons are: (i) The *IPR* index values tend to be low in this (less developed) region, and thus *R&D*, when it does occur, responds to different incentives. (ii) Much of the *R&D* here may be adaptive or imitative *R&D* (for example, in Singapore and S. Korea). Intellectual property protection is likely to matter more for *R&D* activities targeted towards producing new innovations. Note that the result indicates that the less-developed countries' *R&D* is only weakly positively influenced by *IPR*s. The result does not indicate that their *R&D* is strongly negatively influenced by *IPR*s, which would be the case if all or most of their *R&D* were imitative, for in this case, stronger intellectual property protection would discourage their kind of *R&D*.

As for the other variables, *INITIAL* is not important in determining physical or human capital accumulation. This is because less within-group variability exists in *INITIAL* than between-group. The initial stock of education also exhibits low variability among the top 30 but high variability within the bottom 30 group and thus is an important factor in determining the latter's rates of return to investment in physical and human capital. Government size has a negative effect on the less developed countries' research but a positive effect on the developed countries' research. This suggests that in the former, a larger government size reduces *R&D* investment through the distortionary effects of taxation but that in the latter, a larger government size tends to be associated with more subsidies for company and institutional research (including research in higher education). Finally, revolutions have a significantly negative effect on human capital investment only for the top 30. This is due mostly to the presence in this sample of Latin American economies (like Argentina and Venezuela) that experienced coups and assassinations. The results indicate that political instability manifested itself more in disrupting education investments than in discouraging tangible investments.

The split samples show that it is important to distinguish between developed and developing economies when examining the role of intellectual property protection on growth and investment.

V. CONCLUDING REMARKS

According to the evidence presented, stronger intellectual property protection has the potential to improve economic growth. However, stronger *IPR*s will not contribute to growth merely by being codified into laws. Instead, they will do so by making more investment activities possible, particularly research and development activities. The investments in tangible and intangible capital in turn stimulate long-term growth.

The results also show that, while *R&D* is an important determinant of developed and developing country growth rates, *IPR*s matter for the *R&D* activities of the developed economies but not for those of the less developed economies. This suggests that, for the latter group of economies, either their *R&D* responds to different incentives (such as cultural rewards) or a significant part of their *R&D* activity is imitation.

The results have some implications for policy at the international coordination level. First, as countries develop and switch from imitative to innovative *R&D*, they are more likely to be interested in promoting stronger intellectual property protection (see Evenson, 1990, for a discussion of the patterns of international *IPR* protection among countries at different stages of development). Second, it is important to understand that institutions are not created in a vacuum. Institutions, such as an intellectual property rights regime, are costly to create and maintain. Their emergence is likely to depend on whether the incentives are right—that is, whether the benefits outweigh the costs. In this case, the returns to an *IPR* regime are larger the greater the intensity of (innovative) *R&D* activity. As an analogy, consider how institutions for enforcing contracts might have evolved with the development of long distance trade:

> The causation ran both ways. That is, the increasing volume of long distance trade raised the rate of return to merchants of devising effective mechanisms for enforcing contracts. In turn, the development of such mechanisms lowered the costs of contracting and made trade more profitable, thereby increasing its volume. (North, 1991, p. 107).

Likewise, an intellectual property regime requires resources for its creation and enforcement and also exacts welfare and other losses resulting from the granting of temporary market power. In order for an investment in this institution to be worthwhile, the benefits—in the form of new knowledge and improved macroeconomic performance—must exceed those costs. The benefits or returns are larger in economies with a stronger innovative research sector. On the other hand, innovative *R&D* takes place under conditions in which intellectual property rights are well protected and enforced.

Current policy discussions often overlook this interdependence of intellectual property institutions and research. Less developed countries are expected to cooperate in providing stronger levels of IPR protection without regard to whether they have vested interests in creating the necessary institutions. A significant research base in those countries helps to generate incentives for providing *IPR* protection. Imitation therefore harms not just foreign inventors but also domestic inventors. Thus, the more advanced countries that have a vested interest in stronger global *IPR*s should find it in their interests also to support the development of an *R&D* base in the lesser developed countries in exchange for the latters' support of an intellectual property infrastructure. Once such a base is established, *R&D* activities and *IPR* protection could grow in a complementary fashion.

Extending the research here would involve estimating the costs (or some of the costs) of establishing an *IPR* infrastructure. To date, no such estimates exist. Estimates of both the costs and benefits would better explain why some countries provide protection while others do not.

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