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An Empirical Analysis of the Impact of Patent Protection on Economic Growth*

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This research seeks to establish a link between the level of patent protection and the rate of economic growth. Limited prior research asserts that differences in policies which encourage innovation, the "engine of growth", may explain differences in cross-country growth rates. This study provides empirical evidence that universally imposed minimum standards for patent protection are not likely to contribute to increased growth in developing countries. However, the results suggest that stronger patent protection enhances economic growth rates once a particular level of development has been achieved.

I. Introduction

Technological innovation is widely recognized as being an "engine of growth". Innovation stimulates growth by causing the introduction of new goods and services to the market. Additionally, innovation results in improved methods for the production and provision of current goods and services. Differences in policies which encourage innovation may therefore be an important determinant for explaining differences in cross-country growth rates.

Theory suggests that intellectual property rights (IPRs), in the form of patents, trademarks, copyrights, semiconductor maskworks, and

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trade secrets, provide a market incentive which in turn stimulates research and development efforts on the part of the private sector. In addition, patent protection may invite foreign investment, foreign trade, and a flow of new technology. A common argument is that, under protection, the expected rate of return for the devotion of time, energy, and money to "innovate" is increased. In the absence of IPRs, fear of losses from piracy and imitation may adversely affect private sector devotion to research and development. The economic stagnation or slow growth experienced by some underdeveloped countries may be partially explained by a lack of strong or enforced IPRs.

IPRs are a heated issue between developed and developing nations. The issue was addressed in the 1994 Uruguay Round of the General Agreement on Tariffs and Trade (GATT). The inclusion of IPRs signifies the importance of the issue. The result of the Uruguay Round of the GATT is a move toward a uniform code of minimum standards for IPRs across countries along with enforcement mechanisms. It is asserted that this action will aid developing countries to achieve higher rates of economic growth and technological advancement. In addition, developed countries will have protection from loss of revenues due to piracy occurring in developing countries.

The focus of this research is to establish a link between patent protection and economic growth. Previous literature is briefly reviewed in the following section. The third section assesses the explanatory power of differences in patent protection on cross country differences in economic growth. The last section draws some conclusions for policy from the empirical results.

II. The Debate over Patent Protection

Neoclassical models of economic growth, originating with Solow (1956), express a country's production function limiting inputs to labor and capital and further assume constant returns to scale and diminishing returns. The neoclassical model of economic growth would therefore predict that poor countries should grow faster than wealthier countries (i.e., convergence of per capita income should occur). Evidence from cross-country data indicate that poor countries, in general, have not grown faster than wealthier countries (Barro, 1991). The neoclassical response is that diminishing returns to capital in relatively wealthier countries have been avoided due to advances in technology. Hence, an understanding of how technological change has transpired, in turn allowing wealthier countries to grow faster than relatively poorer ones, is crucial to our understanding of disparities in economic growth across countries.

Responding to the shortcomings of the neoclassical models (where technological advance is accounted for in the large residual), theoretical models of endogenous growth have been developed. Endogenous growth models recognize the importance of opportunities for profit from inventions as a driving force for process improvements which aid in sustained growth.

Romer's (1990) model of endogenous growth shifts the primary factor contributing to economic growth away from simple capital accumulation to the use and development of human capital. The model argues that devotion of more human capital to research results in a greater number of innovations. The increase in innovation in turn means a greater stock of knowledge to draw upon for additional research in the future. Romer's arguments are based, in part, on the premise that innovation (and the resulting technological improvements) occurs as a direct result of response by the private sector to market incentives (IPRs).

Judd (1985) develops a theoretical model which examines the impact that different patent rules have on the flow of product innovation by profit maximizing inventor-investors and seeks to determine a socially optimal level of innovation through patent protection. Judd finds that patents contribute to a self-sustaining cyclical pattern of innovation and growth and can lead to optimal allocation between expenditure on consumption and innovation.

Deardoff (1991) develops a theoretical model of invention and patent protection to determine if extending stronger IPRs to countries providing weak or no protection would result in welfare gains. Deardoff argues that geographical limits to IPRs may be justifiable. Deardoff recognizes the potential benefits of stronger protection in some countries. However, he argues, universally imposing a uniform set of patent laws and enforcement mechanisms on all countries may result in decreases in world welfare. He concludes the returns to monopoly profits diminish as more countries adopt patent protection because as the extra market that can be covered becomes smaller, so does the potential level of innovation which might be stimulated by increased patent protection.

Mansfield (1994) looked at the influence of intellectual property protection on foreign direct investment by U.S. corporations. He utilized a rating of sixteen countries perceived to have relatively weak IPR. He surveyed 100 randomly selected U.S. corporations to see to what extent the weakness of intellectual property protection would impact on corporate investment in those countries. He concluded that the strength or weakness of the IPR would effect the level of investment. However, the effect was not uniform. Only 20 percent of the corporations in sales and distribution outlets said weak protection would effect their investment decisions while 80 percent of those firms engaged in R&D said it would negatively influence their decisions.

Ⅲ. Data, Methodology, and Results

The purpose of this study is to assess the explanatory power of differences in patent protections as a contributor to cross-country differences in economic growth. The results allow an assessment of whether or not universally imposed minimum levels of patent protection are likely to positively impact growth in LDCs. Whether or not increased patent protection represents a good policy option at a particular point in the development process is also assessed.

The data for the study cover the years 1970 to 1985 for 112 countries. The data set is the same as that used by Barro (1991). In addition to the Barro data, an index of patent protection developed by Rapp and Rozek (1990) is utilized. The index was constructed based on each country's adherence to the minimum standards for patent laws proposed by the U.S. Chamber of Commerce Intellectual Property Task Force. The index ranks the level of patent protection for each country on a scale of zero to five as follows:

0 - No intellectual property protection laws.
1 - Inadequate protection, no laws prohibiting policy.
2 - Seriously flawed laws.
3 - Flaws in the laws, some enforcement of laws.
4 - Generally good laws.
5 - Protection and enforcement laws fully consistent with minimum standards proposed by the U.S. Chamber of Commerce.

The period of time between 1970 and 1985 is the chosen study period because no significant changes in patent laws across countries occurred. The estimating equation for the i-th country can be expressed as:

$$GR7085_i = \beta_0 + \beta_1 PAT_i + \beta_2 X_i + U_{1i} \tag{1}$$

where $GR7085_i$ is the growth rate of real GDP per capita from 1970 to 1985, PAT_i is the patent level, and X_i is a vector of variables which are likely to influence GDP growth, respectively. The variables in vector X_i are described in Table 1 and reflect variables used by Barro (1991). Descriptive statistics are provided in Table 2. The growth equation is estimated using ordinary least squares (OLS). Standard errors for the coefficients are based on White's (1980) hetero-skedasticity-consistent covariance matrix since heteroskedasticity is likely to be notable across countries.

Regression results are provided in Table 3. Regression 1 includes the full 112 country sample. Regression 2 also includes all countries but adds dummy variables for Latin American and sub-Saharan African countries to the estimating equation. Regression 3 levels out the countries which are members of OPEC since economic growth in these countries is probably largely influenced by oil exports. In all three regressions, patent protection is found to be statistically insignificant.[1] The control variables in the regressions which are common to those in Barro's 1991 work (GDP70, SEC70) behaved similarly. Using the full

1. In addition to theses regressions, a regression using dummy variables for each level of protection is conducted (patent level zero being the reference group). None of the coefficients on the patent dummies are statistically significantly different from zero.

sample, the regression results indicate that differences in patent laws and enforcement across countries do not provide a partial explanation for cross-country differences in economic growth and universally imposed minimum laws are not likely to contribute to increased growth in developing countries where little or no protection exists.

Whether or not increased patent protection is a good policy option at some point in the development process remains a question. Would a country benefit from increased patent protection upon reaching a particular level of economic development? The hypothesis is that a structural change in the coefficient on the patent variable may occur at a particular level of initial development and that at this level of development, and above, patent protection is a determinant of economic growth. Since there is no *a priori* information regarding the point at which a structural change may take place, switching regressions with unknown sample selection (Johnston 1984) are conducted to pinpoint at what level of initial development (as measured by GDP70) a structural break in the parameters occurs, if at all. The switching regression model for the i-th country is expressed as:

$$GR7085_i = \alpha_1 + \theta_1 PAT_i + \phi_1 X_i + u_{1i} \quad \text{for} \quad GDP70_i \geq t \qquad (2)$$

and $$GR7085_i = \alpha_2 + \theta_2 PAT_1 + \phi_2 X_i + u_{2i} \quad \text{for} \quad GDP70_i \geq t$$

where t is the level of GDP70 at which a structural change in the estimated parameter on the patent variable occurs.

Each equation is estimated by splitting the data set at various levels of GDP70.[2] An estimate of the switch point t is obtained by calculating the log-likelihood function value for each discrete value of t and choosing the one which maximizes the likelihood. The results of the switching regressions indicate that the likelihood function value is maximized when the sample is split at a level of GDP70 of $3,400(1980 dollars).[3] A Wald test is conducted to determine if the coefficients on

2. The discrete values for t were chosen such that, for each estimation, one country is shifted from one group to the other. However, at no point was there less than 20 countries in each group.

3. The likelihood function's value is maximized at the split occurring at the level of GDP70

the patent variable are statistically different in the two equations at the switch point. The results of the Wald test indicate that the estimated coefficient on the patent variable for the countries with GDP70 less than $3,400 is statistically different at the 99 percent level in comparison with the coefficient on the patent variable for countries with GDP70 in excess of $3,400.

The sample is divided between those countries which had initial levels of GDP per capita in excess of $3,400, and those that did not. The descriptive statistics for the split sample are provided in Table 4. OLS regression results for each of the samples are reported in Table 5. In the sample including countries which had initial levels of GDP per capita in excess of $3,400, the coefficient on the patent variable is positive and statistically significant at the one percent level. In the sample of countries with initial GDP per capita of less than $3,400, the coefficient on patent protection is statistically insignificant. The conclusion is that a statistically significant relationship between patent protection levels and economic growth rates exists in countries from the sample where GDP70 is in excess of $3,400 in 1980 dollars. Additionally, it is concluded that, upon reaching a particular level of development, increased patent protection represents a possible policy option for countries seeking to increase innovative activity and economic rates of growth.

Twenty-nine of the 112 countries (the 29 countries are listed and ranked by GDP70 in Table A1 in the Appendix) in the sample have an initial level of GDP per capita in excess of $3,400. Of the 29 countries, five had patent protection level of three or less (Saudi Arabia-3, Uruguay-3, Venezuela-2, Chile-2, and Argentina-1). Interestingly, four of these five countries were the only countries to experience decreases in GDP per capita for the period 1970 to 1985 out of the 29 country

of $3,400. A likelihood ratio test is employed to determine if the function's maximum value at this split is statistically significantly different form the likelihood function values calculated at all other splits. This is the case with the exception of the function values with splits in the data at GDP70 of $3,000, $3,130, and $3,500. A Wald test conducted at each of these splits indicates that the coefficients on the patent variables in the two equations are statistically different at the 99 percent level. As a result one could argue that a structural break in the parameter on the patent variable occurs in the range of GDP70 of $3,000 to $3,500.

sample: The fifth county, Uruguay, experienced flat growth. The results suggest that these countries may have benefitted from stronger patent laws and enforcement.[4]

To further establish the significance of patent protection as it relates to the economic growth rates of countries which had GDP70 in excess of $3,400, dummy variables for each level of patent protection are included in the estimating equation. The OLS results from this regression are provided in Table 6. The coefficient on the dummy variable for patent level two (PAT2) is not statistically different from zero. However, the coefficients on the dummy variable for level three through five (PAT3, PAT4, PAT5) are positive and statistically significant. Note that the magnitude of the coefficients on the dummy variables increases with the level of patent protection, providing further evidence that countries within this group would likely benefit from stronger protection.

The suggestion that patent protection levels and economic growth rates are positively related in countries with initial levels of wealth of a minimum $3,400 in per capita income further suggests that patent protection provides an incentive to commitment of resources to R&D which promotes the innovations fueling growth. To provide more direct evidence of the relationship between patent protection levels and R&D efforts, data reflecting R&D expenditures as a percentage of GNP were plotted with corresponding patent protection levels. Data are reported in Tables A2 and A3 in the Appendix. Using these data on R&D/GNP ratio, Figure 1 shows no distinguishable relationship between patent protection levels and R&D expenditures (as a share of GNP) in the sampling of those countries with initial per capita incomes of $3,400 or less. However, Figure 2 reveals a positive relationship between patent protection levels and R&D expenditures in countries with initial per capita income in excess of $3,400. These scatter plots furnish additional evidence suggesting that benefits from enhanced patent protection are not realized until reaching a relatively high level of development.

4. Of the 83 countries making up the sample with GDP70 less than $3,400, 42 have patent levels of 3 or greater. All total, 68 out of the 112 countries have functioning patent systems (patent level 3 or greater).

Ⅳ. Conclusions

The empirical evidence provided in this study points to a correlation between patent protection and economic growth for those countries with an initial level of GDP greater than or equal to $3,400 in 1980 dollars. These results provide support for the reluctance on the part of low income countries to adopt stronger patent laws until reaching a particular level of development.

Beyond the suggestion that relatively poor (non-innovating) countries will not benefit directly from enhanced patent protection (in the form of more rapid economic growth) is the notion that they may in fact be worse off under a stricter regime with benefit accruing to developed (innovating) countries. For example, Helpman (1993) points out that strengthening protection in developing countries may in turn increase the monopoly power of businesses in developed countries at the expense of the developing country. If stronger protection in the developing country causes a shift in production to developed countries, the resulting increase in the demand for resources in the developed country (and decrease in resource demand in the developing country) will result in higher incomes in the developed country at the expense of the developing country. These effects may be offset somewhat by the fact that stronger protection in the developing countries, while making imitation more costly, may result in speedier innovation rates in developed countries with some benefits to developing countries via technology transfer. Deardoff (1992) also provides theoretical evidence to suggest that increased patent protection in a non-innovating country results in increased welfare in an innovating country, and most likely decreases welfare in the non-innovating country. This comes as a result of enhancing monopoly power in innovating countries at the expense of consumers in the non-innovating country.

However, at the appropriate point in the development process, enhanced patent protection may be beneficial. Even so, Frischtak (1990) points out that adopting stronger patent laws is not costless and cannot take place overnight. Industries relying on imitation would incur significant costs as result of stronger patent laws. While an enhanced rate of development may make the costs easier to handle, for changes in patent protection to occur successfully, costs should be minimized during a transitional period to stronger laws. The likelihood that change would occur would be increased if the period of transition was several years in length possibly with some assistance form industrialized countries.

The recent GATT agreements (Uruguay Round, 1994) call for phasing in stronger intellectual property laws and enforcement mechanisms over several years for countries with weak or nonexistent protection. In the case of least-developed countries, full compliance with the GATT can be postponed for up to ten years. While this will reduce the cost of adopting stronger protection, the results of this study that these countries will not benefit from the enhanced protection unless they achieve significant improvements in the level of economic development over the ten year grace period.

Developed countries have valid concerns that weak patent protection in low income countries will likely result in losses from imitation and piracy. However, our results suggest that low income countries would not benefit from stronger protection, in terms of having a positive impact on the rate of economic growth, until achieving a significant level of development as measured by GDP per capita. Clearly, the results presented here are not a definitive statement on the impacts of varying levels of patent protection on economic growth. However, the results provide a previously undocumented link between IPRs and growth.

Table 1

GR7085	-	growth rate of GDP per capita from 1970 to 1985.
GDP70	-	value of real per capita GDP (1980 dollars).
INV	-	average of the ratio of real domestic investment (private plus public) to real GDP from 1970 to 1985.
SEC70	-	secondary school enrollment. The ratio of students in secondary education to estimated number of individuals age 12 to 17 years.
GROP7085	-	growth rate of the population from 1970 to 1985.
PAT	-	patent level index.
AFRICA	-	dummy variable for country in sub-Saharan Africa.
LAAMER	-	dummy variable for country in Latin America.
OIL	-	dummy variable for OPEC member country.

Table 2 Descriptive Statistics - 112 Country Sample

Variable	Mean	Standard Deviation
GR7085	.014	.024
GDP70($1,000)	2.52	2.49
INV	.19	.078
SEC70	.32	.26
GPOP7085	.021	.011
PAT	2.96	1.45

Table 3 Regression Results - Full Sample
(Absolute value of t-ratio in parentheses)

Dependent Variable	(1) GR7085	(2) GR7085	(3) GR7085 OIL = 0
Constant	- .007	.016	- .011
	(.76)	(1.49)	(1.15)
PAT	.0007	.001	.0014
	(.49)	(1.02)	(.94)
GDP70	- .005	- .006	- .005
	(4.5)	(5.62)	(3.61)
GPOP7085	- .36	- .48	- .27
	(1.42)	(2.02)	(.91)
INV	.15	.14	.142
	(4.85)	(5.04)	(4.21)
SEC70	.034	.006	.037
	(2.5)	(.46)	(2.65)
LAAMER		- .016	
		(3)	
AFRICA		- .023	
		(4.45)	
N	112	112	104
R^2	.394	.493	.377

Table 4 Descriptive Statistics for Split Sample

Variable	GDP70 < $3,400		GDP70 > $3,400	
	Mean	Standard Deviation	Mean	Standard Deviation
GR7085	.013	.026	.015	.017
GDP70($1,000)	1.21	.83	6.29	1.65
INV	.17	.075	.247	.055
SEC70	.21	.17	.62	.225
GPOP7085	.024	.008	.01	.01
PAT	2.55	1.35	4.14	1.06
N	83		29	

Table 5 Regression Results
(Absolute value of t-ratio in parentheses)

Dependent Variable	GR7085 GDP70<$3,400	GR7085 GDP70>$3,400
Constant	- .008	- .04
	(.74)	(4.25)
PAT	- .0008	.007
	(.5)	(5.56)
GDP70	- .009	- .002
	(2.71)	(2.16)
GPOP7085	- .28	- .3
	(.81)	(1.43)
INV	.175	.09
	(4.47)	(3.53)
SEC70	.05	.028
	(2.34)	(4.19)
N	83	29
R^2	.394	.816

Table 6 Regression Results
(Absolute value of t-ratio in parentheses)

Dependent Variable	GR7085 GDP70>$3,400
Constant	- .024
	(2.62)
PAT2*	- .005
	(.773)
PAT3	.016
	(2.76)
PAT4	.025
	(7.11)
PAT5	.026
	(10.27)
GDP70	- .002
	(2.35)
GPOP7085	- .3
	(1.69)
INV	.074
	(2.59)
SEC70	.023
	(2.83)
N	29
R^2	.871

Notes: Reference group is PAT1.
There are no countries in the 29 country sample with patent level = 0.

Figure 1 Patent Protection Levels and Ratio of R&D Expenditure to GNP Sample of Countries with GDP70<$3,400

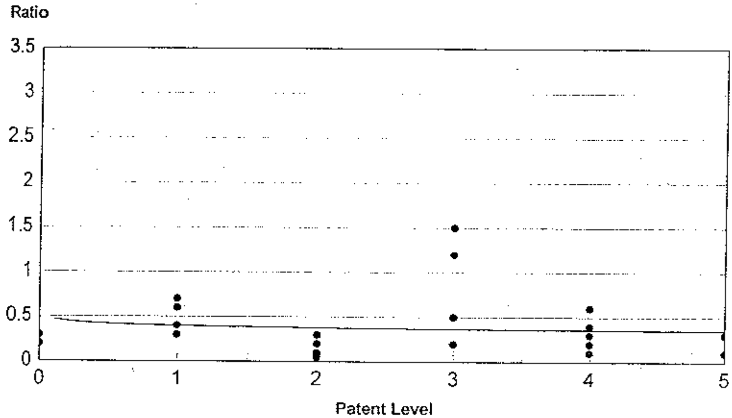
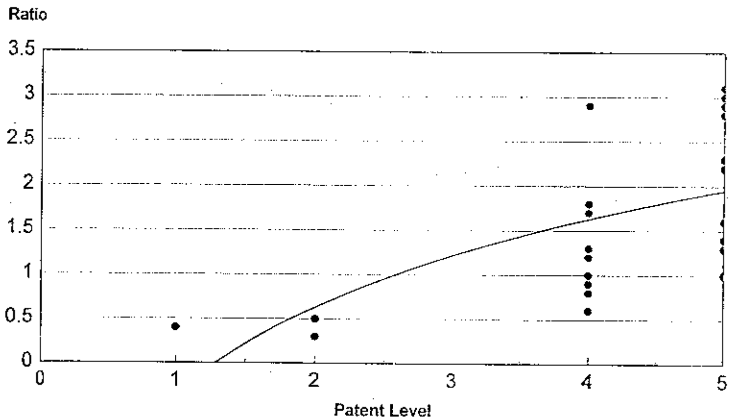


Figure 2 Patent Protection Levels and Ratio of R&D Expenditures to GNP Sample of Countries with GDP70>$3,400



Appendix

Table A1 29 Country Sample

Country	Patent Level	GDP70 ($1,000)	GR7085
United States	5	9.459	.0188
Switzerland	5	9.164	.001
Canada	4	8.495	.0241
Luxemburg	5	7.857	.0196
W. Germany	5	7.443	.0243
Saudi Arabia	3	7.405	- .0144
Sweden	5	7.401	.0194
Australia	4	7.344	.0124
Norway	4	7.104	.0383
France	5	7.078	.0225
Denmark	5	7.064	.0288
Trinidad and Tobago	4	6.957	- .0007
Netherlands	5	6.915	.0183
Belgium	5	6.750	.0243
Venezuela	2	6.608	- .0415
New Zealand	4	6.595	.0129
United Kingdom	5	6.319	.0211
Finland	4	6.186	.0267
Iceland	4	6.157	.0256
Austria	4	5.843	.0283
Japan	4	5.496	.0361
Italy	5	5.028	.026
Israel	5	4.861	.017
Spain	4	4.379	.0257
Argentina	1	4.002	- .0092
Chile	2	3.687	- .0037
Ireland	4	3.628	.0241
South Africa	5	3.609	.0049
Uruguay	3	3.453	0

Table A2 Patent Protection Levels and R&D to GNP Ratios Sampling of Countries with GDP70<$3,400[a]

Country	Patent Level	R&D/GNP
Brazil	1	.7
Burundi	4	.4
Central african Republic	2	.2
Congo	2	.05
Costa Rica	3	.2
Cyprus	5	.1
Egypt	2	.2
Ecuador	1	.4
El Salvador	3	1.5
Greece	5	.3
Guatemala	3	.5
Guyana	4	.2
Indonesia	0	.3
Iran	2	.1
Madagascar	0	.2
Malawi	4	.2
Mexico	2	.2
Nicaragua	2	.3
Nigeria	4	.3
Panama	2	.05
Peru	1	.3
Portugal	3	.5
Rwanda	4	.1
Sri Lanka	4	.6
Sudan	4	.2
Taiwan	3	1.2
Thailand	1	.3
Turkey	1	.6

Note: a. Countries for which private sector R&D/GNP is available.
Source: National Science Foundation, Surveys of Science Research Series, Special Report NSF91-309, International Science and Technology Data Update, 1991.