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*The views expressed in this article are solely those of the authors and should not be attributed to the Federal Reserve Bank of Dallas or to the Federal Reserve System.

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ABSTRACT

Intellectual property rights are an important element of the new theories of endogenous growth. Because of their special relationship to human capital, intellectual property protection may influence innovative activity and technological progress in critical ways. An important question for many countries is whether stricter enforcement of intellectual property is a good strategy for economic growth.

This paper examines the role of intellectual property rights in economic growth, utilizing cross-country data on patent protection, trade regime, and country-specific characteristics. The evidence suggests that intellectual property protection is positively related to economic growth. These effects appear to be slightly stronger in relatively open economies and are robust to both the measure of openness used and to other alternative model specifications.

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The Role of Intellectual Property Rights in Economic Growth

I. Introduction

Explanations of economic growth have increasingly focused on the role of innovation and on the power of expected profits to motivate innovation (Grossman and Helpman, 1991; Romer, 1990b). Meanwhile, policy makers are debating whether stronger protection of intellectual property will stimulate or retard growth in their countries. If innovation is a principal engine of growth and agents innovate to capture or hold a share of the market they would not retain otherwise, then protection of intellectual property might boost long-run growth.

An important question, however, is whether intellectual property protection is always consistent with innovation and higher growth. If agents innovate to capture or hold a share of the market they would not retain otherwise, what happens if they can retain their share of the market without bothering to innovate? What if, for example, agents' markets in a country were protected from competition? Using a survey of more than 3,000 Brazilian companies, Braga and Willmore (1991) found that firms' propensities to develop their own technology or to purchase it abroad were both negatively related to the degree of trade protectionism their industries enjoyed. Braga and Willmore's empirical work suggests that, in closed regimes, protecting intellectual property may not increase innovation because the competitive framework there is inadequate to stimulate much innovation. Rivera-Batiz and Romer (1991) offer a theoretical model that suggests similar conclusions. In their model, copying foreign technology in a closed regime is typically the most profitable option.

By contrast, in open trade regimes there is reason to suspect that intellectual property protection may stimulate innovation and, thereby, growth. Open trade implies that local firms are more likely to face competition from foreign producers that use the latest technology both in their production processes and in their products. Local firms that wish to meet this challenge by purchasing technology from abroad can find that weak intellectual property protection at home

impedes their efforts. Foreign technology-producing firms often refuse to license or lease their latest innovations to firms in countries where intellectual property protection is weak, out of concern that the licensing contract will not ultimately prove enforceable (Sherwood, 1990).

This paper examines the role of intellectual property rights in economic growth, utilizing cross-country data on overall levels of patent protection, trade regime, and country-specific characteristics. We find that intellectual property protection (as measured by the degree of patent protection) is positively related to economic growth. These effects appear to be slightly stronger in relatively open economies and are robust to both the measure of openness used and to other alternative model specifications.

Our findings suggest that the links between intellectual property rights, innovation, and growth may be influenced by market structure. Although our results do not fully capture all of the subtleties of market structure, they suggest that innovation may play a weaker role in less competitive markets.

These results have potentially important implications for developing countries. Many countries, particularly those in Latin America, have been turning away from trade protectionism and are moving toward liberalization. While some countries, such as Mexico, are liberalizing and rapidly tightening their intellectual property protection, others are moving more slowly to strengthen intellectual property protection. The implication of this paper, however, is that a trade liberalization accompanied by stronger intellectual property protection is a stronger conduit for economic growth.

The next section of this paper discusses how intellectual property rights vary across countries and how they may, or may not, be related to increased innovation. Thereafter, we develop more fully the implications of innovation in an endogenous growth theory context. Finally, we present our empirical findings on intellectual property rights protection and

economic growth.

II. Intellectual Property Rights Protection

Because products of the intellect are typically non-rival, intellectual property law incorporates an inherent tension between private gain and public welfare. That is, once such a product has been created, it can be used by many parties besides the creator at little additional cost. To motivate innovation, governments try to ensure that inventors can profit from inventing. But protecting innovators too stringently may limit the dissemination of new ideas and, therefore, opportunities for economic growth.[1]

We consider in more detail below the optimal level of intellectual property protection by focusing on the arguments for weak and strong intellectual property protection.

The Case for Weak Protection

Free access to information that agents would otherwise have to pay for is one, but not the only, argument for weak intellectual property protection. Another argument involves the monopolistic behavior that strong protection permits. It has been shown that under some conditions, a monopoly may accumulate patents to preserve its power by allowing the patents to "sleep" so as to deter entry into an industry (Gilbert and Newbery, 1982).

The argument that firms innovate--in part--to secure monopoly power has particularly compelling implications for developing country policies. Chin and Grossman (1990) demonstrate conditions under which the globally efficient degree of intellectual property protection does not necessarily maximize every country's welfare. Here again, the enforcement of protection mitigates competition and may replace it with monopolistic behavior. In net

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[1]In virtually all countries this problem is addressed by allowing patents to expire after a period of time. It is interesting to note that developing countries have traditionally offered shorter periods of protection for patents than have developed countries.

innovation-consuming countries, the cost of monopolization can more than offset the contribution of stronger intellectual property protection toward stimulating more cost-saving innovations.[2]

Likewise, under conditions presented by Diwan and Rodrik (1991), the net innovation-consuming country will only be motivated to protect intellectual property as long as the type of innovation it demands is different from the type demanded in the net innovation-producing country. If the consuming country demands innovations that are very different from those produced by the innovating country, the innovating country will still innovate on behalf of the consuming country if the consuming country protects intellectual property.

From the perspective of net innovation-consuming countries that also wish to encourage innovation at home, another argument against strong intellectual property protection relates to institutional structures in which innovations are produced and distributed. Vessuri (1990) argues that transnational computer corporations located in Brazil were not interested in developing or absorbing local technology because they typically restricted their research and development to home country locations. So, instead of protecting intellectual property, Brazil attempted to foster local innovation by reserving a portion of its market for domestic producers of mini- and microcomputers and their peripherals.[3]

The Case for Strong Protection

Why offer strong intellectual property protection? Survey evidence suggests that, at least in the United States, protection stimulates innovation (Mansfield, 1986) and the social rate of

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[2] The degree to which the consuming country is motivated not to protect is, in part, inversely related to the relative size of its market.

[3]An additional argument against strong intellectual property laws in net consuming countries is that enforcement costs can be very high (Primo Braga, 1990). Foreigners hold the bulk of patents in developing countries, so enforcement costs may simply lead to increased royalty gains for foreigners and greater royalty expenses for nationals.

return appears to be considerably higher than the rate of return to the innovator (Mansfield, Rapoport, Romeo, Wagner, and Beardsley, 1977). In a Brazilian survey, 80 percent of 377 firms said they would invest more in internal research and would improve training for their employees if better legal protection were available (Sherwood, 1990).

Moreover, despite arguments that strong intellectual property protection significantly enhances the monopoly power of producers in some markets, it does not appear that patent protection--the strongest form of intellectual property protection--has often prevented competitors from entering markets in developed countries for very long (Evenson, 1990; Levin, Klevorick, Nelson and Winter, 1987). Firms surveyed by Mansfield (1985) believed that, for about half of a selected sample of innovations, patent protection deterred imitation by competitors for only a few months.[4]

An additional case for strong intellectual property protection is that, without it, the technology acquirable may not cost much but it will be old (MacLaughlin, Richards, and Kenny, 1988, 106). Productive processes, on average, will be more backward than in regimes of strong intellectual property protection.[5] A net innovation-consuming country that does not protect intellectual property can affect its firms' ability to purchase technology, even when they are

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[4] These findings do not completely gainsay the monopolization argument, even though they weaken it somewhat. Schankerman (1991: 28), in an econometric study of French patents (including patents to applicants from Germany, the United Kingdom, Japan, and the United States, as well as France) finds that "the property rights generated by the patent system confer sizeable economic rents on patentees. On the average, these rents are equivalent to subsidy rate to R&D of about 15 percent. Hence patent protection is a significant source of returns to inventive effort, but it does not appear to be the major one."

[5] They may also be simpler. A United Nations study notes that if "the technical services, management experience and capital resources as well as other connections of the foreign patentee himself are essential for the introduction of the patented process in the under-developed country, basically the situation is that in one form or other the minimum terms and conditions of the foreign patentee must be met if the innovation is to be brought to the under-developed country" (United Nations, 1964, 50).

willing to pay for it. When dealing with firms in such countries, foreign producers of technology are cautious about selling it, out of concern that the prospective buyers may violate purchasing agreements with impunity.[6]

A final motivation for consuming nations to protect intellectual property is that innovation-producing countries may retaliate against those with weak intellectual property protection. Indeed, it has been argued that the recent move of some developing nations toward stronger intellectual property protection may be a direct response to U.S. trade retaliation over the last decade (Gadbaw and Richards, 1988).

III. Intellectual Property Rights and Economic Growth Theory

While the discussion above suggests much about the interaction between intellectual property rights and innovation, little has been mentioned about the dynamic process of innovation, which is the backbone of many new theories of endogenous growth. So far, the theoretical literature on intellectual property rights, innovation, and economic growth has been quite limited, while the empirical work on economic growth--such as that of Barro (1991), Romer (1990a), Mankiw, Romer, and Weil (1992), Levine and Renelt (1992)--has yet to examine the relationship between intellectual property rights and economic growth. This section relates intellectual property rights protection to endogenous growth theories.

Several popular models of endogenous growth are based on the idea that innovation is

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[6]Sherwood (1990) cites anecdotal evidence in which a Brazilian firm's employees have approached companies abroad to gain cost-effective technology, but that negotiations with the foreign source often came to an abrupt end when the source learned of Brazil's weak protection for innovation. The representative interviewed by Sherwood noted that his employees no longer try to keep up with technological advances abroad, since the information will do them little good.

carried out to make profits on the introduction of new products.[7] But every new product adds to the stock of human knowledge, so the cost of innovation falls as human knowledge accumulates. Thus, the rate of growth of the economy will vary directly with the rate of introduction of new products such as the automobile or personal computer. Moreover, economic growth will also be faster the larger is the stock of human capital or the more conducive the economic environment to the accumulation of human knowledge. By creating an environment conducive to the accumulation of human knowledge, intellectual property rights will tend to increase innovation and economic growth.

Economic growth may also depend on the openness of an economy. The work of Paul Romer (1990b) and Grossman and Helpman (1991, 238-46) suggests that if externalities are international in scope, then economic integration will increase economic growth. With openness, a country's economic growth depends on the stock of world human capital; accordingly, higher stocks of human capital in a country should have only a slight marginal impact on economic growth in that country. Likewise, intellectual property rights protection would also have a small marginal impact on that country's growth rate. However from a global standpoint, human capital accumulation and intellectual property rights protection would be very important to economic growth.

In other endogenous growth models, there is a dynamic sector that exhibits learning-by-doing externalities, spillover effects, or other human-capital-type externalities and a traditional sector that does not.[8] Depending on whether free trade shifts resources to or away from the

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[7]See, e.g., Lucas (1988), Romer (1990b), and Grossman and Helpman (1991).

[8]See, for example, Lucas (1988), Rivera-Batiz and Romer (1991), Stokey (1991), and Young (1991). Grossman and Helpman (1991) create a two-factor, three-sector endogenous growth open economy model by including a research and development sector, a high-technology good, and a traditional good.

dynamic sector, economic growth may increase or decrease. How resources are allocated under free trade depends, of course, on the structure of the model and a country's initial factor endowments. While intellectual property rights protection would clearly enhance growth in those countries that move toward free trade and have a comparative advantage in the high-technology sector, its role in a country with a disadvantage in the high-technology sector would be less important.

Although there are many theoretical models of innovation and growth, and static models of intellectual property rights and income, relatively few papers have modeled the dynamic effects of intellectual property rights and growth. Segerstrom, Anant, and Dinopoulos (1990) examine a dynamic general equilibrium model in which research and development (R&D) activity and, hence, technological change is influenced by the length of patent protection and the height of tariffs. They find that increasing the length of patents in the North (the innovating region) can either increase or decrease R&D activity. Although longer patents increase the return to R&D, they may also mean that more fixed resources will be devoted to producing existing products. Segerstrom (1991) examines the dynamic process of innovation and imitation and conditions under which government lump-sum subsidies to innovation (or imitation) alter the rate of innovation.

Building on the work of Grossman and Helpman (1991), Helpman (1993) models intellectual property rights, innovation, and economic growth as an interaction between countries in the North that innovate and countries in the South that imitate. The stronger the level of intellectual property rights, the less imitation there is in the South. He finds that strong intellectual property rights will increase innovation in the short run as the profitability of innovation in the North increases. In the longer run, however, the rate of innovation actually falls because the North produces more old-technology goods, which takes resources away from

innovation.

Although the theoretical literature suggests many possible mechanisms for innovation and growth, it does not suggest any clear-cut relationship between intellectual property rights, trade regime, and economic growth. We attempt to discover the central facts and then suggest a tentative explanation.

IV. Intellectual Property and Economic Growth: The Results

The Benchmark Model

Before examining the role of intellectual property rights in economic growth, we first present the results of a basic benchmark growth model. The model utilizes a formulation that is common to many of the recent cross-country empirical examinations of growth.[9] Equation 1 of Table 1 presents the estimation results of the benchmark model.[10] The dependent variable is the average annual real per capita gross domestic product (GDP) growth rate between 1960 and 1988,[11] and the explanatory variables are 1) the log of real GDP per capita in 1960, ln(Y60); 2) physical capital savings, which is the log of the share of investment in gross domestic product, ln(I/Y); and 3) a proxy for human capital savings--the log of secondary-school enrollment rates in 1960, ln(SEC).[12]

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[9]See, for example, Kormendi and Meguire (1985), Barro (1991), Romer (1990a), Levine and Renelt (1992), Edwards (1992), Roubini and Sala-i-Martin (1992), Backus, Kehoe, and Kehoe (1992), and Mankiw, Romer, and Weil (1992).

[10]The benchmark model utilizes a log-linear formulation for two reasons: 1) it has a basis in Cobb-Douglas production technologies (e.g., Backus, Kehoe, and Kehoe, 1992 and Mankiw, Romer, and Weil, 1992), and 2) this model is superior to a simple linear formulation in minimizing the mean squared error.

[11]Least squares estimates are used because they are less sensitive to the end points of the growth period.

[12]See the appendix for a list of all the data sources.

The results of the benchmark model are consistent with most recent growth studies. Real GDP per working-age person in 1960 is negative and highly significant, suggesting income convergence conditional on human capital.[13] Physical capital savings and the proxy for human capital savings, ln(I/Y) and ln(SEC), are positive and significant at the 1 percent level, consistent with Levine and Renelt (1992) .

Equation 2 of Table 1 examines the role of the stock of human capital, as proxied by literacy rates, in economic growth. We specifically examine the stock of human capital to account for any scale effects that human capital may have in economic growth as suggested by the endogenous growth literature. Our proxy for the stock of human capital is the literacy rate in the early 1960s. As model 2 shows, the coefficient on the stock of human capital, ln(LIT60), has a large standard error but it still contributes to the explanatory power of the model as shown by the higher adjusted R^2. Holding all else constant, the point estimate suggests that a country with a literacy rate in 1960 that was 25 percentage points higher than average would have grown about 1 percentage point per year faster than average. Furthermore, notice that when the literacy rate is included in the benchmark growth equation, the coefficient on total savings falls by 0.2 (model 1 versus model 2).[14] This result suggests that both variables, to some degree, may be accounting for scale effects of human capital in economic growth.

Intellectual Property Rights and Economic Growth

Can intellectual property explain any variation in economic growth once human capital

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[13]Although regressing average growth rates against initial income levels suggests income convergence, it does not necessarily provide statistical evidence of convergence. Quah (1990) and Friedman (1992) note that, because of regression to the mean, a negative relationship between average growth rate and initial income does not necessarily provide statistical evidence of convergence.

[14]Utilizing the White test, we could not find evidence to suggest that heteroscedasticity is a significant problem.

and other determinants of growth are held constant? Before we examine this question, we first discuss how intellectual property rights are measured.

Optimally, a complete picture of a country's intellectual property rights protection would include measures of copyright protection, trade secret laws, and patents. But even when one has measures of all of these aspects of intellectual property law, countries may enforce these laws quite differently. Two countries may have identical laws on their books to protect computer software, but one country may turn a blind eye to its local software pirates while the other country does not. On the other hand, even if a country does not have laws on its books to protect intellectual property, it may nonetheless protect intellectual property by assuming it falls under the same laws as physical property. These are some of the difficulties in obtaining a comprehensive index of intellectual property rights protection.

Rather than attempting to obtain a complete and comprehensive index of intellectual property rights protection, we focus on an aspect of intellectual property protection that is potentially the most important for economic growth--patent protection. The proxy for intellectual property rights we use is taken from an index of patent protection developed by Rapp and Rozek (1990). The index is based on the conformity of each nation's patent laws to the minimum standards proposed in the *Guidelines for Standards for the Protection and Enforcement of Patents* of the U.S. Chamber of Commerce Intellectual Property Task Force.[15] For most countries, the level of patent protection is measured in the early 1960s.

The index ranks the level of patent protection on a scale of one to six, where one is

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[15]In constructing their index, Rapp and Rozek (1990) based their procedure on that found in Gadbaw and Richards, (1988) pp. 11, 52-55. The evaluation of the extent of patent protection and the resulting index value are based primarily on the laws in force against infringement but not on their enforcement or implementation. Thus, they will overestimate the level of protection in a country where strong anti-infringement laws are on the books but do not work in practice because of administrative obstacles.

assigned to a nation having no patent protection law at all and six corresponds to nations whose laws are fully consistent with the minimum standards. For example, the procedure gives a score of two on the patent protection scale for Argentina. Argentina does have a patent law and the duration of protection under the law is 15 years from the date of the grant. According to Rapp and Rozek, however, the combination of high inflation and a maximum fine fixed in 1864 means that there is no practical penalty for infringement. Moreover, the law makes no provision for preliminary injunctions. Thus, enforcement is nearly impossible. By contrast, Singapore registers and protects patents under the United Kingdom Patents Act. Compulsory licensing may be granted three years after registration for certain classes of invention when the invention is being neither practiced nor imported. The government retains the right to exclude pharmaceutical patents for its own purposes, but in all other respects patents are enforceable. Singapore, accordingly, is given a score of five on the patent protection index.

Table 2 shows the countries in the data set, their level of patent protection, and the average growth rate across countries at each level of the patent protection. Without controlling for other important determinates of growth, those countries with the highest level of intellectual property rights protection tended to grow the fastest. However, those countries with the second lowest level of patent protection grew faster on average than those countries in the middle levels of patent protection. Overall, there does appear to be a positive but weak relationship between patent protection and economic growth. There are many other factors that should be taken into account before any conclusions can properly be made.

Model 3 in Table 1 adds our proxy for the level of intellectual property rights (IPROP) to the benchmark model. As the results indicate, intellectual property rights protection has a positive effect on economic growth but is only marginally significant. Still, the error is small enough so that intellectual property rights do contribute to the explanatory power of the

equation. In model 4, its significance level falls only slightly when adding such variables as the amount of government spending, as proxied by the average ratio of real government consumption to real GDP [ln(GovCon)], the degree of political instability, as proxied by the number of revolutions and coups per year [ln(REV)], and the number of assassinations [ln(ASSN)], and dummy variables for sub-Saharan Africa (AFRICA) and Latin America (LATAM).[16]

Figure 1 plots the average yearly growth in real GDP per capita between 1960 and 1988 against (IPROP), holding constant all the explanatory variables in model 3. That is, the figure shows the partial correlation between growth rates and our proxy for intellectual property rights protection. The figure demonstrates the positive relationship between growth and intellectual property rights protection, but also shows the large degree of variation in this relationship.

Problems with measurement error

As mentioned above, the level of patent protection is, at best, a rough measure of the theoretical concept of intellectual property rights protection. Undoubtedly, measurement error is possible because constructing any general measure of intellectual property rights protection requires judgment. A common way to address this problem is to consider our proxy as subject to measurement error and use the instrumental variables technique of estimation. The variables used must be correlated with the independent variable they are instrumenting for, and have to

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[16]Because intellectual property rights are hypothesized to influence economic growth through R&D, one can test whether intellectual property rights protection in the early 1960s is correlated to higher R&D spending in the 1970s and 1980s. Although cross-country data on R&D is extremely limited (only 48 countries in recent United Nations' World Economic Surveys) and is subject to a large degree of error (much of the country data include public with private spending on R&D), we found that the simple correlation coefficient between patent protection and future R&D expenditures as a share of GDP was .504 (significant at the .0001-percent level).

When R&D as a share of GDP is included in our basic benchmark model with patent protection, it is significant at the 10-percent level, while the significance of patent protection does not change. The number of observations, however, is only 48.

be uncorrelated with the primary regression's error term. Several variables that may qualify for this role are the average duration of patent protection, a set of dummy variables indicating a country's membership in an international convention that sets guidelines for intellectual property rights protection (e.g., the Paris Convention, the Berne Convention, and the International Convention for the Protection of New Varieties of Plants), and a set of dummy variables indicating whether a country has patents for pharmaceuticals, petty patents, food products, chemical products, plant/animal varieties, surgical procedures, and microorganisms and like products.[17] Other country-characteristic variables, such as government consumption, from the primary regression equation are also included as instruments.[18]

An advantage of using an IV approach to deal with measurement error is that it is also a method used to address potential endogeneity problems. These problems, however, are unlikely to be significant because the level of patent protection for most countries was measured in the late 1950s and early 1960s, while the dependent variable is based on later data.

Table 3 contains the IV estimates for the four growth equations estimated in Table 1. The data set is smaller because the set of countries with data on the instruments is smaller. When utilizing the IV technique to address the potential problems of measurement error, the results show that intellectual property rights protection becomes significant at the 5-percent level. Moreover, after controlling for the ancillary variables (model 3 versus model 4), the significance level of intellectual property rights protection falls only slightly from the 5-percent level to the 8-percent significance level. However, although this is not a large drop in the significance level, it does raise questions about the importance of intellectual property rights in

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[17]These data are from Siebeck (1990).

[18]The first stage IV equations are available upon request. The variables included in the first stage equations were solely determined on the basis of whether they minimized the equation's mean squared error.

economic growth. As suggested by the empirical work of Braga and Willmore (1991), a firm's development of technology through R&D may be directly affected by the degree of foreign competition. The following section assesses how our results depend on differences in trade regime.

Intellectual property in open and closed trade regimes.

How do intellectual property rights influence growth in open and closed economies? Although quite a few multicountry studies have found that closed economies grow less than outward-orientated economies (Krueger, 1978; Bhagwati, 1978; World Bank, 1987; De Long and Summers, 1991; Michaely et al., 1991; Edwards, 1992; and Roubini and Sala-i-Martin, 1992), the way in which intellectual property rights interact with the trade regime and growth has received little attention.[19]

All studies face the problem of how to measure the degree of outward or inward orientation. Surveys of business opinion, the height of effective tariff rates, black market exchange rate premia, export shares, the growth of export shares, and real exchange rate distortions have all been used (World Bank, 1991). No measure is perfect because the true rate of protection reflects a complicated combination of tariffs, quotas, exchange rate controls, and a host of administrative barriers. We present results based on trade regimes as defined by black market exchange rate premiums, real exchange rate distortions, and a comprehensive index of trade orientation based on several commonly applied indicators of trade regime used in the literature.[20] Export shares or the growth of export shares are not used because of potential

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[19]Maskus and Penubarti (1993) find that trade flows are positively related to intellectual property rights protection, although they do not examine the relationship between economic growth and intellectual property rights.

[20]The index was created by Gould and Ruffin (1994). Measures of trade orientation that contribute to the index are: outward orientation (Syrquin and Chenery, 1988); overall trade openness and trade intervention (Leamer, 1988); trade orientation 1963-37 and 1973-85 (World

inference problems. Export shares reflect the size of a country, and the growth of export shares is itself a complicated endogenous variable reflecting many factors in addition to trade regime.[21]

We begin with one of the most widely used measures of overall trade orientation--black market exchange rate premiums.[22] Countries with high black market exchange rate premiums are typically highly distorted and inward oriented. As in De Long and Summers (1991), we summarize the degree of trade orientation by a zero-one dummy variable. We create the zero-one dummy variable because black market exchange rate premia, although they are good general measures of trade regime, cannot distinguish subtle differences in openness. This is not a problem since we are only interested in a measure of relative openness. The dummy variable is assigned zero for "open" economies--those with black market premiums greater than the median of the sample--and one for "closed" economies--those with black market premiums less than the median of the sample.

Table 4 presents the results on the role of intellectual property rights in open and closed trade regimes. All regressions shown use the instrumental variables technique and the instruments discussed earlier. Because introduction of the trade orientation variable (BMPMED) reduces the size of the data set to 76 observations, a reference model of our benchmark growth equation is estimated with the 76-country data set. In comparing the benchmark model 1 of Table 4 with the corresponding model 3 of Table 3, we see that the signs and magnitudes of the coefficients are all similar. The proxy for intellectual property rights (ln(IPROP)) is significant and the size of its coefficient changes little. This finding implies that

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Bank Development Report, 1987); effective rate of protection (Barro, 1990); black market premium (Levine and Renelt, 1992); real exchange rate distortion (Dollar, 1992); and the ratio of import taxes to imports (Levine and Renelt, 1992).

[21]See also the comments of De Long and Summers (1991).

[22]Black market premium data were obtained from Levine and Renelt (1992).

the original results with respect to intellectual property rights are fairly robust to the countries chosen.

Model 2 of Table 4 includes a term interacting intellectual property rights and the trade orientation variable [ln(IPROP) * BMPMED], as well as intellectual property rights [ln(IPROP)] by itself. By including both variables in the estimating equation, the coefficient on ln(IPROP) represents the effects of intellectual property rights in relatively open trade regimes, and the sum of the coefficients on ln(IPROP) and the interaction term, [ln(IPROP) * BMPMED], represent the effect of intellectual property rights in highly protected trade regimes.

Controlling for differences in trade regimes, we find that ln(IPROP) continues to be statistically significant, and its point estimate increases by about 40 percent to 1.217, while the interaction term itself is negative and insignificant. By summing up the coefficients on ln(IPROP) and [ln(IPROP) * BMPMED], we find that in relatively closed trade regimes the coefficient on intellectual property rights is smaller, only 0.743. These results suggest that intellectual property rights may play a slightly larger role in open economies.

If we assume a moderate level of intellectual property rights protection of 4, the point estimates on ln(IPROP) and [ln(IPROP) * BMPMED] suggest that growth induced by intellectual property rights protection is approximately 0.66 percentage points higher per year in open versus protected economies. For example, both Korea and Jamaica have an index of intellectual property rights protection of 4, but Korea has much lower overall distortions than Jamaica. Between 1960 and 1988, annual growth in per capita income was 5.6 percent in Korea versus 1.9 percent in Jamaica. The results suggest that 0.66 percentage points of this difference may be attributed to the interaction between openness and patent protection.

Figure 2 plots the partial correlation between growth rates and our proxy for intellectual property rights protection (IPROP) in both open and closed trade regimes. The figure shows

how the relationship between growth and the level of intellectual property rights protection varies according to trade regime. The more open the economy, the greater the role of intellectual property rights protection and innovation in economic growth.

Model 3 includes the zero-one dummy variable (BMPMED) by itself to account for shift effects due to the trade regime. The results confirm the previous findings. Intellectual property rights are important determinants of growth. The growth effects, however, are slightly larger in open trade regimes.

Of course, the positive relationship between growth, intellectual property rights, and openness may be sensitive to other factors correlated with trade regime and intellectual property rights. Consequently, we include the ancillary variables discussed earlier: real government consumption as a proportion of real GDP (Govcon), and the degree of political instability, as proxied by the number of revolutions and coups per year (REV), the number of assassinations (ASSN), and Africa (AFRICA) and Latin America (LATAM) dummy variables. After controlling for these other factors, we continue to find that intellectual property rights play a larger role in open trade regimes.

Because the above results may be sensitive to measurement error in trade orientation, we examine trade orientation as defined by two other criteria--real exchange rate distortions and a composite trade regime index.[23] Like black market exchange rate premia, countries with high real exchange rate distortions are typically highly distorted and inward-oriented. The advantage of real exchange rate distortions is that they may be a more general measure of trade orientation. Furthermore, because of data availability, the data set expands to 79 countries.

Table 5 shows the results corresponding to those in Table 4 using Dollar's (1992)

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[23]The real exchange rate distortion data are averaged over 1976-1985 and were from Dollar (1992). The composite trade regime index data were Gould and Ruffin (1994). Real effective rates of protection were also used and strongly confirm the present results.

measure of trade orientation. (RERMED) is a zero-one dummy variable that is equal to one for countries that have a real exchange rate distortion greater than the median of the sample. These countries are considered relatively closed trade regimes.

Model 2 of Table 5 shows results similar to those found earlier. Our proxy for intellectual property rights continues to be significant and positively related to economic growth in open trade regimes but is less important in closed trade regimes. For this definition of trade regime, the point estimate on ln(IPROP) implies that an open economy with a moderate level of intellectual property rights protection of 4 grew about 1.4 percentage points faster than a closed economy with the same level of intellectual property rights protection, all else equal. Models 3 and 4 indicate that the results of model 2 are robust to shifts effects of trade regime, government consumption expenditures, political assassinations and revolutions, and regional dummies.

Table 6 shows the results of the same experiment as conducted in Tables 4 and 5, with the measure of trade orientation as defined by the composite index of trade regime indicators. The dummy variable (TRD) is assigned zero for open economies--those countries above the median index value for openness--and one for closed economies--those countries below the median index value for openness.[24] The results are similar to those in the other tables and are even stronger than previously estimated.

Figures 3 and 4 plot the average yearly growth in real GDP per capita for open and

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[24]For each trade regime variable that is a component of this index (see footnote 18), countries are ranked according to quartiles. Countries that are the least outward oriented, or most protected, will fall into the first quartile and are assigned a value of one. Countries in the second quartile are assigned a value of two, and likewise for the third and forth quartiles. The new aggregate trade regime index is calculated by averaging quartile values for each country. For example, if a country has two indicators suggesting it is in the third quartile and one indicator suggesting it is in the forth quartile, the new indicator takes a value of 3.333 (3.333=(3+3+4)/3).

closed trade regime, as defined by real exchange rate distortions and composite index of trade regime indicators. The results are consistent with those shown in Figure 2 and indicate that the effects of intellectual property rights on growth vary according to trade regime.

V. Conclusion

We find that a nation's trade policy may have important implications for its appropriate intellectual property policy. The more open an economy, the greater are the benefits of stronger intellectual property rights protection.

These results have broader implications. In particular, the findings suggest that the implications of some endogenous growth theories--those that model innovation--may be sensitive to a country's market structure. This is what one would expect given the importance of the profit motive's role in innovation as economic behavior is fundamentally different in competitive versus non-competitive environments.

Under a system of relatively closed markets, we might expect exogenous technology shocks to be more important in determining economic growth. In highly protected, uncompetitive markets, agents are unlikely to innovate much themselves, perhaps preferring to spend their resources on legislative schemes to preserve their market shares. Conversely, under a regime of open markets, we might expect competitive forces to motivate innovation and intellectual property protection to induce even more of it.

Data Source Appendix

Real per capita GDP growth:	Least squares estimates of real per capita GDP growth. Source of primary data: Summers and Heston (1991).
Y60:	Real per capita gross domestic product in 1960. Source: Summers and Heston (1991).
I/Y:	Investment as a share of GDP, 1960-1989. Source: World Bank National Accounts.
SEC:	Secondary school enrollment rates, 1960-1989. Source: Barro (1991).
LIT60:	Literacy rates in 1960. Source: United Nations (1971).
IPROP:	Level of patent protection. Source: Rapp and Rozek (1990).
BMPMED:	Dummy variable for black market premium greater than the median of the sample. Source of primary data: Levine and Renelt (1992).
RERMED:	Dummy variable for real exchange rate distortion greater then the median of the sample. Source of primary data: Dollar (1992).
TRD:	Dummy variable for comprehensive trade index greater than the median of the sample. Source: Gould and Ruffin (1994).
GovCon:	Government consumption share of gross domestic product. Source: Levine and Renelt (1992).
ASSN:	Number of assassinations per year. Source: Barro (1991).
REV:	Number of revolutions and coups per year. Source: Barro (1991).
AFRICA:	Dummy variable for sub-Saharan African countries.
LATAM:	Dummy variable for Latin American countries.
Patent coverage and duration of patents	Source: Siebeck (1990).

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Table 1
Growth and the Role of Intellectual Property Rights
OLS Estimation

Dependent Variable: Average yearly per capita GDP growth 1960-1988				
	(1)	(2)	(3)	(4)
Constant	15.650††	14.182††	13.668††	12.150††
	(8.039)	(6.402)	(6.148)	(5.428)
ln(Y60)	-0.846††	-0.865††	-0.922††	-1.042††
	(-3.960)	(-4.058)	(-4.297)	(-4.688)
ln(I/Y)	3.331††	3.276††	3.149††	3.084††
	(8.314)	(8.175)	(7.751)	(7.572)
ln(SEC)	0.828††	0.642††	0.611††	0.414
	(6.261)	(3.393)	(3.239)	(1.912)
ln(LIT60)		0.308	0.339	0.315
		(1.366)	(1.510)	(1.366)
ln(IPROP)			0.425	0.421
			(1.550)	(1.427)
ln(GovCon)				-1.082††
				(-3.092)
ln(ASSN)				-0.037
				(-1.008)
ln(REV)				-0.043
				(-0.982)
AFRICA				-0.618
				(-1.431)
LATAM				-0.547
				(-1.637)
$\overline{R^2}$	0.62	0.63	0.64	0.68
r.m.s.e.	1.13	1.13	1.12	1.06
observations	95	95	95	95

NOTE: T-statistics in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Table 2
Level of Patent Protection and Average Annual Growth Rate

1		2		3		4		5		6	
Country	Growth Rate	Country	Growth Rate	Country	Growth Rate	Country	Growth Rate	Country	Growth Rate	Country	Growth Rate
Myanmar	2.63	Turkey	2.87	Chile	1.03	Portugal	4.50	Austria	3.95	United States	1.94
Angola	-2.73	Argentina	1.10	Colombia	2.27	Costa Rica	2.45	Norway	3.42	United Kingdom	2.19
Ethiopia	0.79	Bolivia	1.02	Mexico	2.65	Dominica	2.46	Canada	2.43	Belgium	2.95
Madagascar	-1.75	Brazil	4.60	Nicaragua	1.07	El Salvador	1.31	Japan	6.11	Denmark	2.92
Mozambique	-2.02	Ecuador	2.78	Panama	3.50	Guatemala	1.51	Finland	3.63	France	3.38
Papua New Guinea	0.83	Honduras	1.34	Venezuela	2.20	Haiti	0.28	Greece	4.58	W. Germany	3.36
		Paraguay	2.27	Syria	4.06	Uruguay	0.57	Ireland	2.70	Italy	4.00
		Peru	1.67	Egypt	4.26	Jamaica	1.91	Spain	3.64	Netherlands	3.03
		India	0.77	Bangladesh	0.25	Korea	5.55	Australia	2.33	Sweden	2.61
		Thailand	3.59	Algeria	3.73	Malaysia	3.98	New Zealand	1.76	Switzerland	2.19
				Cameroon	3.58	Nepal	0.91	Trinidad & Tobago	3.31	South Africa	1.65
				Central Africa	-0.54	Pakistan	1.93	Jordan	3.12	Israel	3.63
				Chad	-2.37	Somalia	0.23	Sri Lanka	1.05		
				Congo	3.52	Tunisia	3.32	Philippines	2.29		
				Benin	-0.24	Zambia	-1.43	Singapore	6.62		
				Ivory Coast	1.34			Botswana	7.14		
				Mali	0.30			Burundi	1.71		
				Mauritania	0.08			Zaire	0.19		
				Nigeria	-0.40			Ghana	-0.50		
				Senegal	-0.24			Kenya	1.61		
				Togo	1.77			Liberia	-0.45		
				Burkina Faso	1.61			Malawi	1.30		
								Mauritius	1.68		
								Morocco	2.78		
								Nigeria	0.69		
								Zimbabwe	1.63		
								Rwanda	2.03		
								Sierra Leone	-0.01		
								Sudan	0.14		
								Tanzania	2.25		
								Uganda	-0.17		
Average Growth Rate	-0.38		2.20		1.52		1.96		2.35		2.82

Level of patent protection is defined in the early 1960s. Average annual growth rates are from 1960 to 1988.

Table 3

Growth and the Role of Intellectual Property Rights
Instrumental Variables Estimation

Dependent Variable: Average yearly per capita GDP growth 1960-1988

	(1)	(2)	(3)	(4)
Constant	15.822††	14.220††	13.705††	13.075††
	(6.852)	(5.605)	(5.403)	(4.992)
ln(Y60)	-0.857††	-0.916††	-0.990††	-1.201††
	(-3.438)	(-3.653)	(-3.928)	(-4.479)
ln(I/Y)	3.361††	3.352††	3.385††	3.291††
	(6.921)	(6.954)	(7.056)	(6.877)
ln(SEC)	0.835††	0.601††	0.604††	0.429
	(5.388)	(2.717)	(2.748)	(1.551)
ln(LIT60)		0.419	0.374	0.198
		(1.472)	(1.315)	(0.657)
ln(IPROP)			0.938††	1.086†
			(1.985)	(1.766)
GovCon				-1.133††
				(-2.648)
ASSN				-0.045
				(-1.070)
REV				-0.054
				(-1.024)
AFRICA				-0.893†
				(-1.745)
LATAM				-0.156
				(-0.320)
$\overline{R^2}$	0.57	0.58	0.59	0.64
r.m.s.e.	1.17	1.16	1.15	1.08
observations	79	79	79	79

NOTE: T-statistics in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Table 4

Growth: The Role of Intellectual Property Rights and Trade Regime
(Black Market Premium > Median of Sample = Closed Regime)
Instrumental Variables Estimation

Dependent Variable: Average yearly per capita GDP growth 1960-1988				
	(1)	(2)	(3)	(4)
Constant	13.757††	14.433††	14.737††	13.899††
	(5.272)	(5.338)	(5.296)	(4.902)
ln(Y60)	-1.004††	-1.173††	-1.216††	-1.338††
	(-3.914)	(-3.928)	(-3.911)	(-4.363)
ln(I/Y)	3.368††	3.363††	3.357††	3.349††
	(6.864)	(6.779)	(6.697)	(6.682)
ln(SEC)	0.614††	0.552††	0.554††	0.528†
	(2.680)	(2.320)	(2.303)	(1.695)
ln(LIT60)	0.373	0.493	0.525	0.224
	(1.179)	(1.466)	(1.524)	(0.635)
ln(IPROP)	0.986††	1.217††	1.169††	1.409†
	(2.037)	(2.297)	(2.156)	(1.779)
BMPMED * ln(IPROP)		-0.474	-0.382	-0.345
		(-1.141)	(-0.848)	(-0.695)
BMPMED			-0.195	
			(-0.570)	
ln(GovCon)				-1.199††
				(-2.695)
ln(ASSN)				-0.056
				(-1.247)
ln(REV)				-0.032
				(-0.477)
AFRICA				-0.548
				(-0.920)
LATAM				0.009
				(0.018)
$\overline{R^2}$	0.58	0.58	0.57	0.62
r.m.s.e.	1.17	1.18	1.19	1.12
observations	76	76	76	76

NOTE: T-statistics in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Table 5

Growth: The Role of Intellectual Property Rights and Trade Regime
(Real Exchange Rate Distortion > Median of Sample = Closed Regime)
Instrumental Variables Estimation

Dependent Variable: Average yearly per capita GDP growth 1960-1988

	(1)	(2)	(3)	(4)
Constant	13.705††	13.889††	13.949††	13.936††
	(5.403)	(4.954)	(4.925)	(4.731)
ln(Y60)	-0.990††	-1.071††	-1.071††	-1.320††
	(-3.928)	(-3.793)	(-3.763)	(-4.298)
ln(I/Y)	3.385††	3.297††	3.324††	3.237††
	(7.056)	(6.193)	(6.108)	(6.138)
ln(SEC)	0.604††	0.477†	0.468†	0.477
	(2.748)	(1.878)	(1.816)	(1.557)
ln(LIT60)	0.373	0.160	0.159	0.001
	(1.315)	(0.472)	(0.467)	(0.001)
ln(IPROP)	0.938††	2.005††	1.986††	1.892††
	(1.985)	(2.468)	(2.420)	(2.114)
RERMED * ln(IPROP)		-1.025†	-0.949	-0.961
		(-1.714)	(-1.453)	(-1.373)
RERMED			-0.127	
			(-0.299)	
ln(GovCon)				-1.166††
				(-2.478)
ln(ASSN)				-0.055
				(-1.175)
ln(REV)				-0.057
				(-0.988)
AFRICA				-0.369
				(-0.543)
LATAM				-0.117
				(-0.219)
$\overline{R^2}$	0.59	0.54	0.54	0.59
r.m.s.e.	1.15	1.27	1.28	1.19
observations	79	79	79	79

NOTE: T-statistics in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Table 6

Growth: The Role of Intellectual Property Rights and Trade Regime
(Composite Trade Regime Index)
Instrumental Variables Estimation

Dependent Variable: Average yearly per capita GDP growth 1960-1988

	(1)	(2)	(3)	(4)
Constant	13.705††	15.315††	16.024††	14.274††
	(5.403)	(5.421)	(5.474)	(4.857)
ln(Y60)	-0.990††	-1.211††	-1.301††	-1.344††
	(-3.928)	(-4.139)	(-4.257)	(-4.403)
ln(I/Y)	3.385††	3.247††	3.121††	3.255††
	(7.056)	(6.319)	(5.866)	(6.317)
ln(SEC)	0.604††	0.541††	0.556††	0.474
	(2.748)	(2.296)	(2.312)	(1.583)
ln(LIT60)	0.374	0.302	0.312	0.142
	(1.315)	(0.993)	(1.006)	(0.434)
ln(IPROP)	0.938††	1.308††	1.212††	1.474††
	(1.985)	(2.426)	(2.189)	(2.062)
TRD * ln(IPROP)		-0.969†	-0.772	-0.866
		(-1.849)	(-1.392)	(-1.429)
TRD			-0.488	
			(-1.345)	
ln(GovCon)				-1.187††
				(-2.571)
ln(ASSN)				-0.057
				(-1.237)
ln(REV)				-0.010
				(-0.162)
AFRICA				-0.541
				(-0.896)
LATAM				-0.164
				(-0.312)
$\overline{R^2}$	0.59	0.57	0.56	0.60
r.m.s.e.	1.15	1.22	1.25	1.17
observations	79	79	79	79

NOTE: T-statistics in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Figure 1
Partial Correlation Between Average Yearly per Capita Growth (1960-1988) and Level of Patent Protection
(from regression (3) Table 1)

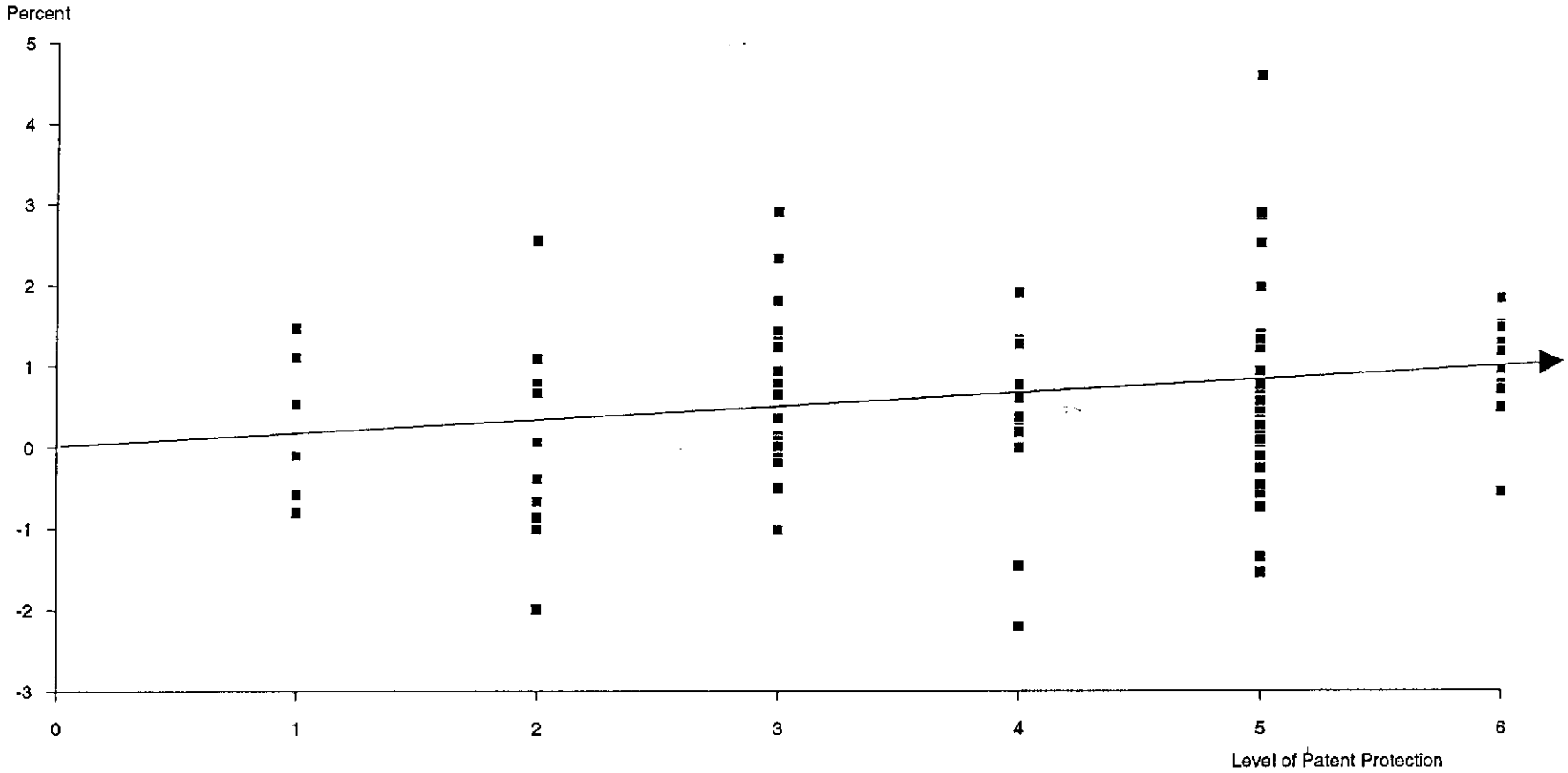


Figure 2
Partial Correlation Between Average Yearly per Capita Growth (1960-1988) and Level of Patent Protection
(from regression (2) Table 4)

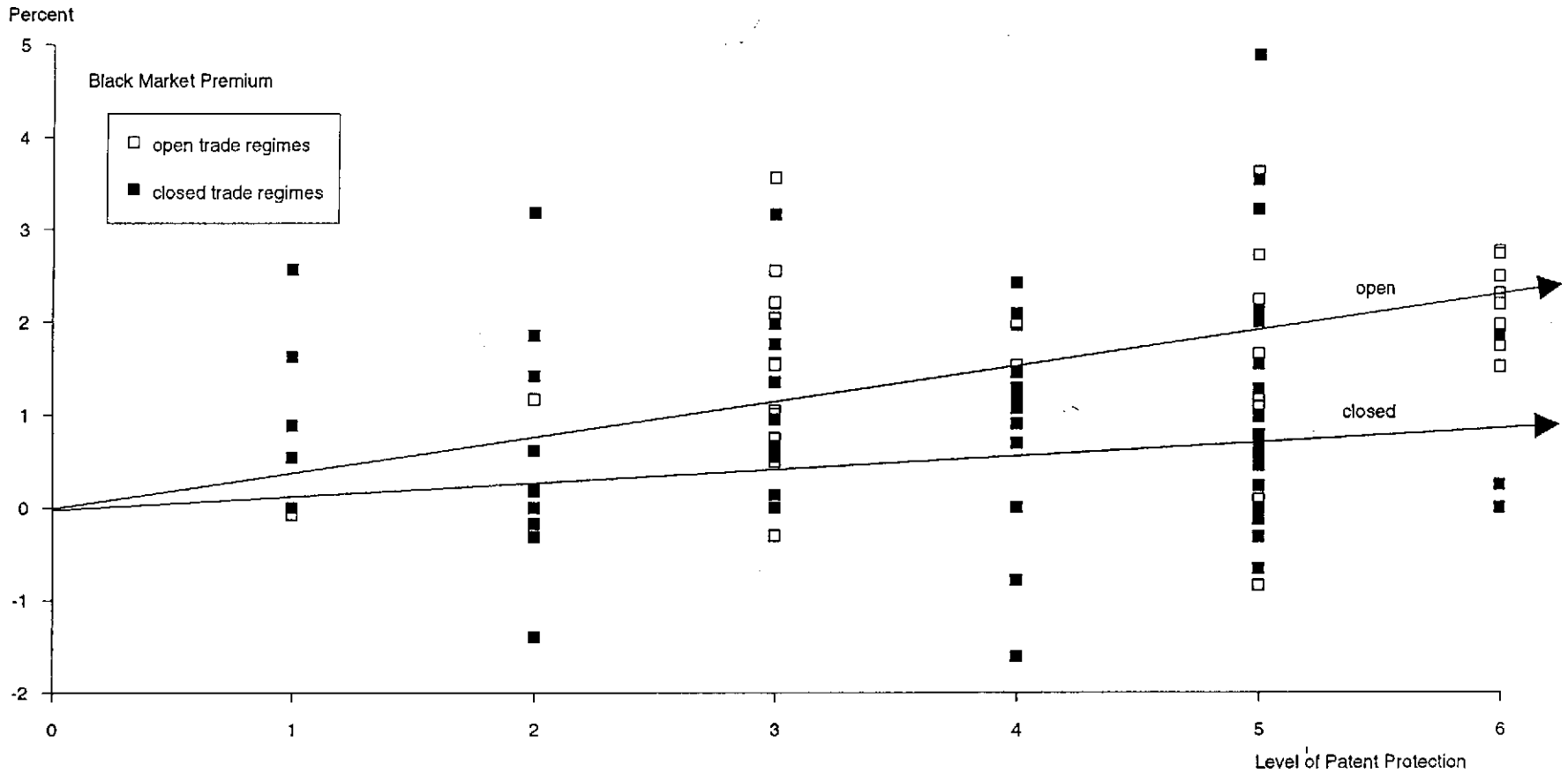


Figure 3
Partial Correlation Between Average Yearly per Capita Growth (1960-1988) and Level of Patent Protection
(from regression (2) Table 5)

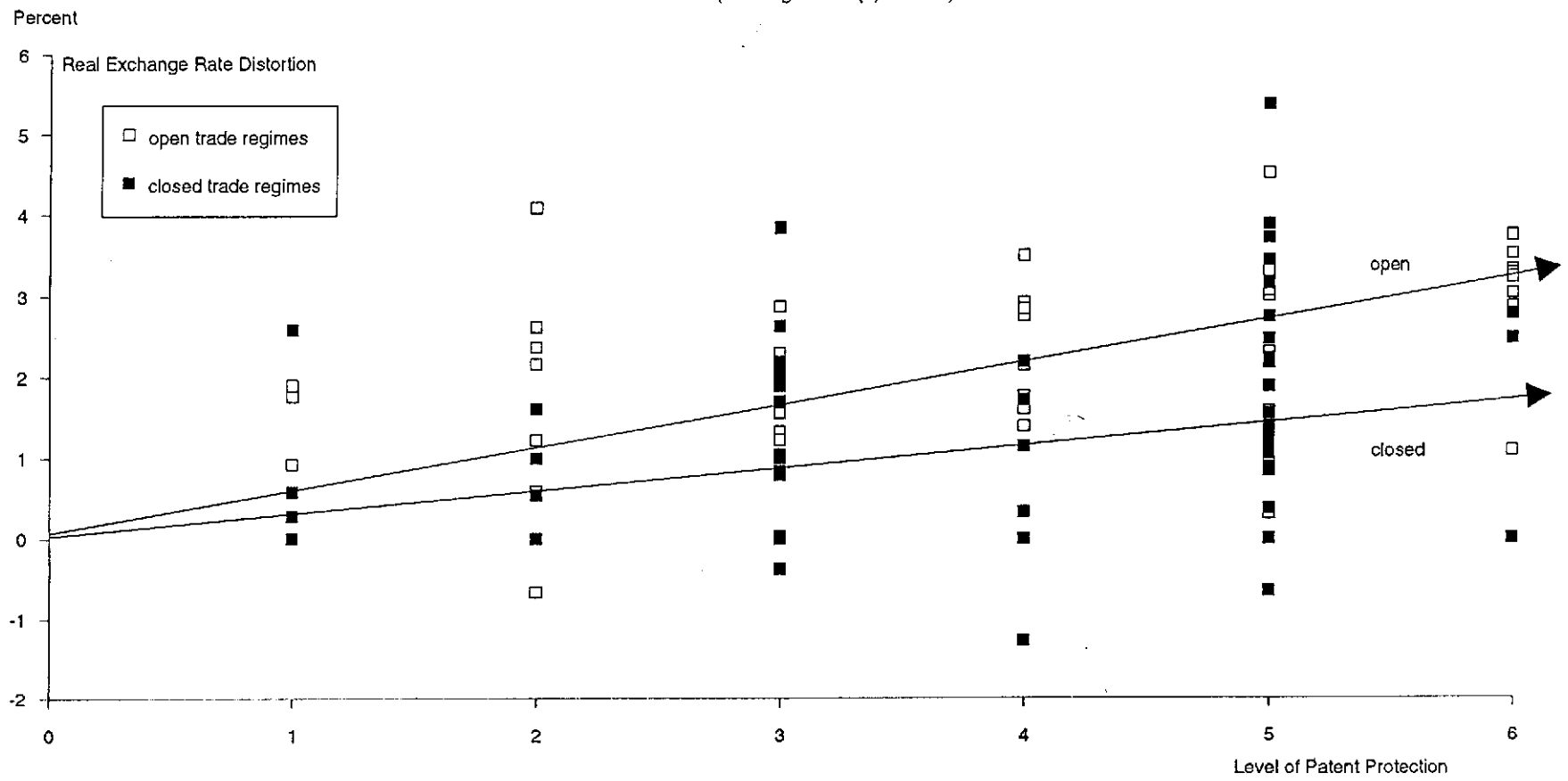
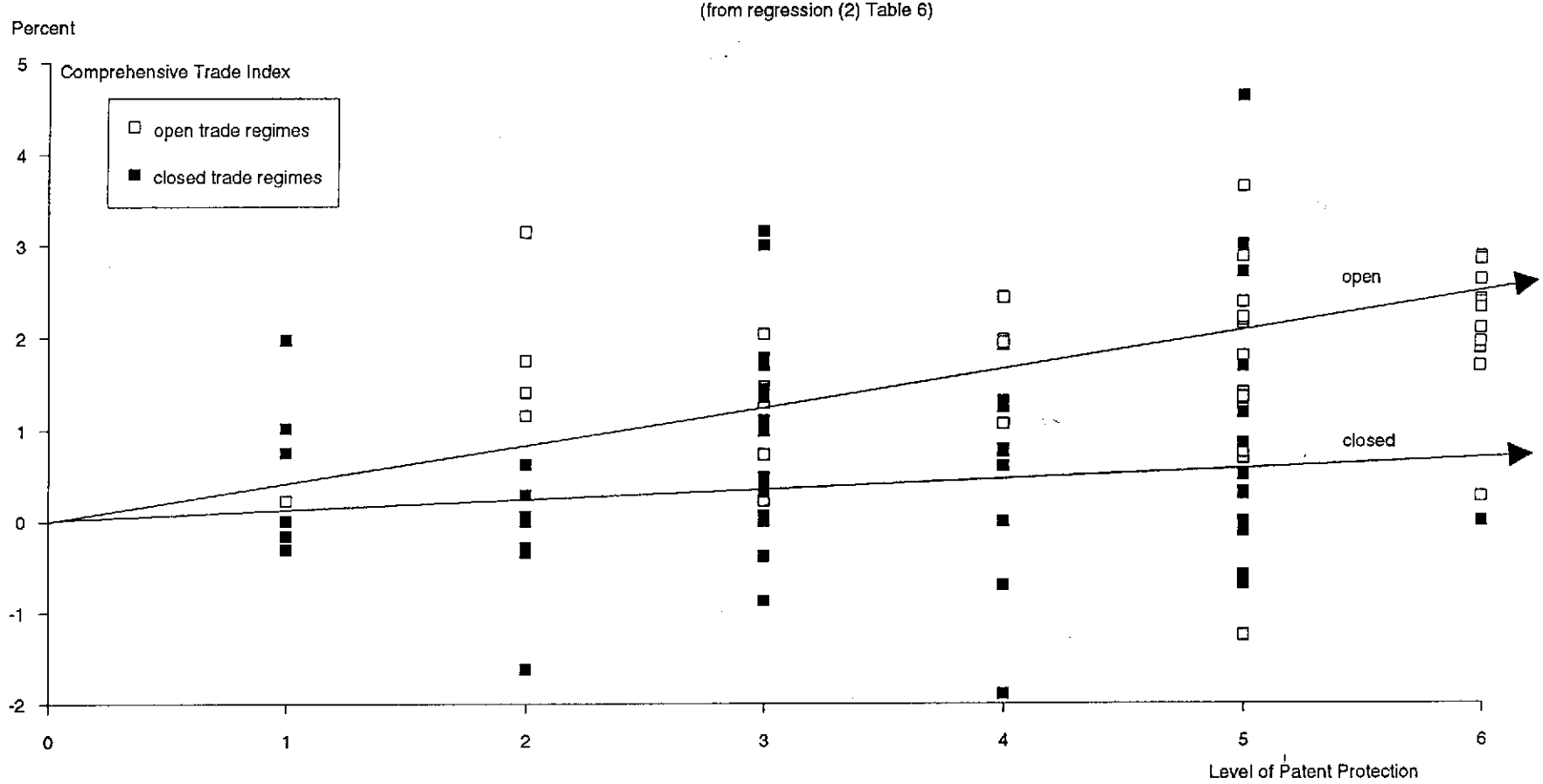


Figure 4
Partial Correlation Between Average Yearly per Capita Growth (1960-1988) and Level of Patent Protection
(from regression (2) Table 6)



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