Appropriate Intellectual Property Protection and Economic Growth in Countries at Different Levels of Development

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Abstract:

This paper provides an empirical analysis of the extent to which stronger intellectual property rights (IPRs) influence economic growth, controlling for other factors. Patent protection is found to have differential effects on developed countries and developing countries. Patent rights have a positive influence on the incentive to innovate in developed countries but a statistically insignificant one in developing countries. However, a second-tier form of IPR – namely utility model patents (or petty patents) – does have a positive influence on developing country innovation and growth. Thus the results indicate that patent protection enhances innovation, and ultimately economic growth, in countries where the capacity to conduct innovative R&D exists. Where this capacity is weaker, a system of IPRs that protects minor, incremental inventions is more conducive to innovation, technological diffusion, and economic growth. The significance of this paper is to help shift the focus of the debate away from the strength of IPRs to the appropriate types of IPR for economic development.

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1. Introduction

This paper addresses the role of intellectual property rights (IPRs) in the economic growth of countries at different levels of economic development. The inclusion of IPR in global trade negotiations, at the level of the World Trade Organization, raises the issue of whether stronger IPRs are appropriate for the economic growth of countries regardless of their stage of economic development. A related issue is whether the same type of IPR policies, systems, or institutions are appropriate for countries at different levels of economic development.

The possibility that stronger and different types of IPRs could have differential effects on countries at different stages of economic development has been partly acknowledged in global IPR reforms. For example, transitional periods were provided for developing and least developed countries. In addition, extensions to comply with the *Trade-Related Intellectual Property Rights Agreement* (TRIPS) have also been granted to certain, poor countries (until 2013). Local circumstances and needs have also been addressed, for example in policies related to essential medicines and public health.

While some evidence on the economic growth effects of IPR exist, the debate is far from settled and the evidence is mixed. Some studies examine the effects of IPR directly on growth; others exam them indirectly by focusing on the determinants of growth (e.g. research and development (R&D)). Existing empirical studies have also not typically controlled for the possible endogeneity between economic growth and IPRs as well as the possibly differential impacts of IPRs on R&D and economic growth by level of economic development or by type of IPRs.

Previous studies have emphasized the "incentive" effect of IPRs on the profitability of innovation and how copying or imitation reduces the incentives to engage in R&D. Other studies emphasize the market power effect of IPRs in limiting the diffusion of new technologies and ability of innovators to build on existing R&D capital.[1] Studies then weigh the net effects of the different influences of IPRs on productivity growth. Our core contribution is to point out that innovation and imitation are not mutually exclusive activities, such that variations in IPRs raise one type of activity (innovation) while lowering the other (imitation). We consider the role of adaptive, imitative innovation, which especially characterizes the nature of innovation in many, developing countries. In certain IPR systems, inventors of minor or adaptive, imitative innovation can also have their inventions protected, for example through a utility model or petty patent. Through adaptation, imitation, and incremental innovation, firms in developing economies acquire knowledge and enjoy some learning-by-doing (Suthersasen (2006)). The innovations they produce may not merit a traditional patent, but a second-tier intellectual property right. The absence of this type of IPR may reduce incentives to engage in incremental innovation, which may be more suitable for local needs, a stepping stone for further technological progress, and the type of innovation which best utilizes local capabilities.

Thus our empirical analysis studies the effects of both patent protection and petty (utility model) patent protection on the R&D and growth of countries by different income

[1] See Aghion et al. (2001), Boldrin and Levine (2006), and other studies cited in Section 3.

groups (high, middle, and low), using a panel data of countries from 1975 – 2003. As an overview, our main finding is that IPRs (using an index of patent protection) do not directly affect the rates of economic growth in any of our income groups, but indirectly by stimulating R&D investments. In high income countries, economic growth has a positive association with the rate of R&D investment, controlling for other factors, so that IPRs which stimulate R&D indirectly stimulate economic growth. In the middle/low income group, R&D has an insignificant effect on economic growth, suggesting that R&D investments are below a critical threshold quality or quantity. However, a positive and statistically significant influence of R&D on growth exists in that subgroup of developing countries which permits a lower form of intellectual property protection, namely utility models. Moreover, in developing countries, patent protection has a negligible influence on R&D investments while petty patents have a positive effect on R&D. This reflects the nature of inventive activity in developing economies, which is geared towards adaptive, imitative R&D. Thus, the reason why a differential impact of IPR on innovation and economic growth exists is two-fold: (1) the nature of R&D differs by level of economic development, (2) different types of intellectual property rights may be more appropriate for countries at different stages of economic development, rather than different levels of strength of IPRs.

This paper is organized as follows: section 2 provides a brief comparison between patent protection and utility model protection. Section 3 reviews the theoretical and empirical literature on the effects of IPRs on innovation and economic growth, focusing on the potentially different effects by level of economic development, and discusses how our paper differs from existing studies. Section 4 discusses our empirical methodology, data, and some sample statistics. Section 5 contains the main results, and section 6 concludes.

2. Patents and Utility Models

This paper focuses on two forms of intellectual property rights protection: patents and utility models (or petty patents). This section briefly describes the key differences between them. Patents are granted for inventions that are novel, non-obvious, and have industrial applicability. They are typically granted for 20 years duration from the date of application, cover products and processes, undergo substantive examination, and are costly to obtain (filing fees, search and examination fees, attorney costs, and translation fees, where applicable). The patent pendency (time to examine, approve, and grant a patent) could range from 3 to 7 years. In exchange for patent protection, the patent holder must disclose the technical specification and details of the invention in such a way that a person ordinarily skilled in the field can repeat the invention (i.e. the enablement requirement).

Utility models are second-tier protection for minor inventions, such as devices, tools and implements, particularly in the mechanical, optical, and electronic fields.[2] Processes or methods of production are typically excluded. The duration of protection is typically 6 – 10 years and the technical details must also be disclosed. Utility models are generally cheaper and do not require substantive examination (for novelty, non-obviousness, and industrial applicability). The inventive step required is small; the invention typically must exhibit a

[2] See Bently and Sherman (2001) for a legal discussion of utility models.

practical or functional advantage over existing prior art. Thus, while utility model protection is easier to acquire, particularly for smaller inventors, there are some downsides. Utility model protection is not as strong a form of IPR as patents. Secondly, they may be harder to enforce due to the fact that there are minor differences between the protected invention and the state of the art and to the lack of substantive examination that supports the protected claims.

Not all countries that provide patent protection include protection for utility models, such as the U.S. and U.K. (see Appendix I). Countries that protect them are largely developing economies, such as Korea, Taiwan, China, and Malaysia. In some cases, utility models are the dominant form of IPR. For example, since China enacted its first patent law in 1984, utility models accounted for nearly two-thirds of its total intellectual property rights granted, while patents accounted for 10%, during the period 1985 - 1998. Even though the ratio of utility models to patents has been declining in China, utility models still account for about half the total IPRs granted (Xue and Liang, 2008).

The few developed countries that protect utility models include Germany, Japan, and some European countries. Moreover, not all countries that protect utility models make intensive use of this form of protection; that is, file applications for them. The degree to which inventors in countries seek utility model protection typically depends on the differences in the standards of inventiveness required for patent protection and utility model protection. The narrower the difference in standards, the more likely it is that agents will file for patent protection since patents provides stronger protection than utility models.

3. Literature Review

We first review the theoretical literature on the impacts of IPRs on innovation and economic growth. We then review the empirical evidence on the effects of patent protection (including those of petty patents).

3.1 Theoretical Literature

This section discusses the theoretical effects of IPRs on innovation and growth, and how the effects could vary by level of economic development. In general, the effects of IPRs on innovation and economic growth are theoretically ambiguous. On the one hand, stronger IPRs better protect innovators against infringement or imitation and thus better enable them to appropriate the returns to their investments in innovation. But stronger IPRs also raise the cost of innovation by raising the price of technological inputs into innovation (see Boldrin and Levine (2006)). Users of proprietary or patented products, like follow-on inventors, must pay licensing fees or royalties.

Recent closed-economy models have identified further opposing influences of IPRs on economic growth. In Horowitz and Lai (1996), stronger IPRs via a longer patent life increase the 'quality jump' of innovations (by influencing the size of the profits from innovation) but lower the frequency of innovations (by increasing the length of time before the next innovation). The overall effect on economic growth is therefore ambiguous. Recently, Horii and Iwaisako (2007) develop a model in which IPRs may adversely affect growth by reducing the number of competitive sectors. In their model, the incentive to innovate is greater in more competitive industries. Aghion et al. (2001) also develop a model in which competitive pressures can positively contribute to innovation. A policy that allows imitation forces firms into neck and neck competition and creates pressures on firms to innovate in order to escape the competition.

In open-economy models, stronger IPRs also give rise to both positive and negative influences on innovation (see, for example, Helpman (1993) and Lai (1998)). If, for instance, Southern (developing) countries strengthen their IPRs, innovators in the North are better able to earn larger rents. However, by preventing Southern imitation, the stronger IPRs in the South force more of the goods to be manufactured in the North, so that fewer resources are available for Northern R&D.

Thus theoretical models indicate that the level of IPRs that is optimal for innovation, economic growth, or welfare is one that balances the costs and benefits of stronger IPRs. Moreover, where that balance should be struck could vary by level of economic development. In particular, the level of IPR strength that is appropriate for developing countries may be lower (or less strict) than that for developed countries. That this may be so is implicit in the models above. For example, the R&D of developing countries is likely to be not as innovative as that of developed countries; i.e. Southern "innovation" tends to be more imitative, adaptive, or incremental in nature (see Evenson and Westphal 1995). Thus, the size of quality jumps in innovation may be smaller. In that case, the strength of IPR should be lower. The relatively lower quality of developing country innovation may not be sufficient to compensate the negative effects, if any, of reduced competition. The burden of licensing fees and royalties may also be greater on developing country innovators than for their developed country counterparts.

There are also theoretical models that *explicitly* consider the stage of economic development in determining the effect of stronger IPRs. For example, Eicher and Penalosa (2008) develop a theoretical model in which the size of the market must reach a certain minimum level in order for stronger IPRs to stimulate innovation and economic growth. The intuition is that there is a positive feedback mechanism at work. Stronger IPRs may stimulate innovation but local agents and policy authorities favor stronger IPRs only if there is something valuable to protect – in other words, if the value of innovation is sufficiently high enough to make it economically worthwhile to create and invest in IPR institutions. The value of innovation in turn depends on the size of the market. Thus below this critical size, IPR is predicted to have negligible (or *zero*) effects on innovation and technological change.

Alternatively, it is possible for IPR to have a *negative* effect on innovation below a critical market size. Grossman and Lai (2004) show that the optimal level of IPR depends on an economy's market size and innovative capacity. The smaller the size of the market and the weaker the innovative capacity are, the lower the optimal strength of IPRs should be. The intuition is that the deadweight losses of IPR are greater if the innovative capacity is too weak to compensate. Furthermore the marginal benefits of stronger IPRs are greater if the market size is greater. Since developing countries have both a smaller market and lower innovative capacity, the balancing of the marginal costs and marginal benefits of IPR occurs at a lower level of IPRs than that in the North. Hence, obliging the South to adopt

Northern standards of IPR would entail Southern economies having a level of intellectual property protection that exceeds their optimal level. Southern innovation could therefore be adversely affected in developing countries if their IPRs are raised above a level that is suitable for their environment of adaptive, incremental R&D and smaller market size.

3.2 Previous Evidence

In this section, we review some previous empirical studies using international data. Thus far, few of these studies have examined the relationship between innovation, growth, and IPR by different income groups. Most studies have also been examined using data prior to the TRIPS Agreement of 1995 and thus do not provide evidence from after the global IPR reforms.

The previous empirical studies that we review can be classified in two ways: those that directly examine the relationship between IPR and growth and those that indirectly examine this relationship by examining a factor that contributes to economic growth, such as R&D. First, on "direct" studies, Gould and Gruben (1996) use cross-sectional data (averaged from 1960 - 1988) using an index of IPR based on conditions in 1984. Controlling for other factors, they find that IPR has a positive but statistically insignificant coefficient when estimated by OLS. Using instrumental variable estimation to account for measurement error (since the index is based on a subjective judgment as to whether a nation's IPR system conforms to international guidelines), they find that IPR does have a statistically significant positive association with the growth rate. They find the coefficient estimate to be higher for countries that are more open to trade (defined as being above the median of various indicators of trade liberalization). The intuition is that in countries more open to international competition, the market power effect of stronger IPRs is mitigated.

Falvey et al. (2006) use threshold regression analysis on a panel data of 79 countries from 1975 – 1995. Controlling for country and time effects, they find that the response of economic growth to IPR varies at different threshold levels of income, based on initial GDP per capita (i.e. as of 1975). For instance, IPR has a significant positive coefficient below a certain threshold level of income and above a certain threshold level of income. Between these two threshold levels, IPR has a statistically insignificant effect on economic growth. A rationale for this result is that in low income countries, IPR stimulates growth by helping to attract technology transfers while in high income countries, IPR helps stimulate growth by creating incentives for innovation. In middle income countries, IPR reduces the ability of countries to catch up technologically via imitation but does help attract technological inflows. The results suggest that these effects offset each other.

Two other empirical studies do not find a direct effect of IPR on growth but an indirect one. Park and Ginarte (1997) using 1960 – 1990 cross country data observe that IPR affects factor accumulation (i.e. physical, human, and R&D capital) which in turn affects economic growth. Thompson and Rushing (1999) using 1975 – 1990 cross-sectional data find that IPR affects total factor productivity which in turn affects economic growth, but only for high income countries (above $4,000 per capita GDP in 1985 dollars).

Hence some recent studies focus on the relationship between IPRs and a determinant of growth, like innovation or R&D (see, for example, Varsekelis (2001) and

Kanwar and Evenson (2003)). These studies use data prior to the TRIPS agreement and find that R&D/GDP ratios are positively related to the strength of patent rights, conditional on other factors. Other studies use patent filings at the U.S. Patent and Trademark Office (USPTO) as a measure of innovation. Chen and Puttitanum (2005) examine 64 developing countries and find that the larger developing countries that strengthen their patent laws are more apt to file patents in the U.S., controlling for other factors. Schneider (2005) finds that stronger patent rights have a positive effect on U.S. patent filings for developed countries only. For developing countries, patent protection has either a negative or insignificant influence once other variables, like infrastructure and FDI, are controlled for.

The empirical studies cited thus far deal with patent protection. The empirical evidence on the effects of utility models on innovation and growth is based largely on anecdotal evidence. Kumar (2002), for example, argues that in the East Asian experience, utility models helped initiate a culture of patenting and innovation. In South Korea, utility models helped facilitate the adaptive and imitative innovations of foreign technologies by domestic enterprises, which helped foster local innovative rivalry. In contrast, India did not provide utility model protection, and Kumar (2002) suggests that this may have adversely affected local engineering industries. The World Bank (2002) documents case studies in the farm machinery sector in Brazil where utility models allowed domestic producers to adapt foreign innovations to local needs and conditions. In the rice sector in the Philippines, utility models enabled locals to adapt rice threshers to suit their needs. More formal econometric evidence is provided in Maskus and McDaniel (1999) who study the use of utility models in Japan and find that such protection on balance had positive impacts on Japanese total factor productivity growth and technological catch-up.

Thus, Evenson and Westphal (1995, p. 2288) summarize the role of utility models in developing countries as follows:

> "Strong IPRs can be a powerful instrument for encouraging many forms of investment at all levels of technological development if they are sufficiently focused on promoting those forms of investment which are respectively important at each level. More imagination than has previously been given to their design is clearly in order. Breeders rights and utility models exemplify the gains in creativity in this area. Utility model protection, for example, is actively sought in the few countries, like Korea, that grant it. Moreover, the evidence suggests that it stimulates the kinds of minor, adaptive inventions that are important in the early to middle phases of technological development."

Our study differs from these previous empirical studies in the following ways: (1) we examine equations for both economic growth and innovation (R&D) so as to study the direct and indirect influences of IPRs; (2) we consider the impact of IPRs on innovation and growth by the level of economic development, and thereby address the role of a second-tier form of IPR, namely utility model protection, that may be more suitable for innovation and growth in developing economies; (3) we take into account the potential simultaneity between IPR and economic growth (or innovation) using dynamic panel data methods, which is important if policy choices on IPRs depend on the level of economic development; and (4) we employ more up-to-date data on IPRs, economic growth, and innovation.

4. Empirical Framework: Model Specification, Methodology, and Data

Our objective is to study the direct and indirect effects of IPR on economic growth, and to assess the extent to which the impact will differ by level of economic development. For the empirical analysis, a panel data set has been assembled for 1975-2003 and divided into five-year spans, except for the last sub-period of 2000-2003. Five-year averaging is used to smooth out business cycles. Time dummies are included to control for common long run growth and innovation rates. The sample countries are classified into two main groups: high-income countries and middle-to-low income countries, using the World Bank's classification. Countries whose GDP per capita in constant 2000 PPP international dollars are above 10,000 dollars are classified as *high-income*, and those below 10,000 international dollars are classified as *mid/low-income.* [3]

For the economic growth rate equation, we augment conventional growth models (such as those of Mankiw et al. (1992) and Caselli et al. (1996)) to incorporate the IPR variable. To fix ideas, if the production function is Y = f(K,R,H,AL), where Y is output, K physical capital, R research and development capital, H human capital, L labor, and A technical efficiency, we assume that A is a function of IPR – i.e. A(IPR). Equation (1) is the model we use to estimate whether IPR has a direct relationship with economic growth:

[3] Unless indicated otherwise, we group the middle and low income countries together due to the limited number of observations for the low income group. Low income countries are those whose per capita GDP (in constant 2000 PPP international dollars) is less than 1,000 dollars.

$$(1)\ \ln(y_{it}) - \ln(y_{it-1}) = \alpha + \beta \ln(y_{it-1}) + \gamma \ln(pop.growth_{it}) + \delta \ln(invest_{it})$$
$$+ \lambda \ln(R\&D\ intensity_{it}) + \varphi \ln(second.enroll_{it})$$
$$+ \phi \ln(IPR\ index_{it}) + \eta D^{*}\ln(IPR\ index_{it}) + \mu_i + \nu_{it}$$

- y_{it} GDP per capita in country i in year t (expressed in constant 2000 international dollars, ppp)
- $y_{i,t-1}$ GDP per capita in country i expressed in year t-1(expressed in constant 2000 international dollars, ppp)
- *pop. growth.* Growth rate of population of country i.
- *invest.* Investment measured by the ratio of gross capital formation to GDP
- *R&D intensity* Ratio of R&D expenditures to GDP
- *second. enroll.* Human capital measured by the secondary school enrollment rate
- *IPR index* Index of patent rights
- D = 1 if mid or low-income countries, D = 0 otherwise
- μ_i is the fixed effect, ν_{it} is assumed to be mean zero, and the correlation between $\mu_i$and ν_{it} to be zero.

Next, the R&D equation is motivated by David et al. (2000), where R&D is a function of technology opportunity and technology cost variables. Furthermore, we allow for dynamics in R&D (e.g. a lagged dependent variable to account for costs of adjustment of R&D and intertemporal knowledge spillovers). The model specification is as follows:

$$(2)\ (R\&D\,intensity_{it}) = \alpha + \beta (R\&D\,intensity_{it}) + \gamma (IPR\ index_{it})$$
$$+ \eta D^{*}(IPR\ index_{it}) + \delta (Phdpop_{it}) + \lambda (DSR_{it-1})$$
$$+ \sigma (exratio_{it}) + \eta_i + \nu_{it}$$

- *R&D intensity* Ratio of R&D expenditures to GDP
- *IPR index* Index of Patent Rights
- *Phdpop* Number of persons who hold doctoral degrees in science and engineering from U.S. universities (per million people)
- *DSR* Ratio of Domestic Savings to GDP
- *exratio* Ratio of Exports to GDP
- D = 1 if mid or low-income countries, otherwise D=0

- μ_i is the fixed effect, ν_{it} is assumed to be mean zero, and the correlation between μ_i and ν_{it} is zero.

Innovation is represented by the ratio of R&D expenditures to GDP. A dynamic specification (i.e. lagged dependent variable) is adopted on two grounds. The first is the adjustment and installation costs associated with R&D expenditures which make such expenditures persistent over time. Another is intertemporal knowledge spillovers that make current R&D dependent on past R&D.

We will say a few words about our choice of control variables. As Hall (1992) points out, lending institutions tend to be reluctant to provide loans for R&D activities, particularly since such ventures are risky with uncertain rates of return. Thus R&D expenditure tends to be financed mainly from internal funds. We follow Kanwar and Evenson (2003) in using use gross domestic savings as a proportion of GDP, lagged one period, to represent the internal funds available for R&D expenditure. Countries whose production factors contain relatively more human capital will tend to innovate at a faster rate than those with relatively less, particularly since human capital is a central input in R&D. More educated countries are also likely to have stronger absorptive capacities; that is, absorb innovations made elsewhere (Nelson and Phelps, 1966). We therefore use the share of the population (per million) with PhD degrees in science and engineering, earned in the U.S., as our measure of R&D human capital; we use the share of the variable in order to control for country size.

The trade orientation of a country can also influence its propensity to be innovative. Relatively more open economies face relatively more competition and have less sheltered markets. As such, they are compelled to invest relatively more in R&D (Chen and Puttitanun (2005) and Aghion et al. (2001)). To measure the degree of openness of an economy, we use exports as a share of GDP. But, as Chen and Puttitanun (2005) point out, openness could also negatively affect innovation to the extent that it provides more opportunities – through exposure to advanced foreign technology – for domestic agents to engage in imitation. This could potentially divert resources away from innovation. Hence this variable could have ambiguous effects a priori.

In both equations (1) and (2), we analyze the role of economic development through the interaction between the IPR variable and a dummy variable (D = 1 if a middle or low income country, and 0 otherwise). Taking the partial derivative of the dependent variable in equation (2) with respect to the IPR variable yields the effect of patent protection on R&D by economic development. For example,

$$\frac{\partial(\text{R\&D intensity}_{it})}{\partial \text{IPR index}_{it}} = \gamma + \eta'$$

is the impact of patent protection on R&D for middle-to-low income countries and γ that for high-income countries.

We now turn to our methodology. We adopt the system GMM approach developed by Arellano and Bover (1995) and Blundell and Bond (1998) for dynamic panel data, instead of the first-difference GMM approach. The latter suffers from a 'weak' instruments problem when explanatory variables lagged at least twice are used as instruments, particularly when the time series data are persistent and the number of observations small. The system GMM estimator uses equations in differences and in levels to bring additional moment conditions and thereby increase efficiency. Such an estimation procedure is useful for panels with large N and relatively small T since it relies on asymptotic properties.[4]

We estimate the system of equations formed by equations (1) and (3) below for the economic growth model and the system formed by equations (2) and (4) below for the R&D model:

$$(3)\ \Delta[\ln(y_{it}) - \ln(y_{it-1})] = \alpha + \beta\,\Delta\ln(y_{it-1}) + \gamma\,\Delta\ln(\text{pop.growth}_{it}) + \delta\,\Delta\ln(\text{invest}_{it}) + \lambda\,\Delta\ln(\text{R\&D intensity}_{it}) + \varphi\,\Delta\ln(\text{second.enroll}_{it}) + \phi\,\Delta\ln(\text{IPR index}_{it}) + \eta\Delta[D^{*}\ln(\text{IPR index}_{it})] + \Delta\nu_{it}$$

$$(4)\ \Delta(\text{R\&D intensity}_{it}) = \alpha + \beta\,\Delta(\text{R\&D intensity}_{it}) + \gamma\,\Delta(\text{IPR index}_{it}) + \eta\,\Delta[D^{*}(\text{IPR index}_{it})] + \delta\,\Delta(\text{Phdpop}_{it}) + \lambda\,\Delta(\text{DSR}_{it-1}) + \sigma\,\Delta(\text{exratio}_{it}) + \Delta\nu_{it}$$

Instrumenting endogenous variables with variables that are at least lagged twice and their differenced equivalents can allow us to control for the endogeneity problem (Bond et al, 2001). Otherwise, both OLS and fixed effects (FE) estimation will yield biased estimates – though in opposite directions – of the coefficient of the AR(1) term (or the lagged dependent variable). More specifically, OLS estimation results in an upward bias due to the positive correlation between the AR(1) term and the country-specific effect term (μ_i), whereas FE estimation results in a downward bias due to the leading negative correlations between the within-transformed AR(1) term and the within-transformed error term,

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[4] Windmeijer (2005) developed a correction for the two-step covariance matrix that significantly increases the efficiency of these GMM estimators, which we implement.

particularly in the case where the time dimension T is fairly short (Nickell, 1981). Therefore, if system GMM properly controls for endogeneity, we expect the coefficient of the AR(1) term to lie between the OLS estimate, which is biased upwards, and the fixed-effect estimate, which is biased downwards (Bond, 2002).

In addition, using instrumental variables that are at least lagged twice and their differenced equivalents allows us to correct for the effects of endogeneity on the coefficient estimates of the other independent variables. As Caselli et al. (1996) and Bond et al. (2001) point out, many determinants of economic growth, such as investment in physical or human capital, government expenditure, population growth, are potentially endogenous. Failure to account for this leads to inconsistently estimated regression models, whether with panel or cross-sectional data.

Finally, if the system GMM model is correctly specified, two criteria should be met: the over-identification test and the test for second order serial correlation of the residuals in the differenced equation (AR2).[5] If the model is correctly specified, the variables in the instrument set should be uncorrelated with the error term. The Sargan-Hansen test statistic for testing the over-identifying restrictions is, under the null of instrument validity, asymptotically distributed as a chi-square with degrees of freedom equal to the number of instruments less the number of parameters. The AR2 test is, under the null of no second-order serial correlation of the differenced residuals, asymptotically distributed as a standard

[5] This test is a necessary condition for the errors in levels to be first-order serially uncorrelated. The identifying assumption is thus no first-order serial correlation (that is, $E[\upsilon_{it}, \upsilon_{i,t-1}] = 0$).

normal. This test provides a further check on the specification of the model and on the legitimacy of variables dated t-2 or earlier as instruments in the differenced equation.

We now discuss our data sources and some sample statistics. Appendix II summarizes the sources of data. As a measure of IPR protection, we use an index of patent protection that has been recently extended to 2005 (though we utilize it up to 2003).[6] This allows us to conduct a longer time-series analyses and should enable us to better track the growth and innovation experiences of a large number of developing countries that have reformed their IPR policies over the past decade.

Table 1 presents summary statistics of the data. The mean growth rates are higher among high income countries, as are the mean investment rates, R&D/GDP ratios, school enrollment rates, and per capita GDP. Furthermore, both the index of patent rights and the volume of utility applications are higher among high income countries. The large numbers of utility model applications in higher income countries are due primarily to Japan, Korea, and Germany, who historically have been heavy users of the utility model system.

[Insert Table 1 here]

[Insert Table 2 here]

Table 2 presents simple correlations among the variables of interest. IPR, R&D, and GDP per capita are all positively correlated with one another. Richer countries generally

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[6] See Park (2008).

have higher rates of, and capacities for, innovation and stronger IPR regimes. Note that utility model protection is also positively correlated with IPR, suggesting that countries (mostly developing) that protect patents also tend to provide petty patents. But note that utility model protection has a negative correlation with R&D/GDP. This is likely due to the fact that utility models protect adaptive, incremental innovations that do not require much R&D expenditure. In countries that provide intellectual property protection for such innovations, and where agents specialize in that type of innovation, the R&D to GDP ratio is smaller. Another way to put this is that countries with high rates of R&D to GDP do not generally provide IP protection for such minor inventions, since they conduct more innovative research. Indeed Table 2 shows that the correlation between utility model protection and GDP per capita for the high income sample is negative indicating that richer economies are less apt to provide intellectual property protection for minor inventions, as most of these countries conduct frontier innovations.

[Insert Figure 1 here]

Figure 1 compares the GDP per capita, R&D/GDP, IPR, and growth rate between countries that protect utility models and those that do not. We do this for each income group. The first bar in each pair is the ratio of the variable for high income countries (of those that provide utility model protection vis-à-vis those that do not) and the second bar is the same for middle and low income countries (of those that provide utility model protection vis-à-vis those that do not). The figure shows that, on average, countries in each income group that have utility model protection have higher GDP per capita, R&D/GDP, and IPR. Among developing countries, the average growth rate is somewhat higher for those countries that protect utility models, but the average growth rates is about the same among high income countries that provide utility models and those that do not. This suggests that utility models play a more important role in developing countries than in developed countries, an issue that we will examine more formally in the next section.

5. Results

We first provide estimates of the growth model and then the R&D model. Throughout we control for time effects (not shown to conserve space). Table 3 presents our estimates of the standard growth model, augmented with IPR. We conducted a few preliminary tests. First, a Hausman test for endogeneity was conducted. The test rejected the null hypothesis that the coefficient estimates of pooled OLS and system GMM had no systematic differences (where $\chi^2(6) = 334.04$, p-value = 0.000). The result of this test favors system GMM over OLS.

[Insert Table 3 here]

Another preliminary test was to compare the results of system GMM to those of OLS and FE (see column 1 – 3 of Table 3). In the presence of a lagged dependent variable, both methods yield biased and inconsistent estimates. As discussed earlier, the OLS estimate of the lagged dependent variable tends to be biased upwards and that of FE biased downwards. Thus system GMM, if valid, should produce a coefficient estimate of lagged GDP per capita lying between the OLS and FE estimates. Indeed, following Bond et al. (2001), we find that our measured coefficient of the lagged dependent variable is neither significantly greater than the OLS estimate nor significantly below the FE estimate. The coefficient estimate of lagged GDP per capita is negative, indicating conditional convergence. Other tests (AR2 and Sargan/Hansen tests) could not reject the null hypothesis of no serial correlation and instrument validity.

We thus focus on the third column of Table 3, which corresponds to the results of system GMM estimation, and discuss the first main result. We find, in particular, that patent protection does not have a statistically significant positive direct effect on the growth rate, contrary to Gould and Gruben (1996) and Falvey et al. (2006).[7] This suggests that merely strengthening IP institutions and laws does not by itself raise the growth rate of output per capita. Rather, the potential role for stronger IP institutions and laws is in affecting the environment in which productive activities take place. For this reason we focus on other, indirect channels of influence of patent rights on economic growth. But before doing so, we comment on the other results in Table 3.

Population, investments in physical capital, and investment in R&D have statistically significant positive influences on the growth rate; the human capital variable (as measured by the secondary school enrollment rate) is statistically insignificant. Once

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[7] Note that the coefficient of IPR is positive and statistically significant at the 10% level under FE estimation. This is consistent with Falvey et al. (2006) who control for fixed (country) effects.

R&D is included, the human capital variable loses statistical significance. One reason is that both are correlated, reflecting investments in knowledge; however, investments in secondary education likely to have a longer lagged effect on productivity than investments in innovation and technology. Moreover, secondary education focuses on more general learning, whereas R&D expenditures are more oriented towards production activities and further innovation. The model also explains about 40% of the variation in the data, using a pseudo R^2 measure.[8]

In column 4, we repeat the analysis shown in column 3 for a sub-sample of middle and low income countries. Again, patent protection is statistically insignificant as an explanatory variable. But what is interesting is that R&D also has a statistically insignificant influence on the growth rate of middle to low income countries. There are two related possibilities. First, the existence of a threshold effect in that R&D/GDP must reach a certain critical level in order for R&D to have a positive influence on production. Secondly, the quality of R&D inputs and outcomes is generally lower in developing countries. R&D in developing countries, as stated earlier, tends to be oriented towards adaptive, incremental innovations. Developing economies also lack complementary factors required for R&D activity to be very productive, such as state-of-the-art machinery and equipment and skilled personnel.

In column 5, we restrict the middle to low income sample to those countries that provide IP protection to utility models. Such countries include China, Russia and Brazil, which have been actively exploiting utility models. Among these countries, their R&D is

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[8] The pseudo $R^2 = (1 - L_1/L_0)$ where L_1 is the log likelihood value of the full model and L_0 that of the constant only model.

likely to be geared more towards adapting existing technologies to local needs, or towards innovating new tools, compounds, or implements that are more appropriate for their economic circumstances. Thus, as the results show, we find that R&D does matter to economic growth for this smaller sample of countries, and that the model explains 66% of the variation in the data. The reason that R&D can matter here is two-fold: on the one hand, this group of countries tends to conduct a greater quantity of research and development. On the other hand, this group of countries may conduct a different type of R&D, one that is more suitable to local production needs. In countries that provide petty patent protection, small inventors and entrepreneurs have greater incentives and opportunities to pursue these kinds of minor inventive activity since their research outputs are recognized and protected with utility model protection. In countries that do not provide petty patent protection, agents may have less incentive to invest in adaptive, incremental R&D.

To recap, we find that patent protection has an insignificant direct effect on growth, and that R&D matters to growth in high income countries and in middle to low-income countries where the content of R&D is more focused on local needs. We next turn to whether patent protection may have a significant indirect effect on economic growth, via its influence on R&D, and whether this influence also varies by level of economic development. The results in Table 4 present estimates of the R&D equation. Again, preliminary tests showed no signs of serial correlation and instrument invalidity, and the Hausman test rejected the null hypothesis of no simultaneity (where $\chi^2(5) = 10.9$, p-value = 0.053). The coefficient estimate of the lagged dependent variable lies between the OLS and

FE estimates. The coefficient estimate shows some persistence in R&D, suggesting that R&D potentially builds on past R&D.

[Insert Table 4 here]

Focusing on column 3 of Table 4, we find that patent protection is a statistically significant determinant of R&D intensity. Thus, to the extent that R&D is important to growth, patent rights are indirectly important to growth via the stimulation of R&D. In addition, scientific human capital, as proxied by the number of persons (per million) with doctoral degrees in science and engineering from U.S. institutions, is also an important explanatory factor. Overall, this particular model explains 85% of the variation in the data.

However, the influence of patent protection on R&D varies by level of economic development. In column 4 of Table 4, we introduce a dummy variable for middle and low income countries and interact it with the IPR index. For high income countries, the index of patent rights has a statistically significant positive coefficient estimate of 0.192. For middle income countries, the measured net effect of patent protection on R&D is negative, suggesting that the effects of patent protection in middle income countries are different from those in high income countries. The net coefficient estimate equals -0.009 (= 0.192 – 0.201, where the latter is the coefficient of the interaction between the middle income country dummy and the IPR variable). However, this net coefficient estimate is not actually statistically significant. We repeated the estimation where the middle income countries were the benchmark group,[9] and find the coefficient estimate of the IPR variable to be negative but statistically insignificant (the results are not shown in order to conserve space).

The results in column 4 of Table 4 also show that, for low income countries, the net effect of patent protection is also negative, with a net coefficient estimate of -0.589 (= 0.192 – 0.781).[10] We also conducted the analysis where the low income countries were the benchmark group. Again the coefficient estimate of the IPR index for low income countries is negative and statistically insignificant.

Thus our findings illustrate the importance of examining the impacts of IPRs on countries by different levels of development. Previous empirical studies on the relationship between IPRs and R&D (e.g. Kanwar and Evenson (2003) and Varsakelis (2001)) or the relationship between IPRs and economic growth (e.g. Gould and Gruben (1996)) have not explicitly examined countries by income group. Our results qualify theirs by indicating that, for developing economies, stronger IPR has a statistically insignificant influence on R&D and economic growth. Our results are consistent, though, with studies that have examined developing country data (e.g. Schneider (2005), Chen and Puttitanun (2005), and partially with Falvey et al. (2006) who find an insignificant influence on the growth rates of middle income countries but not on those of low-income countries).[11]

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[9] That is, where D = 0 refers to the middle income countries.

[10] However, the coefficient estimate of the interaction between the low income dummy and IPR of -0.781 is not statistically significant. This may be due to the fact that we have few countries in this group.

[11] Our methodology controls for potential endogeneity between IPRs and economic growth and innovation, which may account for the difference between our results for low-income countries and those of Falvey et al. (2006).

As for the implications of our empirical results for the theoretical literature, our results are favorable to Eicher and Penalosa (2008) who argue that IPRs are unlikely to have a significant impact on innovation and growth until a threshold level of development has been reached. Our results are only partially supportive of the theoretical analysis of Grossman and Lai (2004). Their model would predict that stronger IPRs (at TRIPS level standards) matter positively for the innovation of richer (Northern) countries and *negatively* for that of poorer (Southern) countries. Our results suggest that, for developing countries, the positive (incentive) effects of IPRs on innovation are likely to be offset, or balanced out, by the effects of stronger IPRs on the cost of innovation. Stronger IPRs make technological inputs into R&D proprietary and more expensive as patent holders are better able to capture rent through higher licensing fees and royalties. These actions reduce the ability of developing country agents to access important technological inputs cheaply.

Table 5, however, provides a different, interesting perspective on the results. Our finding here is that, although patent protection may have a negative or insignificant influence on innovation in developing countries, a second-tier form of IP protection may provide a useful stimulus to developing country R&D, namely utility model (or petty patent) protection. As we saw earlier, in Table 3, growth rates in countries that provide utility model protection tend to respond positively to R&D – particularly, incremental adaptive R&D – that yield innovations that qualify for such utility model protection.

[Insert Table 5 here]

First, in column 1 of Table 5, we present the results of including a dummy variable (as to whether a middle income country provides utility model protection) into our dynamic R&D equation. This variable is positive but statistically insignificant, suggesting that the R&D/GDP is not appreciably different between countries that provide utility model protection and those that do not. But the dummy variable, however, does not indicate whether agents (e.g. firms or small inventors) resort much, if at all, to utility model protection, only whether the laws protect such inventions. Thus, in column 2 of Table 5, we replace this dummy variable with a measure indicating the intensity of use of utility model protection (namely the number of utility model applications per million people). Countries that provide such protection vary in usage or in how often agents utilize such protection. Developing countries like China, Taiwan, and Russia utilize such protection much more than other developing countries. As we mentioned earlier, agents are more likely to resort to utility models if the required inventive step between a patent and utility model is large. Thus the relatively large filings of utility model applications in a country are made possible by the relatively low inventive hurdle set for smaller inventors. Thus the filing data may reflect the ease with which such inventors are able to access some form of IP protection.

The results show that this measure of utility model protection does have a statistically significant positive association (at the 10% level) with the R&D intensity of developing countries, and the model overall explains more than half the variation in the data.[12] Moreover, this effect of utility model protection on innovation seems specific to middle income countries. In column 3 of Table 5, when we include the total sample (i.e. include high income countries), this variable is not quantitatively or significantly important.

What these results suggest is that strong or weak IP protection is not the key issue for developing countries. Rather it is whether such countries have the appropriate kind of intellectual property protection, a point that is relatively neglected in current policy debates and in empirical and theoretical research. In countries where a lower form of protection exists, namely utility model protection for minor inventions, and where firms or agents take advantage of such property rights protection, this type of IPR can be conducive to innovation, at least in middle-income countries. Otherwise, our results show that for higher income economies, conventional IPR (e.g. patent protection) appears to be the mechanism that creates incentives for R&D and that ultimately affects economic growth.

6. Conclusions

This paper is a contribution to the empirical literature on the effects of IPRs on economic growth. Our empirical analysis utilized dynamic panel data methods that accounted for endogeneity among IPR, innovation, and economic growth, and utilized more recent international data on patent protection levels, utility models, and R&D.

The principal finding is patent protection affects economic growth indirectly by influencing R&D intensity. R&D in turn affects economic growth positively in high-

[12] Our dynamic panel data method also controls for the potential simultaneity between R&D and utility model inventions.

income countries and in those middle-income countries that reward imitative and adaptive R&D with intellectual property protection. The rights to traditional, invention patents are positively associated with the R&D intensity of high-income countries and insignificantly with that of middle income countries, controlling for other factors. Instead, petty patents or utility models are positively associated with the R&D intensity of middle to low-income countries, where agents make use of them. The use of these petty patents or utility models, however, is not a significant determinant of innovative activity in high-income countries.

Thus the chief lesson in this paper is that a second-tier form of IPR is likely to be more appropriate for developing economies. In the more developed countries, where patent protection is stronger, innovation is less dependent on utility models, as agents conduct (and have the capacity to conduct) more innovative R&D rather than imitative or adaptive R&D. Where the inventive step of innovations is large, agents should prefer a traditional patent that provides stronger and longer protection. Thus, utility model protection should be most useful to agents whose current capacities lie in conducting incremental research and development.

Our results find some support in case studies of economic development. Consider, for example, the case of South Korea's economic development. Due to its lack of local technological capability before 1980, it depended heavily on reverse engineering and importing equipment and machinery from foreign countries (Lee et al. 2003). Thus, domestic inventors were more apt to modify the imported products, which then qualified for utility model protection. Indeed, over the course of Korea's economic development, the number of utility model applications had been greater than that of traditional, invention patents up until the late 1980s (Lee et al. 2003). Korean inventors especially filed for utility model protection in the electronics and machinery industries. These experiences suggest that the design and strength of IPR systems should be tailored to the indigenous technological capacities of the developing countries in order to provide the appropriate incentives for innovation. Furthermore, the experiences suggest that incremental, imitative innovation may be stepping stones to building the capacity to generate future patentable inventions.

Thus the contribution of this paper is to stress the importance of instituting the right type of incentive mechanism for innovation. Current academic and policy debates have focused on the effects of strong IPRs in general, of raising developing country standards to developed country levels, and restricting imitation, piracy, and infringement in developing countries. Less attention has been paid toward the effects of intermediate levels or types of IPRs and the growth capacity of imitative innovation.

Future research could explore other forms of IPR that might also be suitable for developing countries, such as trade secrets and industrial designs. Secondly, it would be useful to investigate the issues by sector: agriculture, electronics, and machinery. Lastly, it would be interesting to consider at what level of economic development patent protection changes from being an insignificant influence on innovation to a significant influence. In our analysis, the income groupings are given. Future work could endogenize the income thresholds (for example, using the methods of Falvey et al. (2006)).

References

Aghion, P., Harris, C., Howitt, P., and Vickers, J. (2001), "Competition, Imitation, and Growth with Step-by-Step Innovation," *Review of Economic Studies*, 68, 467 - 492.

Arellano, M. and Bover, O. (1995), "Another Look at the Instrumental Variable Estimation of Error-Components Models," *Journal of Econometrics*, 68, 29-52.

Barro, R. J. and Lee, J., (2000), "International Data on Educational Attainment: Updates and Implications," *CID Working Paper* No. 42.

Bently, L. and Sherman, B. (2001), *Intellectual Property Law*, Oxford University Press.

Blundell, R. and Bond, S. (1998), "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics*, 87, 115-143.

Boldrin, M. and Levine, D. (2006), "Globalization, Intellectual Property, and Economic Prosperity," *Spanish Economic Review*, 8, 23 - 34.

Bond, S., Hoeffler, A., and Temple, J. (2001). "GMM Estimates of Growth," CEPR Discussion Paper No. 3048.

Bond, S. (2002), "Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice," *Portuguese Economic Journal*, 1, 141 - 162.

Caselli, F., Esquivel, G. and Lefort, F. (1996), "Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics," *Journal of Economic Growth*, 1, 363 - 389.

Chen, Y. and Puttitanun, T. (2005), "Intellectual property rights and innovation in developing countries," *Journal of Development Economics*, 78, 474-498.

David, P., Hall, B., and Toole, A. (2000), "Is Public R&D a Complement or Substitute for Private R&D? A Review of Econometric Evidence," *Research Policy*, 29, 497-529.

Eicher, T. and Penalosa, C. (2008), "Endogenous Strength of Intellectual Property Rights: Implications for Economic Development and Growth," *European Economic Review*, 52, 237 – 258.

Evenson, R. and Westphal, L. (1995), "Technological Change and Technology Strategy," in J. Behrman and T. N. Srinivasan (eds.) *Handbook of Development Economics*, 3A, Amsterdam: North-Holland, 2209-2299.

Falvey, R., Foster, N. and Greenaway, D. (2006), "Intellectual Property Rights and Economic Growth," *Review of Development Economics*, 10, 700 – 719.

Ginarte, J. and Park, W. (1997), "Determinants of patent rights: a cross-national study," *Research Policy*, 26, 283-301

Gould, D.M. and Gruben, W. (1996), "The Role of Intellectual Property Rights in Economic Growth," *Journal of Development Economics*, 48, 323-350.

Grossman, G. and Lai, E. (2004), "International Protection of Intellectual Property", *American Economic Review,* 95, 1635 - 1653.

Hall, B. (1992), "Investment and R&D at the firm level: Does the source of financing matter?" *National Bureau of Economic Research Working paper* No. 4096, Cambridge, MA.

Helpman, E. (1993), "Innovation, imitation and intellectual property rights," *Econometrica*, 61, 1247-1280.

Herrera, S. and Pang, G. (2005), "Efficiency of Public Spending in Developing Countries: An Efficiency Frontier Approach, " *Policy Research Working Paper Series* 3645, The World Bank.

Horii, R. and Iwaisako, T. (2007), "Economic Growth with Imperfect Protection of Intellectual Property Rights," *Journal of Economics*, 90, 45 – 85.

Horowitz, A. and Lai, E. (1996), "Patent Length and the Rate of Innovation", *International Economic Review*, 37, 785 - 801.

Kanwar, S. and Evenson, R. (2003), "Does Intellectual Property Protection Spur Technological Change?" *Oxford Economic Papers*, 55, 235-264.

Kumar, J. (2002), "Intellectual Property Rights, Technology, and Economic Development: Experiences of Asian Countries," Research and Information System for the Non-Aligned and Other Developing Countries Discussion Paper No. 25.

Lai , E. (1998), "International Intellectual Property Rights Protection and the Rate of Product Innovation," *Journal of Development Economics*, 55, 133-153.

Lee, K. C. Lim and D. Park (2003), The Role of Industrial Property Rights in Technological Development in the Republic of Korea. WIPO Policy Monograph.

Mankiw, G., Romer, D., and Weil, D. (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, 107, 407-437.

Maskus, K. and McDaniel, C. (1998), “Impacts of the Japanese Patent System on Productivity Growth,” *Japan and the World Economy*, 11, 557-574.

Nelson, R. and Phelps, E. (1966), “Investment in humans, technological diffusion, and economic growth,” *American Economic Review*, 56, 59-75.

Nickell, S. (1981), “Biases in Dynamic Models with Fixed Effects,” *Econometrica*, 49, 1417 - 1426.

Park, W. (2008), “International Patent Protection: 1960 – 2005,” *Research Policy* forthcoming.

Park, W. and Ginarte, J. (1997), “Intellectual Property Rights and Economic Growth,” Contemporary Economic Policy, 15, 51 - 61.

Schneider, P. (2005), “International Trade, Economic Growth, and Intellectual Property Rights: A Panel Data Study of Developed and Developing countries,” *Journal of Development Economics*, 78, 529 – 547.

Suthersanen, U. (2006), “Utility Models and Innovation in Developing Countries,” The International Centre for Trade and Sustainable Development Issue Paper 13, UNCTAD.

Thompson, M. and Rushing, F. (1999), “An Empirical Analysis of the Impact of Patent Protection on Economic Growth: An Extension,” *Journal of Economic Development*, 24, 67 - 76.

Varsakelis, N. (2001), “The Impact of Patent Protection, Openness, and National Culture on R&D investment: a Cross-Country Empirical Investigation,” *Research Policy* , 30, 1059-1068.

Windmeijer, F. (2005), “A finite sample correction for the variance of linear efficient two-step GMM estimators”, *Journal of Econometrics* 126: 25-51.

World Bank (1998), *World Development Report*, Oxford University Press, New York.

World Bank (2002), *Global Economic Prospects and Developing Countries*. Oxford University Press, New York.

Xue, L. and Liang, Z. (2008), “Should Developing Countries have the same IPR Regime as that of Industrialized Countries? Relationship between IPR and Technology Catch-up, Some Evidence from China”, Paper presented at the Tokyo Workshop on IPRs and Technological Catch-up,organized by the GRIPS.

Appendix I : List of countries with and without a utility model system (as of year 2000)

High income countries with IPR system (GDP per capita>10,000 ppp constant 2000 int. $)				Mid & Low income countries with IPR system (GDP per capita < 10,000 ppp constant 2000 int. $)			
With utility model system		Without utility model system		With utility model system		Without utility model system	
Country	IPR index	Country	IPR index	Country	IPR index	Country	IPR index
Argentina	3.98	Cyprus	3.48	Angola	1.08	Bangladesh	1.87
Australia	4.17	Great Britain (UK)	4.54	Burkina Faso	2.10	Ethiopia	2.00
Austria	4.33	Iceland	3.38	Bulgaria	4.42	Guyana	1.33
Belgium	4.67	Israel	4.13	Bolivia	3.43	India	2.27
Canada	4.67	Luxembourg	4.14	Brazil	3.59	Iran, Islamic Rep.	1.91
Switzerland	4.33	Malta	3.18	Botswana	3.32	Jamaica	3.06
Czech Republic	3.21	Norway	4.00	Chile	4.28	Jordan	3.03
Germany	4.50	New Zealand	4.01	China	3.09	Sri Lanka	3.11
Denmark	4.67	Saudi Arabia	1.83	Cameroon	2.23	Madagascar	2.31
Spain	4.33	Singapore	4.01	Congo, Rep.	2.23	Malawi	2.15
Finland	4.54	Sweden	4.54	Colombia	3.59	Nigeria	2.86
France	4.67	United States	4.88	Costa Rica	2.89	Nicaragua	2.16
Greece	3.97			Algeria	3.07	Pakistan	2.20
Hong Kong, China	3.81			Ecuador	3.73	Papua New Guinea	1.40
Hungary	4.04			Egypt, Arab Rep.	1.86	Paraguay	2.39
Ireland	4.67			Gabon	2.23	Sudan	2.61
Italy	4.67			Ghana	3.15	Sierra Leone	2.98
Japan	4.67			Guatemala	1.28	Tunisia	2.32
Korea, Rep.	4.13			Honduras	2.86	Tanzania	2.64
Netherlands	4.67			Haiti	2.90	Uganda	2.98
Portugal	4.01			Indonesia	2.47	South Africa	4.25
Slovak Republic	2.76			Morocco	3.06	Congo, Dem. Rep.	1.78
Taiwan	3.29			Mexico	3.68	Zambia	1.74
				Mali	2.10	Zimbabwe	2.60
				Malaysia	3.03		
				Niger	2.10		
				Panama	3.64		
				Peru	3.32		
				Philippines	3.98		
				Romania	3.72		
				Russian Federation	3.68		
				Senegal	2.10		
				El Salvador	3.36		
				Syrian Arab Republic	1.99		
				Togo	2.10		
				Thailand	2.53		
				Turkey	4.01		
				Ukraine	3.68		
				Uruguay	3.27		
				Venezuela, RB	3.32		
				Vietnam	2.90		
Average IPR index	4.21		3.84		2.96		2.41

Appendix II: Data Sources

GDP per capita, PPP (constant 2000 international $): Per capita GDP in Purchasing-Power-Parity constant 2000 international dollars. Source: World Bank, *World Development Indicators*, CD-Rom, 2005.

Population: Total population. Source: World Bank, *World Development Indicators*, CD-Rom, 2005, except for the population data of Taiwan which is from the *Statistical Yearbook of the Republic of China* (various years) published by the Government (Executive Yuan) of Taiwan.

Index of Patent Rights and Utility Model Laws: Ginarte and Park (1997) and Park (2008).

Capital formation: Gross capital formation (% of GDP). Source: World Bank, *World Development Indicators*, CD-Rom, 2005.

R&D expenditure: Total expenditure on R&D (% of GDP or GNP). Source: UNESCO *Statistical Yearbook* (Paris, France), various issues, except for the R&D data of Taiwan which is from the *Statistical Yearbook of the Republic of China* (various years) published by the Government (Executive Yuan) of Taiwan.

Secondary school enrollment: School enrollment, secondary (% of gross). The gross secondary school enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of secondary education. Source: Herrera and Pang (2005), Barro and Lee (2000) and their Database.

Ratio of Gross domestic savings to GDP: Gross domestic savings are calculated as GDP less final consumption expenditure (total consumption). Source: World Bank, *World Development Indicators,* CD-Rom, 2005,

Exports of goods and services (% of GDP): Exports of goods and services as a percentage of GDP. Source: World Bank, World Development Indicators, CD-Rom, 2005.

Number of PhDs in science and engineering from U.S. Universities. Source: National Science Foundation *Science and Engineering Indicators*, various issues, Washington, D.C.

Number of Utility applications: World Intellectual Property Office (WIPO) *Industrial Property Statistics*, various issues, Geneva.

Table 1: Summary Statistics

Variable	Total sample Mean	Std. Dev.	Min	Max	High income countries (GDP per capita>10,000 ppp 2000 constant int. $) Mean	Std. Dev.	Mid & Low income countries (GDP per capita < 10,000 ppp 2000 constant int. $) Mean	Std. Dev.
Growth rate (5-year average) proportion	0.06	0.18	-0.89	0.63	0.11	0.16	0.03	0.19
IPR index	2.30	0.99	0.20	4.88	3.19	0.97	1.93	0.77
Investment to GDP (%)	22.6	7.66	-5.74	73.5	24.1	5.74	22.1	8.42
Export to GDP (%)	34.1	22.4	0.42	170.0	43.3	27.3	29.9	18.3
Population growth (%)	1.77	1.74	-44.4	21.76	1.18	2.20	2.08	1.11
No. of US PhDs per million	2.73	6.46	0.00	82.1	5.98	10.5	1.36	2.57
Enrollment of secondary education (per the population of the corresponding age group)	59.8	34.0	0.46	160.7	93.8	23.2	47.5	26.8
Number of Utility Model Applications	2145	152545	0.00	204803	5797	25907	661	6496
Domestic Savings to GDP (%)	16.4	15.7	-92.8	75.9	25.4	9.8	16.5	12.6
R&D intensity (R&D/GDP as %)	1.11	0.92	0.00	5.11	1.62	0.88	0.53	0.52
GDP per capita (ppp, constant 2000 international dollars)	8608.4	8431.0	453.1	58852.4	18321.4	7168.1	3424.5	2326.9

Table 2: Sample Correlations

	Total sample				High income countries (GDP per capita>10,000 ppp 2000 constant int. $)				Mid and low income countries (GDP per capita < 10,000 ppp 2000 constant int. $)			
	GDP per capita	R&D	IPR index	Utility	GDP per capita	R&D	IPR index	Utility	GDP per capita	R&D	IPR index	Utility
GDP per capita	1				1				1			
R&D	0.6489	1			0.3785	1			0.1766	1		
IPR index	0.6887	0.5225	1		0.6507	0.4379	1		0.3791	0.1009	1	
Utility dummy	-0.0211	-0.0623	0.3377	1	-0.0997	-0.0702	0.1745	1	0.3882	-0.0419	0.7055	1

Note: Utility = 1 if a country provides utility model protection, and zero otherwise.

Table 3: Growth equation with IPR index

	Dependent Variable: 5-year average growth rate				
	Total sample			Mid & low sample only	Mid & low sample with utility model system
	(1)OLS	(2)FE	(3)System GMM	(4)System GMM	(5)System GMM
(Log of GDP per capita)$_{t-1}$	-0.045	-0.177	-0.066	-0.110	-0.006
	(2.95)***	(3.16)***	(3.24)***	(2.75)***	(0.05)
Log of population growth	-0.002	-0.012	-0.036	-0.018	-0.041
	(0.30)	(0.94)	(2.39)**	(0.21)	(0.09)
Log of investment	0.280	0.288	0.425	0.355	0.419
	(8.00)***	(4.69)***	(4.72)***	(3.40)***	(1.05)
Log of R&D intensity	0.022	0.007	0.023	0.019	0.028
	(2.76)***	(0.59)	(1.69)*	(1.17)	(1.88)*
Log of IPR index	0.043	0.055	0.068	0.048	0.022
	(1.53)	(1.68)*	(1.31)	(0.69)	(0.12)
Log of secondary school enrollment	0.021	0.013	-0.012	0.006	0.044
	(1.13)	(0.43)	(0.35)	(0.13)	(0.49)
Constant	-0.456	0.756	-0.591	-0.107	-1.278
	(3.06)***	(1.36)	(1.97)*	(0.23)	(0.61)
Time dummy	Yes	Yes	Yes	Yes	Yes
Observations	248	248	248	113	37
R-squared	0.42	0.37			
Pseudo R-squared			0.39	0.43	0.66
Number of code		72	72	40	20
Hansen			0.90	1.00	1.00
AR2			0.06	0.05	0.71

Notes:
1) *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level, T-value is in parenthesis. The results reported for the Hansen test and AR2 are the p-values of the null hypothesis of the appropriate set of instruments and no second-order autocorrelation, respectively. White-Sandwich standard errors are used.
2) log of GDP per capita: a logarithmic term of GDP per capita (ppp, constant 2000 international $); population growth: a growth rate of population; IPR index: index of patent rights; secondary school enrollment: rate of secondary school enrollment; investment: ratio of gross capital formation to GDP; R&D intensity: ratio of R&D expenditures as a % of GDP (or GNP).
3) The classification of high/mid/low income countries follows the World Bank criterion. High income countries: GDP per capita, ppp > $10,000 constant 2000 international dollars; mid income countries: $1,000 constant 2000 international dollars <GDP per capita, ppp < $10,000 constant 2000 international dollars; and low income countries: GDP per capita, ppp < $1,000 constant 2000 international dollars.

Table 4: Innovation equation with IPR index

	Dependent variable: R&D intensity Total Sample (1)OLS	(2)FE	(3)SYS GMM	H/M/L (4)SYS GMM
(R&D intensity)$_{t-1}$	0.912 (13.85)***	0.599 (5.53)***	0.763 (8.77)***	0.696 (6.35)***
(Domestic saving ratio)$_{t-1}$	0.005 (1.17)	0.013 (1.34)	0.009 (1.23)	-0.002 (0.19)
IPR index	0.116 (2.91)***	-0.012 (0.19)	0.225 (4.48)***	0.192 (3.72)***
Export ratio	-0.001 (1.10)	-0.001 (0.12)	0.001 (0.42)	0.001 (0.40)
No. of US PhDs per million	0.015 (6.25)***	-0.007 (0.55)	0.017 (3.24)***	0.009 (2.72)***
Mid income dummy*IPR index				-0.201 (2.21)**
[Net Effect]				-0.009
Low income dummy*IPR index				-0.781 (0.78)
[Net Effect]				-0.589
Constant	-0.243 (2.02)**	0.175 (0.62)	-0.755 (3.04)***	0.071 (0.13)
Time dummy	Yes	Yes	Yes	Yes
Observations	215	215	215	215
R-squared	0.86	0.46		
Pseudo R-squared			0.85	0.82
No. of code		67	67	67
Hansen			0.51	0.58
AR2			0.14	0.13

Notes:
1) *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level, T-value is in parenthesis. The results reported for the Hansen test and AR2 are the p-values of the null hypothesis of the appropriate set of instruments and no second-order autocorrelation, respectively. White-Sandwich standard errors are used.
2) R&D intensity: ratio of R&D expenditures as a % of GDP (or GNP); IPR index: index of patent protection; No. of US PhDs per million: the number of PhD holders in science and engineering from U.S. universities per million people; domestic saving ratio: gross domestic savings to GDP; export ratio: exports to GDP.
3) The classification of high/mid/low income countries follows the World Bank criterion. High income countries: GDP per capita, ppp > $10,000 constant 2000 international dollars; mid income countries: $1,000 constant 2000 international dollars <GDP per capita, ppp < $10,000 constant 2000 international dollars; and low income countries: GDP per capita, ppp < $1,000 constant 2000 international dollars.

Table 5: Innovation equation with utility variables

Dependent variable: R&D intensity System GMM	Mid Sample only with utility dummy	Mid Sample only with utility intensity	Total Sample
$(\text{R\&D intensity})_{t-1}$	0.341	0.339	0.789
	(5.02)***	(2.01)*	(9.52)***
$(\text{Domestic saving ratio})_{t-1}$	-0.004	-0.002	0.009
	(0.77)	(0.17)	(1.32)
IPR index	-0.053	-0.054	0.172
	(0.48)	(0.42)	(2.82)***
Utility intensity		0.009	0.000
		(1.80)*	(0.99)
Utility dummy	0.022		
	(0.15)		
Export ratio	0.002	0.004	0.001
	(0.68)	(0.50)	(0.24)
No. of US PhDs per million	-0.035	-0.050	0.016
	(1.47)	(1.29)	(2.97)***
Constant	0.606	0.502	-0.556
	(1.48)	(0.89)	(1.75)*
Time dummy	Yes	Yes	Yes
Observations	88	74	183
Pseudo R-squared	0.48	0.56	0.85
No. of code	34	30	61
Hansen	1.00	1.00	0.94
AR2	0.15	0.18	0.14

Notes:
1) *: significant at 10% level, **: significant at 5% level, ***: significant at 1% level, T-value is in parenthesis. The results reported for the Hansen test and AR2 are the p-values of the null hypothesis of the appropriate set of instruments and no second-order autocorrelation, respectively. White-Sandwich standard errors are used.
2) R&D intensity: ratio of R&D expenditures as a % of GDP (or GNP); IPR index: index of patent protection; No. of US PhDs per million: the number of PhD holders in science and engineering from U.S. universities per million people; domestic saving ratio: gross domestic savings to GDP; export ratio: exports to GDP; Utility intensity: Number of utility applications per million people, Utility dummy: a dummy variable = 1 if a utility model patents provided, 0 otherwise.
3) The classification of high/mid/low income countries follows the World Bank criterion. High income countries: GDP per capita, ppp > $10,000 constant 2000 international dollars; mid income countries: $1,000 constant 2000 international dollars <GDP per capita, ppp < $10,000 constant 2000 international dollars; and low income countries: GDP per capita, ppp < $1,000 constant 2000 international dollars.

Figure 1: Characteristics of Countries with Utility Model Protection relative to those without