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Appropriate intellectual property protection and economic growth in countries at different levels of development

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ABSTRACT

This paper examines how the role of patents and utility models in innovation and economic growth varies by level of economic development. Using a panel dataset of over 70 countries, we find that patent protection is an important determinant of innovation and that patentable innovations contribute to economic growth in developed countries, but not in developing. Instead, in developing economies, a minor form of intellectual property rights (IPRs) – namely utility models – is conducive to innovation and growth, controlling for other factors. Using Korean firm level data as a case study, we find that utility model innovations contribute to firm performance when firms are technologically lagging and that those minor innovations can be a learning device and thus a stepping stone for developing more patentable inventions later on. Upon reaching higher levels of technological capabilities, firms become more reliant upon patents and less on utility models. Thus the lesson here is that patent protection enhances innovation and economic growth in countries where the capacity to conduct innovative research exists. Where this capacity is weaker, a system that provides incentives to conduct minor, incremental inventions is more conducive to growth. The significance of this paper is to emphasize the importance not just of the strength of IPRs but of the appropriate type of IPRs for economic development.

1. Introduction

This paper addresses the role of intellectual property rights (IPRs) in the economic growth of countries at different levels of economic development. It addresses two issues. The first is whether stronger IPRs, particularly patent rights, are appropriate for the economic growth of countries regardless of their stage of economic development. The second, and related, issue is whether the same *types* of intellectual properties are appropriate for countries at different levels of economic development.

The possibility that IPRs could have differential effects on countries at different stages of economic development has been acknowledged in a World Bank publication (Fink and Maskus, 2005) and partly addressed in global intellectual property reforms (see Commission on IPR, 2002). 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 poor countries (until 2013). Local circumstances and needs have also been addressed, for example in policies related to essential medicines and public health.

Our contribution is to study not only the *strength* of IPRs but also the different *types* of IPRs that would be appropriate for countries at different stages of economic development. Our starting point is that innovation in many developing countries is of the adaptive, imitative type. Under the intellectual property systems of certain countries, inventors of adaptive, imitative innovations can have their inventions protected, for example through a utility model (or petty patent). Through adaptation, imitation, and incremental innovation, firms in developing economies can acquire knowledge and enjoy some learning-by-doing (Suthersanen, 2006). The innovations they produce may not have the inventive step to merit a regular patent, but they may qualify for this second-tier industrial property right; namely, a utility model. The absence of this type of industrial property right 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.

To date, there have been no formal, comprehensive empirical analyses of patents and utility models from a development perspective. In academic and policy debates, whether in the context of developed or developing countries, the focus has been on the

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appropriate strength of IPRs.[1] While the original TRIPS agreement does not deal with utility models, the *World Intellectual Property Organization* (WIPO) has recently considered the usefulness of utility model systems for lower income countries.[2] Our study should therefore generate further interest in examining alternative means of protecting IPRs at the international level.

Indeed our empirical analysis studies the different roles of patents and utility models in the innovation and economic growth of countries at different levels of economic development, and discusses why these different types of industrial property rights may be more appropriate for different groups of countries. We first conduct our analysis using a large panel data set of countries to assess the impact of utility model laws. We then isolate one developing country in our sample, namely South Korea, in order to conduct a specific case study. Korea's case is illuminating. Due to its limited technological capability before the mid-1980s, it depended heavily on reverse engineering, importation of technology, and imitation in order to fulfill its technological needs (Kim, 1997). Moreover, local inventors tended to modify or adapt existing or imported technologies, and obtained utility model protection for their incremental innovations. By the late 1990s, Korea became one of the world's leading patenting nations. For example, U.S. patents granted to Koreans rose from 14 in 1982 to 3562 in 1999, and the share of Koreans in U.S. patents granted rose from 0.01% to 2.32% (USPTO, 2009). By 1999, Korea ranked seventh in terms of U.S. patents granted. The question is whether all of these events are connected: did utility model protection provide incentives to innovate and help pave the way for increased technological development?

As an overview, our main finding is that the importance of patent rights and utility model protection to innovation and growth varies by level of technological development. We find that patent protection contributes to innovation and economic growth in developed countries but not in developing. This is consistent with the view that patent protection matters to industrial activities only after countries have achieved a threshold level of indigenous innovative capacity along with an extensive science and technology infrastructure (Kim, 1997; Lall and Albaladejo, 2001). In contrast, utility model protection weakly affects innovation and growth in developed countries but allows developing economies to build up their indigenous innovative capacities. In our analysis of Korean firms, we find that when firms are technologically lagging, utility models (or minor inventions) contribute to firm growth and to their capacity to produce (future) patentable inventions. Once firms become more technologically advanced, their performance is driven less by utility model innovations and more by patentable innovations. These results thus indicate that different types of intellectual property rights are more appropriate for countries at different stages of economic development.

This paper is organized as follows: Section 2 reviews previous studies on the effects of IPRs on innovation and economic growth. Section 3 provides a brief comparison between patent rights and utility models, and briefly discusses the experience of utility model protection in Korea. Section 4 discusses our theoretical framework and empirical methodology, and Section 5 our data. Section 6 contains the main empirical results, and Section 7 concludes.

2. Previous literature

Previous empirical studies focus on how the *strength* of intellectual property protection, particularly patent protection, relates to innovation and growth, not on the nature of the instrument used to protect innovation. Few of these studies examine the relationship between growth and IPRs by different income groups. Consequently, few if any address the type of protection that is appropriate for countries or firms at different levels of technological capability.

Moreover, previous empirical work on the relationship between IPRs and economic growth has almost exclusively used a measure of patent protection. Formal analyses of utility models are quite scant. To organize ideas, we can classify previous empirical studies in two ways: those that examine the impact of patent rights directly on output growth, and those that do so indirectly by examining a factor that contributes to output growth, such as R&D or innovation. For example, Gould and Gruben (1996) and Falvey et al. (2006) find instances where patent protection has a significant influence on economic growth. Other empirical studies, however, do not find a direct effect of patent protection on growth but an indirect one. For example, Park and Ginarte (1997) find that patent protection affects factor accumulation which in turn affects economic growth (see also Thompson and Rushing, 1999). Hence, more recent studies examine the relationship between patent protection and a determinant of growth, like innovation or R&D (see Varsakelis, 2001; Kanwar and Evenson, 2003). These studies find that R&D/GDP ratios are positively related to the strength of patent rights, conditional on other factors. Other studies use patents granted in the U.S. as a measure of innovation. For example, Schneider (2005) finds that stronger patent rights have a positive effect on innovation in developed countries only, while Chen and Puttitanun (2005) find a positive effect for large developing economies. The main limitation of these previous studies from our perspective is that they do not examine alternative means of protecting industrial property rights.

It is useful to inquire, though, whether in developing countries patents are an effective instrument for appropriating the returns to innovation. In a well-known survey of U.S. firms, Cohen et al. (2000) find that firms patent for various purposes other than merely as a mechanism for appropriating returns. For example, possession of patent rights plays an important role in litigation (to deter threats of infringement suits or countersuits) and in cross-licensing negotiations, where firms can better gain access to rivals' technologies if they are able to reciprocate with their own patent rights. However, the survey finds that smaller firms or inventors are less able to utilize patents for those purposes and hence are dissuaded from availing themselves of patent protection. Litigation costs are especially onerous for small firms since they have lower levels of output over which to spread the overhead costs of legal protection (e.g. legal staff). Furthermore, smaller firms or inventors have fewer and perhaps less valuable technologies to offer in cross-licensing negotiations. The implication for developing economies is that to the extent that a large share of inventors there is small, patents would not be very effective instruments for appropriating returns or accessing technologies.[3] This may explain why developing economies do not engage as intensively in producing patentable innovations and why something like utility models may serve as a useful alternative outlet for emerging innovation.

Some development economists have discussed alternatives to patent rights, such as utility models. Evenson and Westphal (1995, p. 2288) make the following observation:

> "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

[1] See Commission on IPR (2002) and Correa (2000) for a review of policy discussions.

[2] See http://www.wipo.int/sme/en/ip_business/utility_models/utility_models.htm and http://www.wipo.int/sme/en/ip_business/acquire_protection.htm.

[3] Mazzoleni and Nelson (1998) also discuss how strong, broad patents in less developed countries, by creating entry barriers, could impede the development of indigenous manufacturing capabilities.

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."

Empirical evidence on the effects of utility models on innovation and growth, however, is scant and based largely on anecdotal evidence. Kumar (2002), for example, argues that in East Asia, utility models helped initiate a culture of patenting and innovation. The World Bank (2002) documents case studies in Brazil where utility models allowed domestic producers to adapt foreign innovations to local needs and conditions. More formal econometric evidence is provided in Maskus and McDaniel (1999) which studies the use of utility models in Japan and finds that such protection on balance had positive impacts on the growth of Japanese total factor productivity.

In this paper, we go beyond anecdotal evidence to present econometric evidence on the role of utility models in economic development. Specifically, our study extends previous research in the following ways: (1) we examine both conventional patents and utility model protection as potential determinants of innovation and economic growth; (2) we control for the income group or technological capabilities of different countries; and (3) we utilize both country-level and firm-level panel data.

3. Patents and utility models

This section briefly describes some key differences between patents and utility models, and motivates our analysis by showing how their roles may differ for countries or firms at different stages of technological development. Both patents and utility models are exclusive rights granted for an invention, which allow the rights holder to prevent others from commercially using the protected invention without his authorization for a limited period of time. However, beyond this basic definition, differences exist between invention patents and utility models, based on standards of inventiveness and legal requirements.

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, attorney costs, and translation fees, where applicable). Utility models are second-tier protection for minor inventions, such as devices, tools and implements, particularly in the mechanical, optical, and electronic fields.[4] Processes or methods of production are typically excluded. The duration of protection is typically 6–10 years. Utility models are generally less expensive to apply for 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 practical or functional advantage over existing prior art. Since the perceived threshold inventive step of utility models is much lower than that of patents, in practice utility models are sought for small, marginal innovations which may not meet the patentability criteria (Beneito, 2006).[5] Thus, utility models and patents differ in that they protect different types of innovations. Patents protect innovations of relatively high inventiveness and utility models protect those of relatively low inventiveness.

Not all countries that provide patent rights protect utility models, such as the U.S. and U.K. The few developed countries that protect utility models include Germany, Japan, and some European countries. Countries that protect them are largely developing economies (former or current), such as Korea, Taiwan, China, and Malaysia. In some cases, utility models are the dominant form of IPRs. For example, in China, utility models accounted for nearly two-thirds of the total intellectual property rights granted, while patents accounted for 10%, during 1985–1998. Even though the share of utility models in total IPRs has declined in China, they still account for about half at present.

Korea is also among those developing countries where utility models have been intensively exploited. In 1961 the Korean government revised its entire system of intellectual property laws and established its first autonomous IPR system, protecting both conventional and minor innovations. Since the technological capabilities of Korean firms had been lagging during the 1960s and 1970s, firms relied heavily upon on imported technologies and on reverse engineering and adapting them for local needs (Kim, 1997; Lee et al., 2003). This very exercise enabled them to learn from foreign technologies. Accordingly, Korean inventors actively filed for utility model protection for their incremental innovations (Lee and Kim, 2010). Indeed, as shown in Fig. 1, the number of utility model applications exceeded that of invention patents until the early 1990s. In the 1970s and the early 1980s, the ratio of utility models to patents was nearly two to three. This ratio began to decline after 1984 when the ratio peaked at over 6 that year. Although patent and utility models applications were both still rising, the composition began to shift.

Since the mid-1980s, Korea began to have valuable patentable assets of its own to protect, as much as foreign companies had such assets that they wanted protected within Korea. Major IPR reforms were legislated in the mid-1980s, and since 1987 there was an abrupt rise in the strength of patent protection and an enlarged scope of protection. Substance patents for pharmaceutical and chemical materials and products were newly introduced, as well as protection for computer software and materials. The term of patent protection was also extended from 12 years to 15. Finally, by 1995, patent applications exceeded the number of utility model applications. These trends correspond with the transformation of Korea from a nation with limited technological resources and capabilities to one of the leading patenting nations.

The next section discusses our methodology for investigating more formally the roles played by patents and utility models in economic growth, especially in developing countries.

4. Empirical framework and methodology

4.1. Overview

We specify a production function in which output depends on, among other factors, knowledge capital. 'Knowledge' capital varies in sophistication and inventive steps. For analytical tractability, we posit two types: industrial knowledge that is patentable and knowledge that derives from minor inventive activity. In other words, we assume two kinds of knowledge capital inputs: patentable innovations and utility model innovations. Granted, this is a simplification, since patentable innovations also vary in quality and inventive steps, as do utility models; in some cases, some patentable innovations appear rather minor. However, comparatively speaking, the pool of patentable innovations tends to represent inventions that are more major than that of utility model innovations.

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

[5] For example, utility models are granted to devices embodying a creative idea applicable to the shape, structure or other technological aspects of a product, such as an improved device capable of reducing the amount of water used to flush a toilet, or a bottle cork remover capable of operating faster than known devices. Those devices are not patentable but inventive enough for utility model protection.

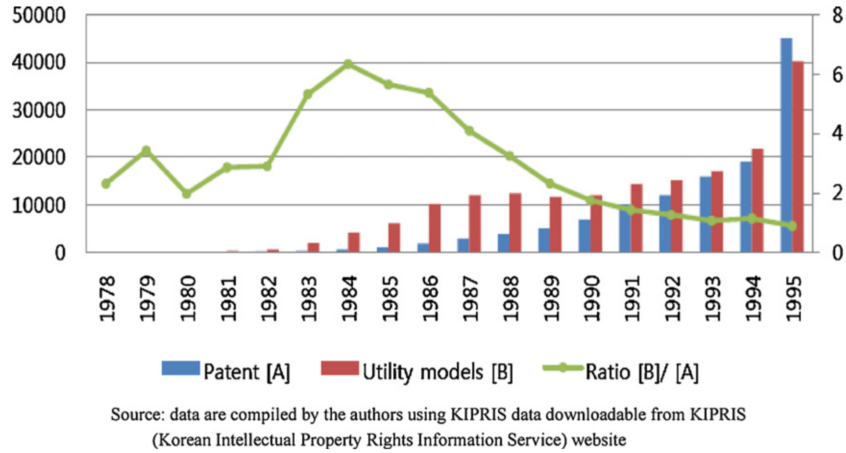

Fig. 1. Patent and utility model applications of Korean firms.
Source: Data are compiled by the authors using KIPRIS data downloadable from KIPRIS (Korean Intellectual Property Rights Information Service) website.

The relative importance of these two types of knowledge capital to production depends on the nature of the products and the associated nature of the technology used in their production. For example, firms or countries that produce a greater mix of high-end rather than low-end goods are more likely to utilize patentable innovations than minor. In technologically lagging economies or firms, the nature of production is such that it tends to involve less R&D, since product designs are often duplicated or creatively imitated from those of technologically advanced economies (Kim, 1997). In this sense, an economy's dependence on these two types of knowledge capital is expected to vary by level of technological development. The production of more advanced economies is less likely to be dependent on utility model innovations, if at all, and that the primary motivation for granting them might be based on legal grounds (e.g. providing recourse against unfair appropriation of effort, even for minor inventive efforts) rather on the promotion of industrial development.[6] In contrast, the production of developing economies is likely to be dependent more on utility model innovations. Again, different countries vary but we consider two main groups – high income and middle-to-low income countries – and expect utility models to have a stronger contribution to the production of the latter group.

Next, we specify an innovation production function in which patentable innovations are a function of research and development (R&D), among other factors. The production of patentable innovations also depends on the environment for innovation, for example the level of patent protection and other factors that can augment the productivity of R&D in generating patentable innovations, such as human capital. Another potential contributor, in the context of lower income countries, is that of a *learning effect* from past utility model innovations – that experience with this can enhance the ability to conduct more innovative research and hence the productivity of R&D invested in developing patentable innovations. The ability of technologically lagging producers to benefit from utility model innovations depends on there being a legal system which protects commercially useful minor inventions. Every economy is likely to conduct minor, adaptive innovations to some extent; however, these innovations can also be copied and misappropriated; hence, legal property rights over them should give minor inventors stronger incentives to produce them and seek to commercialize them. The role of utility model laws and utility model innovations is also likely to vary by the level of economic development, being more consequential in developing economies than in well-developed.

There are two related issues here: first, the economic influence of utility model laws, and second, the economic contribution of minor inventions produced under such systems or laws. They are related issues in that without a utility model system, there would, by definition, be no registered utility model innovations, just as there would be no patents without a patent system, but the absence of utility model laws would not necessarily preclude minor inventive activity, just as we cannot assume that no inventive activity occurs if no patent systems existed. Furthermore, the (observed) registered utility models under a utility model system do not represent the universe of all minor inventions produced under that system (i.e., the unobserved), any more than patented innovations represent the universe of all innovations. Nonetheless, these two issues present two specific tasks: to demonstrate the impacts of a utility model system and to measure the contribution of utility model innovations, both on economic development. We carry out each task with a different dataset, while building upon a common empirical framework and methodology.

We test the importance of utility model laws to developing economies using a panel dataset of countries. Using this sample, we can compare the differences in growth rate and innovation between utility model regimes and non-utility model regimes.[7] We then examine the usefulness of minor inventions in technologically lagging economies by using a sample of Korean firms. During the sample period, Korea provided utility model protection throughout, so that there is no time variation in the adoption of utility models here as there is in the international sample, but there were considerable variations in utility model innovation activity. Thus, we use the Korean firm level data to measure the contribution of minor inventions to production and patentable innovations. We discuss more explicitly below how utility models expand production possibilities and innovation.

[6] For example, copyright laws can protect both the economic and moral interests of creators. Likewise, developed countries may provide intellectual property protection for minor inventions based on motives beyond business and economic interests.

[7] At present, no index of the strength of utility model laws and enforcement exist, and thus we use a dummy variable to indicate the presence or absence of utility model laws (across countries and over time). This should provide sufficient data variation since most countries did not have utility model systems during the sample period.

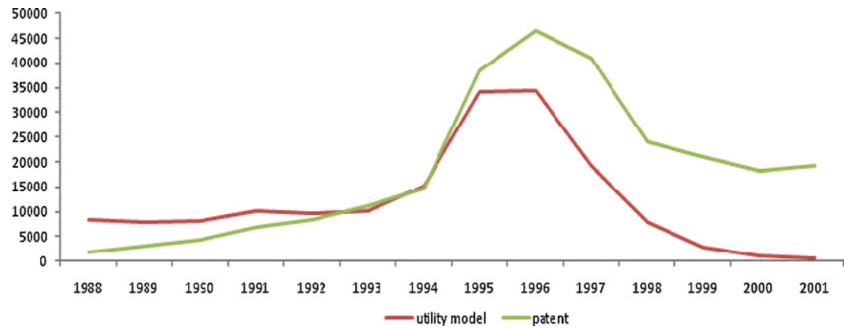

Fig. 2. Utility model and patent applications of the top 10 Korean patent applicant firms (as of 1995).

4.2. Theoretical models

Knowledge capital, Z, is a function of both patentable innovations (P) and minor innovations or utility model innovations (U); that is,

$$Z = Z(P, U|D) \tag{1}$$

where P and U are imperfect substitutes. The marginal rate of technical substitution of patentable innovations for utility models is expected to be lower for more developed economies (i.e. one patentable innovation, for example, can substitute for several incremental innovations). The bar '|' denotes the conditional operator and D an indicator of technological development, where $D=1$ indicates a high level (and 0 otherwise). The purpose is to qualify that the relationships involving utility model laws and innovation depend on the technological development of a country or firm.

Based on our discussions earlier, we postulate the following:

$$P = P(\text{IPR}, U, \ldots |D), \quad P_U > 0 \tag{2}$$

$$U = U(\text{UML}, \ldots |D), \quad U_{\text{UML}} > 0 \tag{3}$$

where IPR denotes the level of *patent rights* and UML *utility model laws*. Eq. (2) also allows for the possibility that, conditional on the technological level of the firm or economy, experience with utility model innovations can affect the capacity to produce patentable innovations (with appropriate lags, not shown to avoid cluttering up the conceptual analysis). Fig. 2, for example, illustrates the industrial property filing behavior of the top ten Korean patenting companies. These include companies such as Samsung Electronics, LG Electronics, Daewoo Electronics, and Hyundai Automotives. Prior to the 1990s, these top patenting companies hardly patented. Rather, they sought tens of thousands of utility models. But by 1995, they filed more patent applications than applications for utility models. These stylized trends suggest a potential link between past utility model innovations and current patentable innovations in developing economies – namely that firms that are technologically lagging can build upon their experiences with minor innovations to help generate patentable innovations later on, which is the basis for Eq. (2).

Eq. (3) expresses the point that – conditional on the level of technological development of the firm or economy – the production of utility model innovations is a positive function of the existence of laws protecting utility models. The underlying assumption is that firms and small inventors have a greater incentive to engage in minor inventive activity if the rewards to it are appropriable through legal protection. Like patentable innovations, minor innovations are also subject to free riding by third parties, perhaps more easily so since they are inventions of small step. Not only therefore is the intensity of minor inventive activity likely to be greater in an economy that legally provides utility model protection, ceteris paribus, but the system also provides inventors of utility model innovations a means for staking their claims – hence we can expect these inventors to file utility model applications for their minor but commercially useful innovations. Note that we do not posit utility model innovations as a function of past patentable innovations – that is, a dynamic learning effect from past patents to current utility models – although we admit that there is some possibility that the R&D process leading to patents could also generate some minor inventions (as by-products) and improvements that could generate utility models (UMs).[8]

Our empirical objective is to examine the effects of utility model laws (UML) and the kinds of innovations they protect (U) on innovation and economic growth. Thus, the rest of this sub-section focuses on two equations: an equation for innovation and an equation for economic growth. Both are dynamic equations, and we describe the derivations of each in turn.

First, the derivation of the growth equation follows Mankiw et al. (1992), Caselli et al. (1996), and Bond (2002). We extend their models by incorporating knowledge capital. For example, consider the following steady state production function in efficiency units:

$$y^* = k^{\alpha_1} z^{\alpha_2} \tag{4}$$

where $y^* = Y^*/AN$ is output per efficiency worker, $k = K/AN$ physical capital per efficiency worker, and $z = Z/AN$ knowledge capital per efficiency worker. N denotes labor force (or population) and A technical efficiency, assumed to be labor augmenting. For now, we suppress subscripts indexing time or country (firm).

The capital accumulation equations are $\dot{k} = s_K y - nk$ and $\dot{z} = s_Z y - nz$ for physical and knowledge capital respectively, where s_K and s_Z are the rates of investment in physical and knowledge capital and $n = \dot{N}/N$. (To avoid cluttering up the derivation of the growth equation, we suppress depreciation rates of capital and the exogenous growth rate of A.) Taking the natural log of (1), time-differentiating the result, and substituting the accumulation equations into it, and then further linearizing the result around steady-state shows that the instantaneous growth rate of output per efficiency worker is inversely related to the positive deviation of the natural log of y above its steady state level:

$$\frac{d\ln y}{dt} = -\lambda(\ln y - \ln y^*) \tag{5}$$

where $\lambda = n(1-\alpha_1-\alpha_2)$ is the speed of adjustment. Solving (2) from $t-1$ to t yields the following equation for estimation (where we now use the subscript t to index time and i to index the unit

[8] We thank the editor (Ashish Arora) for raising this issue. Thus, we have done additional regressions (available upon request) to support our reasoning behind the asymmetric specification in Eqs. (2) and (3), where P is a function of U, but not vice versa. See also footnote 24.

(country or firm)):

$$\Delta \ln\left(\frac{Y}{N}\right)_{it} = \gamma_0 + \gamma_1 \ln\left(\frac{Y}{N}\right)_{it-1} + \gamma_2 \ln s_{Z_{it}} + \gamma_3 \ln s_{K_{it}} + \gamma_4 \ln n_{it} + \gamma_i + \gamma_t + \varepsilon_{it} \quad (6)$$

where $\gamma_1 = -(1 - e^{-\lambda})$, and γ_i, γ_t, and ε_{it} are the individual fixed effects, time effects, and spherical error term respectively. As in the previous literature, we think of s_K broadly to include human capital (h) as well as physical (non-human) capital (ι) formation:

$$s_{K_{it}} = \iota_{it}^{\varphi_1} h_{it}^{\varphi_2}$$

When all relevant data are available, our best specification for the rate of knowledge capital investment is $s_Z = s_Z(p, u)$, where p and u are patenting and utility model intensities respectively (that is, $p = P/N$ and $u = U/N$). Recall from Eq. (3) that utility model innovations are assumed to be a function of utility model laws. We utilize our firm-level data to assess the effects of utility model innovations on economic growth, so that for our *firm-level sample*,

$$s_{Z_{it}} = p_{it}^{\phi_1} u_{it-j}^{\phi_2}$$

and we utilize country-level data to study differences in growth owing to variations in the presence of utility model laws, so that for our *international sample*,

$$s_{Z_{it}} = p_{it}^{\phi_1 + D\phi_3} \exp\{(\phi_2 + D\phi_4)\mathrm{UML}_{it-j}\}$$

where UML = 1 indicates that utility model laws exist (and UML = 0 otherwise). As we introduced earlier, $D = 1$ indicates a high income country in our cross-country sample (and $D = 0$ a middle and low income country). Note that we will be taking into account that utility model innovations or the adoption of utility model laws will affect economic growth with a lag (to be specified further below).

Our second equation of interest is the following knowledge production function, as based on Pakes and Griliches (1980) and Hausman et al. (1984), in which patenting is a function of research and development (R) and the efficiency of knowledge production (Λ) due to internal and external factors (such as institutions related to knowledge production):

$$P_{it}^{*} = \Lambda_{it} R_{it}^{\beta} e^{\upsilon_{it}} \quad (7)$$

where υ is the disturbance term. The above equation is for the steady-state level of patenting. Patenting is not likely to adjust to its steady state level immediately but with a lag. One reason has to do with R&D adjustment costs (such as the costs of altering research facilities or the workforce) which affect the decision to patent. Another is that innovation is a sequential, cumulative process whereby current patentable innovations build upon or improve previous patentable innovations. This dynamic dependence can be captured using the following partial adjustment model:

$$\frac{P_{it}}{P_{it-1}} = \left(\frac{P_{it}^{*}}{P_{it-1}}\right)^{\psi} \quad 0 < \psi < 1 \quad (8)$$

where ψ measures the speed of adjustment. Thus, substituting (7) into (8) and taking natural logs yields the following dynamic patenting equation which we will estimate[9]:

$$\ln P_{it} = \rho_0 + \rho_1 \ln P_{it-1} + \rho_2 \ln R_{it} + \rho_3 \ln \Lambda_{it} + \rho_i + \rho_t + \nu_{it} \quad (9)$$

where $\rho_1 = (1 - \psi)$ and $\rho_2 = \psi\beta$, and ρ_i, ρ_t, and ν_{it} are the individual fixed effect, time effect, and spherical error term respectively.

As per Eq. (2), patenting can, within the context of lower income countries and the firms therein, depend on past utility model innovations; that is, experience with utility model innovations helps augment the technical efficiency of patenting, along with other factors such as openness (o), human capital (h), and the strength of relevant institutions. Using the *firm-level sample*, we study how utility model *innovations* per se can enhance patenting (with a lag of j periods, to be discussed further in the next sections):

$$\Lambda_{it} = \Lambda(h_{it}, o_{it}, U(\mathrm{UML}_{it-j}, \ldots)) = h_{it}^{\rho_4} o_{it}^{\rho_5} U_{it-j}^{\rho_6}$$

Using the *international sample*, we can study how specific institutions related to knowledge production, such as the strength of patent protection (IPR), as well as *variations* in the availability of utility model *systems*, can enhance patenting:

$$\Lambda_{it} = \Lambda(h_{it}, o_{it}, U(\mathrm{UML}_{it-j}, \ldots), \mathrm{IPR}_{it}) = h_{it}^{\rho_4} o_{it}^{\rho_5} \exp\{(\rho_6 + D\rho_7)\mathrm{UML}_{it-j}\}\mathrm{IPR}_{it}^{\rho_8 + D\rho_9}$$

where, as before, D is a dummy variable indicating a high income country when equal to one and UML is a dummy variable indicating that utility model protection is available when equal to one. Most countries have adopted patent systems and thus we can employ a continuous index that gauges the strength of patent laws. But a substantial number of countries have not adopted a utility model system (or at least not until very recently) and hence there is a great degree of cross-country variation in the UML dummy.

One of our key ideas is that the efficiency of knowledge production is affected not only by the availability of patent rights but also by that of a utility model system (with a lag) which protects minor inventions. In developing countries that are at an early stage of economic development, as was the case in the past with some of today's developed countries, like Japan, firms are at lower levels of technological capabilities, and thus largely produce minor inventions. But as they accumulate technological learning and enhance their technological capabilities, they would be better able to produce patentable inventions at later stages. If this is the case, it is important to recognize and protect minor forms of inventions. To capture the dynamic effects of utility model adoptions on patentable innovations, and to show how their effects are conditional upon the stages of economic development, we lag the UML variable and interact it with the dummy variable (D) that distinguishes between higher and lower income countries. We find that the lags should be long enough to consider the underlying processes at work, such as, first, the adoption of a utility model system intensifying minor inventive activity, and then the increased experience with minor inventive activity leading to greater technological learning and a rise in patentable inventions.

To summarize, the equations to be estimated are (6) and (9). Next, we discuss the data issues related to estimating these equations at the both country and firm levels.

4.3. Empirical issues

Our empirical analysis begins with the country level sample, where we estimate the innovation Eq. (9) first and then estimate the growth Eq. (6). In Eq. (9), for the international sample, the dependent variable is the natural log of U.S. patents granted. To measure human capital, we consider both the quantity of resources and the educational level. We use working age population to control for labor resources in innovation rather than the number of scientists and researchers due to data limitations in developing countries. For the educational level of human capital, we use the share of the population (per million) with PhD degrees in science and engineering

[9] Other studies of innovation behavior have also incorporated a lagged dependent variable; see for example, Adams and Clemmons (2008), Bloom et al. (2002), and Bosch et al. (2005).

earned in the U.S.[10] More educated economies are likely to have stronger capacities to absorb innovations made elsewhere (Nelson and Phelps, 1966). The trade orientation of a country can also influence its propensity to innovate. 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; Aghion et al., 2001). To measure the degree of openness of an economy, we use the Fraser Institute's index of the freedom to trade internationally.

Next, in Eq. (6), the dependent variable is the growth rate of per capita GDP. We use the population growth rate to proxy for n and the secondary school enrollment rate to proxy for h. Patenting intensity (p) is measured as the ratio of U.S. patents *granted* per million working age persons. The intensity of innovation is defined in terms of the working age population to control for country size. We also focus on patents awarded in the U.S. since they are likely to represent the relatively high value innovations developed by a country, given that patenting in the U.S. is rather costly, and that firms would largely do so if the expected value of the patent right exceeds the cost. Furthermore, since patent examination and granting standards vary across countries, focusing on patents granted in the U.S. helps to avoid variations in patenting due to differences in such standards.[11]

For the international sample, we use a dummy variable to indicate whether a country provides utility model protection and observe how variations in this variable across countries are associated with differences in cross-country growth rates and innovation. But its coefficient should be interpreted with caution. We should not presume its significance to suggest that in other non-utility model countries that minor inventions are not produced or have no impacts. Rather, the coefficient estimate captures the marginal additional effects on growth (or innovation) of adopting a utility model system.

For the firm level estimation of the growth Eq. (6), we use sales growth as our dependent variable. The RHS therefore includes lagged sales (in natural logs), in addition to the natural logs of patentable and utility model innovations. We also control for firm size (number of employees) and firm age.[12] Firm age helps control for efficiencies due to entrepreneurs learning about their abilities over time (Jovanovic, 1982; Evans, 1987). Our measure of innovation (i.e. patents and utility models) is the *applications* filed by Korean firms. Since we are examining a single country, we do not face issues of differences in international granting standards.

A key function of a patent is to help a company achieve sufficient returns on its investment and commercialization of a new technology (Geroski et al., 1993; Geroski and Machin, 1993; Granstrand, 1999). Thus, if this function is fulfilled, the product of the innovative process should be associated with superior performance. Previous empirical findings show a positive association between patents and corporate performance at the firm level.[13] However, several limiting factors make it difficult for firms to profit from their innovations, such as the inability to prevent other firms from copying their technology, the high cost of or limited access to capital and technology, the challenges of putting a product into production in time, and the high cost of marketing (Lee et al., 2003). Thus, firms that are at their early developmental stages with limited resources may find incremental innovation more advantageous in helping to position themselves in existing markets at low cost. Hence Eq. (6) will help determine whether utility models, representing incremental innovations, contribute to the performance of firms whose technologies are below the frontier.

For the innovation Eq. (9) at the firm level, we also model patents as a function of lagged patents, past utility models, R&D expenditures, and firm size dummies. Firm size helps control for economies of scale in generating patents due to the fixed costs of maintaining a legal department that handles intellectual property matters (Lerner, 1995; Lanjouw and Lerner, 1996). As we employ annual firm-level data, we find persistence in the data and thus control for second period lags as well. One and two-year lagged R&D expenditures are included to incorporate time lags in knowledge production (Pakes and Griliches, 1980; Hausman et al., 1984).

Eq. (9) at the firm level also helps us test whether knowledge acquired through past utility model applications provide a stepping stone for further technological progress. But the accumulation of knowledge that allows firms to generate future new patentable inventions is an incremental process and therefore takes quite some time. For this reason we modeled and examined relatively long lag lengths (e.g. five years). For both Eqs. (6) and (9) we control for firm fixed effects, year effects, and industry effects.

4.4. Estimation methodology

Eqs. (6) and (9) will be estimated by the two-step system Generalized Method of Moments (GMM), as well as by OLS and fixed effect (FE) estimations.[14] When the results from the FE model and the GMM are different (mostly in terms of the significance of the coefficients), we provide the results of the Hausman test to show which one is consistent. In general, the GMM results are advantageous since the method can take care of the possible endogeneity of explanatory variables, as well as omitted variable biases. The consistency of GMM estimation, though, depends on the instruments being valid (i.e. no correlation between the error term and the instruments) and on the absence of second order serial correlation in the first differences of the residuals; both assumptions will be tested using the Sargan–Hansen (SH) and Arellano–Bond (AB) tests for second-order autocorrelation, respectively.

This estimation method has other advantages. As discussed in Caselli et al. (1996) and Bond (2002), it deals with cases where the regressors (e.g. investment rates) are endogenous. These endogenous regressors can be instrumented with variables that are at least lagged twice and with their differenced equivalents. Otherwise, both OLS and fixed effects (FE) estimation will yield biased estimates of the coefficient of the lagged dependent variable, though in opposite directions. More specifically, OLS estimation results in an upward bias due to the positive correlation between the AR(1) term and the individual effect (γ_i or ρ_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 (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).

[10] This variable probably underestimates human capital since scientists and engineers also earned their PhDs from their home country or other countries, e.g. Canada, Israel, UK, Korea, France, Germany, and Australia.

[11] In Eq. (6), the measure of knowledge inputs are patents and utility models. We do not control for R&D as well. Given that patents are already function of R&D in Eq. (9), we are assuming that these two measures of knowledge are comprehensive enough to reflect the effects of R&D. When we actually add R&D in the regressions, the results do not change with regard to the impacts of these two variables; utility models are significant in the early period only, while patents and R&D are significant only in the later period. The results are available upon request.

[12] We do not have information on the schooling of firm employees.

[13] See Ernst (2001) for a survey of this literature. Studies find that at least one of two patent indicators – either simple counts of patent applications or patents adjusted for quality – is found to have a positive impact on firm performance.

[14] See Arellano and Bond (1991) and Blundell and Bond (1998) for details. In one-step system-GMM, the weighting matrix makes use of differenced errors, whereas in the two-step version, the one-step residuals are used to compute a new weighting matrix.

5. Datasets and basic descriptions

Appendix A summarizes our data sources. For the country-level analysis, we utilize data from the *World Development Indicators* along with other data, such as an index of patent rights. 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. GDP and related data are in constant 2000 international purchasing power parity dollars. Data on patent protection levels come from Park (2008), where an index of patent protection is available for over 120 countries from 1960 to 2005 (every five years). The index provides a score that reflects a given country's overall level of patent rights and restrictions at a given point in time. The underlying data are based on statutory and case laws, which interpret and apply the statutes. The strength of patent rights is a composite index measuring the duration of protection, subject matter that is patentable, membership in international treaties, enforcement mechanisms available, and the degree to which limitations on patent holders are not imposed (such as compulsory licensing). The index ranges from 0 (no patent system) to 5 (strongest level of protection). Our information on utility model laws comes from Greene (2010).

For the firm level analysis, a panel data set has been assembled annually from 1970 to 1995. This specific period in the course of Korea's economic development should suffice for our analysis since it covers the transition of Korea from a middle-to-low-income, underdeveloped country to a high-income, industrialized country. We compiled a detailed database of firm-level patenting and utility model applications and matched the data to the firms' financial data. Patent and utility model data are from the *Korea Intellectual Property Rights Information System* (KIPRIS) and financial, operating data from Lee et al. (2007, 2008).[15] These data are the most extensive firm level data in Korea. From a population of 17,165 firms in the dataset, we pulled out 3635 firms. The selection criterion was that a firm applied for at least one utility model or patent. We limit the analysis to this subset of the data since our goal is to understand the differential impacts of utility models and patents on firm performance as well as the impact of utility models on patenting. Sales and related data are deflated using the industry-level GDP deflator where the base year is 1995.[16]

Table 1 presents summary statistics and correlations of the country level data for the full sample and for different utility model regimes. Less patenting has been conducted by countries that have utility model systems. For more perspective, Table 2 divides our sample of countries according to their intensities of patenting and whether they provide utility model protection as of 2000, and compares their per capita GDP levels and growth rates. The table shows that countries with above median patenting intensity have on average a higher per capita GDP and growth rate. Countries which have adopted utility model laws also have on average a higher per capita GDP.

Table 3 shows summary statistics and correlations for the firm level data. Patent applications and utility models have a positive correlation, suggesting that firms that seek patent protection also seek utility models. Note that R&D expenditures have a higher correlation with patents than with utility models. This may reflect the different characteristics between inventive innovation and incremental innovation. As Beneito (2006) analyzed, utility models tend to be associated more with external contract R&D while patents more with in-house R&D activities.

[15] Lee et al. (2007, 2008) constructed their data from the firm-level database of the *Korea Information Service* (KIS). This database covers firms subject to external audit reports, namely those firms with more than 7 billion won assets (about 5.8 million U.S. dollars if 1 USD equals 1200 Korean Won). Thus, small scale companies with less than 7 billion won assets, such as microenterprises, are excluded from our sample.

[16] Industry level GDP deflators are from the Bank of Korea.

6. Empirical results

6.1. Country-level results

First, there is a preliminary issue to be addressed. Our key interest is whether utility model protection has a statistically significant association with economic growth. However, there may be a self-selection problem: countries with greater growth potential may be the ones that adopt a utility model system, rather than achieve faster growth as a result of a utility system. To address this selection issue, we conducted a logit regression to study the adoption of a utility model system, using both economic growth and GDP per capita as determinants (see Table 4). In addition, legal origin dummies, such as French and German origins, are included. The benchmark legal origin is British. Indeed, utility model laws are more likely to exist under a civil law system, such as that in Germany, Korea, and Japan, rather than under a common law system, such as that of the U.K. and U.S.

As shown in Table 4, the growth rate and GDP per capita are not statistically significant determinants of the adoption of a utility model system. Even when the sample is divided by income level, no statistically significant relationship is found between economic growth and utility model adoption. Rather, utility model adoption is determined by the legal origin of the countries, which is consistent with several studies emphasizing the role of legal and ethnic origins as the sources of institutional differences, such as Acemoglu et al. (2001) and La Porta et al. (2008).

To best explain the effects of utility model adoption at the aggregate level, we find it more useful to discuss the estimates of the innovation model first, i.e. Eq. (9), before the growth Eq. (6). Throughout, we control for time effects using period dummies (but are not shown to conserve space). Table 5 presents our estimates of innovation Eq. (9) using three different methods: OLS, Fixed Effects (FE), and system GMM. While these methods yield similar results with regards to the coefficients of the variables of our main interest, we attach our highest reliability on the GMM results for the reasons discussed above, such as endogeneity and omitted variable problems. As we discussed earlier, system GMM, if valid, should produce a coefficient estimate of lagged GDP per capita lying between the OLS and FE estimates. Indeed, we find this to be the case in our results. Other tests (AR2 and Sargan/Hansen tests) could not reject the null hypothesis of no serial correlation and instrument validity.

We thus focus mainly on the system GMM results of Table 5. A first issue is whether patent protection has a statistically significant association with our measure of innovation, namely patenting, and whether this association also varies by level of economic development. From columns 1–3 of Table 5, we see that patent protection is not a statistically significant determinant of patenting, under OLS, FE, or GMM. However, when the influence of patent protection on patenting is analyzed by level of economic development, we find that the strength of patent protection has a significant, positive association with the patentable innovations of high-income countries (based on the FE and GMM results), while it has a statistically insignificant coefficient for middle-to-low income countries under OLS, FE, and GMM (see columns 4–6 of Table 5). From column 6, the measured net effect of the strength of patent protection on patenting in high income countries is 0.681 (=0.191 + 0.490), where the latter is the coefficient of the interaction term between the high income country dummy and the patent rights index. To test its significance, we ran an additional regression to find that the impact of patent protection in high income countries is significantly different from zero, while it is negative and significant in

Table 1A
Sample statistics: international sample.

Variable	Full sample		Countries with utility model system		Countries without utility model system	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
GDP per capita growth rate (5-year average) proportion	0.06	0.21	0.07	0.16	0.06	0.17
GDP per capita annual growth rate proportion	0.14	0.04	0.015	0.053	0.012	0.052
Patent rights index	2.3	1.00	2.38	1.03	2.18	0.93
Investment to GDP (%)	23.2	9.2	22.67	7.69	21.67	7.77
Population growth (%)	1.8	1.7	1.63	1.55	1.93	1.16
Working age population (million people)	22.3	77.2	27.92	88.96	26.99	81.79
Number of US PhDs per million	2.7	6.5	2.47	5.71	4.10	8.86
Enrollment of secondary education (per population of corresponding age group)	59.8	34.0	61.44	35.72	54.01	34.67
Number of U.S. patents granted	2040	12,008	1330	5188.38	4662	21,665.55
Total R&D expenditure to GDP (%)	1.11	0.92	1.16	0.86	1.20	1.10
Index of freedom to trade internationally	6.2	1.61	6.44	1.47	5.78	1.82
GDP per capita (PPP, constant 2000 international dollars)	7842.5	8020.5	8290.57	7843.40	7715.12	8963.25

Note: Country list:

(1) Utility model system: Angola, Argentina, Australia, Austria, Belgium, Benin, Burkina Faso, Bulgaria, Bolivia, Brazil, Botswana, Central African Republic, Canada, Switzerland, Chile, China, Cameroon, Congo, Rep., Colombia, Costa Rica, Czech Republic, Germany, Denmark, Algeria, Ecuador, Egypt, Arab Rep., Spain, Ethiopia, Finland, France, Ghana, Greece, Guatemala, Hong Kong, Honduras, Haiti, Hungary, Indonesia, Ireland, Italy, Japan, Kenya, Korea, Rep., Lithuania, Morocco, Mexico, Mali, Mauritania, Malaysia, Niger, Netherlands, Panama, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Rwanda, Senegal, El Salvador, Somalia, Slovak Republic, Syrian Arab Republic, Chad, Togo, Thailand, Turkey, Taiwan, Ukraine, Uruguay, Venezuela, RB, Vietnam.
(2) No utility model system: Burundi, Bangladesh, Cyprus, Dominica, Fiji, United Kingdom, Grenada, Guyana, India, Iran, Islamic Rep., Iraq, Iceland, Israel, Jamaica, Jordan, Liberia, Sri Lanka, Luxembourg, Madagascar, Malta, Myanmar, Mozambique, Mauritius, Malawi, Nigeria, Nicaragua, Norway, Nepal, New Zealand, Pakistan, Papua New Guinea, Paraguay, Saudi Arabia, Sudan, Singapore, Sierra Leone, Sweden, Swaziland, Trinidad and Tobago, Tunisia, Tanzania, Uganda, United States, South Africa, Congo, Dem. Rep., Zambia, Zimbabwe.

Table 1B
Sample correlations: international sample.

	Full sample				
	GDP per capita	Patent intensity	Utility model	Patent rights index	R&D intensity
GDP per capita	1				
Patent intensity	0.6918	1			
Utility model laws	0.0296	−0.0302	1		
Patent rights index	0.719	0.5746	0.3362	1	
R&D intensity	0.6698	0.7623	−0.0164	0.5819	1

Table 2
Sample GDP per capita and growth by intensity of patenting and utility models laws, 1975–2003.

		Patenting intensity	
		Below (and equal to) median	Above median
Utility model laws	No	3412.5 *0.046* (11)	10,324.0 *0.081* (37)
	Yes	4547.5 *0.048* (23)	10,708.3 *0.078* (50)

Note: Patenting intensity is U.S. patents granted per local (own-country) working age population. In each entry, the top figure is GDP per capita, the middle italicized figure is the average five-year growth rate, and the bottom number in parentheses is the number of countries in that group as of the year 2000.

Table 3A
Sample statistics: firm level sample.

	Mean	Std. dev.	Min	Max
Utility models	2	71.6	0	10,630
Patent	1	61.8	0	10,077
Sales (million USD)	134	550	0.0004	16,083
R&D expenditure (million USD)	1.4	16	0	983
Employees	1140.7	7083.5	2	841,050
Sales growth (proportion)	0.1	0.4	−6.0	7.2
Investment (%)	5.3	11.6	−21	112.1
Firm age	9.0	11.0	1	100

Note: Sales and R&D expenditures were in constant 1995 Korean won and converted to U.S. dollars.

Table 3B
Sample correlations: firm level sample.

	Utility models	Patent	Employees	Sales growth	Investment rate	Firm age	R&D expenditure
Utility models	1.00						
Patent	0.75	1.00					
Employees	0.18	0.16	1.00				
Sales growth	0.01	0.01	−0.004	1.00			
Investment rate	0.02	0.02	0.02	0.17	1.00		
Firm age	0.04	0.04	0.07	−0.19	−0.06	1.00	
R&D expenditure	0.47	0.70	0.22	0.01	0.02	0.05	1.00

middle to low income countries.[17] Thus our findings illustrate the importance of examining the impacts of patent protection on countries by different levels of development. Previous empirical studies on the relationship between patent rights and R&D (e.g. Kanwar and Evenson, 2003; Varsakelis, 2001) have not explicitly examined countries by income group. The result supports our arguments earlier that patents may not be very effective mechanisms in innovation among firms or inventors that are relatively small and unable to utilize patents for litigation or cross-licensing negotiations.

In columns 7–9 of Table 5, we include the dummy variable for utility model laws to examine whether a system that protects minor inventions enhances innovation potential. For the estimation, we lagged the dummy variable for utility model laws by two periods to take into consideration first the lagged effect of utility model protection on incremental innovations and another lagged effect of incremental innovations on the production of patentable innovations. We also included an interaction term between the dummy variable for utility model laws and a dummy variable for high income countries to take into consideration the level of economic development. The results show that the effect of utility model protection on innovation seems specific to middle and low income countries, as shown by the statistically significant positive coefficient estimate of 0.411 at the 1% level of significance according to the FE results, or the coefficient estimate of 0.170 at the 10% significance level according to the GMM results. On the other hand, the presence of utility model laws in high income countries seems to have a lower impact on patenting, as seen from the negative coefficient of the interaction term between the high income country dummy and the utility model dummy, suggesting that the effects of utility model laws in mid-to-low income countries might be different from those in high income countries. We also verified by an additional regression that the dummy variable for utility model laws has a statistically insignificant and negative association with the patenting of developed countries.[18]

Thus, our results show that utility models protection can be an important factor affecting the production of patentable innovations only in middle-to-low income countries. In addition, the control variables all have the expected sign. The variables like working age population, number of PhDs, and openness, consistently have strong explanatory power, but the significance of the R&D intensity variable varies.

Table 6 presents estimates of the growth Eq. (6) from a different and, we believe, interesting perspective. Patenting intensity is our measure of patentable innovations. In columns 1–3, we see that, controlling for other factors, the intensity of patenting is significant (at the 5% level of statistical significance), but the dummy variable for utility model laws is statistically insignificant. In columns 4–6 of Table 6, we repeat the analysis shown in columns 1–3 by incorporating the high income country dummy. First, patenting intensity in middle-to-low income countries has a negative but statistically insignificant association with GDP per capita growth in all of the OLS, FE, and GMM results. But the impact of patenting intensity on growth is much larger in high income countries, as can be seen from the positive coefficient of the interaction term between the high income country dummy and patenting intensity – this coefficient being statistically significant at the 1% level of statistical significance. From column 6, the measured net effect of patent intensity on growth in high income countries is 0.0683 (=−0.027 + 0.953, where the former is the coefficient of the patenting intensity of middle-to-low income countries and the latter the coefficient of the interaction term between the high income country dummy and patenting intensity). An explanation for this result is that in middle-to-low income countries, patents raise the cost of doing business, via royalties and licensing fees. These in turn raise the cost of production by making technological inputs more expensive. These costs may not be too burdensome for firms in high-income countries, but in middle-to-low income countries, these costs are likely to be a more significant share of the cost of production. Thus a greater dominance of proprietary technologies may be a hindrance or at least not conducive to the growth of middle and lower income economies. This result is consistent with Lee and Kim (2009), which also finds the relationship between patenting and growth to be positively and significantly related among higher income, but not lower income, countries.[19]

In contrast, the dummy variable for utility model laws in middle-to-low income countries has a positive and statistically significant association with the growth rate in all of the OLS, FE, and GMM results. It has a statistically significant positive coefficient estimate of 0.0907 at the 5% level (see column 6 of Table 6); following Hausman test results, we refer to the system GMM results in column 6.[20] Moreover, the negative interaction term between the dummy variable for utility model laws and the dummy variable for high income countries suggests that the utility model system has a smaller impact on economic growth in high income countries than it has in middle-to-low income countries. For high income countries, the measured *net* effect of utility model protection on GDP per capita growth is positive (specifically 0.0157 = 0.0907 − 0.075, where the latter is the coefficient estimate of the interaction term). We confirmed with an additional regression that the overall effect of utility model protection on the growth of GDP per capita in high income countries is insignificant.[21] The intuition for this finding is

[17] In this regression, we use the patent rights index, a dummy for middle-to-low income countries, and its interaction with the patent rights index, together with other control variables. In this regression model, the coefficient of the patent rights variable captures its impacts on the baseline group (high income countries) and it turns out to be statistically significant at the 1% significance level. The results are available upon request.

[18] That is, we re-ran a regression using a dummy variable for mid-to-low income countries so that the coefficient of the utility model law dummy represents the impact of utility models protection for the high income countries as the baseline group.

[19] Lee and Kim (2009) focus on the determinants of long run growth, such as innovation, institutions, and human capital, but not on the relationship between IPRs and innovation.

[20] The test finds that the system GMM estimator is consistent (i.e. chi-square = 35.53 and p-value = 0.000), while the fixed effects results are not.

[21] Again, in this regression, we use a dummy for utility model law, a dummy for middle-to-low income countries, and its interaction with the dummy for utility

Table 4
Logit regressions on utility model adoption.

	Dependent variables: utility model dummy					
	Logit			Logit		
	Full sample (1)	High income countries (2)	Mid-to-low income countries (3)	Full sample (4)	High income countries (5)	Mid-to-low income countries (6)
(Log of GDP per capita)$_t$	0.0399	−0.188	−0.0791			
	(0.381)	(−0.441)	(−0.457)			
(5-Year average GDP per capital growth)$_t$				0.307	1.436	0.285
				(0.417)	(0.790)	(0.341)
French legal origin dummy	2.617***	1.936***	3.114***	2.605***	1.805***	3.103***
	(9.249)	(4.076)	(7.233)	(8.903)	(3.561)	(7.611)
German legal origin dummy	3.783***	3.346***	3.710***	3.703***	3.354***	3.827***
	(9.355)	(6.970)	(5.270)	(8.942)	(6.627)	(4.865)
Constant	−4.968***	−1.327	−5.586***	−3.446***	−3.229***	−3.815***
	(−5.566)	(−0.323)	(−4.178)	(−9.868)	(−5.281)	(−8.021)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−287.6	−92.76	−188.3	−254.7	−77.45	−174.1
Wald chi^2	181.40	69.18	105.80	142.00	57.40	84.90
p-Value	0.00	0.00	0.00	0.00	0.00	0.00
Observations	672	214	458	545	175	370

Note: (1) Log of GDP per capita: a logarithmic term of GDP per capita (PPP, constant 2000 international $); 5-year average GDP per capital growth: a growth rate (proportion) of GDP per capita; French legal origin dummy = 1 if a country has French legal origin, 0 otherwise; German origin dummy = 1 if a county has German legal origin, 0 otherwise. (2) The classification of high/mid-to-low income countries follows the World Bank criterion. High income countries: GDP per capita, PPP > $10,000 constant 2000 international dollars; Mid-to-low income countries: GDP per capita, PPP ≤ $10,000 constant 2000 international dollars. *T*-statistics are in parentheses. ***, **, and * indicate 1%, 5%, and 10% levels of significance, respectively.

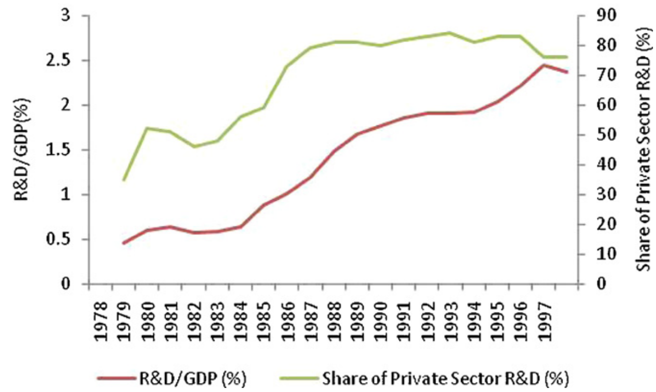

Fig. 3. The composition of R&D expenditure in Korea.

that the required inventive step between a patent and utility model differs. Hence, developing countries that are mostly engaged in incremental or adaptive R&D are more likely to resort to utility models; for example, China, Russia, and Brazil, have been actively exploiting utility models. Among these countries, their research and innovation are likely to be geared more towards adapting existing technologies to local needs or developing innovations that are more appropriate for their economic circumstances. Thus, as the results show, we find that utility model protection does matter to the economic growth of this group of countries. In countries that make such protection available, the small inventors and entrepreneurs have greater incentives and opportunities to pursue minor inventive activity and adapt it to local production needs 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.

As for the control variables, population growth and secondary school enrollment rates have mixed signs and significance levels, but the physical capital investment variable has a consistently significant positive influence on growth. The coefficient of the lagged dependent variable is negative and statistically significant at conventional levels, indicating conditional convergence in growth rates across countries, a result that is consistent with previous empirical work.

To summarize, our finding here is that a second-tier form of intellectual property protection, namely utility models, helps make it possible for a developing country to build its technological capacity. Incremental, adaptive R&D leads to innovations that qualify for such utility model protection and provides a foundation upon which to eventually produce patentable innovations. 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 previous research. We next turn to a further corroboration of this point using Korean firm level data.

6.2. Firm level results

Table 7 presents the results of estimating Eq. (6) using a firm's annual sales growth as the dependent variable. Our goal here is

model law, together with other control variables, so that the baseline group is the high income countries. Thus, the coefficient of the dummy for utility model law in this regression represents the impacts for the high income countries, and the estimate for it turns out to be positive but insignificant. The coefficient estimate of the dummy for utility models in high income countries is 0.016. The results are available upon request.

Table 5
Estimates of innovation equation – international sample.

	Dependent variable (log of US patents granted)$_t$								
	Full sample			Full sample w/high income dummy [mid-to-low income country base]			Full sample w/high income dummy [mid-to-low income country base]		
	OLS (1)	FE (2)	SYS GMM (3)	OLS (4)	FE (5)	SYS GMM (6)	OLS (7)	FE (8)	SYS GMM (9)
(Log of US patents granted)$_{t-1}$	0.939***	0.698***	0.927***	0.911***	0.647***	0.806***	0.909***	0.589***	0.838***
	(33.340)	(10.270)	(19.570)	(31.580)	(9.298)	(11.44)	(29.250)	(7.302)	(14.50)
(Log of R&D intensity)$_t$	0.101*	0.0327	0.0797	0.0924*	0.0328	0.0431	0.0968*	0.0235	0.0567
	(1.808)	(0.361)	(0.731)	(1.704)	(0.382)	(0.343)	(1.674)	(0.271)	(0.608)
(Log of no. of US PhDs per million)$_t$	0.170***	0.107	0.195***	0.157***	0.155*	0.189**	0.191***	0.138	0.172**
	(5.049)	(1.302)	(3.005)	(4.602)	(1.831)	(2.607)	(5.012)	(1.538)	(2.296)
(Log of working age population)$_t$	0.145***	1.344***	0.167***	0.169***	2.082***	0.258***	0.171***	1.987***	0.218***
	(4.945)	(2.817)	(4.039)	(5.476)	(3.914)	(5.901)	(4.818)	(2.814)	(4.865)
(Log of patent rights index)$_t$	−0.132	0.0139	0.0937	−0.186	−0.125	0.191	−0.247*	−0.149	0.0884
	(−1.124)	(0.071)	(0.574)	(−1.501)	(−0.644)	(1.048)	(−1.774)	(−0.615)	(0.420)
High income dummy* (log of patent rights index)$_t$				0.0926	0.577***	0.490**	0.241	0.549**	0.554**
				(0.536)	(2.679)	(2.231)	(1.279)	(2.283)	(2.488)
(Utility models law dummy)$_{t-2}$							0.141	0.411***	0.170*
							(0.991)	(4.047)	(1.720)
High income dummy* (utility model law dummy)$_{t-2}$							−0.157	−0.377***	−0.193
							(−0.985)	(−2.809)	(−0.981)
(Log of openness)$_t$	0.699***	0.070	0.730**	0.697***	0.018	0.514**	0.675***	0.0988	0.631**
	(4.131)	(0.272)	(2.377)	(4.194)	(0.072)	(2.074)	(3.492)	(0.359)	(2.079)
High income dummy				0.120	–	−0.0299	−0.0773	–	−0.256
				(0.633)		(−0.115)	(−0.333)		(−0.840)
Constant	−3.287***	−20.60***	−3.594***	−3.649***	−32.36***	−4.615***	−3.383***	−30.59***	−4.125***
	(−5.568)	(−2.755)	(−3.841)	(−6.125)	(−3.896)	(−6.152)	(−4.802)	(−2.782)	(−4.775)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.98	0.793		0.981	0.803		0.981	0.783	
Hansen			0.33			0.88			0.74
AR2			0.59			0.48			0.29
Observations	255	255	255	255	255	255	216	216	216
Number of countries		73	73		73	73	73	73	73

Note: (1) 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) Patent: the number of U.S. patents granted; utility model dummy = 1 if utility model laws exist, 0 otherwise; patent rights index: index of patent rights protection; no. of US PhDs per million: the number of PhD holders in science and engineering from U.S. universities per million people; R&D intensity: R&D expenditures to GDP; working age population: the number of people in the age group 15–64 years. (3) The classification of high/mid-to-low income countries follows the World Bank criterion. High income countries: GDP per capita, PPP > $10,000 constant 2000 international dollars; mid-to-low income countries: GDP per capita, PPP ≤ $10,000 constant 2000 international dollars. (4) Hausman tests between fixed effects (column 8) and system GMM (column 9) indicate that system GMM estimates are consistent (chi-square = 21.47 and p-value = 0.0440). T-statistics are in parentheses.

* 10% level of significance.
** 5% level of significance.
*** 1% level of significance.

Table 6
Estimates of growth equation – international sample.

	Dependent variable (5-year average GDP per capita growth rate)$_t$					
	W/both utility model dummy ($t-2$) and log of patent intensity (t)			High income interaction w/both utility model dummy ($t-2$) and log of patent intensity (t)		
	OLS (1)	FE (2)	SYS GMM (3)	OLS (4)	FE (5)	SYS GMM (6)
(Log of GDP per capita)$_{t-1}$	−0.0556**	−0.151	−0.106**	−0.0501**	−0.156	−0.0965*
	(−2.075)	(−1.411)	(−2.068)	(−2.030)	(−1.472)	(−1.898)
(Log of population growth)$_t$	−0.0137	−0.0102	−0.0387*	−0.0129	−0.0125	−0.0217
	(−1.511)	(−0.524)	(−1.871)	(−1.167)	(−0.654)	(−0.889)
(Log of investment)$_t$	0.246***	0.209***	0.448***	0.249***	0.210***	0.431***
	(7.873)	(2.645)	(6.275)	(7.893)	(2.656)	(6.330)
(Log of secondary school enrollment)$_t$	0.0520**	0.0245	0.0499	0.0518**	0.034	0.161**
	(2.265)	(0.705)	(0.802)	(2.319)	(0.964)	(2.099)
(Utility models law dummy)$_{t-2}$	0.014	0.070	−0.0107	0.0482*	0.102**	0.0907**
	(0.894)	(1.630)	(−0.270)	(1.830)	(2.122)	(2.014)
High income dummy* (utility model law dummy)$_{t-2}$				−0.054	−0.133***	−0.075
				(−1.610)	(−2.671)	(−0.935)
(Log of patent intensity)$_t$	0.0145**	0.018	0.0319**	−0.004	0.002	−0.027
	(2.303)	(0.889)	(2.371)	(−0.447)	(0.125)	(−1.167)
High income dummy* (log of patent intensity)$_t$				0.0207**	0.0460*	0.0953***
				(2.052)	(1.666)	(2.705)
High income dummy				0.020	–	−0.200
				(0.484)		(−1.200)
Constant	−0.395**	0.671	−0.573	−0.472**	0.621	−1.102***
	(−2.041)	(0.665)	(−1.647)	(−2.517)	(0.623)	(−2.752)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.380	0.221		0.401	0.234	
Hansen			0.32			0.6
AR2			0.34			0.68
Observations	299	299	299	299	299	299
Number of countries	90	90	90	90	90	90

Note: (1) 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) Patent rights index: index of patent rights protection; log of GDP per capita: a logarithmic term of GDP per capita (PPP, constant 2000 international $); population growth: a growth rate of population; secondary school enrollment: rate of secondary school enrollment; investment: ratio of gross capital formation to GDP. Utility model dummy = 1 if utility model laws exist, 0 otherwise; patent rights index: index of patent rights protection. (3) The classification of high/mid-to-low income countries follows the World Bank criterion. High income countries: GDP per capita, PPP > $10,000 constant 2000 international dollars; mid-to-low income countries: GDP per capita, PPP ≤ $10,000 constant 2000 international dollars. (4) Hausman tests between fixed effects (column 5) and system GMM (column 6) indicate that system GMM estimates are consistent (chi-square = 35.53 and *p*-value = 0.0002). *T*-statistics are in parentheses.

* 10% level of significance.
** 5% level of significance.
*** 1% level of significance.

Table 7
Impacts of utility models and patents on firm performance – Korean firm sample.

	Dependent variable (annual sales growth rate)$_t$								
	Full sample			1970–1986			1987–1995		
	OLS (1)	FE (2)	SYS GMM (3)	OLS (4)	FE (5)	SYS GMM (6)	OLS (7)	FE (8)	SYS GMM (9)
(Log of sales)$_{t-1}$	−0.0836***	−0.391***	−0.168***	−0.103***	−0.559***	−0.168***	−0.0783***	−0.452***	−0.207***
	(−9.691)	(−18.49)	(−5.883)	(−6.287)	(−12.11)	(−3.881)	(−7.656)	(−19.30)	(−8.887)
(Log of utility model)$_{t-1}$	0.00466*	0.0122**	0.00934	0.0149**	0.0572***	0.0473**	0.00272	0.00361	0.00456
	(1.662)	(2.553)	(0.874)	(2.071)	(3.397)	(2.141)	(0.884)	(0.894)	(0.448)
(Log of patent)$_{t-1}$	0.0175***	0.0108**	0.0250**	0.0222**	0.0126	−0.0192	0.0162***	0.00712*	0.0529***
	(5.993)	(2.506)	(2.435)	(2.215)	(0.911)	(−0.987)	(5.233)	(1.746)	(4.958)
(Log of investment)$_{t-1}$	0.0294***	0.0158***	0.0461***	0.0292***	0.00906**	0.0163	0.0291***	0.0135***	0.0371***
	(13.240)	(7.996)	(6.093)	(6.022)	(2.084)	(1.072)	(11.730)	(6.110)	(5.375)
(Log of employees)$_{t-1}$	0.0736***	0.161***	0.153***	0.0697***	0.114***	0.112**	0.0739***	0.179***	0.168***
	(9.356)	(7.336)	(4.355)	(5.091)	(2.966)	(2.468)	(7.757)	(7.415)	(6.134)
(Log of firm age)$_t$	−0.0631***	0.0086	−0.0431***	−0.0349***	0.2	−0.00369	−0.0702***	0.00859	−0.0339**
	(−11.37)	(0.277)	(−3.564)	(−2.789)	(1.598)	(−0.162)	(−11.14)	(0.256)	(−2.188)
Constant	1.361***	5.757***	2.216***	1.820***	8.759***	7.784	1.209***	6.999***	2.795***
	(6.012)	(18.530)	(6.934)	(7.435)	(9.188)	(1.463)	(9.420)	(20.180)	(9.687)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.131	0.313		0.166	0.381		0.121	0.338	
Hansen			0.67			0.54			0.28
AR2			0.795			0.625			0.583
Observations	14359	14359	14359	3034	3034	3034	11325	11325	11325
Number of firms	1717	1717	1717	861	861	861	1708	1708	1708

Note: (1) Year dummies for 1970–1995 and industry dummies for 21 industries are included. Utility model refers to number of utility model applications, patent to number of patent applications, investment to ratio of investment to assets, and employees to number of employees. White–Sandwich standard errors are used. (2) The results of the full sample model and the 1970–1986 model are mixed. Hausman tests between fixed effects estimates and system GMM indicate that system GMM is consistent in both models (i.e. chi-square = 3888.5 and p-value = 0.000 for the full sample, and chi-square = 1508.09 and p-value = 0.00 for the 1970–1986 sample). *T*-statistics are in parentheses.

* 10% level of significance.
** 5% level of significance.
*** 1% level of significance.

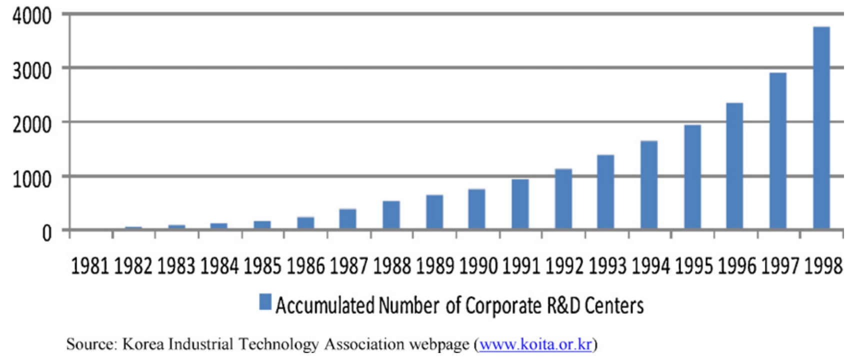

Fig. 4. The establishment of corporate R&D centers by year and field (Korea, 1981–1995).
Source: Korea Industrial Technology Association webpage (www.koita.or.kr).

to test the hypothesis that utility models contribute to firm performance. We find that the contributions of utility models and patents depend on the time period. First, for the entire period 1970–1995, patents dominate utility models in explaining sales growth, as shown in column 3.[22] This is consistent with previous empirical findings underlining the economic significance of patents (see Ernst, 2001). The investment and labor control variables each have significant positive associations with sales growth, while the age of a firm has a significant negative association (i.e. younger firms generally have faster growth in sales). The latter result is consistent with Jovanovic (1982) and Evans (1987).

When the sample is split by period around the mid-1980s, we find a kind of role reversal. The mid-1980s are in fact a turning point for Korea's technological development (Lee and Kim, 2010). Its indigenous R&D capabilities began to grow markedly. The aggregate R&D/GDP ratio was less than 1% before this point in time and exceeded 2.5% soon after (see Fig. 3). The share of private R&D in national R&D was less than half before the early 1980s and was 80% by the late 1980s. The number of corporate R&D centers in Korea also began to increase substantially after the mid-1980s. As Fig. 4 shows, there were 45 such centers in 1981. But by the mid-1980s, the number increased more than five-fold. The rise in the number of corporate R&D centers indicates that more Korean firms were able to fund their own internal R&D activities. It was also then that the growth rate of utility model filings began to decline and the number of patent applications to rise. Overall, it is widely perceived that Korean technological capabilities had made some jump during the mid-1980s.

Our regressions find that during the period when Korean firms were still technologically lagging (i.e. 1970–1986), incremental innovations have a positive impact on firm performance, controlling for other variables (see column 6). However, patents do not have a statistically significant effect. Thus, this strongly supports the view that utility models are a good strategy for a latecomer's growth, particularly at its early stages. But for the period 1987–1995, when Korea had acquired greater technological and R&D capabilities, patents significantly and positively explain sales growth, while utility model applications do not (see column 9). By the time a firm achieves greater technological competence, it relies less on minor innovations for its performance and more on inventive, patentable innovations – hence the role reversal.

The implication here is that utility model innovations are likely to be quite appropriate for companies that are resource-poor or below the technological frontier. Patent protection is likely to be more conducive to innovation after companies have reached some critical technological capability; that is, once they have the capacity and wherewithal to produce innovations with sufficient inventive steps to qualify for patent protection.

Finally, the results in Table 8 show the estimates of Eq. (9) for the firm level data. The objective here is to test the hypothesis that past utility models can stimulate future patentable innovations. The argument is that utility model innovations and filings allow firms to engage in learning-by-innovating, however incrementally, and to accumulate technological capabilities. Here, the knowledge production function model is augmented with one and two-year lagged patents and R&D to control for persistence in patenting. Utility models are lagged 5 and 6 years to incorporate the feature that learning-by-innovating is occurring incrementally.[23] Both lagged utility models and patents have positive associations with the flow of new patents, as shown in column 6. That is, the new patentable innovations of firms build upon their past utility model knowledge as well as their past, more inventive knowledge.[24] The results support the hypothesis that through adaptation, imitation, and incremental innovation, firms acquire some learning-by-doing (Suthersanen, 2006). Note, however, that once past knowledge accumulation (from both utility model and patentable innovation) is considered, the twice lagged R&D expenditure loses its statistical significance, as shown in columns 3 and 6. A reason could be that older R&D is reflected in the lagged patenting variables. Lastly, we note that larger firms (by size of employment) tend to produce more patentable innovations, a feature of Schumpeterian-type models.

[22] We discuss the system GMM results since they are consistent. See notes to Table 7.

[23] The reason that the utility model variables are lagged five to six years is that we are dealing with *annual* firm level data. Earlier in our country level panel data, each single time period was five years in length (i.e. *quinquennial*). Thus a five-to-six year annual lag corresponds to our cross-country lag of one to two periods. We would also argue that five-to-six year lags would be a reasonable time period of learning in order for real innovation to take place, particularly since utility model experiences provide incremental learning. In that case, an extended cumulative period of learning is required to develop greater inventive potential.

[24] In Table 8, patenting is a function of past utility models, controlling for other factors. There is also the possibility raised earlier that utility models might be a function of patents. We have performed a check on this to find that lagged patents ($t-5$, $t-6$) are not significant in contributing to current utility model innovations (which is in sharp contrast to the results in Table 8 where lagged utility models are significantly related to current patents). These "asymmetric" results suggest that firm-level utility model and patentable innovations are not really driven by common time varying effects, but that there is a feedback from utility model learning and experience to later patenting, but not from patenting experience to later utility model innovations. As Fig. 2 shows, the leading Korean IP firms no longer file that many utility model applications. This interesting pattern suggests that the dynamic learning relationship (from past UMs to current patents) is subject to change and is most applicable at certain stages of a firm's development.

Table 8
Impact of past patents and utility models on new knowledge generation – Korean firm sample.

	Dependent variable (log of patent application)$_t$					
	OLS (1)	FE (2)	SYS GMM (3)	OLS (4)	FE (5)	SYS GMM (6)
(Log of patent application)$_{t-1}$	0.592***	0.438***	0.721***	0.577***	0.420***	0.539***
	(33.560)	(19.460)	(15.390)	(32.250)	(18.600)	(21.690)
(Log of patent application)$_{t-2}$	0.358***	0.279***	0.159***	0.334***	0.250***	0.258***
	(19.350)	(13.440)	(3.979)	(17.800)	(13.020)	(12.560)
(Log of utility model application)$_{t-5}$				0.0446***	0.0569***	0.0841**
				(3.607)	(3.673)	(2.329)
(Log of utility model application)$_{t-6}$				0.0350***	0.0557***	0.0397*
				(2.782)	(4.010)	(1.865)
(Log of R&D expenditure)$_{t-1}$	0.0120***	0.0102***	0.0204*	0.0119***	0.00987***	0.0165**
	(6.116)	(4.170)	(1.859)	(6.024)	(4.125)	(1.974)
(Log of R&D expenditure)$_{t-2}$	0.00966***	0.0103***	0.00103	0.00906***	0.00973***	0.00338
	(4.800)	(4.050)	(0.269)	(4.481)	(3.870)	(0.935)
Firm size dummy (51–300 employees)	−0.00497		−0.00659	−0.00567		0.0057
	(−0.137)		(−0.215)	(−0.156)		(0.125)
Firm size dummy (301–1000 employees)	0.0118		0.0165	0.0112		0.0437
	(0.316)		(0.461)	(0.302)		(0.871)
Firm size dummy (more than 1000 employees)	0.167***		0.208***	0.162***		0.266***
	(4.191)		(4.213)	(4.072)		(4.655)
Constant	−0.298**	−0.706***	−0.283***	−0.239**	−0.637***	(0.186)
	(−2.523)	(−7.010)	(−3.014)	(−2.026)	(−6.447)	(−1.459)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.776	0.501		0.778	0.506	
Hansen			0.72			0.770
AR2			0.156			0.206
Observations	9903	9903	9903	9903	9903	9903
Number of firms	1464	1464	1464	1464	1464	1464

Note: Year dummies for 1970–1995 and industry dummies for 21 industries are included. R&D expenditures are in thousands of constant 1995 Korean Won. *T*-statistics are in parentheses.
* 10% level of significance.
** 5% level of significance.
*** 1% level of significance.

7. Conclusions

This paper extends previous empirical research on the effects of intellectual property protection on innovation and economic growth by focusing on the relative role of two types of protection: patents and utility models. We exploited both country level and firm level data. The results from both datasets are complementary. First, in high income economies, differences in economic growth and innovation can be explained by variations in patent rights, but not by variations in the provision of utility models, controlling for other variables. In middle-to-low income countries, the reverse is the case. Correspondingly, in the Korean firm level data, patentable innovations matter positively and significantly to firm growth, while utility model innovations matter insignificantly, when firms are technologically advanced. The reverse is the case when firms are technologically lagging: utility model innovations matter positively and significantly to firm growth while patentable innovations do not. Furthermore, utility model innovations can be an important input into the generation of future patentable innovations.

Thus the chief lesson in this paper is that what matters to innovation and growth is not only the strength of intellectual property rights but also the type of protection. For example, the availability of legal protection for minor, adaptive inventions should be most useful to firms with low technological capacities and limited resources. In developing markets, patents raise the cost of doing business and innovation. This cost tends to be more onerous for lower income economies. In contrast, a utility model system provides an alternative way for such economies to create incentives for innovation, albeit incremental, without affecting the cost of doing business adversely, and while providing the technological inputs appropriate for local needs. For more developed firms and firms with better access to resources, such as those in the more developed countries, patent protection plays a more important role in the innovation process than do utility model laws. The longer terms and wider breadth associated with patents provide incentives to create and commercialize innovations with larger inventive steps.

The experience of Korean firms and the country level analyses suggest that the design and strength of intellectual property systems should be tailored to the indigenous technological capacities of firms in order to best provide the appropriate incentives for innovation. Current academic and policy debates have largely focused on the effects of strong patents and copyrights, of raising developing country standards to developed country levels, and restricting imitation, piracy, and infringement in developing countries. Less attention has been paid towards the effects of other types of IPRs and the growth-enhancing capacity of imitative innovation.

Future research could explore other national case studies (say other developing countries in Asia or Latin America) to examine their experiences with the different types of IPRs, such as utility models, industrial designs, trade secrets, copyrights, or trademarks. Secondly, it would be useful to investigate the issues by sector; for example, agriculture, electronics, and machinery.

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Appendix A. Data sources

Symbols used	Variable and sources	
	Country-level data	Firm-level data
Y/N	GDP per capita in purchasing power parity constant 2000 international dollars. World Bank, *World Development Indicators*	Sales, in constant 1995 Korean Won Lee et al. (2007, 2008)
N, n	Total population and population growth. World Bank, *World Development Indicators* and *Statistical Yearbook of the Republic of China*, Government of Taiwan	
P	U.S. Patent Grants U.S. Patent and Trademark Office, www.uspto.gov	Patent applications by Korean firms. Korea Intellectual Property Rights Information System (KIPRIS), www.kipris.or.kr
U	Utility model applications. World Intellectual Property Office, Geneva, *Industrial Property Statistics*, various issues	Utility model applications by Korean firms. Korea Intellectual Property Rights Information System (KIPRIS), www.kipris.or.kr
ι	Gross capital formation as a % of GDP. World Bank, *World Development Indicators*	Change in fixed assets as a percentage of total assets Lee et al. (2007, 2008)
R	Research and development expenditures as a % of GDP. UNESCO *Statistical Yearbook* (Paris, France) and *Statistical Yearbook of the Republic of China*, Government of Taiwan	Research and development expenditures, in constant 1995 Korean Won Lee et al. (2007, 2008)
IPR, UML	Index of patent rights and utility model laws Park (2008) and Greene (2010)	
O	Index of freedom to trade internationally, aggregating measures of restraints that affect international exchange: (1) taxes on international trade, (2) regulatory trade barriers, (3) size of the trade sector relative to expected, (4) black-market exchange rates and (5) international capital market controls. Fraser Institute, *Economic Freedom of the World*, Vancouver, Canada	
h, η	Secondary school enrollment (% of gross). This ratio is the total such enrollment, regardless of age, to the population of the age group that officially corresponds to the level of secondary education Herrera and Pang (2005), Barro and Lee (2001) Working age population (15–64 years). World Bank, *World Development Indicators* Number of PhDs in science and engineering from US universities. National Science Foundation *Science and Engineering Indicators*, Washington, DC	
Other	Legal origins La Porta et al. (2008)	Number of employees Lee et al. (2007, 2008)

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