Determinants of Innovation and the Role of Intellectual Property Rights

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Abstract

The effect of intellectual property (IPR) on innovation is often debated in the field of economics. In recent history, policy makers have moved to strengthen international protection of patent rights, though an economic consensus remains to be found. While some theorists claim intellectual property laws are essential to create the incentive to innovate, other authors believe that the demand for IPR only increases after a country moves from imitating to innovating, and that the relationship is not causal.

The purpose of the paper is to investigate intellectual property's effect on innovation and identify other possible determinants. We will measure these effects using an OLS analysis that will include variants for national culture, IPR, openness, human capital, corruption, tax competitiveness, and savings. Furthermore we will attempt to control for innovative capacity using country fixed-effects and later by adding GDP size.

The findings of the study are that IPR weakens as a determinant of innovation when innovative ability is controlled for, while human capital is found to be the most important determinant. We can conclude that while IPR is correlated with innovation, the effect of IPR may not be causal. Investment in human capital is found to be the most powerful determinant and is likely to be a causal factor for innovation.

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1. Introduction

In recent history, intellectual property rights (*IPR*) reform has become a major international trade issue. Intellectual property rights include trademarks, copyrights and patents (which will be the main focus of the paper). Patents are legal rights of an inventor to exclude his competitors from using an invention, preventing immediate imitation (Hall 2007). Preventing imitation is thought to create an economic incentive to invest heavily in innovative activity.

International Trade has complicated the issue, as national patents may not protect the inventor in overseas markets. The adoption of the 1995 Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) helped ensure patent protection by requiring member countries to protect *IPR* from foreign countries (Hall 2007). While international pressure for streamlined *IPR* regulation has grown, economic theorists are still debating whether *IPR* has benefitted countries by increasing innovation.

Intellectual Property has been found to be positively correlated with economic growth, especially in competitive markets (Gould and Gruben 1996). Yet another analysis for other studies have found that patents only have a significant effect in a small range of industries such as pharmaceuticals and chemicals (Mansfield 1986). However, the correlation between innovation and *IPR* may be misleading as many studies don't have enough controls for different innovative abilities between countries (Qian 2007).

This paper will provide a brief literature review where it will outline basic theoretical concepts and compare some recent empirical models. This paper will also feature an OLS Cross Country growth analysis that will attempt to quantify the relationship between R&D and *IPR*. The goal of this paper is to measure the determinants of innovation, and specifically, to see if IPR leads to more innovation. Furthermore, we will attempt to identify other possible determinants of innovation. The base model will be derived from Varsakelis's (2001) analysis, which makes a unique use of national culture as a variant of innovation. This paper will build on his analysis by adding variables such as human capital, corruption, taxes and savings while attempting to control for innovative capacity as stressed by Qian (2007). The finding will be presented in six different regressions by incrementally adding different control variables.

Section 2 of the paper will outline the theoretical framework for intellectual property. Section 3 will review and compare some recent empirical studies. Section 4 will outline the empirical methodology and data that will be used in this paper's analysis. Section 5 will provide results to the empirical analysis and section 6 will conclude the paper.

2. Do Patents Spur Innovation? A Theoretical Framework

The economic rationalization of patents has always come from the belief that they result from bargaining between society and the inventor, where the inventor agrees to make his invention public in return for a temporary monopoly of his/her achievement (Hall 2007). This temporary monopoly acts as an incentive to innovate, as it protects the inventor from his competitors' ability to steal. Hall (2007) points out that there are tradeoffs associated with well-enforced intellectual property rights

(*IPR*) that are much more complicated than the above theory. As mentioned above, *IPR* creates an incentive to innovate by granting temporary monopoly status and creating a public record of the innovation. Also, *IPR* can create more competition by facilitating the entry of new firms with limited assets and scale. Large firms will not be able to just simply duplicate the inventor's products and use their size to run them out business (Hall 2007). But Hall also argues that patents can be a cost to innovation as they hamper the combination of new inventions and raise transaction costs for companies. Also patents restrict competition by creating short-term monopolies, which may become long-term in network industries. These reductions in competition will restrict the free flow of information, which may have a negative effect on economic growth. When we take these offsetting effects into account, the patents debate becomes much more complex.

The degree of patent laws has different effects on the developed and developing world. Helpman (1993) outlines that supporters of more stringent *IPRs* in the developing world use the argument that soft patent protection reduces the innovative effort from rich countries. A reduced innovative effort will lead to lower welfare for all. This is similar to the argument outlined by Hall's (2007) that tough patent laws create an incentive for innovation. If the developing world is able to imitate and steal the inventions of rich countries, the developed world loses some incentive to innovate. In Helpman's (1993) analysis he finds that the developing world always gains from a weak IPR regime. In one scenario he finds that in the absence of FDI, strong patent laws causes the reallocation of manufacturing in the direction of higher priced products in which the developed world has a low competitive advantage in production. In the scenario of a strong IPR regime and high FDI, the developed world still suffers a welfare loss as they are restricted on imitation and are forced to purchase the more expensive patented products. Therefore there is a significant negative trade-off for the developed world to strengthen their IPR regulations.

There is also the issue of private property rights as stated by Tortensson (1994). Well enforced property rights lead to increased GDP per capita, as investment share of GDP is higher, due to the fact that private property rights give agents the confidence that they can benefit from the gains of investment (Tortensson 1994). In the absence of the rights, consumption will be prioritized at the expense of savings and investment. If this same rational is true for intellectual property rights, increased IPR enforcement should lead to more innovation. However, Heller and Eisenberg (1998) view property rights differently.

The phrase "Tragedy of the Commons", a metaphor that explains the overuse of resources in a system that lacks private ownership and hence the incentive to conserve, is often used to urge stronger property rights (Heller and Eisenberg 1998). The rationale is that the privatization of intangible property (i.e. intellectual property) should create the same efficiency benefits as the privatization of tangible property. The metaphor identifies the cost of overuse, but fails to recognize the possibility of underuse when the government gives too many individuals the right to exclude and no one has an effective privilege of use (Heller and Eisenberg 1998). As Heller and Eisenberg point out, this offsetting effect to the privatization of intangible items leads to what they call the "Tragedy of the Anticommons". If this metaphor is correct, strong protection of *IPR* can actually have a negative effect on innovation and economic growth. From a simplistic theoretical point of view, patents do create incentives to undertake risky R&D as the innovator can use exclusivity to recover costs of R&D. On the other hand, if patent laws are too stringent too many patent owners can create obstacles to future research.

One of the obstacles when there is strong protection of *IPR* is the threat and cost of litigation. Consequently, richer firms, and hence richer countries, will have an advantage under a strong patent regime (Hall 2007). Players with deep pockets can use their size to outlast smaller firms in litigation and there is an economic incentive for large firms to misuse their power. Therefore it's not just a question of who has acted legally, but also a question of who can survive a lawsuit. As a result, threat of litigation may discourage firms from entering certain areas and therefore discourage R&D (Lerner 1995). According to Lerner's (1995) findings, firms with high litigation cost are less likely to patent in the same areas as competitors. This provides a rationale to why certain market players and certain countries may not feel that stronger enforcement of intellectual property rights will help spur innovation.

Another obstacle is that technology is far more complex than traditional literature suggests. In real life innovation is sequential, wherein innovation needs inputs from past innovations (Bessen and Maskin 2009). The economic literature often doesn't take into account the sequential nature of innovation. Bessen and Maskin (2009) were able to formulate a model that took into account both sequential and non-sequential cases. According to the model, patents create higher social welfare and innovation in a non-sequential case, but reduce social welfare and innovation in a sequential case (Bessen and Maskin 2009). Thus, too many owners of innovation can create friction and increase the transaction costs of innovation. This is similar to Heller and Eisenberg's (1998) assessment of the 'Tragedy of the Anti-Commons'. This will surely slow the pace of innovation when inventors are forced to invent around patents instead of focusing on end products. Furthermore, these findings show that while *IPR* enforcement is important to innovation and R&D, they may be over-enforced in a system that has liberal standards as to what is patentable.

3. Past Empirical Works

Numerous empirical works have been conducted in an attempt to capture the effect that *IPR* have on innovation (and R&D). This section will review some of these empirical works. Different approaches have been taken to capture this effect.

Kanwar and Evenson (2003) formulate a model that tests the effects that *intellectual property* has on *R&D investment,* while also considering variables such as change in GDP/capita, education, trade openness, and political instability. The findings of their paper are that *intellectual property* is significant and has a positive influence over *research and development* even when the above control variables are considered. Since R&D has a positive influence on economic growth, *IPR* has an indirect but positive influence on growth too. With the inclusion of these control variables, Kanwar and Evenson make a strong case for intellectual property rights, most importantly patents.

In a cross-country analysis, Varsakelis (2001) tests the effects of *IPR* on *R&D intensity* using economic openness, power distance index and country dummies as control variables. Varsakelis finds that *IPR* is positively related to R&D with the inclusion of the above explanatory variables. The results provide a strong argument for patents, although they can be challenged on the basis that panel data wasn't used and that education wasn't considered to be a determinant for R&D. This model will form the basis for my own analysis later in this paper.

In another cross-country analysis, Gould and Gruben (1996) measure the effects of *intellectual property* using *productivity growth* as a proxy for *innovation*. The findings of the study are that *intellectual property* is significant in open trade economies, but plays a weaker role in less competitive protectionist markets. It must also be noted that convergence, savings, and secondary school enrolment are found to be stronger determinants of productivity growth. It shouldn't be surprising that these are the most important determinants of productivity growth as they correspond to human capital growth models. On the other hand, it should be further investigated whether the link between *IPR* and *productivity growth* in free trade economies is a causal link. It can be the case that one country respects another country's patents, resulting in healthy trade relations and better economic returns as a result. Another explanation can be that corporations will only take part in foreign investment if they feel their patents will be protected abroad. And of course it can be the case that patents are a causal link to strong economic returns, though this argument becomes weaker due to the fact that patents are weak indicators in closed economies.

This link is better explained by Park and Ginarte (1997) who measure the effects of *IPR* on factor accumulation variants (*investment, education* and *R&D*). The main finding is that *IPR* does not directly affect productivity growth but instead affects it indirectly by stimulating factor inputs such as *capital* and *R&D*. Interestingly it is also found that while *R&D* is important in both developed and developing countries, *IPR* is a significant determinant of *R&D* only in the developed countries (Park and Ginarte 1997). According to the authors, this is a result of the fact that poorer countries lack an *R&D* base that the rich countries have. Consequently the *R&D* in the poorer countries tends to be imitative rather than innovative (Park and Ginarte 1997). This could be the explanation as to why there is a discrepancy in the *IPR* effect in rich versus poor countries. On the other hand, it may just be that industries begin to demand stronger *IPR* enforcement once their R&D moves from being imitative to innovative. Therefore a strong R&D base could be the causal factor to strong *IPR* rather than the opposite.

Qian (2007) constructs a cross-country model, which measures the effect of *IPR* on *innovation* controlling for variables such as *GDP/capita, GDP Growth, Economic Freedom, Legal Systems, Education,* and *Innovative Potential.* Qian controls for *Innovation Potential* on the basis that it is presumably correlated with patent policies and the failure to control for this can potentially lead to biased estimates (Qian 2007). Undeniably, countries with strong *IPR* enforcement have more innovation, though it may just be the capacity to innovate that is a causal factor. After controlling for these variables, it is found that there is no statistical significance between patent enforcement and R&D, though it is found that there is a correlation at higher development levels (Qian 2007). Also, as found in many other studies, there is no correlation at lower development levels. The earlier assessment that *innovative potential* is the causal factor of higher *innovation*, further opens the possibility that countries have no interest in stronger *IPR* enforcement until they become significant exporters of technology.

Qian also references past surveys of American manufacturing firms, which found that secrecy was more important than *IPR*. In some industries such as high tech, it would take only the tweaking of some code in order to get around a patent. On the other hand the use of secrecy can still give companies the important, first mover advantage. Qian further asserts that patents may be counter-productive by forcing firms to incur higher legal and licensing costs (Qian 2007). This is similar to the assessment mentioned by Hall, Heller and Eisenberg.

The above review indicates that there is correlation between strong *intellectual property rights* and *R&D/innovation*. Countries with the highest levels of innovation also have the strongest enforcement of *IPR*. On the other hand, there are some inconsistencies found in the studies, such as the fact that *IPR* is not an important factor in less developed nations. These inconsistencies create some doubt over whether the correlation between strong *IPR* and high innovation is causal.

In the next section of the paper, I will formulate my own empirical analysis to measure the link between *intellectual property* and *R&D intensity*.

4. Data and Methodology

The empirical model in this paper is based on the analysis by Varsakelis (2001), where he tests the effects of *IPR* on *R&D intensity* using a cross-country model. Varsakelis specifically uses R&D as he recognizes that it is positioned in the beginning of the causal chain of innovation. Several authors (such as Park-Ginarte, and Kanwar-

Evenson) use R&D as a proxy for innovation, legitimizing Varsakelis' choice of the dependant variable. And while not all R&D fructify into innovation, investment in R&D is more directly related to incentive activity than variables such as non-residential investment in physical capital (Kanwar and Evenson 2003). The *R&D intensity* variable used in this paper's model is taken from the World Bank database rather than Unesco as used by Varsakelis as the data from the World Bank was more accessible. Varsakelis uses the same patent protection index variable formulated in Park and Ginarte (1997) and uses this as a proxy for *intellectual property*. This paper will use the *intellectual property* variable used by the Fraser Institute's Yearly Economic Freedom Study. The Fraser Institutes variable is more widely used and encompasses all intellectual property, which makes it a better proxy than the Park and Ginarte's patent index. The average IP score can be seen in **Appendix 5**, where a higher value corresponds to more effective intellectual property rights.

Varsakelis also tests the effects of the black market premium (BMP) on R&D Intensity. BMP is used as a proxy for *economic openness*, as a bigger black market should indicate lower levels of openness. Varsakelis also indicates that previous studies use other *economic openness* determinants related to trade such as average tariff, and quota coverage. BMP only takes into account some aspects of openness such as national laws. While highlighting that trade variables are important measuring a countries economic openness, he chooses not to use any trade variables. Gould and Gruben (1996) stress the importance of *trade openness* in the effectiveness of *IPR*. In the interest of testing the robustness of Varsakelis' model and incorporating trade, I will instead use the *trade openness* variable from the Penn World Tables as a proxy for *economic openness*. This variable is calculated by adding imports and exports and dividing the sum by GDP.

Varsakelis' model is very unique in its use of the *Power Distance Index (PDI)*, which quantifies interpersonal authority between the superior and subordinate as perceived by the subordinate in society. *PDI* defines the level of acceptance of inequality and level of dependence and independence in a society (Varsakelis 2001). *PDI,* as first formulated by Geert Hofstede, proxies national culture that can help explain a society's willingness to advance new technology (Varsakelis 2001). In high *PDI* societies, the first person to blame when there is a problem in the system is the people (including subordinates and superiors), where a change in the system requires a change in leadership. On the other hand, in low *PDI* societies the system is blamed rather than the people (Varsakelis 2001). As stated by Varsakelis, low *PDI* societies are more likely to push for systematic changes leading to new processes. Therefore, a low *PDI* leads to a more innovative society where there is more investment in R&D to overcome problems in the system. Also, according to Hofstede (1984), Low *PDI* countries such as the United States and Japan, have higher social mobility, which is a key variant in the mobility and development of technology. This paper will use the same national *PDI* numbers as used in the Varsakelis paper. National *PDI* values can be found in **Appendix 2**.

Varsakelis' use of *PDI* makes his analysis very unique. However, the paper lacks robustness in that it fails to recognize other very important determinants of *R&D intensity*. For example, there is a lack of any *human capital* proxies in his paper. Countries with higher levels of *human capital* have a tendency to innovate more and invest in *R&D* at a faster rate (Romer 1990). Some models such as Gould and Gruben (1996), use literacy rates as a proxy for human capital. However, literacy is a weak determinant of R&D as it has become widely achieved especially in richer OECD where it is common to have literacy rates in the high 90s (Kanwar and Evenson 2003). This paper will instead use *education spending* (as a % of GDP) as a proxy for *human capital* (from World Bank Database).

Other social and economic variables have been added to further test the robustness of the model. Political instability for example is a significant factor in influencing investment decisions. Countries with unstable political and economic climates tend to have reduced productive investment (Kanwar and Evenson 2003). At times even isolated political conflicts that tend to be drawn out can stifle investment in a particular country or region (Kanwar and Evenson 2003). Like political instability, corruption can have similar effects on investment and growth. According to Hung Mo (2000), corruption can be a major depressant to economic growth and investment, and that political stability accounts for 53% of corruptions total effect. In order to account for corruption, this paper will use Transparency International's *Corruption Index (CPI)*. The higher the corruption index value, the less corrupt the country. These values can be found in **Appendix 4** where they are ranked in descending order according to the average ranking.

There is a general consensus that *savings* is highly correlated with national investment expenditure. Therefore a high level of *savings* may induce higher amount of investment in *R&D*. *Gross savings* (% of GDP) data from the World Bank will be used to measure this potential relationship.

Tax policy may be a determinant of *R&D investment*, as a lower tax rate will lead to more disposable income being spent on *R&D*. Furthermore, governments strategically use taxation (especially corporate taxes) to attract more foreign direct investment (FDI) to their countries (Janeba 1995). For example, if Canada has lower corporate taxes than a competitor nation, it may entice companies to move some operations to Canada in order to save money. Therefore lower taxation may lead to more FDI and domestic investment, in effect inducing *R&D investment*. This paper will use *corporate tax rates* in an attempt to capture this relationship. Corporate tax rates will be able to capture the disposable income effect of businesses and also capture the effect of FDI competition. The data used in this analysis is the *highest marginal corporate tax rate* figures from the World Bank database. A legend and explanation of all variables can be found in **Appendix 3**.

This paper will also expand on the Varsakelis study by doing a 5-year (2000-2004) panel-data analysis. Varsakelis' values are only for one year and fail to use consistent year values. For example, the R&D values are from 1998 while the patent index values are from 1990. The use of panel data and time consistency will provide a much more vigorous analysis of *R&D intensity*.

This paper will also use a very different sample than the ones used in the above reviewed empirical studies. All of these studies including Varsakelis used a very diverse group of countries, which includes highly developed nations, middle-income countries, and countries with very low development levels (Jamaica, Pakistan, Tunisia, Nigeria etc). However, when *innovative capacity* is controlled for, *intellectual property* only correlates with *innovation* in rich countries, while poor countries have no such correlation (Qian 2007). According to Qian, failing to control for *innovative capacity* leads to biased results. Similar results were found by Park and Ginarte's (1997) analysis, therefore our study will restrict its analysis to countries with higher *innovative capacities*. Since poor countries have no correlation between *IPR* and *innovation*, excluding these countries will make it very easy to control for *innovative capacity*. Two sets of countries will be incorporated in the analysis, which include all OECD and BRIC nations (Brazil, India, Russia, China). OECD countries are very technologically advanced and have high living standards; therefore, they can easily be identified as having high *innovative ability*. The BRIC nations are newly industrialized, have large populations and are sizable fast growing economies. These factors give them higher *innovative capacities* than the typical developing country. Furthermore the BRIC countries are members of the G20 due to their large economies and rapidly growing importance to the international economic system. Therefore it is important to include these countries in the analysis. A country legend outlining organizational membership can be found in **Appendix 1**.

Like Varsakelis, this paper will use the OLS method of estimation. Furthermore, most of the estimations will use country fixed effects to control for structural economic differences. The choice of country fixed effects variables will be discussed later in section 5 of the paper.

5. Results

In this section a series of empirical analyses will be presented. The first analysis will follow Varsakelis' base model. The second regression will expand on the base model by adding other possible determinants (as discussed in section 4) to R&D. This will be followed by a series of fixed effects analyses that will use different country dummies to control for *innovative ability*.

Table 1: Regression Results

	(1) rd	(2) rd	(3) rd
open	-0.00158*	-0.00219	-0.00204
	(-1.98)	(-1.65)	(-1.53)
ip	0.243***	0.0984+	0.0809
	(5.30)	(1.90)	(1.52)
pdi	-0.0126**	-0.0155***	-0.0163***
	(-3.29)	(-3.82)	(-3.98)
educ		0.134*	0.135*
		(2.12)	(2.13)
cpi		0.0919**	0.0910**
		(2.83)	(2.81)
ctax		0.0322**	0.0320**
		(3.18)	(3.17)
save		0.0426***	0.0465***
		(3.51)	(3.73)
usa			0.502
			(1.30)
N	169	144	144

Marginal effects; t statistics in parentheses
+ p<.10, * p<.05, ** p<.01, *** p<.001

5.1 Base Model

The following model was tested using the OLS method of estimation and cross-country panel data:

$$RD_t=\beta_0+\beta_1 Open_t+\beta_2 IP_t+\beta_3 PDI_t+\varepsilon_t$$

Results of this analysis are presented in **Table 1** (regression 1). *Intellectual property* has a coefficient of 0.24 and is strongly statistically significant. *Openness* is shown to be statistically significant, though the coefficient is very small. According to this analysis, *trade openness* has no effect on *R&D intensity*. *PDI* is statistically significant with a coefficient of -0.126.

The Varsakelis paper had a statistically insignificant result for *openness* though it had an economic significance of -0.224. This paper's results show no economic significance, but statistical significance. Gould and Gruben (1996) find a very strong relationship between open trade economies and effectiveness of *IPR*. This analysis finds that trade openness has no effect on R&D Intensity. This may be due to the fact that the analysis includes only OECD and BRIC countries, all of which take part in open trade relative to the countries not included in this analysis.

Intellectual property, while being both economically and statistically significant, is a much weaker determinant when compared to the results of the Varsakelis' paper (0.559). Furthermore this analysis shows that these results are even weaker when compared to Park-Ginarte (1997) and Gould-Gruben (1996). On the other hand, *IPR* is found to have some level of significance unlike the figures found by Qian (2007).

The *PDI* figures are very similar to the findings of Varsakelis, which is not surprising as this paper uses the same values. These results are consistent with Hofstede's theory that a lower *PDI* leads to more *R&D* in an economy. For example, if China was to "Americanize" their culture and have *PDI* numbers that were comparable (40 point drop), *R&D intensity* could rise by more then 0.6, significantly raising China's research investment.

This analysis simply tested the robustness of the Varsakelis' study by using 5-year panel data, changing the data set, and using a more homogeneous group of countries. The overall findings are that, with a more robust analysis, *IPR* is not as significant as found by Varsakelis' model.

5.2 Base Model with Additions

The following analysis is an extension of the base model tested using the OLS method of estimation and cross-country panel data:

$$RD_t=\beta_0+\beta_1 Open_t+\beta_2 Educ_t+\beta_3 IP_t+\beta_4 \mathit{PDI}_t+\beta_5 CPI_t+\beta_6 Ctax_t+\beta_7 Save_t+\varepsilon_t$$

Results for this regression can be seen in **Table 1** (regression 2). *Education spending, corruption, corporate taxes,* and *savings* have been added to the analysis as explained above.

With the new variables added, *openness* remains economically insignificant and now becomes statistically insignificant. *PDI* (-0.0155) becomes more significant statistically and becomes a slightly stronger determinant of *R&D intensity*. *IPR* is now only significant at a 90% confidence interval and the coefficient is reduced significantly (0.0984). While *intellectual property* is now a weaker determinant of *R&D* when compared to the Varsakelis' study, it still has a positive effect. *Education* is statistically significant and is the most powerful determinant for *R&D intensity* (0.134). *Corruption* (0.0919) is statistically significant and has about the same level of economic significance as *intellectual property*. The positive coefficient for *corporate tax* (0.0322) is an interesting result, as economic rationale would suggest that it should be negatively related to R&D. This result suggests that higher *corporate tax* wields higher levels of R&D. Finally, the *savings* figure shows very strong statistical significance with a coefficient of 0.0426.

With the new variables, the lower significance value for IPR suggests that both the base model and Varsakelis' study are potentially deficient in choosing determinants of *R&D*. Much of the correlation between *IPR* and *R&D* may have been structural differences between the countries. Now that some of these differences (such as *education, culture, savings* and *corruption*) have been controlled for, *IPR* is a much less important determinant of *R&D intensity*. Nonetheless, *intellectual property* remains a determinant of *R&D investment*. There is also the possibility that the *IPR* variable is just mediated by the control variables. When a relationship between the independent variable and the control variable exists, it is common to see the independent variable diminish in significance when controls are added (MacKinnon, 2008).

As mentioned before, *education* is now the most economically significant determinant of *R&D*. This is consistent with Romer's (1990) assessment that a higher level of human capital leads to more *innovation* and *R&D investment*. The base model is therefore lacking in that there is no variable to account for *human capital*. These results are also consistent with Gould and Gruben (1996), who found that secondary school enrolment was a significant determinant. Kanwar and Evenson (2003) noted that educated countries invest considerably more in skilled trade creating the pre-requisite to higher *R&D intensity*. As a result, *education spending* is the most important variant in creating an environment of high *innovation* while *IPR* is a relatively weaker factor.

Corruption is found to be as important as *intellectual property rights*. This result is consistent with Kanwar and Evenson's (2003) assessment that instability can stifle productive investment. A one-unit increase in the CPI score (less corrupt) can raise R&D Intensity by 0.091 units. For example, in 2000 India had a very low *CPI* score of 2.8 and *R&D intensity* of 0.77. A modest one point rise in their corruption score would push India's R&D to 0.86, which would give it a comparable R&D level to a country like Portugal (which has substantially higher living standards). If India was able to significantly reduce corruption and receive a score of 6, they could produce an R&D level higher than 1. These results demonstrate that corruption alone can stifle a country's development level.

The results for Savings are in line with economic theory in that a rise in savings will result in a rise in R&D investment.

As discussed earlier, the results for *corporate tax* contradict economic theory. As mentioned by Jeneba (1995), countries will often use corporate taxes to attract FDI, much of which will fund R&D. Furthermore, theory states that more disposable income resulting from lower taxes should lead to more productive spending. However, these results suggest that countries with higher taxes have more *R&D intensity*. One possible explanation for this is that small differences in tax rates differences are not enough for investors to re-route capital, as most tax rates of the countries considered are within a 5 point differential. Also it is possible that low tax rate countries such as Hungary (18%), are attractive to investors in terms of tax rates but don't have the *innovative capacity* of high tax rate G7 countries such as Canada

(36-44%), USA (40%), and Japan (42%). It is also a possibility that the 5-year time frame used in this study isn't enough to recognize gains from competitive tax policy.

5.3 US Dummy Variable

$$RD_t=\beta_0+\beta_1 Open_t+\beta_2 Educ_t+\beta_3 IP_t+\beta_4 PDI_t+\beta_5 CPI_t+\beta_6 Ctax_t+\beta_7 Save_t+\beta_8 USA_t+\varepsilon_t$$

The previous analysis has controlled for factors such as *human capital, corruption, tax competitiveness* and *savings.* Yet there may be other factors not considered by these variables. For example, some countries may have better *innovative potential* simply because of the size of their economies, regardless of policies. The dummy variable used in this model is the United States, as they have the world's largest and most advanced economy. The results of this regression can be seen in **Table 1** (regression 3).

With the inclusion of the dummy variable, *openness* remains statistically and economically insignificant. Interestingly, *IPR* weakens slightly in terms of economic significance (0.0809), and now becomes statistically insignificant. These findings become more in line with Qian's (2007) analysis. The significance of *PDI* increases slightly and the results for *education* remain consistent with the previous analysis. *Corruption, corporate tax,* and *savings* have results that are in line with the last regression.

These results are consistent with Qian's (2007) analysis, that there is no statistical significance between *IPR* and *R&D intensity.* However, a correlation still remains between the two variables, as was the case with Qian's paper. This again feeds the possibility that *innovative capacity* is the causal factor to higher R&D and that the desire for stronger *IPR* enforcement is the result of high *R&D intensity* rather than

IPR inducing *R&D.* In other words, countries have no desire for strong *IPR* until they become exporters of advanced technology. This increase in *innovative capacity* may be the result of *human capital* development.

5.4 G7 Dummy Variable

$$RD_t=\beta_0+\beta_1 Open_t+\beta_2 Educ_t+\beta_3 IP_t+\beta_4 PDI_t+\beta_5 CPI_t+\beta_6 Ctax_t+\beta_7 Save_t+\beta_8 G7_t+\varepsilon_t$$

This analysis will expand on the USA dummy variable regression by creating a dummy variable for all G7 countries. By just having a USA dummy variable, much of the *innovative capacity* in the world economy may not be controlled for. Note that G7 was used rather then G8 as Russia has a significantly lower level of technological advancement than the G7 countries. Russia will be grouped into the BRIC countries in the next analysis. The G7 countries are often considered to be amongst most technologically advanced economies in the world. Therefore they share a higher level of *innovative capacity* and should help further control for it. Results for this regression are presented in **Table 2** (regression 1).

The results of this regression show similar outputs for *openness, PDI, corruption, corporate tax,* and *savings. Education* (0.166) has become considerably stronger and remains statistically significant. *IPR* on the other hand has an even weaker coefficient (0.054) and becomes even more statistically insignificant. The G7 dummy shows very strong economic significance though the variable is statistically insignificant.

This result further produces support for Qian's (2007) assessment that *IPR* becomes insignificant once *innovative ability* is controlled for. Also this result further proves Romer's (1990) belief that increased *human capital* will lead to more R&D, as it will improve a country's innovative skills.

Table 2: Regression Results

	(1) rd	(2) rd	(3) rd
open	-0.00180 (-1.33)	-0.00162 (-1.14)	-0.000728 (-0.51)
educ	0.166* (2.47)	0.168* (2.50)	0.194** (2.92)
ip	0.0524 (0.86)	0.0559 (0.91)	0.0640 (1.06)
pdi	-0.0169*** (-4.06)	-0.0172*** (-4.07)	-0.0175*** (-4.23)
cpi	0.0898** (2.78)	0.0901** (2.78)	0.0785* (2.45)
ctax	0.0281** (2.68)	0.0278** (2.64)	0.0284** (2.75)
save	0.0469*** (3.77)	0.0454*** (3.52)	0.0334* (2.49)
g7	0.283 (1.41)	0.293 (1.45)	0.340+ (1.71)
bric		0.122 (0.46)	0.291 (1.08)
kor			1.036** (2.67)
N	144	144	144

Marginal effects; t statistics in parentheses
+ p<.10, * p<.05, ** p<.01, *** p<.001

5.5 G7 and BRIC Dummy Variable

$$RD_t=\beta_0+\beta_1 Open_t+\beta_2 Educ_t+\beta_3 IP_t+\beta_4 PDI_t+\beta_5 CPI_t+\beta_6 Ctax_t+\beta_7 Save_t+\beta_8 G7_t+\beta_9 BRIC_t+\varepsilon_t$$

This analysis expands on the last by adding a dummy variable for BRIC countries (Brazil, Russia, India, China). These countries have been added as they are all newly industrialized and represent a very large proportion of international output. The BRIC nations are members of the G20 and have a much higher *innovative capacity* than typical developing nations. The results for this regression can be seen in **Table 2** (regression 2).

The results show similar coefficients as the previous model. *Openness, corporate taxes* and *savings* produce slightly weaker coefficients. *Savings* remains statistically significant while *corporate taxes* and *openness* are insignificant. *Education and CPI* generate slightly stronger coefficients then in the last model. Interestingly *IPR* is also shown to have a slightly stronger coefficient though it remains statistically insignificant. The G7 dummy has a much stronger coefficient than the BRIC variable (0.293 and 0.122, respectively) though they are both statistically insignificant.

Overall these results remain consistent with the analysis of the last model where *IPR* remains statistically insignificant when we try to control for country fixed-effects.

5.6 Korea Dummy Variable

$$RD_t=\beta_0+\beta_1 Open_t+\beta_2 Educ_t+\beta_3 IP_t+\beta_4 PDI_t+\beta_5 CPI_t+\beta_6 Ctax_t+\beta_7 Save_t+\beta_8 G7_t+\beta_9 BRIC_t +\beta_{10} Kor_t+\varepsilon_t$$

In this final fixed-effects analysis, a dummy variable for South Korea will be added to the analysis as their *R&D investment* is amongst the highest in the world. Furthermore, being a member of the G20, Korea is recognized as a major world economy. Therefore, controlling for Korea's advanced economy could be instrumental in producing more accurate results. Results for this regression can be seen in **Table 2** (regression 3).

Results for this regression are in line with the previous two. *Education* now shows even stronger results with a coefficient of 0.194 and is statistically significant at a 99% confidence interval. Interestingly, *IPR* strengthens slightly as a determinant of *R&D* though it remains statistically insignificant. Also, note that *savings* and *CPI* have slightly weaker coefficients than the previous analysis. Coefficients for both G7 and BRIC dummies increase significantly and the former variable becomes statistically significant. The G7 countries are 0.34 times more likely to invest in R&D. The Korea dummy has the strongest coefficient (1.036) and is statistically significant, meaning that they are 1.036 times more likely to invest in R&D than the countries not controlled for.

Overall, *human capital (education spending)* is shown to be the most significant determinant of *R&D*. *IPR* has some correlation but is statistically irrelevant.

6. Conclusion

This paper has provided an empirical analysis on how *intellectual property* affects *innovation*. Theoretically, patents give an inventor a temporary monopoly over her product. This temporary monopoly is attributed as the incentive for more investment in innovation as the inventor can use the monopoly profits to recoup the cost of his product. But we found that patents can also be a cost to innovation by raising transaction costs, or by unintentionally creating long-term monopolies that can be a drag on competition (Hall 2007). Furthermore, Heller and Eisenberg (1998), formulate an idea known as the "Tragedy of the Anti-Commons", where we can face an underuse of a resource when there are too many property owners.

In the review of empirical studies, we found that the link between *IPR* and *innovation* is also debatable. Many of the studies that were reviewed (such as Gould-Gruben 1996, and Park-Ginarte 1997), found a definite correlation between *IPR* and *innovation.* However Qian (2007) finds that this link becomes insignificant once he accounts for the fact that different countries have varying degrees of *innovative capacity.*

In our own analysis, we employ a model formulated by Varsakelis (2001), which is very unique as it includes a variable that accounts for differences in national culture. Yet we found that the model lacked robustness as it failed to use panel data and was lacking important variables such as *human capital.* Also we chose to follow Qian's study by controlling for *innovative capacity.* The first step in controlling for this was to limit the sample to only countries that had high levels of *innovative capacity.* In the **Base Model,** results were similar to Varsakelis in that *IPR* and *PDI* were significant determinants of R&D. In the **Base Model with Additions,** *IPR* remains significant, though it has a weaker coefficient. However, *human capital* is found to be the most significant determinant. Once Dummy variables were added to further control for *innovative ability, IPR* continues to diminish as a determinant and *education* strengthens.

The results are consistent with Qian's assessment that *IPR* may not be a causal factor, as it becomes statistically insignificant once *innovative capacity* is accounted for. But as discussed earlier in the paper it must be noted that we might be seeing the effects of statistical mediation. This potential effect, which is caused by the relationship between *IPR* and the control variables is something that should be further considered in a future analysis. Therefore, while our analysis fails to find a statistically significant relationship, we cannot confidentially conclude that *IPR* doesn't have any positive effect on innovation. However, investment in *education (human capital)* is very important in a country's R&D activity and therefore appears to be the most causal factor of *innovation.* We also found that R&D has a strong correlation between other determinants such as *corruption, culture,* and *savings.*

As international pressures increase for countries to modernize and streamline *IPR* regulation, empirical evidence shows that there is no economic consensus on its benefits.

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Appendix 1-Country Legend

Australia	OECD
Austria	OECD
Belgium	OECD
Brazil	BRIC, G20
Canada	OECD, G7, G20, G8
Chile	OECD
China	BRIC, G20
Czech Rep.	OECD
Denmark	OECD
Finland	OECD
France	OECD, G7, G20, G8
Germany	OECD
Greece	OECD
Hong Kong	Non-OECD Asian Tiger
Hungary	OECD
Iceland	OECD
India	BRIC, G20
Ireland	OECD
Israel	OECD
Italy	OECD, G7, G20, G8
Japan	OECD, G7, G20, G8
Korea, Rep.	OECD, G20, Asian Tiger
Luxembourg	OECD
Mexico	OECD
Netherlands	OECD
New Zealand	OECD
Norway	OECD
Poland	OECD
Portugal	OECD
Russia	BRIC, G20, G8
Singapore	Non-OECD Asian Tiger
Slovak Rep.	OECD
Slovenia	OECD
Spain	OECD
Sweden	OECD
Switzerland	OECD
Turkey	OECD
UK	OECD, G7, G20, G8
USA	OECD, G7, G20, G8

Appendix 2-National *PDI* Values

Country	*PDI* Value*
Australia	36
Austria	11
Belgium	65
Brazil	69
Canada	39
Chile	63
China	80
Czech Rep.	57
Denmark	18
Finland	33
France	68
Germany	35
Greece	60
Hong Kong	68
Hungary	46
Iceland	n/a
India	77
Ireland	28
Israel	13
Italy	50
Japan	54
Korea, South	60
Luxembourg	40
Mexico	81
Netherlands	38
New Zealand	22
Norway	31
Poland	68
Portugal	63
Russia	93
Singapore	74
Slovak Rep.	104
Slovenia	n/a
Spain	57
Sweden	31
Switzerland	34
Turkey	66
UK	35
USA	40

*Geert Hofstede Cultural Dimensions. Web. 23 Nov. 2010. <www.geert-hofstede.com/>.

Appendix 3-Variable Legend

RD_t	R&D expenditure (% of GDP)	World Bank
$Open_t$	Trade Openness (Proxy for Economic Openness)	Penn World Tables
$Educ_t$	Education spending (% GDP)(Human Capital Proxy)	World Bank
IP_t	Intellectual Property Index	Fraser Institute
PDI_t	Power Distance Index	Gert Hofstede Cultural Dimentions
CPI_t	Corruption Index	Transparency International
$Ctax_t$	Highest marginal tax rate, corporate rate (%)	World Bank
$Save_t$	Gross savings (% of GDP)	World Bank
GDP_t	GDP in 2000$	World Bank

Appendix 4-Corruption Index

Country	Average Score (2000-2004)*
Finland	9.8
Denmark	9.56
New Zealand	9.48
Iceland	9.36
Singapore	9.26
Sweden	9.24
Netherlands	8.86
Canada	8.86
Norway	8.78
Luxembourg	8.68
Switzerland	8.68
Australia	8.6
UK	8.6
Hong Kong	7.96
Austria	7.94
Germany	7.64
USA	7.62
Chile	7.44
Ireland	7.32
Spain	7.02
Belgium	6.98
Isreal	6.98
Japan	6.9
France	6.74
Portugal	6.38
Slovenia	5.72
Italy	5.08
Hungary	5
Greece	4.38
South Korea	4.3
Czech Rep	4
Brazil	3.94
Poland	3.86
Slovak Rep	3.72
Mexico	3.56
Turkey	3.38
China	3.38
India	2.76
Russia	2.52

*Transparency International. Web. 23 Nov. 2010. <www.transparency.org>.

Appendix 5-Average IPR Score

Country	Average IPR Score (2000-2004)*
USA	8.92
Germany	8.6
UK	8.58
Denmark	8.56
Switzerland	8.52
Finland	8.5
Netherlands	8.44
Australia	8.26
Sweden	8.24
France	8.14
Austria	7.96
Singapore	7.96
Iceland	7.84
Canada	7.72
New Zealand	7.62
Luxembourg	7.38
Belgium	7.36
Norway	7.22
Ireland	6.88
Israel	6.88
Hong Kong	6.86
Japan	6.78
Portugal	6.3
Spain	6.14
Italy	6.08
Slovenia	5.84
Korea, South	5.54
Hungary	5.44
Greece	5.06
Czech Rep.	5
Chile	4.98
Slovak Rep.	4.58
Brazil	4.56
India	4.1
Mexico	4.02
Poland	4
China	3.92
Turkey	3.12
Russia	2.32

*The Economic Freedom of the World Project. Fraser Institute. Web. 23 Nov. 2010. <www.freetheworld.com/>.