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The Impact of Stronger Property Rights in Pharmaceuticals on Innovation in Developed and Developing Countries

By

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Abstract: We use dynamic panel data regressions to investigate whether the strength of a country's patent protection for pharmaceuticals is associated with more pharmaceutical patenting by its residents and corporations in the United States. Using the Pharmaceutical Intellectual Property Protection (PIPP) Index to measure patent strength, we run dynamic probit and Poisson regressions on panels from 25 developing and 41 developed countries over the 1970-2004 period. Results vary, depending on whether we examine partial effects at the mean or average partial effects for the PIPP Index. APEs for the PIPP Index are positive but statistically insignificant in both developed and developing country samples.

1. Introduction

Over the last 30 years, virtually every country has substantially strengthened its patent system. Changes in the patent systems of developing countries have taken place due to changes in the size and structure of their own economies and diplomatic pressure exerted on them by the European Union and the United States. This diplomatic activity culminated in 1995 with the establishment of the World Trade Organization (WTO) and the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which obligated WTO members to substantially strengthen and harmonize patent rights.

There is controversy regarding how stronger patent rights affect innovation and welfare in both developing and developed countries. The conventional economic rationale for stronger patent rights is that they stimulate inventions of new products and technologies (Arrow 1962; Nordhaus 1969; Scherer 1972), promote domestic and foreign investment (Maskus 1998; Javorcik 2004), facilitate technology transfer, and improve the availability of essential medicines (Giacotto et al. 2005; Vernon 2005). The conventional arguments were challenged by the "North-South" general equilibrium models of patent protection in which increases in patent protection in the developing South reduce innovation in the developed North under plausible assumptions and parameter specifications (e.g., Deardorff 1992; Helpman 1993; Grossman and Lai 2004; Parello 2008).[1]

A large empirical literature has arisen to examine the relationship between patent strength and innovation in both developed and developing countries, e.g., Maskus and Yang 2001; Chen and Puttitanun 2005; Allred and Park 2007; Branstetter, Fisman, and

[1] See Park (2008) for a survey of the literature relating stronger IPRs to national and international innovation.

Foley 2006 Branstetter, Fisman, Foley, and Saggi 2011; and Lerner 2002 and 2009. Virtually all papers since the late 1990s have used the Ginarte-Park Patent Index as a measure of the strength of a country's patent system. They have typically acknowledged that patent strength is likely to be endogenous, affected by a country's flow of innovations and its level of economic development, and some have attempted to control for it in their econometric analysis. The use of an index measuring the overall strength of a country's patent system may, however, be less appropriate for studies of innovation in a particular industry if the strength of patent protection for the industry differs substantially from the country's average patent protection or has a different data-generating process. This problem is particularly acute for studies of the pharmaceutical industry, as IPRs protecting pharmaceutical in in both developed and developing countries were, prior to the 1994 TRIPS Agreement, typically much weaker than the patent protection provided to innovations in other industries.

This study focuses on determining whether a country's enactment of stronger protection of pharmaceutical innovations is associated with an increase in grants of U.S. pharmaceutical patents to the country's citizens. To enable us to consider this question, we have developed a new index—the Pharmaceutical Intellectual Property Protection (PIPP) Index—to measure the strength of pharmaceutical patent protection in each country (Liu and La Croix, 2014). For both developing and developed countries, we explicitly model the PIPP Index as an endogenous regressor. We instrument for the PIPP Index using a measure of cumulative U.S. pressure on a country to upgrade its intellectual property laws and/or enforcement. First-stage regressions on the PIPP Index for the developing and developed country samples yield valid instruments. We then estimate dynamic probit and Poisson regressions for each sample, and account for endogeneity of the PIPP Index and unobserved heterogeneity by using a control function approach that incorporates residuals from the first-stage regression and initial values of the dependent variable in the second-stage regression (Wooldridge 2005; Giles and Murtazashvili 2013).

In both the developed and developing country samples, APE estimates for the PIPP Index using dynamic panel probit regressions are positive in specifications with and without interaction variables (between the PIPP Index and log of GDP per capita, secondary education, and openness) but are not statistically significant at the ten percent level. We find a similar pattern of results for APE estimates for the PIPP Index using dynamic panel Poisson regressions on patent counts. APE estimates for the PIPP Index are positive in both developed and developing country samples but are not statistically significant in any specifications at the ten percent level. Partial effects evaluated at the sample means for the developed country sample provide more support for a relationship between the PIPP Index and pharmaceutical invention. Estimated coefficients for an interaction variable between the PIPP Index and secondary education attainment are positive and statistically significant at the five percent level and estimated coefficients for an interaction variable between the PIPP Index and a measure of openness are positive and statistically significant at the ten percent level.

In the developing country samples, APEs for three other covariates—log of GDP per capita, secondary education attainment, and the log of population—are all positive and statistically significant at the ten percent level in specifications with linear and quadratic PIPP Index variables. In the developed country sample, APEs for a measure of openness are positive and statistically significant at the five percent level in specifications with linear and quadratic PIPP Index variables. Placing too much emphasis on estimates of control variables is always to be resisted. Nonetheless, these results point towards links between innovation in pharmaceuticals and the country's innovative capacity, size, and integration with global markets.

2. Literature Review

Until recently, most empirical studies of the effects of stronger patent rights on R&D and patent awards analyzed either firm-level data for a specific country or national data for a sample of developed countries (Comanor and Scherer 1969; Griliches and Mairesse 1984; Goto and Suzuki 1989; Giaccotto et al. 2005; Branstetter et al. 2006). The focus on analyzing data samples from developed countries was due to four factors: (1) The relatively small amount of R&D activity in developing countries; (2) their weak patent laws and facilitating organizations; (3) a lack of reliable data on inputs to and outputs from R&D activities within developing countries; and (4) the absence of a quantitative measure of the scope and strength of each country's patent protection for specific industries.

Ginarte and Park's (1997) index of national patent rights provided researchers with the first comprehensive measure of the strength of a country's patent laws, incorporating variables covering the patent law's scope, the nature of the property rights provided, treatment of foreign applicants and patent holders, and public and private enforcement provisions. The Ginarte-Park Patent Index's coverage of both developing and developed countries facilitated an extension of earlier research on the determinants of R&D and innovative outputs in developed countries to developing countries (Lai and Yan 2007; Chen and Puttitanun 2005). Chen and Puttitanun (2005) found that within their sample of 65 developing countries, increases in the Ginarte-Park Index were negatively related to R&D activity. Allred and Park (2007) studied the relationship between increases in the Ginarte-Park Index and foreign patent filings in the United States. They found that a country's "[p]atent protection has an inverted-U relationship with foreign patent filings (that is, stimulates international diffusion of innovation up to some point) in developed countries, but no significant relationship in developing countries" (p. 895).

A natural extension of these studies is to examine the relationship between patent strength and innovation in industries where patent strength is thought to be essential for innovation to occur, i.e., where product development is lengthy, uncertain, and expensive, and imitation by competitors is quick and cheap. Economists (Taylor and Silberston, 1973; Scherer 1977; Mansfield 1986; Levin et al. 1987; Tocker 1988; DiMasi, Hansen, Grabowski, 2003; Bessen and Meurer, 2008; Adams and Brantner, 2010) have typically put the pharmaceutical industry in this category and have conducted three distinct types of empirical studies to determine whether a relationship between pharmaceutical patent protection and innovation exists and, if so, its magnitude. We briefly survey results from (1) case studies of a single country that examine changes in industry-level innovation measures; (2) regression analysis of pooled cross-sections of matched countries; and (3) panel regression analysis of country-level data using instrumental variables to account for endogeneity and measurement error.

Case studies of the decisions of four countries to provide product patent protection to new pharmaceuticals have found differential effects on pharmaceutical R&D expenditures and patenting activity. Scherer and Weisburst (1995) found that Italy's transition in 1977 to pharmaceutical product patents was not associated with a significant increase in R&D expenditures by domestic pharmaceutical manufacturers. Kawaura and La Croix (1995) found that after Japan's introduction of a pharmaceutical product patent in 1975, Japanese pharmaceutical companies with R&D programs specializing in new products experienced large gains in firm value, while companies with R&D programs specializing in developing and patenting imitative production processes did not. La Croix and Kawaura (1997) found that the introduction of pharmaceutical product patents in Korea in 1986 did not lead to patenting of significant new drugs by Korean pharmaceutical companies and was associated with a 74 percent decline in the value of listed Korean pharmaceutical companies, most of which had R&D activities concentrated on developing new processes to produce existing pharmaceuticals. McFetridge (1997) and Pazderka (1999) found that the introduction of pharmaceutical product patents in 1987 led to statistically significant increases in R&D expenditures by Canadian pharmaceutical companies.

Yi's (2007) analysis of the relationship between pharmaceutical patents and innovation addressed the endogeneity of pharmaceutical patent laws by using Mahalanobis matching methods to create several smaller samples of matched countries. Yi's econometric analysis uses 3-year and 5-year averaged data for 85 countries from 1980 to 1999 to estimate the impact of instituting pharmaceutical product patents on citation-adjusted pharmaceutical product patents awarded to each country's residents by the USPTO. While estimated coefficients on the bivariate product patent variable were statistically insignificant, Yi also found that estimated coefficients for interaction terms between the product patent variable and three covariates—the log of per capita GDP, the log of average years of schooling of the population, and the log of the Frasier Institute's

Economic Freedom of the World Index—were generally positive and sometimes statistically significant at either the 5 or 10 percent level. In other words, the presence of a pharmaceutical product patent in a developed country is associated with more patenting by residents at the USPTO as measures of the country's innovative capacity increase. Yi's results should be viewed with some caution, as her matched data sets fail to meet tests of covariate balancing with respect to control and treated observations, a necessary condition for reliably estimating propensity score matching models.

Another strand of the literature used instrumental variables to try to overcome the bias associated with using OLS to estimate the coefficient on an endogenously-determined measure of patent strength. Maskus and Penubarti (1995) found that an early index of patent protection—the Rapp and Rozek (1990) Index—was endogenously determined. They found a positive relationship between the Rapp-Rozek Index and GNP per capita as well as a more tentative U-shaped relationship between the Rapp-Rozek Index and GNP. Ginarte and Park (1997) and Maskus (2000) provided econometric analyses of the determinants of the Ginarte-Park Patent Index. Ginarte and Park's (1997) central finding from their empirical analysis was that "more developed countries tend to provide stronger [patent] protection" (p. 283). Maskus (2000) extended Ginarte and Park's research by adding more countries to their sample and the square of log GDP per capita to the regression specification. He identified a U-shaped, statistically significant relationship between the log of GDP per capita and the Ginarte-Park Patent Index.[2]

Chen and Puttitanun (2005) built a two-sector open economy model of innovation within a developing country that incorporated quality ladders and product cycles and thereby highlighted the tradeoff faced by firms in developing countries between imitative

[2] Lerner (2002a) found results similar to those in Maskus (2000).

and innovative activities. They tested their model using pooled first-differenced panel data spanning 64 developing countries and six five-year data aggregates covering the 1975-2000 period. A first-stage regression on the Ginarte-Park Patent Index pointed to an inverted U-shaped relationship between GDP per capita and the Ginarte-Park Patent Index. Results from second-stage estimates revealed a positive and often statistically significant relationship between patent strength and innovation, as measured by the number of patents awarded to country residents by the U.S.P.T.O.

Lerner (2009) investigated how 177 major changes in 60 large countries' patent laws between 1850 and 1999 affected the propensity of each country's residents to file patent applications for their inventions in the United Kingdom. His decision to focus on international patenting activity in the United Kingdom was driven by the availability of long data series on patent applications in the United Kingdom as well as by its "relatively constant patent policy" (p. 343). Controlling for changes in the overall propensity to patent over time and using a weighted least squares estimator, Lerner finds that the effect of a positive change in patent protection depends on the country's initial level of patent protection. Countries with weak initial patent protection that implemented a substantial positive change in patent protection had statistically significant (at the five percent level) *increases* in UK patent applications from their researchers, while countries with strong initial patent protection that implemented a positive change had statistically significant (at the five percent level) *decreases* in UK patent applications from their researchers. Instrumenting for changes in patent protection did not appreciably change these results (p. 347).

3. Methodology

For developing and developed country samples, we specify dynamic Poisson models to investigate whether an increase in a country's protection of pharmaceutical innovations is associated with increases in pharmaceutical product patenting. We specify dynamic rather than static models, as our prior knowledge of patenting activity points to the possibility of positive state dependence. We estimate dynamic Poisson regressions using $Patent\_Number_{it}$, a count of the number of pharmaceutical patents issued by the USPTO to residents of country *i* in year *t*. In all regressions, $PIPP_{it}$, our newly-developed index of pharmaceutical property rights, measures the strength and scope of exclusive marketing and patent rights in pharmaceutical inventions. A standard set of four covariates—$Open_{it-1}$, $lnPerCapitaGDP_{it-1}$, $lnPopulation_{it-1}$, and $Secondary\_Education_{it-1}$—are included in each specification to control for country characteristics associated with innovative capacity and trade in patented products. An unobserved time-invariant country effect, μ_i, could be correlated with $PIPP_{it}$, the four covariates, or patent activity, thereby raising endogeneity concerns. Serial correlation in the error term is another source of concern. Each specification includes a set of time dummies (α_t) to control for macroeconomic shocks, clusters standard errors by country *i*, and accounts for heteroskedasticity. All specifications are first estimated with $PIPP_{it-1}$ and then with $PIPP_{it-1}$ and $PIPP_{it-1}^2$, a standard practice in the patenting literature. Variables are discussed in more detail in Section 4. Our samples are two panels of annual data for 41 developing countries and 25 developed countries over the 1985-2005 period.

Our baseline dynamic Poisson specifications for developing and developed countries treat $PIPP_{it-1}$ and $PIPP_{it-1}^2$ as exogenous and provide a basis of comparison for a second set of estimates that instrument for $PIPP_{it-1}$ and $PIPP_{it-1}^2$. We estimate the following regression equation using a random-effects probit estimator:

$$\begin{aligned} Patent\_Number_{it} = {} & \beta_0 + \beta_1 Patent\_Number_{it-1} + \beta_2 PIPP_{it-1} + \beta_3 PIPP_{it-1}^2 \\ & + \beta_4 \ln PerCapita\_GDP_{it-1} + \beta_5 Open_{it-1} + \beta_6 Population_{it} \\ & + \beta_8 Secondary\_Education_{it-1} + \beta_9 Patent\_Number_{i1970} + \alpha_t + \varepsilon_{it} \end{aligned} \tag{1}$$

where $Patent\_Number_{i1970}$ was included to control for initial conditions (Wooldridge, 2005).

Next, we conduct a two-stage estimation that allows for instrumental specifications of $PIPP_{it-1}$ and $PIPP_{it-1}^2$ and uses a control function approach to account both for endogeneity of the PIPP Index and unobserved heterogeneity in the second-stage regression (Wooldridge 2005; Giles and Murtazashvili 2013). Our instrument is a measure of the cumulative pressure imposed by the United States Trade Representative (USTR) on a country with either intellectual property laws or enforcement practices that the USTR evaluated as compromising the intellectual property of U.S. firms and citizens. More detail on this instrument is provided in Section 4. Our first-stage regression (specified in 6) is estimated using pooled OLS, and we experiment with linear, quadratic, and cubic functions of the USTR instrumental variable to account for possible non-linearity in its relationship with the PIPP Index:

$$\begin{aligned} PIPP_{it} = {} & \beta_0 + \beta_1 USTR_{it-1} + \beta_2 USTR_{t-1}^2 + \beta_3 USTR_{t-1}^3 + \beta_4 \ln PerCapita\_GDP_{it-1} \\ & + \beta_5 Open_{it-1} + \beta_8 Secondary\_Education_{it-1} + \alpha_t + \varepsilon_{it} \end{aligned} \tag{2}$$

The second-stage control function follows Wooldridge (2010) and Giles and Murtazashvili (2013) by incorporating the serial-correlation-adjusted residuals from the first-stage, $\hat{v}_{it}$, to control for potential endogeneity, the average serial-correlation-adjusted residual for each country, $\hat{v}_i$, and the initial value of the dependent variable for each country, ($Patent\_Number_{i1970}$), to control for initial conditions:

$$\begin{aligned} Patent\_Number_{it} = \beta_0 + \beta_1 Patent\_Number_{it-1} + \beta_2 PIPP_{it-1} + \beta_3 PIPP^2_{it-1} \\ + \beta_4 \ln PerCapita\_GDP_{it-1} + \beta_5 Open_{it-1} + \beta_6 Population_{it} \\ + \beta_8 Secondary\_Education_{it-1} + \beta_9 Patent\_Number_{i1970} \\ + \alpha_t + \widehat{v_{it}} + \widehat{v_i} + \varepsilon_{it} \end{aligned} \quad (3)$$

We also estimate specifications that include interaction terms between $PIPP_{it-1}$ and $Secondary\_Education_{it-1}$, $Open_{it-1}$, and $lnPerCapita\_GDP_{it-1}$.

Determining the magnitude of state dependence requires calculation of the average partial effect (APE) of the lagged *Patent_Number* variable on the current value of *Patent_Number*. We follow procedures outlined in Wooldridge (2010) and Giles and Murtazashvili (2013) to calculate APEs that are averaged over both the cross-section and time.

We also analyze “patent activity”, i.e., whether country *i* residents in year *t* obtain pharmaceutical patents at the USPTO. $Patent_{it}$ is coded as “zero” when there is no pharmaceutical patent activity at USPTO and “1” when country residents obtain a non-zero number of patents. Our analysis of both the developed and developing country samples proceeds using the same methodology as outlined above, with *Patent* replacing *Patent_Number*, in regression specification (1) and (3). One difference is that for the lagged *Patent* variable, we calculate APEs separately for $Patent_{it-1}$=1 and $Patent_{it-1}$=0, as the mean of this variable is never observed. We report results from the $Patent_{it}$ regressions in the Appendix.

4. Data Description

We have three unbalanced panel data sets covering 25 developed, 41 developing, and 27 least developed countries for the years 1985 to 2004. We follow the United Nations in classifying a country as developed if real GDP per capita was greater than US$10,000 in 2000, developing if between US$900 and US$10,000 and least developed if less than US$900. Table 1 displays summary statistics for each of the data sets. Our discussion of the three samples begins with characterizations of the binary patent measure,

<Table 1 here>

$Patent_{it}$, the patent count measure, $Patent\_Number_{it}$, and the index of pharmaceutical patent protection, $PIPP_{it}$, which is our main focus in the regression analysis.

4.1 $Patent_{it}$

Our measure of a country's pharmaceutical innovation is whether any U.S. pharmaceutical patents are awarded to a country's residents and corporations ($PATENT_{it}$). $PATENT_{it}$ is a standard measure of the source of international innovations that has been widely used by other researchers analyzing cross-country innovation rates as well as innovation in specific industries e.g., Comanor and Scherer (1969), Basberg (1987), Pavitt (1988), Griliches (1990), Chen and Puttitanun (2005), Yi (2007), Allred and Park (2007), and Park (2008). A central reason to use patents issued by a single economy is that the process of patent review and standards for issuing a patent is held constant across applicants from different countries.[3] Our patent data are from a database compiled by the

[3] This assumes that U.S. patent examiners do not discriminate with respect to the nationality of the applicant.

USPTO (2007). We assign a patent application or patent award to the country of residence reported for the first listed applicant.

<Figure 1 here>

Figure 1 provides data on the percentage of countries in our three samples that registered patent activity in the United States over the 1970-2004 period. For the least developed country sample, only 12 of 27 countries ever patent in the United States. India is an outlier, as it showed patent activity from 1970 and received 431 pharmaceutical product patents over the full sample period. Seven of the 12 countries with patenting activity registered less than three pharmaceutical patents over the full period and their patenting was very sporadic. In fact, 95 percent of the country-year cells do not show patent activity. Because the level of innovation is either nonexistent or very low and sporadic in 22 of 27 countries, we do not conduct econometric analysis of this sample.

For the developing country sample, none of the 41 countries exhibited patent activity in 1970, the first year of the sample, compared to 34 in 2004, the last year of the sample. Seventy-eight percent of the country-year cells in this sample do not show patent activity. For the developed country sample, 12 of 25 countries exhibited patent activity in 1970, compared to 24 in 2004.[4] Twenty-three percent of the country-year cells in this sample do not show patent activity.

4.2 $\textit{Number\_Patent}_{it}$

Another measure of pharmaceutical inventions is the number of U.S. pharmaceutical patents awarded to a country's residents and corporations. $\textit{Number\_Patent}_{it}$, is drawn from the same database as $\textit{Patent}_{it}$ and is a standard

[4] Luxembourg and Cyprus each have just one patent grant over the 1970-2004 period, with Luxembourg receiving its patent in 2004 and Cyprus in 1970.

innovation measure that has been widely used by other researchers analyzing cross-country innovation rates as well as innovation in specific industries, e.g., Comanor and Scherer (1969), Basberg (1987), Pavitt (1988), Griliches (1990), Chen and Puttitanun (2005), Yi (2007), Allred and Park (2007), and Park (2008). Figure 2 tracks USPTO pharmaceutical patent awards to residents of developed, developing, and least developed countries. Two outliers, the United States and India, are tracked separately.

The average annual number of U.S. pharmaceutical patent awards to residents of developed countries rose substantially over our sample period, from 21.52 (7.04 w/o US) in 1970, to 84.44 (45.71 w/o US) in 1985, 151.52 (70.29 w/o US) in 1995, and 290.64 (111.79 w/o US) in 2004. The number of U.S. pharmaceutical patents awarded to U.S. residents and corporations greatly exceeded the number awarded to residents in the runner-up country. Compare 1970 (369 to U.S.; 42 to Germany), 1985 (1014 to U.S.; 299 to Japan), 1995 (2101 to U.S.; 495 to Japan) and 2004 (4583 in U.S.; 588 in Japan). Because the United States is an extreme outlier, we exclude the United States from our econometric analysis.

4.3 $PIPP_{it}$

To measure the strength of a country's protection of property rights in pharmaceutical innovations, we use our recently developed Pharmaceutical Intellectual Property Protection ($PIPP_{it}$) Index (Liu 2008; Liu and La Croix 2014). Ranging over the interval [0, 5], $PIPP_{it}$ provides annual data for 154 countries from 1960 to 2005. The PIPP Index is the multiplicative aggregation of three sub-indexes that aggregate particular types of information for each country: (1) the Pharmaceutical Patent Rent Appropriation (PPRA) index which aggregates the range of pharmaceutical innovations for which the country provides intellectual property protection; (2) the Pharmaceutical Patent Enforcement (PPE) Index which aggregates provisions of the country's statute and case law limiting the duration of pharmaceutical patent rights and increasing the ability of a pharmaceutical patent holder to enforce rights; and (3) the Pharmaceutical Patents International Agreements (PPIA) Index which aggregates a country's participation in three international agreements that allow a pharmaceutical innovation developed in one country to receive protection in other member countries.

The PPRA Index aggregates weighted binary variables indicating whether country *i* provided patent or other intellectual property protection for each of five types of pharmaceutical innovation in year *t*: 1) new chemical entities; (2) new pharmaceutical processes; (3) new medical indications for existing pharmaceuticals; (4) new formulations of a medicine, e.g. new dosing schedule, new dosage form, new strength and new time-release variations; and (5) exclusive marketing and patent extensions for orphan drugs, biologics, or pediatric population-tested drugs.

The Pharmaceutical Patents International Agreements (PPIA) Index aggregates binary variables indicating whether country *i* was a signatory to each of three international agreements in year *t*: The Paris Convention of 1883 (and subsequent revisions), the Patent Cooperation Treaty (PCT) of 1970, and the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement of 1995. By participating in international intellectual property rights agreements, signatories indicate a willingness and capacity to provide national, nondiscriminatory treatment to foreign holders of and applicants for intellectual property and to reduce the costs to inventors of filing multiple foreign patent applications.

The Pharmaceutical Patent Enforcement (PPE) Index aggregates binary variables indicating whether the statutory or case law of country i provided for seven measures that either facilitate or impede enforcement of pharmaceutical patents. The enforcement category includes four provisions: (a) preliminary injunctions; (b) contributory infringement pleadings; (c) burden-of-proof reversals; and (d) national exhaustion. We also include two provisions of national patent laws that weaken the rights of patent holders, including (e) working requirements and (f) revocation of patents for non-working.

Table 1 and Figure 3 provide comparisons of the average PIPP Index value for the three sets of countries and the United States, an outlier within the developed country data

<Table 1 and Figure 3 here>

set. From 1960 to 1975, average values of the PIPP Index were very low—less than 0.522—in all three samples. Average PIPP values in developed and least developed countries began to increase in the late 1970s, while those for developing countries did not increase until the United States Trade Representative began to exert pressure in 1986 and the first draft of what would become the TRIPS Agreement circulated among WTO members in 1990. PIPP series for individual countries in each of the three samples monotonically increase over the sample period, with absolute increases being largest in the developed country sample and smaller but about the same in the least developed and developing country samples.

4.3 $USTR_{it}$: U.S. Government Pressure as an Instrument for $PIPP_{it}$

Our candidate for an excluded instrument for $PIPP_{it}$ is the designation of countries by the Office of the U.S. Trade Representative for diplomatic pressure due to weak intellectual property rights. The $USTR_{it}$ variable provides a cumulative measure of pressure from the U.S. government on the foreign country's government to upgrade its IPR statutes to provide additional depth and scope of protection for intellectual property and to devote more resources to public enforcement of these laws. Countries targeted by the USTR for IPR violations are reported in its Special 301 Report, which has been published annually from 1984.[5] The Report lists countries for which the USTR has concluded that the country's IPR statutes and/or enforcement of these statutes fail to meet US standards. USTR pressure tends to have roots in complaints from U.S. firms (and industry associations) holding U.S. patents or other protected intellectual property that are sold, licensed, embodied in their exports, or used in plants of their foreign affiliates. The correspondence between a country's listing in the Special 301 Report and the pressure actually brought to bear by the U.S. government varies somewhat, due to strategic importance, recent favors to the U.S. government, or a small internal market that reduces the value of IPR enforcement by the country to U.S. firms.

The USTR explicitly regards the Special 301 process as an instrument to pressure countries into increasing their levels of patent protection. In 2003, the USTR's stated policy[6] was that it

> … intercede[s] directly in countries where piracy is especially prevalent or governments are exceptionally tolerant of piracy. Among our most effective tools in this effort is the annual "Special 301" review mandated by Congress in the 1988 Trade Act.
>
> This tool has vastly improved intellectual property standards around the world. Publication of the Special 301 list warns a country of our concerns. And it warns potential investors in that country that their intellectual property rights are not likely to be satisfactorily protected. The listing process itself has often helped win improvements in enforcement. In many cases, these actions lead to permanent improvement in the

[5] The USTR did not publish a Special 301 Report in 1988.

[6] USTR, 2004. Fact Sheet: The Work of USTR—Intellectual Property, as quoted in Taylor and Cayford (2004, 372).

> situation. At times, however, we must use the sanction authority granted to us for worst case offenders.

A USTR Special 301 Report listing for a country should be correlated with establishment and strengthening of the country's patent laws due to the U.S. trade sanctions and diplomatic pressure that would otherwise be triggered and the large costs they could impose on the country. A USTR Special 301 listing of a country is, however, unlikely to directly affect the incentives of a foreign country's researchers to develop pharmaceutical innovations except through the indirect channel of the strength of protection provided to pharmaceutical innovations by the country's patent system.

According to the USTR Special 301 Reports, countries with deficient intellectual property rights are grouped in one of four categories, in increasing order of severity: Watch List (WL), Priority Watch List (PWL), Section 306 Monitoring, and Priority Foreign Country (PFC). We code the annual USTR variable as "4" for PFC countries, "3" for Section 306 monitoring countries, 2 for PWL countries, 1 for WL countries and .5 for other observations,[7] and "0" for countries not listed in the annual USTR Special 301 report. Because the PIPP Index is monotonically increasing for all countries in each of the three samples, we infer that effect of USTR pressure leads to permanent increases in the value of the PIPP Index. Thus, as our instrument for the PIPP Index, we use the sum of all previous USTR Special 301 listings of the country. We use a one-year lag to account for the time required for a foreign government to respond to the Special 301 listing, change enforcement practices, and draft and enact new IPR legislation.

4.4. Control Variables

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[7] Before 1998, the USTR categorized some countries in "Other Observations," which was considered less serious than being placed on the Watch List.

We use combinations of four control variables, each lagged one period, in our regressions on $Patent\_Number_{it}$ and $PIPP_{it}$. We use the log of per capita GDP ($lnPerCapita\_GDP_{it-1}$) and log of the country's population ($lnPopulation_{it-1}$) to control for scale effects in innovation, and the percent of the country's population with some secondary education ($Secondary\_Education_{it-1}$)—to control for innovative capacity.[8] We have chosen to use data on educational attainment rather than enrollment due to the development by Lutz et al. (2007) of a sophisticated new data set on educational attainment that covers both developed and developing countries and measures educational attainment much better than the Barro-Lee (2000) data on educational attainment.[9] A standard control for the degree of openness of an economy—total trade volume divided by GDP ($Open_{it-1}$)—is also included, as more open economies are more likely to rely on the import and export of patent-protected intermediates and final goods.

5. Econometric Analysis of Developing Country Sample

5.1 First-Stage Pooled OLS Regressions on $PIPP_{it}$

As described in Section 3, we estimate first-stage regressions on $PIPP_{it}$ with a set of control variables and an instrument, $USTR_{it}$, that measures the cumulative pressure imposed by the Office of the United States Trade Representative on country *i* at time *t* to upgrade its intellectual property laws and enforcement activities. Because of a possible non-linear relationship between $USTR_{it}$ and $PIPP_{it}$, we experiment with linear, quadratic, and cubic functions of the instrument in our estimation of equation (3). We lag the

[8] $PerCapita\_GDP_{it}$ and $Population_{it}$ are from the World Development Indicators (WDI) database.

[9] Ginarte and Park (1997) and Maskus (2000) used secondary school enrollment rates from Barro and Lee (2000).

instrument one period to account for the time required for each country's political process to make adjustments to their pharmaceutical patent laws.

Results from the first-stage equation for developing countries using linear, quadratic, and cubic specifications are reported in Table 2. All three specifications

<Table 2 here>

provide results that are strongly supportive of proposed instruments. All estimated coefficients are positive and statistically significant at least at the ten percent level but for the estimated coefficient on the quadratic term in the cubic specification which is negative and statistically insignificant. These results are consistent with our hypothesis that U.S. pressure on governments of developing countries leads to increases in the PIPP Index. The *F*-statistic for the instruments exceeds the rule of thumb of ten in each of the three specifications, ranging from 21.81 to 39.70 for the six reported values. While the partial R^2 increases somewhat from the linear to the cubic specification, we use the linear specification in second-stage regressions to avoid any confusion regarding the use of non-linear instruments. In addition, estimated coefficients for three of the four covariates in the first-stage regression— $lnOpen_{it-1}$, $lnGDPperCapita_{it-1}$, and $Secondary\_Education_{it-1}$, and—have the expected positive sign, with $Secondary\_Education_{it-1}$ statistically significant at the one percent level in all three specifications. $lnPopulation_{it-1}$ has an unexpected negative sign and is statistically significant at the ten percent level in all three specifications.

5.2. Dynamic Poisson Regressions on $Patent\_Number_{it}$ Treating $PIPP_{it}$ as Exogenous

We estimate dynamic Poisson regressions in which $PIPP_{it-1}$ is treated as exogenous to facilitate comparison with estimates, reported in the next section, in which

$PIPP_{it-1}$ is treated as endogenous. Econometric analysis of patent count data is typically conducted with a Poisson estimator and recent research has used variations of Wooldridge's (2005) method for estimating a dynamic Poisson model with unobserved effects. Wooldridge handles the well-known initial conditions problem by modeling the distribution of the unobserved effects conditional on the dependent variable's initial value and all exogenous regressors. We estimate regressions with initial conditions ("correlated") and without initial conditions ("pure") to see how regression results are affected by the adjustment for unobserved effects. The likelihood function that emerges from this exercise is the Poisson random effects estimator augmented by two additional explanatory variables, the vector of the within-mean of each covariate, $z_i = \frac{1}{N}\sum_{t=1}^{N} z_{it}$, and the initial value of the dependent variable for each country *i* (*Patent_Number*$_{i1985}$). Rabe-Hesketh and Skrondal (2013) identify commonly occurring situations in which Wooldridge's estimator can be severely biased and show how this problem can be remedied by replacing the within-mean in the augmented Poisson regression with

$$\bar{z}_i^{+} = \frac{1}{N-1}\sum_{t=2}^{N} z_{it}.$$

Table 3 reports results from pure (columns 4-6) and correlated (columns 7-9)

<Table 3 here>

random effects Poisson models and, for comparison, from a naïve linear probability model (columns 1-3). Estimated coefficients on *Patent_Number*$_{it-1}$ range between 0.017 and 0.037 and are not statistically significant at the ten percent level in all specifications. Estimated coefficients on $PIPP_{it-1}$ are negative in all specifications except the correlated RE specification with interaction variables (column 6). Estimated coefficients on

$PIPP_{it-1}^2$ are positive and not statistically significant at the ten percent level in all specifications.[10]

Adding interaction variables between control variables and $PIPP_{it-1}$ to the regression yields negative signs on all estimated coefficients for the interaction variables. The estimated coefficients on $PIPP*Open_{it-1}$ in both the pure and correlated RE specifications are statistically significant at the five percent level (column 9). Estimated coefficients on control variables are positive in all specifications, with $lnPerCapita\_GDP_{it-1}$, $Secondary\_Education_{it-1}$, and $lnPopulation_{it-1}$ statistically significant in the correlated RE specifications with $PIPP_{it-1}$ and $PIPP_{it-1}^2$ (column 4).

5.3 Second-Stage Control Function Regressions for Developing Countries

Table 4 reports second-stage control function (CF) estimates for developing countries for a baseline specification (columns 1 and 2) and two specifications that use

<Table 4 here>

combinations of $PIPP_{it-1}^2$ (columns 3 and 4) and three interaction variables with $PIPP_{it-1}$ (columns 5 and 6). All estimates are evaluated at the sample means for all variables. Estimated coefficients on $Patent_{it-1}$ are similar to those reported in Table 3, ranging between 0.015 and 0.028. One notable change in the control function estimates vis-à-vis those reported in Table 3 is that estimated coefficients on $PIPP_{it-1}$ and $PIPP_{it-1}^2$ are positive in all specifications; all are statistically insignificant. None of the estimated coefficients on interaction variables between $PIPP_{it-1}$ and other covariates are statistically significant. Results for estimated coefficients on covariates follow the same general

[10] Estimated coefficients for year dummies (not reported in Table 3) increase substantially over the sample period, from 0.15 in 1977 to 2.94 in 2004.

pattern as estimates (reported in Table 3) made under the assumption that the PIPP Index is exogenous. To sum up our results: The instrumented Poisson regressions do not reveal any evidence of a statistically significant relationship between a country's PIPP Index and the number of pharmaceutical patents received by its residents.

5.4. Average Partial Effects

Calculation of the average partial effects (APEs) of the regression variables on $Patent\_Number_{it}$ allows us to evaluate the magnitude of state dependence in pharmaceutical patenting and to evaluate the effect of $PIPP_{it-1}$ on patenting activity from a second perspective. We follow the methodology set forth in Wooldridge (2010) and Giles and Murtazashvili (2013) for calculating APEs from our two-step estimation results. APEs were averaged across both the cross sections of covariates and time. A bootstrapping approach is employed to generate asymptotic standard errors in all specifications.

Table 5 reports APEs for both pure and correlated RE models. One notable

<Table 5 here>

change from regression results evaluated at the sample means (Table 4) is that the APEs for $Patent\_Number_{it-1}$ (evaluated at the average of $Patent\_Number_{it-1}$) are positive and statistically significant in three specification (columns 3, 4, and 6), thus revealing a degree of state dependence. The magnitudes of the APEs for $PIPP_{it-1}$ vary somewhat, ranging from 0.40 to 0.96; all are statistically insignificant but for the estimated coefficient in the pure RE specification with linear PIPP (column 1) which registers at the ten percent level; we note, however, that statistical significance does not persist into the correlated RE specification (column 2).

APEs for all covariates have the expected positive sign in all six specifications, with $lnPopulation_{it-1}$, $lnPerCapita\_GDP_{it-1}$, and $Secondary\_Education_{it-1}$ statistically significant at least at the ten percent level in pure and correlated specifications using quadratic PIPP variables (columns 3 and 4). Sizeable differences between estimated coefficients in the pure and correlated models are found throughout our results, indicating the importance of accounting for unobserved heterogeneity in this sample. Changes in covariate values have substantial effects on patent counts. A one-standard deviation increase in $lnPopulation_{it-1}$, $lnPerCapita\_GDP_{it-1}$, and $Secondary\_Education_{it-1}$ is associated with increases in the likelihood of pharmaceutical patenting in the United States of 42 percent, 75 percent, and 17 percent, respectively.

Our APE results reveal no evidence that the level of a developing country's PIPP Index has an effect on patenting of new pharmaceutical inventions by its residents. Instead, covariate estimates point to the possibility that pharmaceutical patenting may be more closely associated with the overall capacity of a developing country to engage in innovation as well as the scale of its economy.

6. Dynamic Poisson Regressions on $Patent\_Number_{it}$ in Developed Country Sample

6.1 First-Stage Pooled OLS Regressions on $PIPP_{it}$

First-stage results for regressions on the PIPP Index for the developed country sample are reported in Table 6. Results are supportive of our proposed instruments. In

<Table 6>

the specifications with quadratic and cubic instruments (columns 2 and 3), none of the estimated coefficients for linear or cubic instruments are statistically significant at the ten percent level; the estimated coefficient for the quadratic instrument (column 2) is negative and statistically significant at the ten percent level. In the specification with only a linear instrument (column 1), the estimated coefficient on the instrument is negative and statistically significant at the one percent level. The *F*-statistic on the instrumental variable is more than the rule of thumb of 10 in all three specifications. While the partial R^2 increases somewhat from the linear to the cubic specification, we use the linear specification in second-stage regressions because the estimated coefficient on the linear instrument is statistically significant and this enables us to avoid any confusion regarding the use of non-linear instruments.

In addition, estimated coefficients for three of the four covariates in the first-stage regression—$lnPopulation_{it-1}$, $lnGDPperCapita_{it-1}$, and $Secondary\_Education_{it-1}$,—have the expected positive sign, with $lnGDPperCapita_{it-1}$ statistically significant at the one percent level in all three specifications and $lnPopulation_{it-1}$ statistically significant at least at the ten percent level in all three specifications. The estimated coefficient on $lnOpen_{it-1}$ has a negative sign but is statistically insignificant in all three specifications.

6.2. Dynamic Poisson Regressions on $Patent\_Number_{it}$ Treating $PIPP_{it}$ as Exogenous

We follow the same methodology for analyzing patent counts in the developed country sample as in the developing country sample. We begin by estimating dynamic Poisson regressions in which $PIPP_{it-1}$ is treated as exogenous and all estimates are evaluated at the sample means.[11] Results are reported in Table 7. Little state dependence

<Table 7>

[11] We also estimated a parallel set of dynamic probit regressions on $Patent_{it}$. See Appendix Tables 1-6.

can be detected in any of the specifications; estimated coefficients on $Patent\_Number_{it-1}$ are all positive but none register statistical significance. Estimated coefficients on $PIPP_{it-1}$ vary in sign but do not reach statistical significance in any specification; and estimated coefficients on $PIPP_{it-1}^2$ are all negative and statistically insignificant. When we include interaction terms between $PIPP_{it-1}$ and $lnPerCapita\_GDP_{it-1}$, $Open_{it-1}$, and $Secondary\_Education_{it-1}$ (columns 5 and 6), the estimated coefficients on $Secondary\_Education_{it-1}$ are positive and statistically significant at the five percent level; other estimated coefficients for interaction variables are statistically insignificant. These results support the conclusion that the PIPP Index has bigger effects on pharmaceutical patenting in developed countries with more human capital.

Twenty of twenty-four estimated coefficients for the four control variables ($lnPerCapita\_GDP_{it-1}$, $Secondary\_Education_{it-1}$ $Open_{it-1}$, and $Population_{it-1}$) are positive, with $lnPerCapita\_GDP_{it-1}$ and $Population_{it-1}$ statistically significant at the ten percent level in the correlated RE specifications without interaction variables (columns 1-4). Accounting for unobserved heterogeneity has little effect on estimates, which are similar in both pure and correlated specifications,

6.3 Second-Stage Control Function Regressions for Developed Countries

Table 8 reports second-stage control function (CF) estimates for developed countries for a baseline specification (columns 1 and 2) and two specifications using

<Table 8 here>

combinations of $PIPP_{it-1}^2$ (columns 3 and 4) and three interaction variables with $PIPP_{it-1}$ (columns 5 and 6). All estimates are evaluated at the sample means for all variables. The pattern of signs and statistical significance for estimated coefficients on $Patent_{it-1}$, $PIPP_{it-}$

$_1$, *and* $PIPP_{it-1}{}^2$ is very similar to the pattern reported in Table 7. None of the estimated coefficients on these three variables are statistically significant at the ten percent level.

In the control function regressions, $PIPP_{it\text{-}1}{*}Secondary\_Education_{it-1}$ retains the positive sign and statistical significance seen in the "exogenous PIPP" regressions. $PIPP_{it-1}{*}Open_{it-1}$ is statistically significant at the ten percent level in the pure RE specification (column 5) but the statistical significance disappears in the correlated RE specification (column 6). These results support the conclusion that the PIPP Index has bigger effects on pharmaceutical patenting in developed countries with more human capital.

Signs on estimated coefficients on the four control variables are exactly the same as those in the regressions estimated under the assumption that the PIPP Index is exogenous. The pattern of statistical significance is somewhat different. While $lnPopulation_{it}$ continues to be significant at the ten percent level, $lnPerCapita\_GDP_{it-1}$ loses significance in all specifications and $Open_{it-1}$ becomes significant at the five percent level in specifications without interaction variables (columns 1-4).

6.4. Average Partial Effects

Table 9 reports calculations of APEs for each of variables in the six Poisson regression specifications. APEs for each variable vary very little across the six specifications. Estimated coefficients for *Patent_Number* are all positive but never approach statistical significance. State dependence in pharmaceutical patenting is, surprisingly, absent. Estimated coefficients on $PIPP_{it-1}$ vary in sign across specifications but never reach statistical significance. As in the developing country sample, our APEs estimates provide no evidence that stronger pharmaceutical patent rights are associated with more patenting by country residents in the world's leading market for pharmaceuticals, the United States.

APEs for the four covariates—$Secondary\_Education_{it-1}$, $lnPopulation_{it}$-*1*, $lnPerCapita\_GDP_{it-1}$, and $Open_{it-1}$—are positive in all specifications, with $Open_{it-1}$ statistically significant in specifications without interaction variables. In the pure RE specification with a linear PIPP Index (column 1) $lnPopulation_{it-1}$ is statistically significant at the ten percent level, but the statistical significance does not persist into the correlated RE specification (column 2). Unlike the covariate results from the developing country sample, where increases in a country's innovative capacity and scale possibly point to more patenting of pharmaceutical inventions, covariate results for developed countries leave fewer tea leaves for future researchers to read.

8. Conclusion

We used dynamic panel Poisson regressions to investigate whether the strength of a country's patent protection for pharmaceuticals is associated with more pharmaceutical patenting by its residents and corporations in the United States. For the developing country sample, we found no evidence for a relationship between the PIPP Index and pharmaceutical patent counts for either partial effects evaluated at the sample means or average partial effects. For the developed country sample, we found different results for partial effects and APEs. In the control function estimates evaluated at the sample means, estimated coefficients on two interaction variables—$PIPP_{it\text{-}1}$ *$Secondary\ \_Education_{it-1}$ and $PIPP_{it-1}$*$Open_{it-1}$—have positive signs and are statistically significant at the five percent level (Table 8). These results support the conclusion that the PIPP Index has a positive effect on pharmaceutical patenting that is magnified when countries have more human capital and more open economies. However, the APEs for the PIPP Index tell a different story. Although the APEs are positive in all six specifications, they never reach statistical significance (Table 9).

In many ways, the results are not surprising. Studies using both contemporary and historical data typically have found little connection between patent strength and innovation (Bessen and Meuer, 2008/2009). Regardless, one would think *a priori* that the pharmaceutical industry would an exception. Surveys of industry R&D managers identify the pharmaceutical and chemical industries as ones that require patent protection for innovation to be undertaken (Levin *et al.*, 1987; Mansfield, 1994; Cohen *et al.*, 2000). Given our study's results, perhaps the importance of pharmaceutical patent rights to the industry is to be found in their effects on other variables affecting firm value besides innovation. In the context of the nineteenth-century United States, Lamoreaux and Sokoloff (1999) showed that establishment of property rights in new products via patenting allowed inventors to contract with firms that had comparative advantages in production and marketing of new products. We note that small pharmaceutical firms that have developed new drugs have frequently sold their product and/or their firm to larger pharmaceutical firms with larger production and distribution networks. Patent rights could also be important for trade, foreign direct investment, and technology licensing. Yang and Maskus's (2009) general equilibrium model shows how both developed and developing countries can both gain from stronger patent rights if this facilitates technology licensing. The development of the PIPP Index should facilitate future research on these topics for the pharmaceutical industry.

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Table 1. Descriptive Statistics: Mean and Standard Deviation, 1985-2004

	All Countries	Developed Countries	Developing Countries	Least Developed Countries
PIPP [0-5]	0.97 (0.89)	1.51 (1.05)	0.67 (0.69)	0.91 (0.76)
Patent [0,1]	0.32 (0.47)	0.77 (0.42)	0.22 (0.41)	0.07 (0.25)
Number_Patent [0, 6504]	39.15 (291.92)	143.38 (549.87)	1.06 (3.72)	0.49 (4.90)
PerCapita_GDP (2000 US dollars)	6,442 (8,717)	18,008 (8,210)	2,674 (1,607)	374 (212)
Population (millions)	47.75 (144.73)	33.27 (52.59)	49.24 (168.97)	59.14 (161.45)
Tertiary_Education [0-1]	0.15 (0.19)	0.23 (0.21)	0.15 (0.18)	0.07 (0.12)
Secondary_Education [0-1]	0.34 (0.23)	0.53 (0.21)	0.34 (0.19)	0.15 (0.15)
Open [0-	0.51 (0.37)	0.62 (0.54)	0.52 (0.31)	0.40 (0.18)
USTR [0-4 values]	0.22 (0.58)	0.18 (0.46)	0.32 (0.67)	0.11 (0.49)
USTR_Cumulative [Cumulative Values]	1.67 (4.63)	1.55 (3.76)	2.32 (5.39)	0.78 (3.89)
Observations	3255	875	1435	945

Table 2. Determinants of the PIPP Index (First Stage): Developing Countries, 1985-2004

	(1) Model 1	(2) Model 2	(3) Model 3
lnPerCapita_GDP $_{i, t-1}$	0.053	0.00062	-0.031
	(0.16)	(0.15)	(0.16)
lnPopulation $_{i, t-1}$	-0.72*	-0.72*	-0.78*
	(0.44)	(0.43)	(0.44)
Secondary_Education $_{i, t-1}$	1.00***	0.99***	1.11***
	(0.36)	(0.35)	(0.36)
Open $_{i, t-1}$	0.20	0.21	0.21
	(0.16)	(0.16)	(0.16)
USTR_Cumulative $_{i, t-1}$	0.031***	0.017*	0.039**
	(0.0049)	(0.0097)	(0.017)
USTR_Cumulative $_{i, t-1}^2$		0.00059*	-0.0015
		(0.00030)	(0.0012)
USTR_Cumulative $_{i, t-1}^3$			0.000046*
			(0.000025)
Observations	700	700	700
R^2	.614	.616	.618
F-Statistic on IVs with Averages	39.04	29.50	21.81
F-Statistic on IVs w/o Averages	39.70	30.92	22.66
Partial R^2, IVs with Averages	0.029	0.031	0.033
Partial R^2, IVs w/o Averages	.0.029	0.031	0.032

Note: Fully robust standard errors are in parentheses [*** p<0.01, ** p<0.05, * p<0.1]. All regressions include time averages of the explanatory variables and year dummies.

Table 3. Dynamic Poisson Estimates of Number of U.S. Pharmaceutical Patents Awarded to Country *i* Residents at Time *t* with PIPP Index Treated as Exogenous: Developing Countries, 1985-2005

	(1) Pure RE	(2) Correlated RE	(3) Pure RE	(4) Correlated RE	(5) Pure RE	(6) Correlated RE
Patent_Number $_{i,\,t-1}$	0.037 (0.070)	0.036** (0.015)	0.033 (0.071)	0.032 (0.070)	0.024 (0.081)	0.017 (0.081)
PIPP $_{i,\,t-1}$	-0.0042 (0.10)	-0.025 (0.10)	-0.68 (0.67)	-0.71 (0.66)	-0.24 (0.78)	0.26 (0.75)
PIPP $_{i,\,t-1}^{2}$			0.20 (0.72)	0.20 (0.71)	0.19 (0.18)	0.19 (0.20)
PIPP*lnPerCapita_GDP$_{i,\,t-1}$					-0.0028 (0.33)	-0.052 (0.30)
PIPP*Secondary_Education $_{i,\,t-1}$					-0.53 (0.68)	-0.76 (0.77)
PIPP*Open $_{i,\,t-1}$					-0.62** (0.30)	-0.84** (0.41)
lnPerCapita_GDP $_{i,\,t-1}$	1.38*** (0.24)	1.28*** (0.33)	1.37*** (0.31)	1.28*** (0.34)	1.28*** (0.47)	1.12** (0.46)
lnPopulation $_{i,\,t-1}$	0.76*** (0.15)	0.74*** (0.14)	0.76*** (0.15)	0.74*** (0.14)	0.74*** (0.13)	0.71*** (0.15)
Secondary_Education $_{i,\,t-1}$	2.97* (1.68)	2.69* (1.57)	3.55 (2.19)	3.28* (1.94)	2.95 (1.79)	2.38 (1.56)
Open $_{i,\,t-1}$	0.59 (0.49)	0.39 (0.49)	0.49 (0.56)	0.29 (0.59)	1.34** (0.65)	1.31* (0.71)
Patent_Number_1985$_{i}$		0.10 (0.10)		0.10 (0.18)		0.16 (0.14)
Intercept	-25.5*** (4.99)	-24.4*** (4.25)	-25.4*** (4.59)	-24.4*** (4.17)	-24.5*** (4.76)	-22.9*** (4.77)
N	700	700	700	700	700	700
Rep. for Boot Strap Errors	100	100	100	100	100	100

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. Dynamic Poisson Estimates of Number of U.S. Pharmaceutical Patents Awarded to Country *i* Residents at Time *t* with PIPP Index Treated as Endogenous: Developing Countries, 1985-2005

	(1) Pure RE	(2) Correlated RE	(3 Pure RE	(4) Correlated RE	(5) Pure RE	(6) Correlated RE
Patent_Number $_{i,\ t-1}$	0.028 (0.022)	0.027 (0.021)	0.025 (0.029)	0.024 (0.030)	0.021 (0.023)	0.015 (0.024)
PIPP $_{i, t-1}$	0.85 (0.52)	0.84 (0.73)	0.054 (0.68)	0.080 (0.79)	0.11 (1.89)	0.55 (3.00)
PIPP $_{i, t-1}^2$			0.19 (0.18)	0.19 (0.21)	0.13 (0.16)	0.13 (0.17)
PIPP*lnPerCapita_GDP $_{i, t-1}$					0.058 (0.24)	0.011 (0.36)
PIPP*Sec_Education $_{i, t-1}$					-0.72 (0.84)	-0.92 (0.93)
PIPP*Open $_{i, t-1}$					-0.34 (0.32)	-0.55 (0.37)
lnPerCapita_GDP $_{i, t-1}$	0.99** (0.43)	0.89* (0.46)	1.03*** (0.38)	0.94** (0.39)	0.92** (0.40)	0.82* (0.42)
lnPopulation $_{i, t-1}$	0.67*** (0.16)	0.65*** (0.14)	0.67*** (0.14)	0.66*** (0.19)	0.65*** (0.16)	0.63*** (0.18)
Secondary_Education $_{i, t-1}$	2.48 (1.85)	2.11 (1.70)	3.11* (1.80)	2.75 (1.67)	2.94* (1.68)	2.40 (1.63)
Open $_{i, t-1}$	0.50 (0.53)	0.21 (0.59)	0.39 (0.54)	0.12 (0.75)	0.74 (0.78)	0.70 (0.97)
Patent_Number_1985$_i$		0.12 (0.29)		0.12 (0.26)		0.15 (0.25)
_cons	-12.0*** (3.81)	-11.1*** (4.00)	-12.2*** (3.36)	-11.4*** (3.32)	-11.4*** (3.52)	-10.5*** (3.59)
Observations	658	658	658	658	658	658
Rep. for Boot Strap Errors	100	100	100	100	100	100

Note: Fully robust standard errors are in parentheses [*** *p*<0.01, ** *p*<0.05, * *p*<0.1]. All regressions include year dummies.

Table 5. Average Partial Effects of Determinants of *$Patent\_Number_{it}$* for Developing Countries, 1985-2004

	W/o interaction variables		With PIPP and PIPP^2		With interaction variables	
	Pure RE	Correlated RE	Pure RE	Correlated RE	Pure RE	Correlated RE
$Patent\_Number_{i, t-1}$	0.032 (0.023)	0.032 (0.022)	0.025** (0.028)	0.025** (0.027)	0.022 (0.027)	0.018*** (0.021)
$PIPP_{it-1}$ (at mean)	0.92* (0.55)	0.96 (0.72)	0.42 (0.55)	0.51 (0.59)	0.40 (0.69)	0.45 (0.56)
$lnPerCapita\_GDP_{it-1}$	1.02** (0.44)	0.87* (0.48)	1.03*** (0.36)	0.87** (0.44)	0.98*** (0.32)	0.73* (0.44)
$lnPopulation_{it-1}$	0.67*** (0.18)	0.59*** (0.18)	0.67*** (0.15)	0.59*** (0.18)	0.65*** (0.19)	0.53*** (0.21)
$Secondary\_Education_{it-1}$	2.38 (1.92)	2.17 (1.55)	3.11* (1.81)	2.88* (1.70)	2.26 (2.17)	1.88 (1.80)
$Open_{it-1}$	0.50 (0.53)	0.35 (0.51)	0.39 (0.53)	0.24 (0.55)	0.41 (0.65)	0.27 (0.65)
$Patent\_Number\_1985_i$		1.06** (0.49)		1.15*** (0.51)		1.45*** (0.54)
Observations	658	658	658	658	658	658
Replications for Boot Strap Errors	100	100	100	100	100	100

Bootstrapped standard errors are in parentheses for developing countries [* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$]. The APEs are averaged across both the cross section of the covariates and time.

Table 6. Determinants of the PIPP Index (First Stage): Developed Countries, 1985-2004

	(1)	(2)	(3)
lnPerCapita_GDP $_{it-1}$	0.94***	0.97***	1.06***
	(0.33)	(0.33)	(0.34)
lnPopulation $_{it-1}$	1.43**	1.23*	1.26*
	(0.72)	(0.72)	(0.73)
Secondary_Education $_{it-1}$	0.083	0.099	0.080
	(0.36)	(0.36)	(0.36)
Open $_{it-1}$	-0.36	-0.38	-0.39
	(0.29)	(0.29)	(0.30)
USTR_Cumulative $_{it-1}$	-0.022***	-0.0015	-0.030
	(0.0044)	(0.013)	(0.025)
USTR_Cumulative $_{it-1}^2$		-0.0013*	0.0034
		(0.00066)	(0.0032)
USTR_Cumulative $_{it-1}^3$			-0.00017
			(0.00011)
Observations	442	442	442
R^2	.702	.796	.796
F-Statistic on IVs with Averages	16.74	19.85	15.72
F-Statistic on IVs w/o Averages	24.74	22.10	16.79
Partial R^2, IVs with Averages	.008	.009	.010
Partial R^2, IVs w/o Averages	.006	.007	.008

Notes: Fully robust standard errors are in parentheses [*** p<0.01, ** p<0.05, * p<0.1]. All regressions include time averages of the explanatory variables and year dummies.

Table 7. Dynamic Poisson Estimates of Number of U.S. Pharmaceutical Patents Awarded to Country *i* Residents at Time *t* with PIPP Index Treated as Exogenous: Developed Countries, 1985-2005

	(1) Pure RE	(2) Correlated RE	(3) Pure RE	(4) Correlated RE	(5) Pure RE	(6) Correlated RE
Patent_Number $_{i, t-1}$	0.00011	0.00012	0.00020	0.00020	0.00041	0.00042
	(0.0080)	(0.0080)	(0.0081)	(0.0081)	(0.0086)	(0.0049)
PIPP $_{i, t-1}$	-0.16	-0.16	0.35	0.34	0.50	0.43
	(2.18)	(2.18)	(2.65)	(2.65)	(4.43)	(4.51)
PIPP $_{i, t-1}^2$			-0.12	-0.12	-0.00061	-0.0075
			(0.15)	(0.15)	(0.26)	(0.11)
PIPP*lnPerCapita_GDP $_{i, t-1}$					-0.16	-0.15
					(0.54)	(0.44)
PIPP*Secondary_Education $_{i, t-1}$					1.27**	1.21**
					(0.62)	(0.60)
PIPP*Open $_{i, t-1}$					0.99	0.99
					(0.92)	(0.64)
lnPerCapita_GDP $_{i, t-1}$	2.14*	2.17*	2.05*	2.08*	1.31	1.36
	(1.15)	(1.15)	(1.15)	(1.15)	(1.17)	(1.21)
lnPopulation $_{i, t-1}$	4.25*	4.36*	4.16	4.28*	2.77	3.12*
	(2.36)	(2.35)	(2.37)	(2.35)	(2.43)	(2.05)
Secondary_Education $_{i, t-1}$	0.69	0.67	0.64	0.63	-1.94	-1.84
	(1.10)	(1.10)	(1.10)	(1.10)	(1.32)	(1.60)
Open $_{i, t-1}$	1.75	1.75	1.62	1.61	-1.46	-1.45
	(1.13)	(1.13)	(1.13)	(1.13)	(1.30)	(1.91)
Patent_Number_1985 $_i$		-0.038		-0.037		-0.022
		(0.064)		(0.063)		(0.04)
Intercept	-85.9*	-87.4*	-84.0*	-85.7*	-52.8*	-58.3*
	(45.96)	(45.73)	(46.02)	(45.77)	(27.12)	(30.2)
N	442	442	442	442	442	442
Reps for Boot Strap Errors	100	100	100	100	100	100

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8. Dynamic Poisson Estimates of Number of U.S. Pharmaceutical Patents Awarded to Country *i* Residents at Time *t* with PIPP Index Treated as Endogenous: Developed Countries, 1985-2005

	(1) Pure RE	(2) Correlated RE	(3) Pure RE	(4) Correlated RE	(5) Pure RE	(6) Correlated RE
Patent_Number $_{i,\ t-1}$	0.000016	0.00017	0.000023	0.00026	0.00037	0.00042
	(0.0006)	(0.00048)	(0.00049)	(0.00046)	(0.00041)	(0.00043)
PIPP $_{i,\ t-1}$	0.28	0.27	0.98	0.97	0.59	0.43
	(1.01)	(0.88)	(0.95)	(0.90)	(4.19)	(4.74)
PIPP $_{i,\ t-1}^{2}$			-0.12	-0.12	0.02	0.0034
			(0.10)	(0.12)	(0.12)	(0.13)
PIPP*lnPerCapita_GDP $_{i,\ t-1}$					-0.15	-0.14
					(0.37)	(0.45)
PIPP*Sec_Education $_{i,\ t-1}$					1.43**	1.26**
					(0.58)	(0.63)
PIPP*Open $_{i,\ t-1}$					0.92*	0.93
					(0.50)	(0.76)
lnPerCapita_GDP $_{i,\ t-1}$	1.75	1.78	1.50	1.55	1.16	1.28
	(0.93)	(1.14)	(1.28)	(1.05)	(1.37)	(1.21)
lnPopulation $_{i,\ t-1}$	3.83*	3.97*	3.67*	3.86*	2.29*	2.67**
	(2.32)	(2.35)	(2.27)	(2.15)	(1.18)	(1.10)
Secondary_Education $_{i,\ t-1}$	0.59	0.56	0.59	0.49	-2.38	-2.06
	(0.81)	(0.67)	(0.61)	(0.72)	(1.78)	(1.71)
Open $_{i,\ t-1}$	1.74**	1.74**	1.65**	1.65**	-1.33	-1.34
	(0.86)	(0.77)	(0.75)	(0.79)	(1.12)	(2.25)
Patent_Number_1985$_i$		-0.033		-0.032		-0.016
		(0.035)		(0.030)		(0.014)
_cons	-22.48***	-23.1**	-22.53*	-21.3**	-14.61	-13.7
	(6.72)	(10.4)	(11.02)	(9.62)	(11.03)	(11.4)
Observations	442	442	442	442	442	442
Reps for Boot Strap Errors	100	100	100	100	100	100

Note: Fully robust standard errors are in parentheses [*** p<0.01, ** p<0.05, * p<0.1]. All regressions include year dummies.

Table 9. Average Partial Effects of Determinants of *$Number\_Patent_{it}$* for Developed Countries, 1985-2004

	W/o interaction variables		With PIPP and PIPP^2		With interaction variables	
	Pure RE	Correlated RE	Pure RE	Correlated RE	Pure RE	Correlated RE
$Patent\_Number_{i,\ t-1}$	0.000016	0.00017	0.000023	0.00025	0.00039	0.00037
	(0.0007)	(0.0005)	(0.00049)	(0.00045)	(0.00041)	(0.00040)
$PIPP_{it-1}$ (at mean)	0.29	0.27	0.44	0.47	0.34	0.37
	(0.82)	(0.97)	(0.57)	(0.68)	(0.79)	(1.27)
$lnPerCapita\_GDP_{it-1}$	1.74	1.78	1.61	1.50	0.90	0.83
	(1.47)	(1.24)	(1.19)	(1.17)	(1.10)	(1.44)
$lnPopulation_{it-1}$	3.83*	3.97*	3.70	3.68	2.08	1.29
	(2.31)	(2.18)	(2.49)	(2.58)	(1.27)	(0.95)
$Secondary\_Education_{it-1}$	0.58	0.56	0.51	0.51	0.53	0.53
	(0.75)	(0.76)	(0.79)	(0.80)	(0.70)	(0.78)
$Open_{it-1}$	1.74*	1.74**	1.67**	1.66**	0.56	0.63
	(1.02)	(0.73)	(0.58)	(0.76)	(0.98)	(1.31)
$Patent\_Number\_1985_i$		-0.038		0.26		2.59
		(0.038)		(3.27)		(1.45)
Observations	442	442	442	442	442	442
Reps for Boot Strap Errors	100	100	100	100	100	100

Bootstrapped standard errors are in parentheses for developing countries [* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$]. The APEs are averaged across both the cross section of the covariates and time.

Figure 1. Percent of Countries Registering Patent Activity in the United States: Developed, Developing, and Least Developed Country Samples, 1970-2004

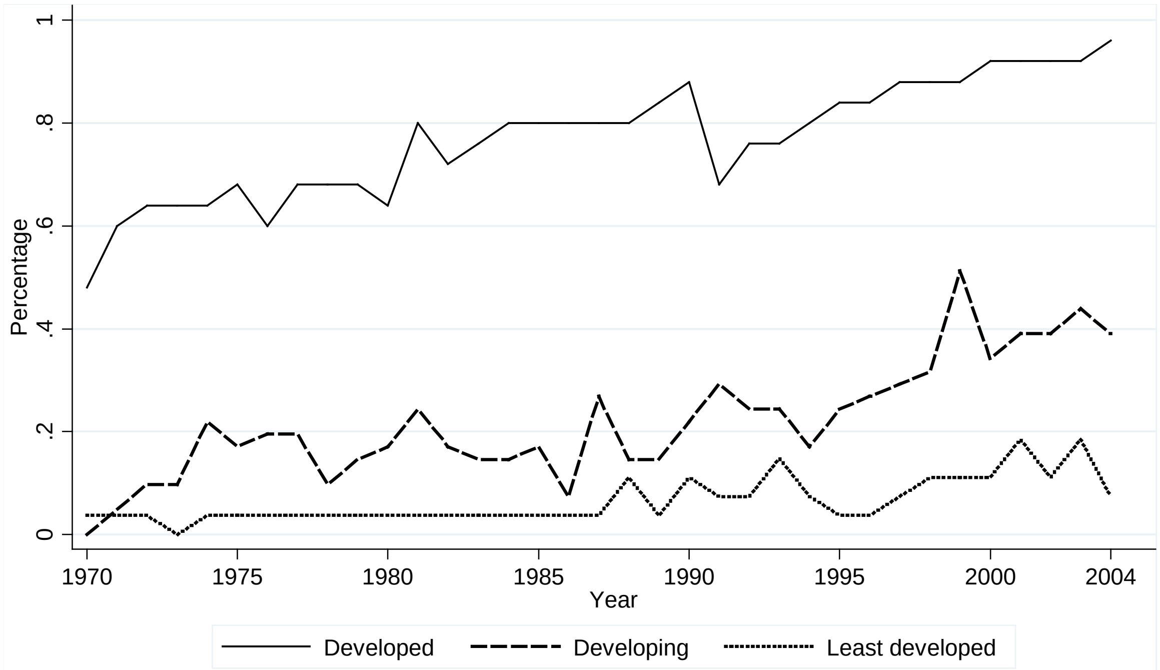


Figure 2. Number of Pharmaceutical Patents Awarded by USPTO: Developed, Developing, and Least Developed Country Samples, 1970-2004

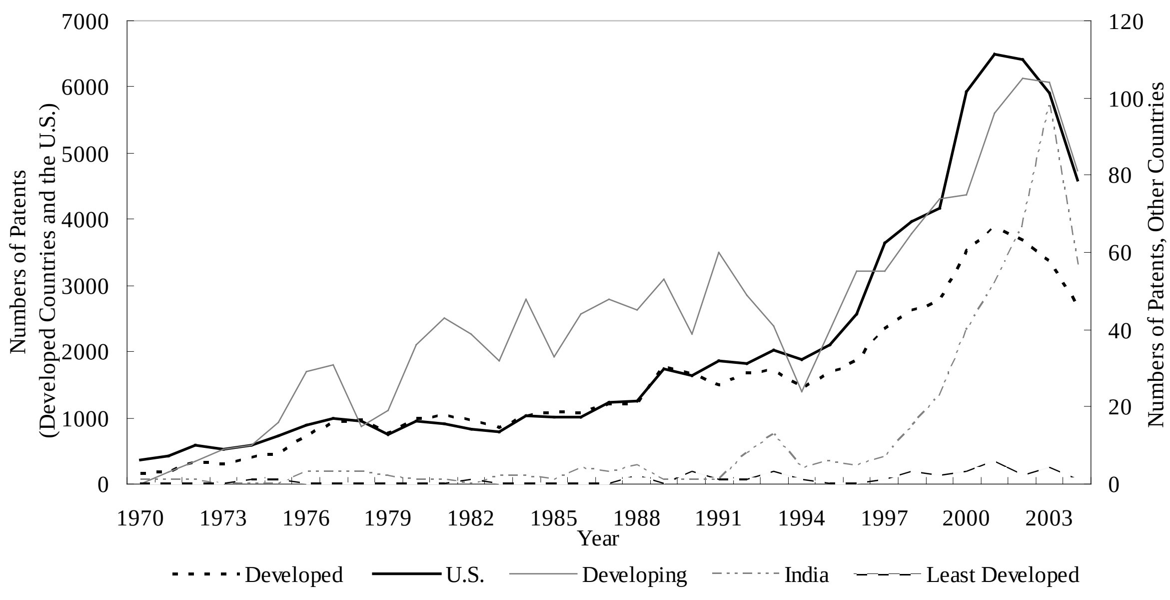
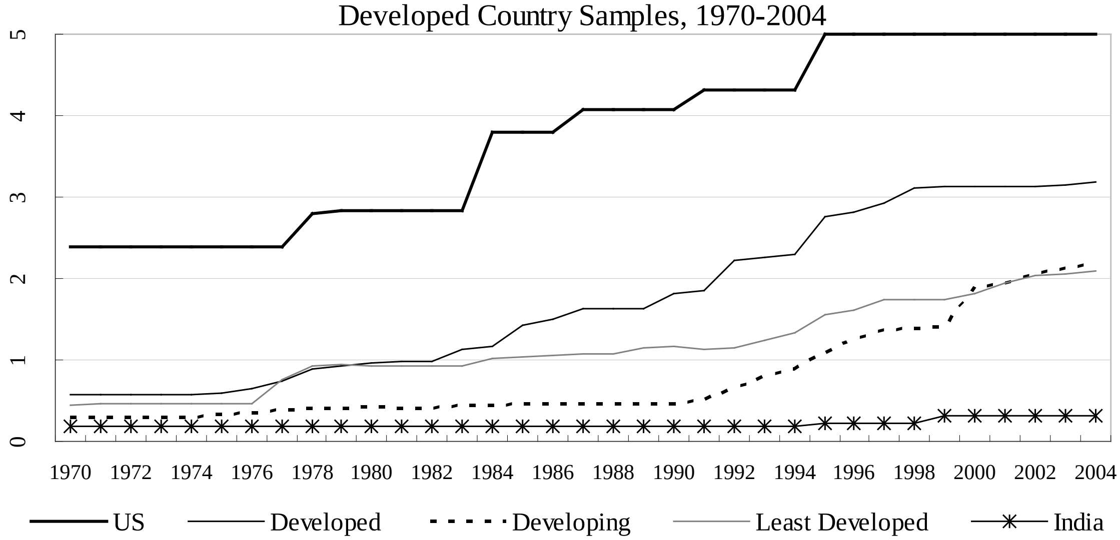


Figure 3. Average PIPP Index: Developed, Developing and Least Developed Country Samples, 1970-2004



Appendix Table 1. Dynamic Probit Estimates of *Patent*$_{it}$ with PIPP Index Treated as Exogenous: Developing Countries, 1985-2004

	Linear Probability Model			Probit, Pure Random Effects			Probit, Correlated Random Effects		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Patent $_{i, t-1}$	1.03***	1.01***	0.88***	0.44**	0.39*	0.41**	0.44**	0.39*	0.41**
	(0.15)	(0.15)	(0.15)	(0.19)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
PIPP $_{i, t-1}$	-0.13	-0.45	0.55	-0.10	-0.87	0.11	-0.16	-0.91*	0.34
	(0.12)	(0.32)	(1.15)	(0.19)	(0.53)	(1.74)	(0.20)	(0.52)	(1.73)
PIPP $_{i, t-1}^2$		0.14	0.075		0.32	0.060		0.31	0.050
		(0.12)	(0.14)		(0.21)	(0.24)		(0.20)	(0.23)
PIPP*lnPerCapita_GDP $_{i, t-1}$			0.0014			0.043			0.019
			(0.15)			(0.22)			(0.21)
PIPP*Sec_Education $_{i, t-1}$			-1.28**			-1.42*			-1.59*
			(0.60)			(0.84)			(0.87)
PIPP*Open $_{i, t-1}$			-0.96***			-0.61			-0.74**
			(0.29)			(0.38)			(0.38)
lnPerCapita_GDP $_{i, t-1}$	-0.36	-0.43	-0.47	0.97***	1.00***	0.98***	0.00015	-0.039	-0.23
	(0.49)	(0.49)	(0.49)	(0.27)	(0.29)	(0.33)	(0.63)	(0.66)	(0.66)
lnPopulation $_{i, t-1}$	-1.51	-1.68	-2.28	0.50***	0.50***	0.50***	-1.45	-1.58	-2.15
	(1.57)	(1.60)	(1.59)	(0.10)	(0.10)	(0.097)	(1.48)	(1.50)	(1.50)
Secondary_Education $_{i, t-1}$	2.19	2.42*	2.99*	1.53*	1.76*	2.40**	2.06*	2.27*	3.06**
	(1.34)	(1.39)	(1.59)	(0.89)	(0.93)	(1.13)	(1.24)	(1.27)	(1.42)
Open $_{i, t-1}$	0.78	0.69	1.44**	0.47	0.39	1.00	1.17*	1.06*	1.44*
	(0.50)	(0.49)	(0.56)	(0.43)	(0.45)	(0.63)	(0.63)	(0.64)	(0.74)
Patent_Status_1985$_i$	0.79***	0.81***	0.77***				1.29***	1.36***	1.20***
	(0.16)	(0.16)	(0.16)				(0.42)	(0.44)	(0.39)
Observations	700	700	700	700	700	700	700	700	700
R^2	.420	.423	.443						

Note: Fully robust standard errors in parentheses [*** *p*<0.01, ** *p*<0.05, * *p*<0.1]. All regressions include year dummies.

Appendix Table 2. Dynamic Probit Estimates of *Patent*$_{it}$ with PIPP Index Treated as Endogenous: Developing Countries, 1985-2004

	(1)	(2)	(3)	(4)
Patent $_{i, t-1}$	0.329	0.282	0.301	0.303
	(0.22)	(0.23)	(0.26)	(0.23)
PIPP $_{i, t-1}$	1.074	0.432	0.791	0.802
	(0.61)	(0.80)	(2.91)	(2.97)
PIPP $_{i, t-1}^2$		0.281		-0.024
		(0.25)		(0.35)
PIPP*lnPerCapita_GDP$_{i, t-1}$			0.134	0.137
			(0.33)	(0.32)
PIPP*Secondary_Education $_{i, t-1}$			-1.561*	-1.604
			(0.93)	(1.17)
PIPP*Open $_{i, t-1}$			-0.651	-0.649
			(0.53)	(0.51)
lnPerCapita_GDP $_{i, t-1}$	0.541	0.559	0.482	0.468
	(0.38)	(0.37)	(0.37)	(0.39)
lnPopulation $_{i, t-1}$	0.309**	0.313**	0.318**	0.319**
	(0.15)	(0.15)	(0.15)	(0.13)
Secondary_Education $_{i, t-1}$	0.315	0.524	1.378	1.400
	(1.14)	(1.29)	(1.26)	(1.41)
Open $_{i, t-1}$	-0.112	-0.189	0.501	0.497
	(0.61)	(0.61)	(0.98)	(0.96)
Patent_Status_1985$_i$	1.26*	1.256*	1.229**	1.224**
	(0.65)	(0.65)	(0.60)	(0.59)
Intercept	-6.20**	-6.231**	-6.322**	-6.272*
	(3.02)	(3.08)	(3.13)	(3.31)
Observations	658	658	658	658
Replications for Bootstrap Errors	100	100	100	100

Notes: Bootstrapped standard errors are in parentheses [* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$]. All regressions include year dummies, first-stage residuals free of serial-correlation, and time averages of first-stage residuals. The instrumental variables are quadratic polynomials of USTR_Cumulative.

Appendix Table 3. Average Partial Effects of Determinants of *Patent*$_{it}$: Developing Countries, 1985-2004

	W/o interaction variables		With interaction variables	
	Pure RE	Correlated RE	Pure RE	Correlated RE
Patent $_{i, t-1}$	0.336	0.329	0.314	0.303
	(0.25)	(0.22)	(0.25)	(0.26)
PIPP$_{it-1}$ (at mean)	1.02*	1.074	0.881	0.968
	(0.65)	(0.61)	(0.74)	(0.70)
PIPP$_{it-1}$ (at lag patent=0)	0.168	0.189	0.092	0.097
	(0.12)	(0.13)	(0.07)	(0.13)
PIPP$_{it-1}$ (at lag patent=1)	0.221	0.234	0.122	0.126
	(0.12)	(0.15)	(0.10)	(0.10)
lnPerCapita_GDP$_{it-1}$	0.692**	0.541	0.751**	0.598
	(0.35)	(0.38)	(0.32)	(0.39)
lnPopulation$_{it-1}$	0.413**	0.309**	0.420***	0.319**
	(0.18)	(0.15)	(0.16)	(0.16)
Secondary_Education$_{it-1}$	0.597	0.315	0.167	-0.115
	(1.20)	(1.14)	(1.41)	(1.31)
Open$_{it-1}$	0.085	-0.112	0.52	0.116
	(0.67)	(0.61)	(0.75)	(0.77)
Patent_Status_1985$_i$		1.256*		1.224**
		(0.65)		(0.59)
Observations	658	658	658	658
Reps for Boot Strap Errors	100	100	100	100

Bootstrapped standard errors are in parentheses for developing countries [* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$]. The APEs are averaged across both the cross section of the covariates and time.

Appendix Table 4. Dynamic Probit Estimates of *$Patent_{it}$* with PIPP Index Treated as Exogenous: Developing Countries, 1985-2004

	Linear Probability Model			Probit, Pure Random Effects			Probit, Correlated Random Effects		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Patent_{i,\,t-1}$	1.13***	1.13***	0.99***	0.52***	0.49***	0.48***	0.49***	0.45***	0.43***
	(0.12)	(0.12)	(0.12)	(0.16)	(0.16)	(0.17)	(0.16)	(0.17)	(0.17)
$PIPP_{i,\,t-1}$	-0.15*	-0.040	0.42	-0.15	-0.57	0.18	-0.19	-0.72*	0.41
	(0.091)	(0.24)	(0.86)	(0.14)	(0.37)	(1.05)	(0.15)	(0.39)	(1.15)
$PIPP_{i,\,t-1}^2$		-0.041	-0.11		0.15	0.017		0.18	0.044
		(0.074)	(0.094)		(0.12)	(0.14)		(0.12)	(0.15)
PIPP*lnPerCapita_GDP $_{i,\,t-1}$			0.058			0.024			-0.014
			(0.11)			(0.13)			(0.15)
PIPP*Sec_Education $_{i,\,t-1}$			-1.00**			-0.94			-1.12*
			(0.48)			(0.62)			(0.65)
PIPP*Open $_{i,\,t-1}$			-0.76***			-0.55**			-0.60**
			(0.20)			(0.25)			(0.25)
lnPerCapita_GDP $_{i,\,t-1}$	0.69**	0.70**	0.79***	0.99***	1.04***	1.01***	0.83**	0.88**	0.85**
	(0.27)	(0.27)	(0.29)	(0.21)	(0.22)	(0.22)	(0.35)	(0.36)	(0.36)
lnPopulation $_{i,\,t-1}$	-0.67	-0.63	-0.83	0.47***	0.47***	0.48***	-1.49*	-1.64*	-1.84**
	(0.80)	(0.80)	(0.83)	(0.085)	(0.088)	(0.083)	(0.89)	(0.91)	(0.90)
Secondary_Education $_{i,\,t-1}$	2.75**	2.72**	2.87**	1.77**	1.80**	2.17**	2.71**	2.67**	3.12**
	(1.14)	(1.14)	(1.35)	(0.81)	(0.83)	(0.97)	(1.13)	(1.15)	(1.29)
Open $_{i,\,t-1}$	0.47	0.49	1.43***	0.45	0.42	1.04**	1.04**	1.02*	1.48**
	(0.41)	(0.40)	(0.50)	(0.36)	(0.37)	(0.50)	(0.51)	(0.52)	(0.61)
Patent_Status_1971$_i$	0.95***	0.95***	0.97***				1.59**	1.64*	1.49*
	(0.35)	(0.35)	(0.37)				(0.81)	(0.85)	(0.76)
Observations	1110	1110	1110	1110	1110	1110	1110	1110	1110
R^2	.429	.429	.450						

Note: Fully robust standard errors in parentheses [*** p<0.01, ** p<0.05, * p<0.1]. All regressions include year dummies.

Appendix Table 5. Dynamic Probit Estimates of *Patent$_{it}$* with PIPP Index Treated as Endogenous: Developed Countries, 1985-2004

	(1)	(2)	(3)	(4)
Patent $_{i, t-1}$	0.78*	0.68	0.63	0.41
	(0.41)	(0.42)	(0.43)	(0.45)
PIPP $_{i, t-1}$	-0.10	-3.51	10.6*	12.8
	(1.71)	(2.82)	(6.18)	(7.82)
PIPP $_{i, t-1}^2$		1.01		1.65*
		(0.63)		(0.86)
PIPP*lnPerCapita_GDP$_{i, t-1}$			-1.38*	-2.37**
			(0.79)	(1.04)
PIPP*Secondary_Education $_{i, t-1}$			5.00**	6.86**
			(2.28)	(2.71)
PIPP*Open $_{i, t-1}$			-0.13	0.30
			(0.50)	(0.56)
lnPerCapita_GDP $_{i, t-1}$	0.62	0.82	2.66	4.62*
	(1.30)	(1.34)	(2.53)	(2.71)
lnPopulation $_{i, t-1}$	0.79**	1.03***	0.72	1.07**
	(0.37)	(0.39)	(0.49)	(0.53)
Secondary_Education $_{i, t-1}$	2.50	3.48	-5.73	-7.53
	(2.21)	(2.44)	(4.72)	(5.00)
Open $_{i, t-1}$	0.27	0.42	0.49	0.12
	(0.27)	(0.28)	(0.90)	(0.93)
Patent_Status_1985$_i$	1.25*	1.30*	2.16**	2.59**
	(0.72)	(0.79)	(0.95)	(1.05)
Intercept	-9.21	-10.3	-24.5	-39.2*
	(10.8)	(11.0)	(20.4)	(21.6)
Observations	418	418	418	418
Replications for Bootstrap Errors	100	100	100	100

Notes: Bootstrapped standard errors are in parentheses [* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$]. All regressions include year dummies, first-stage residuals free of serial-correlation, and time averages of first-stage residuals. The instrumental variables are quadratic polynomials of USTR_Cumulative.

Appendix Table 6. Average Partial Effects of Determinants of *Patent$_{it}$*, *1985-2004*

	W/o interaction variables		With interaction variables	
	Pure RE	Correlated RE	Pure RE	Correlated RE
Patent $_{i, t-1}$	0.957**	0.781*	0.740*	0.411
	(0.40)	(0.41)	(0.43)	(0.45)
PIPP$_{it-1}$ (at mean)	0.206	-0.102	0.44.	0.222
	(1.73)	(1.71)	(2.47)	(2.60)
PIPP$_{it-1}$ (at lag patent=0)	0.109	-0.100	0.227	0.118
	(0.11)	(0.16)	(0.13)	(0.09)
PIPP$_{it-1}$ (at lag patent=1)	0.009	-0.007	0.135	0.175
	(0.08)	(0.12)	(0.24)	(0.13)
lnPerCapita_GDP$_{it-1}$	0.641	0.622	-0.248	-0.219
	(1.314)	(1.30)	(1.73)	(1.19)
lnPopulation$_{it-1}$	0.883**	0.791**	0.987*	1.074**
	(0.37)	(0.37)	(0.523)	(0.53)
Secondary_Education$_{it-1}$	5.251***	2.497	10.07***	6.46*
	(1.63)	(2.21)	(2.94)	(3.32)
Open$_{it-1}$	0.136	0.272	0.239	2.591*
	(0.26)	(0.27)	(0.369)	(1.35)
Patent_Status_1985$_i$		1.251*		1.224**
		(0.72)		(0.59)
Observations	418	418	418	418
Reps for Boot Strap Errors	100	100	100	100

Bootstrapped standard errors are in parentheses for developing countries [* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$]. The APEs are averaged across both the cross section of the covariates and time.