

Are Developing Countries Converging on Intellectual Property Rights?
Evidence from Plant Patents and Non-Patents, 1977 -2007

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Abstract

Provisions of the TRIPs agreement to increase protection of intellectual property rights in developing countries and emerging markets have been and will be expensive to implement. What has been the developing-country response to the opportunity and challenge of greater intellectual-property protection? Have foreign patent offices become complements or substitutes for domestic patent offices? Using unique new data on intellectual property related to plants, we find that there is increased activity in protecting intellectual property in and by developing countries after laws related to intellectual property are introduced. This finding implies that foreign patent offices are complements in most countries. (*JEL* O13,O34,O38,Q16)

For decades, researchers in developed and developing countries have attempted to develop better, more efficient sources of biofuels, recently in response to historically high oil prices and high food prices that are at least partly explained by redirecting food resources for use in producing alternatives to fossil fuels. On the one hand, this development could represent a significant boon for developing countries. For example, sorghum in the Philippines has been found to have higher sugar content in its root than sugar cane, which is one of the best sources for efficient production of cellulosic biofuels. Economists have long advised developing countries, among others, to become less dependent on fossil fuels, whether in consumption or production. In addition, some types of biofuels may increase opportunities in production, employment, and research in the home country.

On the other hand, this could be problematic for developing countries. Provisions of the TRIPs agreement to increase protection of intellectual property rights in developing countries and emerging markets have been expensive to implement. Finger (2004) estimates that the annual cost to the least developed countries would be \$60 billion. Nogues (1993) finds that Argentine pharmaceutical consumers transfer \$425 million yearly to foreign patent holders. With little home-country capacity or legal framework to issue patents and protect ideas, foreign (and domestic) residents may seek greater protection abroad. Such a move could increase the price of R&D and of use of plant varieties for domestic and foreign residents and reduce gains to output, employment, and R&D. Despite widespread ratification of the UN Convention on Biological Diversity, some developing countries argue that royalties are still underpaid due to biopiracy and bioprospecting.

What has been the developing-country response to the opportunity and challenge of greater intellectual-property protection? Have foreign patent offices become complements or substitutes for domestic patent offices? The contribution of this paper is to examine the empirical record of this response.

Using data on intellectual property related to plants, we find that there is increased activity in protecting intellectual property in and by developing countries after laws related to IP are introduced. In Brazil, India, Mexico, there is a noticeable TRIPS effect, and protected inventions increase at home and abroad after TRIPS passage in 1997. This finding implies that foreign patent offices are complements in most countries.

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The paper proceeds in four parts. Parts I and II give a brief description of methods to protect ideas related to plants and of the data. Parts III and IV present the evidence, and Part V concludes and describes opportunities for future research.

I. Protection of Plants

The TRIPs Agreement states that "Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof." There are six main means by which plant-related innovations may be protected.

There are two types of patents most relevant for plants. Utility patents are granted to plant-related inventions that meet the standards of novelty, usefulness, and non-obviousness. These can either be process, e.g., “method of using a plant or plant part in a breeding process which includes a step of sexual hybridization,” or product, e.g., “plant, seedling, plant seed, or plant part, *per se*,” patents.¹ Plant patents are for products only and are granted to inventors who have “invented or discovered and asexually reproduced a distinct and new variety of plant.”² An additional requirement is that the plant must be stable. Among developed countries, only the U.S., Japan, and Australia recognize plant patents, and no developing country recognizes them.³

The criteria for plant variety protection (PVP) or plant breeders’ rights (PBR) are uniformity, stability, and distinctness. TRIPs compliance requires that countries offer some form of protection to breeders, and many countries selected this option. This is the principal means by which plants are protected in the EU and in many developing countries. The first plant variety act was enacted in 1973, and many of these countries have joined or are in the process of joining the International Union for the Protection of New Varieties of Plants (UPOV). Others, such as India, Taiwan, and Thailand, have adopted national PVP programs. While PVP certifications are considered less restrictive than patents, costs associated with application vary significantly and can be prohibitive. The application fee represents three percent of GDP per capita in China and Colombia and 16 percent in Kenya. The annual maintenance fee represents up to 13 percent of GDP per capita in China, 16 percent in Kenya, and zero percent in the U.S.⁴

¹ The scope of *per se* patents is not only the application identified but applications not yet identified.

² USPTO definition, <http://www.uspto.gov/web/offices/pac/plant/>.

³ World Bank (2006), p. 25.

⁴ World Bank (2006), UNDP (2008), and author’s calculations. GDP per capita data are for 2005.

Trade secrets are another way plants might be protected. That is, fines may be imposed if non-public information about plant varieties is made public. This type of protection is often sought when replication is difficult, e.g., hybrids.

Trademarks and geographic designations are words or symbols used to identify novel or geographic characteristics of plant varieties to consumers. Michigan cherries, Egyptian cotton, and Ethiopian coffee are examples.

Genetic use restriction technologies constrain the use of genetically modified plants by rendering second-generation seeds sterile. This method is considered useful in environments where intellectual property rights are poorly enforced.

Finally, licensing is another means by which plants may be protected. With the exclusive right to grow and sell plants, inventors would seek to allow others to use the technology upon the collection of royalties. Plant varieties and trademarks are typically the objects of licensing.⁵

While all aforementioned forms of protection are simultaneously possible, the focus of the analysis here will be patents and PVP certifications.

II. Data

⁵ See Lesser (1995) and Helfer (2002) for a rich discussion of differences among the major types intellectual-property protection for plants.

Patents for innovations related to plants are prohibited in most countries in our sample. Therefore, all patent data used in this analysis are patents issued to residents of developing countries and emerging markets by the U.S. Patent and Trademark Office (USPTO). For plant patents, application data are only available from 2002. Rejection rates are calculated as the ratio of patent grants to patent applications in a given year. The rejection rate is intended to capture the quality of plant patents being issued by the U.S.

Data on PVP certifications have been obtained from the International Union for the Protection of New Varieties of Plants (UPOV) and the World Intellectual Property Organization (WIPO). Data on laws related to laws and agreements have been collected from the Convention on Biodiversity (CBD), Farmers' Rights, the Food and Agriculture Organization (FAO) of the UN, WIPO, and the WTO.

Additional data, e.g., patents per resident and R&D expenditure as a fraction of GDP, have been gleaned from various sources to present the broader context in which decisions about plant-related intellectual property protection are being made.

III. Evidence

Table 1 provides background data on the 14 developing countries and emerging markets in the sample. There is significant heterogeneity among countries for all measures: income per capita, share of agriculture in GDP, patents granted to residents per million, R&D expenditure as a fraction of GDP, and number of researchers in R&D per million.

Since 1975, the quantity of plant-related innovations receiving intellectual-property-rights protection has been rising in emerging markets and developing countries both at home and abroad. Figure 1 reports data on plant patents obtained in the U.S., utility patents related to plants obtained in the U.S., and PVP certifications issued in the home country. The patterns observed in the data suggest that innovations with weaker protection, PVP certifications, began to increase earlier than those seeking stronger protection through patents issued in the U.S. While plant and utility patents began to rise significantly in the mid-1990's, PVP certifications began climbing significantly in the mid-1980's. Interestingly, the PVP data correspond more closely to plant and total patenting patterns in the U.S., and the patent data in this sample follow plant and total plant patenting patterns in the U.S. with a lag of approximately 10 years.

Figure 2a gives data on applications for, grants of, and rejection rates for plant patents. Although patent protection of plant innovations is increasing, it is unclear whether the quality of these innovations is increasing. While the rejection rate as calculated is an imperfect measure of quality of innovations, it should give an indication of whether simply more plant-related ideas are seeking protection rather than better ideas. The high degree of variation between 2002 and 2006, the only years for which there are data, makes inference difficult. Rejection rates for all U.S. utility patents are available for a longer period and are recorded in Figure 2b. Rejection rates were largely stable at around 60% in the 1990's but climbed to 70% by the mid-2000's.⁶

⁶ One must be careful in interpreting the data on rejection rates, as applications and rejections arrive at irregular and different intervals.

Developing countries and emerging markets have received plant-related utility patents in all subcategories. However, shares attributed to developing countries and emerging markets are relatively low in most subcategories and are largest in mushrooms, pepper, and conifers. These data appear in Figure 3.

For each country, we are interested in answering the following questions. Are there significant differences in intellectual-property protection sought at home and abroad? Do inventors respond to measures adopted to increase protection of plant-related ideas? Are these patterns different across countries? Figures 4 to 9 present data for each country in the sample and include dates of implementation of the UPOV, TRIPs, CBD, and national PVP certifications.

For Argentina and Brazil, most of the activity in IP protection of plants is in PVP certifications. In both countries, plant-related utility patents rose after 1999. Among the countries in the sample, Argentina and Israel are the earliest users of plant protection in the home country. In India and Taiwan, all the activity related to protection of plant innovations is in protection sought abroad. For Brazil, India, and Mexico, nearly all plant IP activity is concentrated in the post-TRIPs era. Following membership in the International Union for the protection of plant varieties (UPOV), PVP certificates in Israel rose above non-zero levels consistently for more than 20 years. Of course, a formal multivariate econometric test would be warranted to ascribe causality or simply sequencing, but the country-specific graphical analysis is suggestive.

IV. Regression Results

In this section we test the hypothesis that changes in the protection of intellectual property at home are correlated with changes in innovative activity abroad and at home. Specifically, we regress developing-country patents obtained in the U.S. and PVP certifications on dummies for years in which relevant reforms took place. Included are years of adoption of TRIPS, UPOV, CBD, and national PVP legislation. The analysis follows Griliches (1990) and Kortum (1997), among others, who postulate that innovative outcomes, such as patenting, and investment in R&D covary. Data on R&D expenditure are not available for many developing countries over time. In place of this series, we use PPP-adjusted GDP per capita. OLS models and GLS models with fixed effects are estimated for 10 countries, and results are reported in Tables 3 to 6.

Two features of results from these regressions are striking. First, greater IP protection is correlated with innovative activity. Second, however, this correlation is not uniform across types of invention. Across countries, while TRIPS adoption is positively correlated with increases in patents obtained in the U.S., adoption of rules related to non-patents is negatively correlated with patenting in the U.S. This finding suggests that patent-related reforms are encouraging patenting abroad and that non-patent-related reforms are encouraging greater innovative activity domestically. In this sense, domestic and foreign patent offices are substitutes, and broad IP policies are complements.

The findings in this study are broadly consistent with the recent literature on plant-related intellectual property rights, such as Helfer (2002) and World Bank (2006). Particularly on the issue of patents, the conventional wisdom is that developing countries prefer weaker IP rights

and that these will spur innovation. This analysis suggests that a more nuanced and time-series investigation of the empirical record is in order and that the issue is not settled.

V. Conclusion

An examination of data on intellectual property related to plants finds that there is increased activity in protecting intellectual property in and by developing countries. This finding implies that foreign patent offices are complements in most countries. In Brazil, India, Mexico, there is a noticeable TRIPS effect, and protected inventions increase at home and abroad after TRIPS passage in 1997. From the data it is difficult to glean implications for taking advantage of new biofuel opportunities, for example, beyond protection of ideas. Were these pre-existing ideas or new ideas seeking protection? Did new knowledge arise as a result of new protection or in spite of it? What are the results with respect to commercialization? This is still an open research question and deserves further attention in future research.

References

- Convention on Biodiversity, "List of Parties," <http://www.cbd.int/convention/parties/list/>, last accessed January 2009.
- Cook, Lisa D., "Are Developing Countries Converging on Intellectual Property Rights? Evidence from Plant Patents, 1977 -2007," forthcoming Upjohn Institute and Western Michigan University Press.
- Council for Economic Planning and Development, *Taiwan Statistical Data Book (Various issues)*, <http://www.cepd.gov.tw>, last accessed August 2009.
- Farmers' Rights, "Legislation and Policy Database," <http://www.farmersrights.org/database/index.html>, last accessed January 2009.
- Finger, J. Michael, "Poor People's Knowledge," World Bank Policy Research Paper Series #3205, 2004.
- Food and Agriculture Organization, United Nations, "Legal Office," <http://faolex.fao.org/>, last accessed January 2009.
- Food & Fertilizer Technology Center for the Asian and Pacific Region, *Agricultural Statistics 2007*, <http://www.agnet.org/situationer/stats/21.html>, last accessed October 2008.
- Griliches, Zvi, (1990) "Patent Statistics as Economic Indicators: A Survey," *Journal of Economic Literature*, 28, 4, 1661-1707.
- Helfer, Laurence R., "Intellectual Property Rights in Plant Varieties: An Overview with Options for National Governments," *FAO Legal Papers Online* #31, 2002.
- International Monetary Fund, *World Economic Outlook Database*. April 2008 Edition., <http://www.imf.org/external/pubs/ft/weo/2008/01/weodata/index.aspx>, last accessed August 2009.
- International Union for the Protection of New Varieties of Plants, *Plant Variety Protection Certifications*, http://upov.int/index_en.html, last accessed January 2009.
- Kortum, Samuel S., (1997) "Research, Patenting, and Technological Change," *Econometrica*. 65, 6, 1389-1419.
- Lesser, W., "Patenting of Plants and Animals: The Impacts on the Canadian Agri-Food Sector," 1995, <http://www.agr.gc.ca/policy/patent/elesser.html#B.%20Plant%20Breeders'%20Rights>, last accessed January 2009.
- Nogués, J. J. (1993), 'Social Costs and Benefits of Introducing Patent Protection for Pharmaceutical Drugs in Developing Countries', *The Developing Economies*, 31, 1, 24-53.

Taiwan Intellectual Property Organization, Annual Statistics, <http://www.tipo.gov.tw>, last accessed August 2009.

United Nations, Department of Economic and Social Affairs, Population Division. *World Population Prospects 1950-2050: The 2006 Revision Database*. New York: United Nations, 2007, <http://esa.un.org/unpp/>, last accessed July 2007.

United Nations Development Programme, *Human Development Indicators* 2008, <http://hdrstats.undp.org>, last accessed October 2008.

United States Patent and Trademark Office, <http://www.uspto.gov>, last accessed October 2008.

_____, U.S. Patents – Custom Data Extracts, 2009.

World Bank, *World Development Indicators* Online, <http://go.worldbank.org/3JU2HA60D0>, last accessed October 2007.

_____. *Intellectual Property Rights: Designing Regimes to Support Plant Breeding in Developing Countries*. Washington: The World Bank, 2006.

World Intellectual Property Organization, "*Patents Granted by Office (1883-2007)*," <http://wipo.int/ipstats/en/statistics/>, last accessed August 2009..

_____, Statistics on Plant Varieties, <http://www.wipo.int/ipstats/en/statistics/plants/>, last accessed August 2009.

World Trade Organization, http://www.wto.org/english/tratop_e/trips_e/trips_e.htm, last accessed January 2009.

Table 1: Country Data, Developing Countries and Emerging Markets

	GDP per capita, PPP	Agriculture	Patents Granted to Residents per million population	R&D Expenditure	Researchers in R&D
	\$US 2005	% GDP 2005	2005	% GDP 2000-2005	per million population 1990-2005
All developing countries	1,939	11.1	..	1.02	..
East Asia and the Pacific	2,119	6.4 ^{1,3}	..	1.61	722
Latin America and the Caribbean	4,480	8.7 ⁴	..	0.56	256
High income	34,759	1.7 ¹	286	2.45	3,781
Middle income	2,808	9.6	..	0.85	725
Low income	610	21.4	..	0.73	..
Israel	17,828	3.0	48	4.46	..
Argentina	4,728	9.4	..	0.41	720
Chile	7,073	5.5	1	0.61	444
Costa Rica	4,627	8.7	..	0.39	..
Mexico	7,454	3.8	1	0.40	268
Brazil	4,271	8.1	1	0.98	344
Colombia	2,682	12.5	..	0.17	109
Thailand	2,750	9.9	1	0.26	287
Ecuador	2,758	6.5	..	0.07	50
Indonesia	1,302	13.4	..	0.05	207
Honduras	1,151	13.9	..	0.05	..
South Africa	5,109	2.5	..	0.76	307
India	736	18.3	1	0.85	119
Taiwan	16,067	1.7	1,865	2.26	3,972 ²

Source: Columns 1, 2, 4, and 5: World Bank, *World Development Indicators 2007*; aggregates calculated for UN *Human Development Indicators* by the World Bank; UNDP, *Human Development Indicators 2007/2008*.

Column 3: UNDP, *Human Development Indicators 2007/2008*; calculated on the basis of data on patents from WIPO (2007).

Data on Taiwan agriculture GDP, researchers, R&D expenditure, and population: *Taiwan Statistical Data Book 2007*. Patent data are from <http://www.tipo.gov.tw>. Data on Taiwan GDP per capita are from Food & Fertilizer Technology Center for the Asian and Pacific Region (2007).

Data on population are from United Nations (2007).

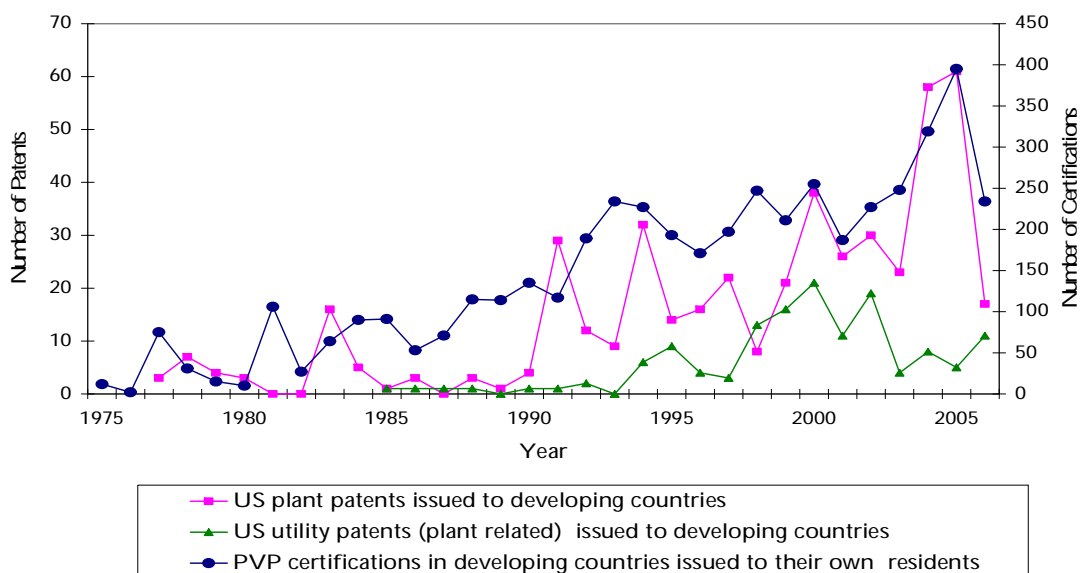
Note: ¹ 2004 data.

² 1998-2005 data.

³ Asia (excluding Middle East).

⁴ Only Latin America.

Figure 1: Intellectual Property Related to Plants, Developing Countries and Emerging Markets, By Application Year, 1975 - 2006



Source: US plant patents: 1994 - present data are from <ftp://ftp.uspto.gov/pub/taf/plant.htm>. Data before 1994 are from Patent Technology Monitoring Team.

PVP certifications: 2002 – 2006 data are from <http://www.upov.int/en/publications/statistics.htm>. 1975 - 2001 data are from <http://www.wipo.int/ipstats/en/statistics/plants>.

US utility patents related to plants: Data retrieved from USPTO.gov by author.

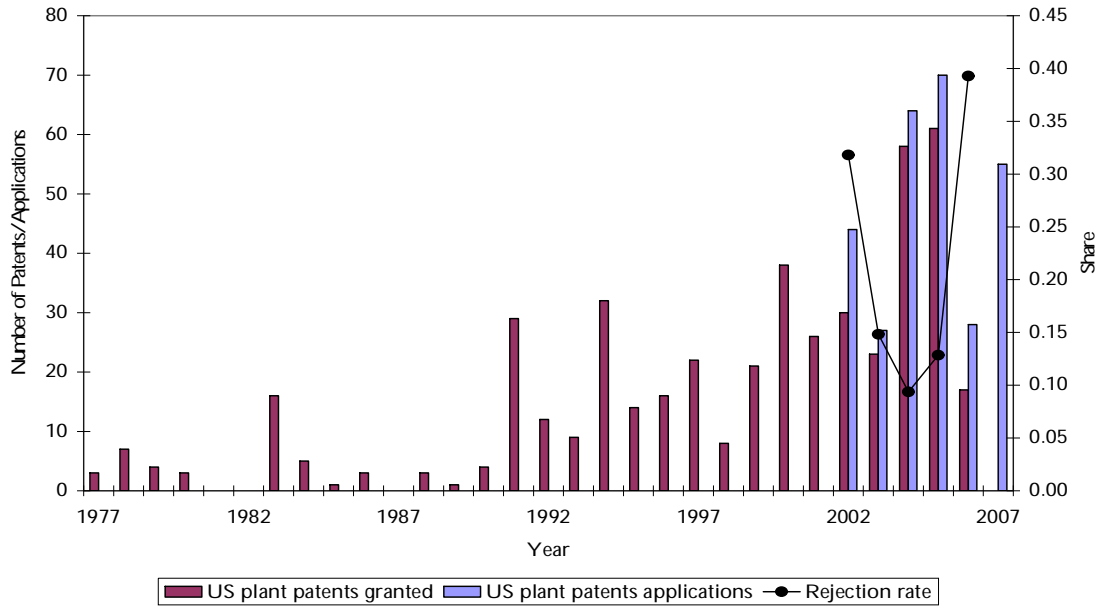
Notes: Developing countries and emerging markets for US utility and plant patents data are Israel, Costa Rica, India, South Africa, Brazil, Colombia, Argentina, Indonesia, Chile, Honduras, Mexico, Taiwan, Thailand, and Ecuador.

Developing countries and emerging markets for PVP certification data are Argentina, Brazil, Chile, Colombia, Ecuador, Israel, Mexico, and South Africa.

Patent origin is determined by the residence of the first-named inventor in case of US plant patent and by the residence of any inventor in case of US utility patent (plant related).

PVP certifications are presented by grant year

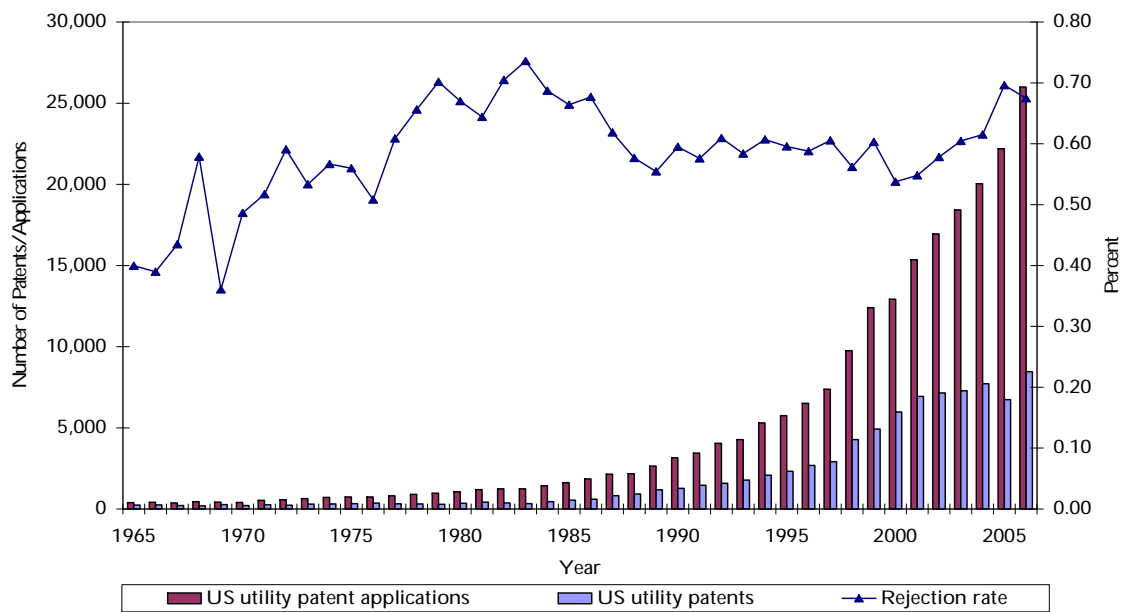
Figure 2a: U.S. Plant Patents, Grants and Applications, Developing Countries and Emerging Markets, By Application Year, 1977 - 2007



Source: Data prior to 1994: Patent Technology Monitoring Team; 1994 – present: <ftp://ftp.uspto.gov/pub/taf/plant.htm>.

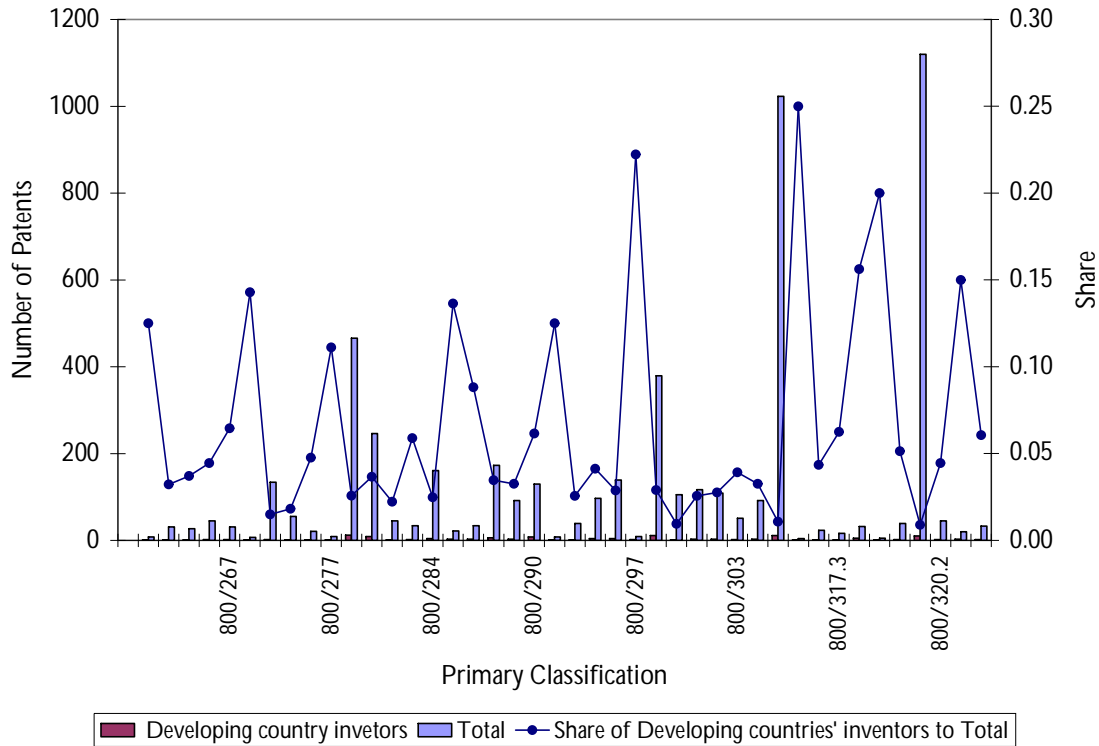
Note: Developing countries and emerging markets are Israel, Costa Rica, India, South Africa, Brazil, Colombia, Argentina, Indonesia, Chile, Honduras, Mexico, Taiwan, Thailand, and Ecuador.

Figure 2b: U.S. Utility Patents, Grants and Applications, Developing Countries and Emerging Markets, By Grant Year, 1965 - 2006



Source: US utility patent data: http://www.uspto.gov/web/offices/ac/ido/oeip/taf/appl_yr.htm.
 US utility patent application data: http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utlh.htm.
 Note: Developing countries and emerging markets are Israel, Costa Rica, India, South Africa, Brazil, Colombia, Argentina, Indonesia, Chile, Honduras, Mexico, Taiwan, Thailand, and Ecuador.

Figure 3: U.S. Utility Patents Issued to Developing Countries and Emerging Markets, By Plant Category, 1985 – 2006

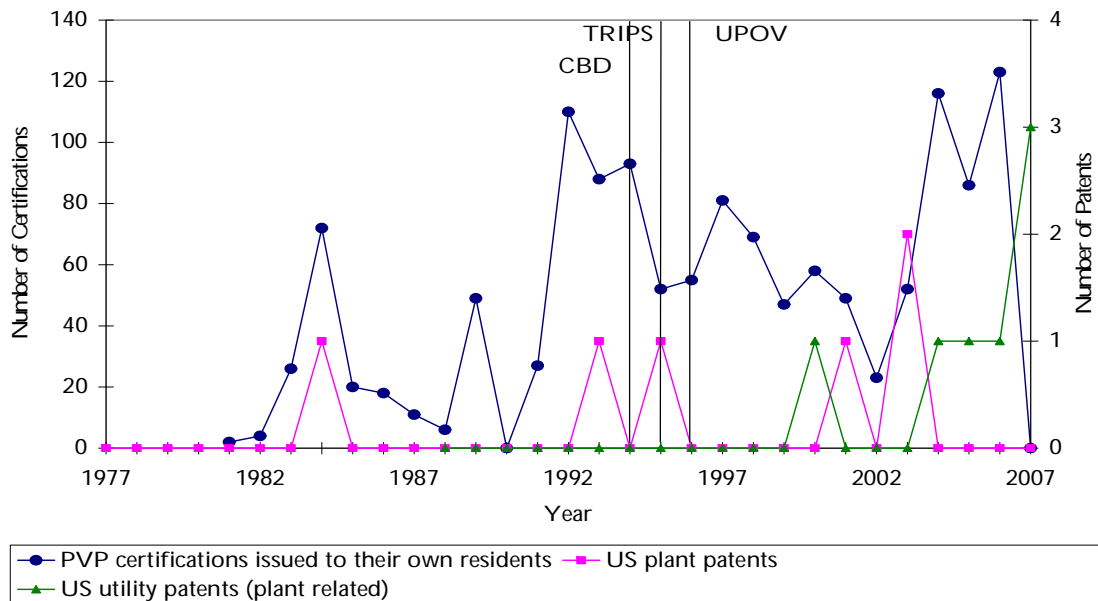


Source: USPTO

Note: Developing countries and emerging markets are Israel, Costa Rica, India, South Africa, Brazil, Colombia, Argentina, Indonesia, Chile, Honduras, Mexico, Taiwan, Thailand, and Ecuador.

Patent origin is determined by the residence of at least one inventor. Categories are defined in the appendix.

Figure 4: Argentina, Intellectual Property, Plants, 1977 - 2007



Source: US plant patent data: prior to 1994: Patent Technology Monitoring Team; 1994 - present:

<ftp://ftp.uspto.gov/pub/taf/plant.htm>.

PVP certification data: 1975 - 200: <http://www.wipo.int/ipstats/en/statistics/plants>; 2002 - 2006:

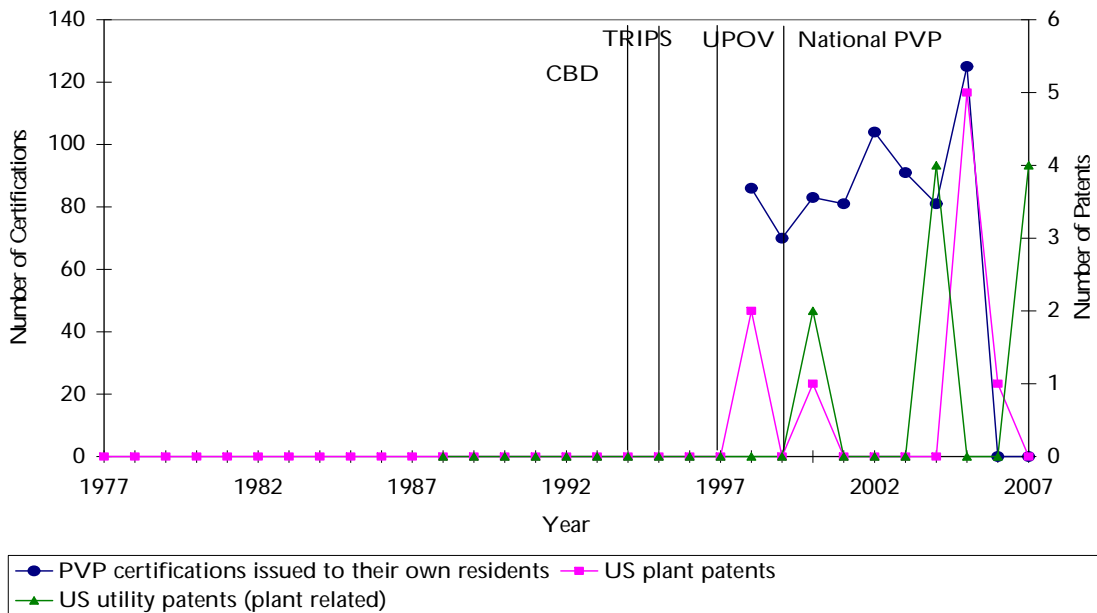
<http://www.upov.int/en/publications/statistics.htm>.

US utility patent data related to plants: USPTO.

Law data: Summary from <http://www.wipo.int>, <http://www.cbd.int/convention/parties/list>, <http://faolex.fao.org>, and <http://www.farmersrights.org>.

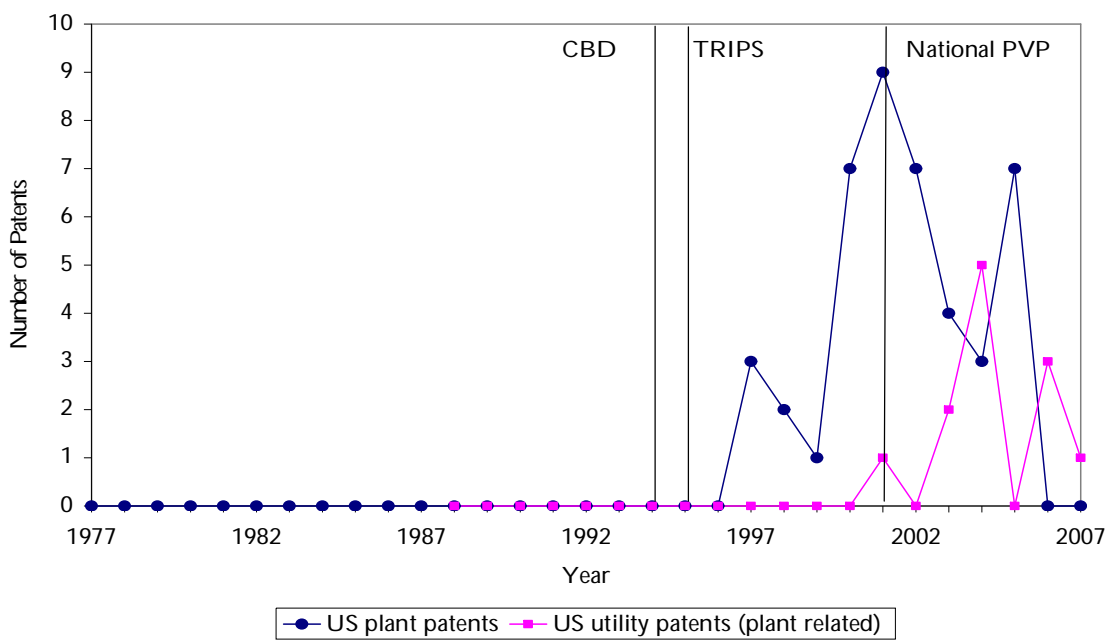
Note: Patent origin is determined by the residence of the first-named inventor. CBD, TRIPS, and UPOV represent year that country ratifies the Convention on Biological Diversity, joins the World Trade Organization, and joins International Union for the Protection of New Varieties of Plants. The first national Plant Variety Protection law was enacted in 1973.

Figure 5: Brazil, Intellectual Property, Plants, 1977 - 2007



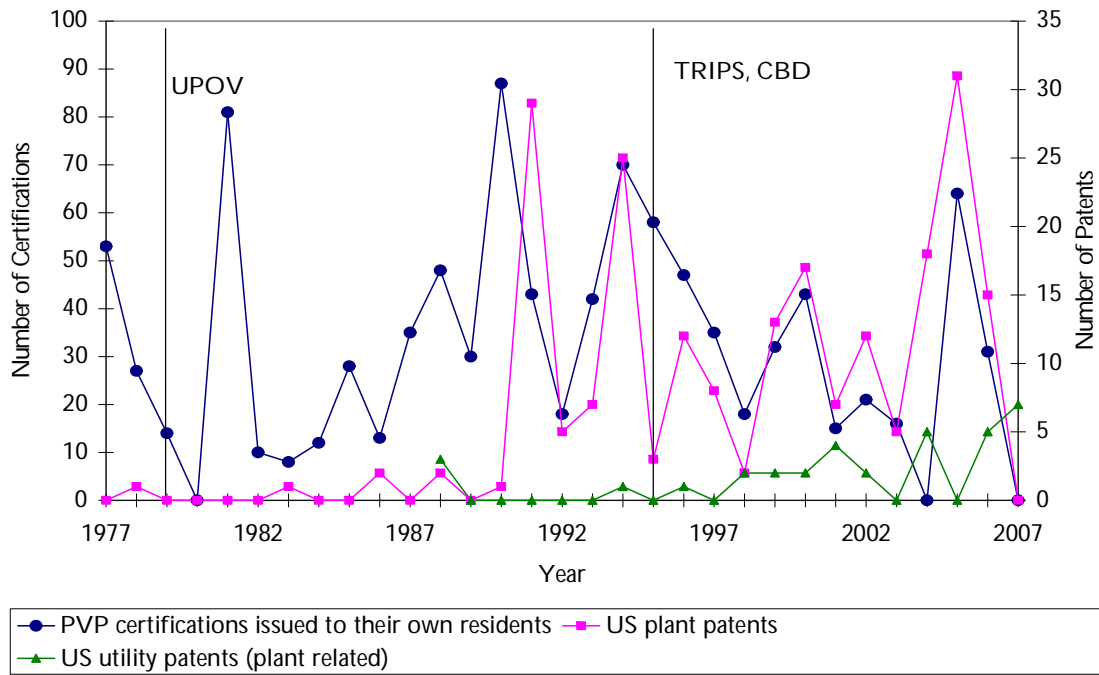
Source, Note: See Figure 4.

Figure 6: India's Intellectual Property, Plants, 1977 - 2007



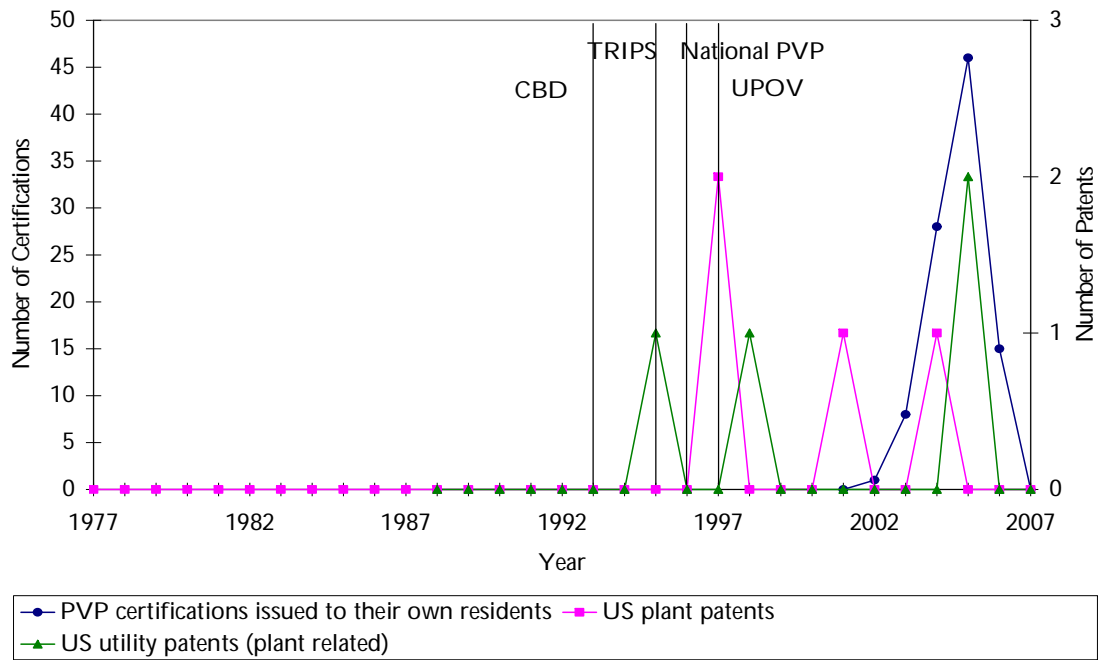
Source, Note: See Figure 4.

Figure 7: Israel's Intellectual Property, Plants, 1977 - 2007



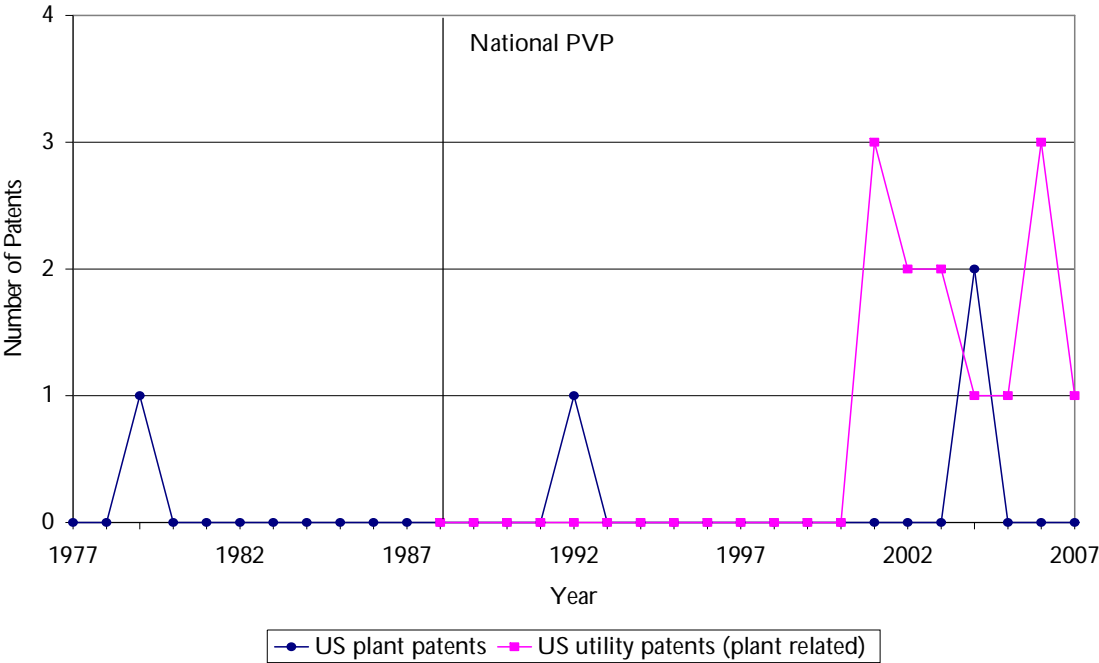
Source, Note: See Figure 4.

Figure 8: Mexico's Intellectual Property, Plants, 1977 - 2007



Source, Note: See Figure 4.

Figure 9: Taiwan's Intellectual Property, Plants, 1977 - 2007



Source, Note: See Figure 4.

Table 2: Selected Plant Patents and Utility Patents Related to Plants Granted to Inventors in Developing Countries and Emerging Markets

Patent Number	Title	Inventors	Assignee
<i>Plant Patents</i>			
PP19275	Calathea plant named "TWYCA0043"	Hambali, Gregori Garnadi (Bogor, ID)	Kerry's Bromeliad Nursery, Inc. (Apopka, FL, US)
PP19176	Torenia plant named "Danmoon20"	Danziger, Gabriel (Moshav Nir-Zvi, IL)	Danziger Dan Flower Farm (Post Beit Dagan, IL)
PP19149	Solenostemon plant named "Balcenna"	Ramirez, Rolando Solano (Dulce Nombre de Cartago, CR)	Ball Horticultural Company (West Chicago, IL, US)
PP17983	Blackberry plant named "Driscoll Thornless Sleeping Beauty"	Cabrera Avalos, Reynaldo (Jacona, MX)	Driscoll Strawberry Associates, Inc. (Watsonville, CA, US)
PP13948	Monopsis plant named "Royal Flush"	Fick, Amanda (George East, ZA)	Outeniqua, Protea Nursery (Emerald, AU)
<i>Utility Patents</i>			
7411115	Sweet potato sporamin gene promoter	Yu; Su-May (Taipei, TW)	Academia Sinica (Taipei, TW)
7381865	Soybean Variety 98R31	Wehrmann; Verni Kitzmann (Brasilia, BR), Prado; Luis Claudio (Brazilian, BR)	Pioneer Hi-Bred International, Inc. (Johnston, IA)
7335822	Plants and seeds of corn variety I211986	Graham; Michael J. (St. Louis, MO), Queijo; Marcelo (Buenos Aires, AR)	Monsanto Technology LLC (St. Louis, MO)
7319181	Transgenic rice plants with reduced expression of Os2AP and elevated levels of 2-acetyl-1-pyrroline	Vanavichit; Apichart (Nakornpathom, TH), Tragoonrung; Somvong (Pathumthani, TH), Toojinda; Theerayut (Samutsakorn, TH), Wanchana; Samart (Nakornpathom, TH), Kamolsukyonyong; Wintai (Nakornpathom, TH)	National Science & Technology Development Agency (Klong Luang, Phatumthani, TH)
6965063	Hybrid maize plant and seed 30A29	Torres Montalvo; Jose Heriberto (Guadalajara, MX), Gutierrez Gaitan; Miguel Angel (Guadalajara, MX)	Pioneer Hi-Bred International, Inc. (Johnston, IA)
5939603	Plants transformed with a potato virus Y gene	Sela; Ilan (Nes Ziona, IL), Vardi; Eyal (Rehovot, IL), Stram; Yehuda (Bat Yam, IL)	Yissum Research Development Company of Hebrew University of Jerusalem(IL)

Source: <http://www.uspto.gov>

Table 3: International Patenting Activity

Dependent variable: U.S. Plant Patents Granted to Developing Country Inventors, per Million, by Application Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP PPP per capita, constant price, lag	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
TRIPS	0.046 (0.072)	0.069 (0.093)	0.082 (0.094)	0.200** (0.097)	0.097 (0.068)	0.188 (0.116)	0.179* (0.108)	0.202* (0.115)
UPOV		-0.075 (0.093)	-0.074 (0.095)			-0.219 (0.136)	-0.225 (0.141)	
CBD			-0.025 (0.110)	0.046 (0.114)			0.029 (0.061)	0.060 (0.066)
National PVP				-0.429*** (0.120)				-0.281* (0.163)
Constant	-0.179** (0.073)	-0.183** (0.074)	-0.183** (0.075)	-0.175** (0.074)	-0.029 (0.253)	0.024 (0.240)	0.036 (0.255)	0.031 (0.230)
R ²	0.104	0.106	0.106	0.150	0.019	0.029	0.029	0.038
Number of observations	392	392	392	392	392	392	392	392

Sources: [Patents] USPTO (2009), [GDP, Population] IMF (2009).

Notes: Results are reported for OLS models in columns (1) through (4) and GLS fixed-effects models in columns (5) through (8).

Marginal effects are reported for GLS estimates.

Heteroskedasticity-robust standard errors are in parentheses.

The sample period is 1980 to 2008.

Developing countries and emerging markets are Israel, Costa Rica, India, South Africa, Brazil, Colombia, Argentina, Indonesia, Chile, Honduras, Mexico, Taiwan, Thailand, and Ecuador (14 countries).

TRIPS, UPOV, CBD, and National PVP are dummies for the year prior to joining the World Trade Organization, joining the International Union for the Protection of New Varieties of Plants, ratifying the Convention on Biological Diversity, and enacting national Plant Variety Protection laws.

Coefficients marked with an asterisk (***) are significant at the 1 percent level of significance; (**), at the 5 percent level; and (*), at the 10 percent level.

Table 4: International Patenting Activity

Dependent variable: U.S. Utility Patents (Plant-Related) Granted to Developing Country Inventors, per Million, by Application Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP PPP per capita, constant price, lag	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
TRIPS	0.026** (0.012)	0.017 (0.013)	0.043* (0.023)	0.061** (0.025)	0.034 (0.034)	0.054 (0.051)	0.064 (0.059)	0.068 (0.059)
UPOV		0.030* (0.017)	0.033* (0.018)			-0.048 (0.045)	-0.033 (0.031)	
CBD			-0.060* (0.036)	-0.052 (0.036)			-0.052 (0.052)	-0.047 (0.050)
National PVP				-0.034** (0.016)				-0.044 (0.032)
Constant	-0.115*** (0.032)	-0.116*** (0.031)	-0.118*** (0.032)	-0.113*** (0.030)	-0.084 (0.089)	-0.062 (0.076)	-0.095 (0.108)	-0.088 (0.104)
R ²	0.269	0.274	0.290	0.288	0.064	0.072	0.089	0.094
Number of observations	220	220	220	220	220	220	220	220

Sources: [Patents] USPTO (2009), [GDP, Population] IMF (2009).

Notes: Results are reported for OLS models in columns (1) through (4), a fixed-effects model in columns (5) through (8).

Marginal effects are reported for GLS estimates.

Heteroskedasticity-robust standard errors are in parentheses.

The sample period is 1985 to 2008.

Developing countries and emerging markets are Israel, Costa Rica, India, South Africa, Brazil, Colombia,

Argentina, Mexico, Taiwan, and Thailand (10 countries).

TRIPS, UPOV, CBD, and National PVP are dummies for the year prior joining joins the World Trade Organization, joining International Union for the Protection of New Varieties of Plants, ratifying the Convention on Biological Diversity, and enacting national Plant Variety Protection law, respectively, and onwards.

Coefficients marked with an asterisk (***) are significant at the 1 percent level of significance; (**), at the 5 percent level; and (*), at the 10 percent level.

Table 5: International Patenting Activity

Dependent variable: U.S. Utility Patents Granted to Developing Country Inventors, per Million, by Application Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP PPP per capita, constant price, lag	0.015*** (0.002)	0.017*** (0.002)	0.017*** (0.002)	0.016*** (0.002)	0.019*** (0.004)	0.019*** (0.003)	0.020*** (0.003)	0.021*** (0.003)
TRIPS	1.257 (2.308)	11.050*** (3.500)	15.745*** (3.896)	11.787*** (3.683)	-3.858 (4.023)	3.486 (6.964)	7.679 (8.091)	5.539 (6.884)
UPOV		-31.277*** (6.901)	-30.768*** (7.028)			-17.579** (8.667)	-14.535* (8.108)	
CBD			-9.303 (5.719)	-8.919 (6.432)			-13.228** (6.026)	-13.315** (6.393)
National PVP				-14.084*** (4.693)				-8.412* (4.350)
Constant	-39.466*** (5.553)	-41.091*** (5.650)	-41.434*** (5.539)	-39.749*** (5.392)	-54.089*** (14.428)	-49.850*** (12.005)	-55.241*** (11.519)	-57.628*** (13.409)
R ²	0.516	0.574	0.578	0.532	0.282	0.299	0.316	0.309
Number of observations	392	392	392	392	392	392	392	392

Sources: [Patents] USPTO (2009), [GDP, Population] IMF (2009).

Notes: Results are reported for OLS models in columns (1) through (4) and GLS fixed-effects models in columns (5) through (8).

Marginal effects are reported for GLS estimates.

Heteroskedasticity-robust standard errors are in parentheses.

The sample period is 1980 to 2008.

Developing countries and emerging markets are Israel, Costa Rica, India, South Africa, Brazil, Colombia, Argentina, Indonesia, Chile, Honduras, Mexico, Taiwan, Thailand, and Ecuador (14 countries).

TRIPS, UPOV, CBD, and National PVP are dummies for the year prior to joining the World Trade Organization, joining the International Union for the Protection of New Varieties of Plants, ratifying the Convention on Biological Diversity, and enacting national Plant Variety Protection laws.

Coefficients marked with an asterisk (***) are significant at the 1 percent level of significance; (**), at the 5 percent level; and (*), at the 10 percent level.

Table 6: Domestic Innovative Activity

Dependent variable: Developing Country PVP Certifications Granted to Resident Inventors, per Million, by Application Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP PPP per capita, constant price, lag	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
TRIPS	-1.544*** (0.552)	-2.179*** (0.836)	-1.448* (0.862)	-0.882 (0.694)	0.821*** (0.240)	0.304* (0.178)	0.397 (0.277)	0.789** (0.351)
UPOV		1.500** (0.760)	1.565** (0.751)			1.259*** (0.133)	1.270*** (0.179)	
CBD			-1.259*** (0.395)	-1.213*** (0.397)			-0.322 (0.532)	-0.239 (0.508)
National PVP				0.354 (0.550)				1.226*** (0.318)
Constant	-1.456*** (0.523)	-2.009*** (0.489)	-2.030*** (0.466)	-1.689*** (0.402)	6.092*** (1.541)	5.560*** (0.774)	5.357*** (0.540)	5.529*** (0.494)
R ²	0.430	0.447	0.469	0.451	0.065	0.082	0.084	0.076
Number of observations	137	137	137	137	137	137	137	137

Sources: [PVP] WIPO (2009a), [GDP, Population] IMF (2009).

Notes: Results are reported for OLS models in columns (1) through (4) and GLS fixed-effects models in columns (5) through (8).

Marginal effects are reported for GLS estimates.

Heteroskedasticity-robust standard errors are in parentheses.

The sample period is 1980 to 2008. The data constitute an unbalanced panel.

Developing countries and emerging markets are Israel, South Africa, Brazil, Colombia,

Argentina, Chile, Mexico, and Ecuador (8 countries).

TRIPS, UPOV, CBD, and National PVP are dummies for the year prior to joining the World Trade Organization,

joining the International Union for the Protection of New Varieties of Plants, ratifying the Convention on Biological Diversity,

and enacting national Plant Variety Protection laws.

Coefficients marked with an asterisk (***) are significant at the 1 percent level of

significance; (**), at the 5 percent level; and (*), at the 10 percent level.

Appendix

Classification	Explanation for Classification
	METHOD OF USING A PLANT OR PLANT PART IN A BREEDING PROCESS WHICH INCLUDES A STEP OF SEXUAL HYBRIDIZATION
800/263	Breeding for altered carbohydrate composition
800/264	Breeding for altered fat, fatty oil, ester-type wax, or fatty acid composition
800/265	Breeding for pathogen or pest resistance or tolerance
800/266	Method of breeding involving a genotypic or phenotypic marker
800/267	Molecular marker is used
800/269	Method of breeding using interspecific (i.e., interspecies) crosses
800/271	Method of breeding using gametophyte control
800/274	Via a male sterility genetic trait
800/276	METHOD OF CHEMICALLY, RADIOLOGICALLY, OR SPONTANEOUSLY MUTATING A PLANT OR PLANT PART WITHOUT INSERTING FOREIGN GENETIC MATERIAL THEREIN
800/277	METHOD OF PRODUCING A PLANT OR PLANT PART USING SOMATIC CELL FUSION (E.G., PROTOPLAST FUSION, ETC.)
800/278	METHOD OF INTRODUCING A POLYNUCLEOTIDE MOLECULE INTO OR REARRANGEMENT OF GENETIC MATERIAL WITHIN A PLANT OR PLANT PART
800/279	The polynucleotide confers pathogen or pest resistance
800/280	Plant virus gene expression from the polynucleotide
800/282	The polynucleotide alters pigment production in the plant
800/284	The polynucleotide alters carbohydrate production in the plant
800/285	The polynucleotide encodes an inhibitory RNA molecule
800/286	The RNA is antisense
800/287	The polynucleotide contains a tissue, organ, or cell specific promoter
800/288	Nonplant protein is expressed from the polynucleotide
800/290	The polynucleotide alters plant part growth (e.g., stem or tuber length, etc.)
800/291	The polynucleotide comprises a transposon
800/293	Involving particle-mediated transfection (e.g., biolistic, etc.)
800/294	Via Agrobacterium
800/295	PLANT, SEEDLING, PLANT SEED, OR PLANT PART, PER SE
800/297	Mushroom
800/298	Higher plant, seedling, plant seed, or plant part (i.e., angiosperms or gymnosperms)
800/300	Herbicide resistant plant which is transgenic or mutant
800/301	Pathogen resistant plant which is transgenic or mutant
800/302	Insect resistant plant which is transgenic or mutant
800/303	Male-sterile
800/306	Brassica
800/312	Soybean
800/317.1	Pepper
800/317.2	Potato
800/317.3	Tobacco
800/317.4	Tomato
800/319	Conifer
800/320	Gramineae (e.g., barley, oats, rye, sorghum, millet, etc.)
800/320.1	Maize
800/320.2	Rice
800/322	Sunflower
800/323	Ornamental plant

Source: <http://www.uspto.gov>