Intellectual Property Rights and Asian Agriculture

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Developing countries have traditionally been antagonistic to the introduction of strengthened Intellectual Property Rights (IPR) systems. This is the case in spite of the obvious fact that virtually all Organization for Economic Cooperation and Development (OECD) market economies have "strong" IPR systems, and that they have full "reciprocity" in recognizing the IPRs of other OECD countries. That is, each OECD country offers "national treatment" to inventors from other OECD countries. Additionally, each of these countries has actually strengthened IPR implementation and scope, primarily through "case law" over recent decades.[1]

It is also the case that many internationally traded products have implicit "royalty payments" for IPRs included in their prices. The purchaser of a new Toyota automobile, for example, may be paying up to one hundred royalties, even if the purchase is made in a country antagonistic to IPRs. Similarly, the purchase of a new computer entails the payment of several royalties. But most consumers of these products are unaware of these royalty payments because they are made between intermediate goods suppliers and simply included in the price of the product.

It is also the case that most IPR-protected products are "bargains" in the sense that the price of the product, including the royalty payment, must make the product attractive to some buyers. As long as reasonably good substitutes for the product are available in the market, this insures that the product generates "consumers surplus" that would not be produced in the absence of IPRs.

Why then, are Asian developing countries reluctant to embrace stronger IPR systems in view of the OECD experience and the fact that they are already paying royalties? Most Asian developing countries have embraced other OECD style property rights systems but resist stronger IPR systems. This will be analyzed in Part III of this paper.

Three major changes in international IPR systems have been implemented over the past two decades. These are:

1. Case law strengthening of IPRs for biological inventions.
2. The Trade-Related aspects of Intellectual Property Rights (TRIPs) agreements associated with the World Trade Organization (WTO) in the Uruguay Round.
3. The rules and regulations associated with the Convention on Biological Diversity (CBD).

It is not always appreciated that the WTO-TRIPs and the CBD agreements are in conflict with one another. The WTO-TRIPs agreement commits WTO members to some degree of IPR law "harmonization" and pressures WTO members to recognize the IPRs of inventors from other countries, particularly from OECD countries.

There are two provisions in the WTO-TRIPs agreement affecting agriculture. The first is that "contracting parties shall provide for the protection of plant varieties by patents and/or by an effective "*sui generis* system" (Section 5, Article 27 3b).

[1] The term "case law" refers to important court decisions interpreting existing legislation in a new light, thus effectively changing the legislation.

This is widely interpreted as a commitment to introduce a form of "breeders rights" for plant varieties.[2] Laws on plant breeders' rights are generally regarded to be "weak" IPRs and most developing countries lobbied for this *sui generis* treatment for plant varieties in the TRIPs negotiations.

But the WTO-TRIPs negotiations also call for more effective patent protection systems in member countries. In addition, more effective patent protection systems may have more important consequences for developing countries than the sui generis systems for plant varieties. This is because the scope of coverage for patents has been expanded by case law in the US and to some extent in other OECD countries. It is also the case that the term "plant varieties" is unlikely to include "transgenic" varieties produced by recombinant DNA (rDNA) techniques. Transgenic varieties are likely to be given patent protection under TRIPs.

The Convention on Biodiversity (CBD) introduced a new right associated with genetic resources. The CBD states that States have "a sovereign right to natural resources" and that "the authority to determine access to genetic resources rests with the national government and is subject to national legislation." The CBD further notes that the genetic resources subject to such legislation are "countries of origin" of such resources.

Since plant breeders have relied on genetic resources in the form of "landraces" or farmer-selected varieties and on related "wild" genetic resources for many years, the CBD provisions raise the prospects of limitation of exchange of genetic resources between countries.[3] As Gollin and Evenson (1997) have shown, such limitations would have severe consequences for plant breeding programs.[4]

IPRS RELEVANT TO AGRICULTURE: A TAXONOMY

Table 1 provides a taxonomy for 11 types of IPRs. Some of these IPRs are in conflict with other IPRs. The most important rights for inventions and innovations are patent rights. A distinction is made in Table 1 between traditional patent rights and expanded patent rights. Traditional (original) patent protection has been provided to inventors in the chemical, electrical and mechanical fields of invention for many years.

The "expanded" patent now protects genetic inventions. The expansion in question occurred primarily in the United States and was achieved through case law. That is, the expanded coverage of patent protection was the result of court decisions, not of legislation. In the case of Diamond vs. Chakarbarty (447US 303[1980]), the court ruled that multicellular living plants and animals were not excluded from patent protection.[5] Further, court rulings in ex parte Hibberd for plants (227 USPQ 443(1985)) and ex parte Allen (2 USPQ 2d 1425) reaffirmed this. These opened the door to the patenting of plants and of genes and gene constructs.[6]

To obtain a patent right, the right holder must demonstrate that the invention is:

a) Novel, i.e., new to the world, the first of its kind;
b) Useful in the sense that it can be incorporated into a useful device;
c) An "inventive step." Courts test this by requiring that the invention be "unobvious to a practitioner skilled in the art."

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[2] The International Union for the Protection of New Varieties of Plant (UPOV) is the governing body for international recognition of breeders rights.

[3] The CBD provisions are different from patent laws in one very important respect. Patent protection is limited in time. An invention can only be protected for a period of 20 years. CBD rights in genetic resources are not time limited. Indeed, few farmers varieties have been created in the last 20 years.

[4] Gollin and Evenson (1997) show that most modern varieties of rice produced in the Green Revolution utilized parent materials from more than one country.

[5] Other IPR systems have not fully adopted US practice in this regard, but the WTO-TRIPs agreement puts pressure on many countries to follow the US lead on this.

[6] The Board of Patent Appeals and Interferences of the US Patent and Trademark Office has interpreted Diamond v. Chakarbaty to mean that any plant can be patented provided that it satisifes the basic standards for patentability. The US Supreme Court in JEM. Ag Supply vs. Pioneer Hibred Int. Inc. (534US124 (2001)) agreed with this interpretation and ruled that the availability of plant variety protection was not in conflict with patent regulations for plants (Barton 2004).

Table 1. Intellectual Property Rights (IPRs): A Taxonomy

IPRs	Scope	Period of Protection	Conditions for Obtaining IPR: Novelty	Usefulness	Inventive Step	International Convention	IPRs Rights	Disclosure Requirement	Research	Reproduction Exemption
Patent (original)	Inventions: Chemical, electrical, mechanical	17-20 years	Yes (global)	Yes	Strong	Paris, TRIPS	Patent (original)	Enabling (conceptual)	None	Negotiable
Patent (expanded)	Inventions: Genes, plants and animals	17-20 years	Yes (global)	Yes	Strong	Paris, TRIPS	Patent (expanded)	Enabling	None (germplasmic)	Negotiable
Utility Model	Minor Inventions	5-15 years	Yes (national)	Weak	Weak	None	Utility Model	Enabling	None (conceptual)	Negotiable
Industrial Design	Designs	Permanent	Yes	None	None	None	Industrial Design	None	None (conceptual)	None
Breeders' Rights	Plant Varieties	5-16 years	Yes	Yes	Weaker None	UPOV, TRIPS	Breeder's Rights	None Deposit	Allowed	Limited (Farmers' Rights)
Appelation of Origin	Food Products	Permanent	Regional	None	None	Lisbon	Appelation of Origin	Location of Protection	Allowed	None
Folkloric Rights	Indigenous Products	Permanent	Yes	None	None	FAO/ UNESCO	Folkloric Rights		Allowed	Negotiable
Farmers' Rights (CBD)	Genetic Resources	Permanent	Yes	None	None	CBD Undertaking	Farmers' Rights	Location of Genetic Resource	None (use of rights)	(Use of rights)
Copyrights	Written Works	Life + 50 Years	Yes	None	None	Berne, TRIPS	Copyrights	None	Allowed	None
Trademarks	Brand Names	Permanent	Yes	None	None	TRIPS	Trademarks	None	Allowed	None
Trade Secrecy	Trade Secrets	Permanent	None	None	None	None	Trade Secrecy	None	None	None

SOURCE: Evenson (2000)

In addition, the patent document must provide an "enabling disclosure" of the invention. This must be in adequate detail to allow the replication of the invention. This is part of the IPR "bargain." In return for IPR protection, the invention must be removed from secrecy. International Conventions affect patent rights. The Paris Convention enacted in 1887 allowed for diversity in patent laws in different countries, but required that each member country provide "national treatment" to inventors from another member country. The Paris Convention (and its amendments) allows member countries the right to obtain patent protection in another country within one year of application in the country and to maintain the original date of filing. This is important because most countries (except the US) operate on a "first to file" basis to establish novelty.[7]

The utility model is used in many countries in Asia. It is often referred to as a "petty patent" because it protects minor inventions. In some countries, novelty is judged against a national standard. The utility model can be used to protect "adaptive invention."

Industrial Designs protect shapes and designs and are important for marketing.

Breeders Rights (BR) protect plant varieties that meet Uniformity and Stability standards. Protection is weakened by a researcher exemption and a farmers exemption. The research exemption allows a researcher (plant breeder) to utilize a BR-protected variety as a parent variety. The farmers exemption allows a farmer to save seed from his crop. A recent US Supreme Court ruling allows a plant variety to be protected by a patent or a Breeders Right. The WTO-TRIPS *sui generis* system for plant variety is widely expected to be a Breeders Rights system.[8]

Appellation of Origin rights are largely used for labeling and identification purposes. These rights are important for "niche" markets in wine, cheese and similar products.

Folkloric Rights, including Farmers Rights in the CBD, are relatively new and untested in courts. They are often seen as "developing country" rights, because of the perception that developing countries actually produced most "farmers varieties" or landraces of major cultivated crops.

Copyrights protect written works. They also protect the "copying" of such items as computer programs.

Trademarks are important in most food markets. They "identify" brand names and prevent other companies from benefiting from brand loyalty.

Trade secrets are protected in cases where an employee may reveal secrets. Fundamentally, a company must make a choice between holding an invention in secrecy or obtaining patent rights.

THE ECONOMICS OF PATENT RIGHTS

1. Inventions in a Single Economy

When an inventor obtains a patent right, this right has three features:

a. It is a "right to exclude" others from making or using the invention. It is not a right to actually make and use the invention.
b. The right to exclude is limited in time. Under current WTO-based rules, the patent right expires after 20 years from the date of application.
c. The right to exclude is granted in return for the "removal from secrecy" of the invention. The patent documentation must include an "enabling disclosure."

Patents provide important incentives for invention because the patent right can be licensed. Many efforts to develop an invention fail, but the patent right does provide incentives for inventive effort. Many large industrial companies invest millions of dollars in research and development (R&D) programs.[9]

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[7] The US uses a "first to invent" principle. This is a costly principle, because of disputes over which inventor was first.

[8] See Lesser (1994) for an evaluation of the US plant varieties protection. Lesser (1999) discusses Breeders Rights under TRIPS.

[9] See Nordhaus (1969), Machlup (1958), and Siebeck, et al. (1990) for studies of patent systems.

But patents are also important to protect investments made in innovation, the commercialization of the invention. Fewer than 10% of the patent grants made by the US Patent and Trademark Office actually become innovations. Most inventions are made by R&D employees in a firm and assigned to the firm.

The firm then has to evaluate the merit of investing to commercialize the invention. Patent protection to protect innovation is important because investments in pilot production, testing, and marketing can be quite large; and unless the investing firm can exclude other firms from taking advantage of these investments, innovations will not take place. This does not mean, however, that the inventor and the innovator have to be the same party. An inventor can provide an "exclusive license" to an innovator preserving the incentive.

The dominant IPR for encouraging invention and innovation is the utility patent (usually referred to as a letters patent or simply a patent). The logic for the patent right is shown in Figure 1. The figure depicts two potential inventions. The upper panel depicts a major invention, the lower panel, a "run of the mill" invention. For each invention, shown are the first period after the patent is granted, the last period of the patent grant, and the period after the patent is no longer valid.

For both inventions, there is a demand for the invention depicted by the curve D_1D_1 in Period 1. This demand is expresssed as the quantity or units of use demanded at different royalty rates r(u). In Period 1, the holder of the patent right has a monopoly right over the products in which this invention is embedded. That is, the IPR holder has the "right to exclude" others from making or using the product. In the same period, the monopoly rate is r*(u) for both inventions.[10] The area PR_1 represents payments to the IPR holder. These may be licensing revenues or in the form of price premia for the product. The area CS_1 is the "consumer surplus" associated with the monopoly IPR grant.

PLEASE SEE FILE: Evenson Figure 1.pdf

Fig. 1. Basic Economics of the Patent Rights

The area UCS is the unrealized consumer surplus associated with the monopoly IPR grant.

By Period T, the final period of the patent monopoly, the market for both inventions will have been eroded by the development of substitute products. This erosion is a natural part of the market economy. Substitute product development is a central feature of industrial markets. The development of substitutes is accelerated by the requirement that the patent documents provide an enabling disclosure of the invention. As shown in Figure 1, the major invention has modest market erosion; the run-of-the-mill invention has major market erosion.

In a patent system with significant renewal fees, the major invention is likely to be renewed into year T. The run-of-the-mill invention will not be renewed to year T.[11] In Period T+1, both inventions will be "off-patent" and will contribute consumer surplus gains that may continue for many years.[12] The run-of-the-mill invention may be converted to consumer surplus earlier than year T under an optimal renewal fee structure.

The gains from IPR systems depend in part on alternative R&D systems. Public sector agricultural research systems produce inventions (plant varieties) without the UCS components associated with IPR systems. Ideally, one would like to realize the UCS components if possible. Without the UCS gains, however, IPR systems do produce partial CS gains up to period T and full CS gains thereafter. These are important gains, because for many inventions, the invention lives on as a "building block" in products that have eroded the market for the original invention. Note that the IPR is necessary to protect both the invention and the innovation, i.e., the commercialization of the invention. Most private sector R&D is actually D, i.e., development or commercialization expenses.[13]

Can public sector agricultural research programs really be an alternative to IPR-based private firm R&D? Almost certainly, not. It would be almost unimaginable that the range of inventions used in agriculture in many countries could have been produced in a public sector agricultural research system. Literally thousands of inventions of farm machines and farm chemicals have been made by private individuals and private firms in the industries supplying products to the agricultural sector and buying products from the sector.

Two recent developments in the United States have dramatically expanded the scope of U.S. patent law. The first is administrative. The United States established a Federal Court of Appeals in 1980 specifically to deal with intellectual property rights. This institution has contributed both to more efficient adjudication of disputes and conflicts, and to a climate for strengthened property rights. This Court has made major damage awards in litigated cases.

The second and much more important development has been in case law expansion. This expansion was facilitated by modern bio-technology advances allowing novelty to be identified more precisely. A large number of agricultural plants now have been patented including a large number of corn hybrid varieties.

2. International Agreements

Most countries of the world are members of at least one international agreement that attempts to protect an inventor's rights to his or her invention in foreign countries (Barton 2004). These agreements perform a function that is similar to the way free trade agreements protect commerce from tariffs and other unilateral trade restrictions.

The most widely held agreement is the International Convention for the Protection of Industrial Property. It is sometimes called the "Paris

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[10] The monopoly price is set where marginal revenue is equal to marginal cost. For simplicity, marginal cost is assumed to be zero in Figure 1.

[11] Actually, the consumer surplus from the invention can continue even though the market for the invention is eroded by substitutes. This is because following an invention may have "built upon" the original invention, but the new invention can only obtain IPR rights for the added value of the new invention.

[12] It is important that renewal fees be high enough to convert patented inventions into public domain inventions. The market erosion in time T can reduce PR and create CS2, but unless renewal fees are set high enough, CS1 + CS2 in period T may be less than CS1 in Period 1.

[13] Many analysts ignore these gains, focusing instead on the UCS component. But unless an alternative to a patent system is in place, these gains are real.

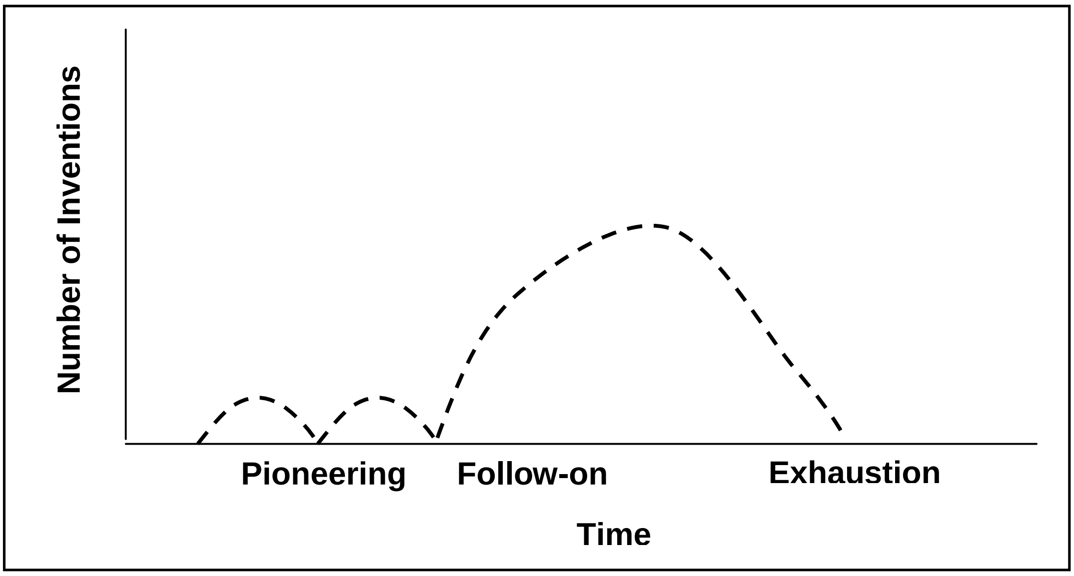

Fig. 2. The Invention Cycle

Convention" because of the location of its formulation in 1883. This agreement, as subsequently amended at the Hague (1925), London (1934), Lisbon (1958), and Stockholm (1967), provides that any country belonging to the convention should grant to citizens of another convention country the same rights that it grants to its own citizens.

Two other treaties have a more direct bearing on agricultural inventions: the International Convention for the Protection of New Varieties of Plants (UPOV) and the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the purpose of Patent Procedure. The UPOV Convention was amended most recently in 1978 and provides for patent or patent-like protection to member-country breeders of new plant varieties. These plants may be sexually as well as asexually reproduced (which gives protection to hybrid varieties), but member states may exclude hybrid varieties from protection at their discretion (on the grounds that the breeder retains control over the parents, which renders protection unnecessary).

3. Asymmetries in International Invention

Inventors respond to disclosure as noted above. The disclosure of one invention stimulates "follow-on" invention. Most invention fields in developed countries exhibit the "cycle" pattern in Figure 2.

In the first phase of the cycle, key pioneering inventions are made. In the second stage, follow-on inventions are made exploiting permutations and combinations of the original pioneering invention. The third stage is a stage of "exhaustion" where the number of inventions declines.

Most developing country invention systems are not well positioned to produce pioneering inventions. In fact, many developing countries produce few, if any, inventions simply because they do not invest in R&D, particularly in industrial R&D. For those countries where R&D investment is observed, much of the invention is "adaptive."

Adaptive invention is similar to the follow-on invention observed in developed countries, except that it serves to modify and "adapt" inventions to developing country conditions.[14] For example, because developing country wages are lower than wages in developed countries, adaptive inventions will be labor-using and capital-saving relative to the originating inventions in developed countries.

The utility model with its relatively weak inventive step and novelty requirements is well suited to the protection of adaptive invention. Japan used the utility model effectively in its

[14] Adaptive inventions are modifications of an invention to better suit local wage conditions and local institutional settings.

PLEASE SEE FILE: Evenson Figure 3.pdf

Fig. 3. Adaptive Invention Asymmetry

industrialization period and continues to use it effectively today.[15]

One of the consequences of adaptive invention, however, is that an invention adapted from a developed country invention is unlikely to have a large market in the developed country. This can create an asymmetry between developed and developing countries, which explains why developing countries have been less than enthusiastic about adopting stronger IPR systems. It also explains why widespread "piracy" of Intellectual Property has occurred in developing countries, but not in developed countries (developing countries pirate from developed countries; developed countries generally do not pirate from other developed countries). Figure 3 illustrates this asymmetry.

In the upper panel with low levels of adaptive invention as would be the case for two developed countries, Country A has a significant market in Country B. The reverse is also the case. Both countries have a stake in maintaining the IP markets in both countries. Both countries benefit from larger IP markets. Both countries have an interest in preventing piracy and respecting the IPRs of foreigners. The rules of the Paris Convention are respected by countries with low-levels of adaptive inventions.

The lower panel shows the case with high levels of adaptive invention. In this case Country B is adapting inventions made in Country A. Country A has a market in Country B for its inventions (even though they are not adapted to

[15] See Evenson and Ranis (1990) for studies of the utility model system.

Table 2. International invention flows

Origin Countries Country of residence of applicant		AT	AU	BE	CA	CH	DE	DK	FI	FR	GB
		Destination Countries									
AT	Austria	1,284	86	166	51	243	453	125	45	308	266
AU	Australia	101	1,239	103	63	100	140	102	2	138	199
BE	Belgium	167	105	1,050	39	150	373	129	23	364	354
CA	Canada	157	283	152	1,347	151	315	137	22	309	410
CH	Switzerland	839	391	750	240	1,455	1,509	585	98	1,308	1,192
DE	Germany	3,758	822	3,469	714	3,980	18,811	2,075	496	7,792	7,283
DK	Denmark	160	112	185	50	169	280	353	37	237	251
FI	Finland	218	183	184	111	185	384	191	7	360	395
FR	France	1,188	549	1,658	637	1,413	3,046	964	234	11,500	2,903
GB	United Kingdom	813	959	1,051	416	944	1,881	894	153	1,829	4,465
IT	Italy	548	175	539	147	589	1,171	415	90	1,185	1,034
JP	Japan	617	1,207	903	2,070	1,157	8,454	563	38	6,734	7,900
LU	Luxembourg	31	14	35	17	30	55	29	9	50	46
NL	Netherlands	440	372	614	127	456	1,108	404	77	1,083	1,058
NO	Norway	74	97	78	46	70	124	107	13	118	147
NZ	New Zealand	10	107	10	19	12	20	12		18	37
SE	Sweden	343	366	350	149	360	707	366	27	639	673
US	USA	3,163	5,924	4,052	7,190	3,488	9,538	2,935	211	9,081	10,243
BG	Bulgaria		1								
CZ	Czech Republic	6	2	3	1	5	8	3		7	8
HU	Hungary	21	8	19	5	19	24	15	2	22	22
RO	Romania	2		1		2	2	2		2	2
RU	Russian Federation	9	14	11	9	11	18	9		16	17
PL	Poland	5	2	3		5	14	3		7	7
SK	Slovakia	4	1	1		2	4	1		3	2
ES	Spain	73	42	89	28	75	137	71	7	179	140
GR	Greece	8	2	8	1	9	13	7	1	15	14
IE	Ireland	30	34	37	19	38	49	32	5	45	157
IL	Israel	54	75	54	19	66	102	48	2	97	111
KR	Republic of Korea	22	83	29	87	27	345	22	2	263	707
PT	Portugal	6	3	7	1	6	14	4	2	16	14
AR	Argentina	1	6	2	5	2	3	1		4	3
BR	Brazil	4	7	4	5	3	15	2		15	18
CN	China	2	17	2	9	1	7	2		9	11
IN	India	1	7	3	1	3	9	1		8	11
MX	Mexico	4	2	4	3	5	10	3		7	6
TR	Turkey	1	1	1	1	1	1	1	1	1	1
OTH	Others	183	230	175	151	202	404	141	14	518	576
# of patents granted to to Residents		0.1284	1,239	1,050	1,347	1,455	18,811	353	7	11,500	4,465
# of patents granted to Non-Residents		13,063	12,289	14,752	12,431	13,979	30,737	10,401	1,611	32,787	36,218
# of patents granted Total		14,347	13,528	15,802	13,778	15,434	49,548	10,754	1,618	44,287	40,683

B). But since Country B is adapting Country A's inventions to its conditions, Country B does not have a significant market in Country A. Country B has little in the way of technology sellers' interest to protect, and as a result, has a strong interest in pirating the IP of Country A.

Table 2 reports patterns of international invention flows in 1999 (the latest year for which data are available). Because of Paris Convention rules, inventors in an origin country can obtain protection in other countries for their invention. In Table 2, origin countries are the "rows." Destination

Table 2. Continued

Origin Countries Country of residence of applicant		Destination Countries									
		IT	JP	LU	NL	NO	NZ	SE	US	BG	CZ
AT	Austria	316	76	94	191	25	9	196	479	10	57
AU	Australia	126	76	87	115	14	195	112	707	3	4
BE	Belgium	233	163	96	337	24	45	151	648	11	18
CA	Canada	236	187	100	193	22	63	199	3,226	6	14
CH	Switzerland	1,204	592	353	871	84	107	753	1,279	18	97
DE	Germany	6,492	2,665	1,170	4,213	297	187	3,458	9,337	77	418
DK	Denmark	220	99	108	209	56	35	198	487	12	30
FI	Finland	280	131	99	222	73	31	406	649	4	19
FR	France	2,741	1,085	800	1,646	166	78	1,467	3,820	22	107
GB	United Kingdom	1,506	646	585	1,260	135	214	1,086	3,572	29	59
IT	Italy	6,481	283	281	603	35	34	586	1,492	7	39
JP	Japan	3,194	133,960	447	2,213	107	115	1,166	31,104	7	23
LU	Luxembourg	55	14	68	51	7	1	32	22	4	5
NL	Netherlands	797	551	256	2,960	79	43	504	1,247	4	58
NO	Norway	101	36	45	100	431	12	134	224	3	7
NZ	New Zealand	16	6	8	13	2	321	12	114		1
SE	Sweden	579	287	162	454	193	91	2,526	1401	6	46
US	USA	7,004	7,049	2,488	5,056	542	834	4,177	83,907	80	201
BG	Bulgaria								2	204	
CZ	Czech Republic	7	2	2	3	1	1	3	24		228
HU	Hungary	16	6	10	18	2	3	20	39	2	10
RO	Romania	2		1	2			2	4		
RU	Russian Federation	13	6	4	11	2	1	13	181	6	4
PL	Poland	6	3	2	5		2	6	19		
SK	Slovakia	2		1	1			3	5	2	7
ES	Spain	141	25	44	88	13	11	82	222	2	4
GR	Greece	14	2	4	11	2		12	23	1	
IE	Ireland	51	12	23	37	6	4	34	94	1	5
IL	Israel	91	36	36	76	4	10	63	743	1	5
KR	Republic of Korea	151	1,628	13	118	1	4	33	3,562	2	1
PT	Portugal	25		5	7			5	5		
AR	Argentina	7			3	1	4	1	44		
BR	Brazil	18	6	2	6	8		5	91		
CN	China	5	18		3		2	2	90		
IN	India	4	6	1	4	1	1	2	112		1
MX	Mexico	7	2	2	4			3	76		1
TR	Turkey	3		1	1			1	4		
OTH	Others	332	401	92	298	29	5	196	4,432	9	13
# of patents granted to to Residents		6,481	133,960	68	2,960	431	321	2,526	83,907	204	228
# of patents granted to Non-Residents		25,995	16,099	7,422	18,443	1,931	2,142	15,123	69,580	329	1,254
# of patents granted Total		32,476	150,059	7,490	21,403	2,362	2,463	17,649	153,487	533	1,482

countries are the "columns." Thus, inventors in Austria obtained 1284 patents in Austria and patented 453 of these inventions in Germany and 308 in France. The decision to obtain patent protection in another country is based on the perceived "market" for the invention in other countries.

Table 2 covers four "blocks" of countries organized by rows in the table. The first block is the OECD market economies from Austria to the US. The second block is the transition economies, Bulgaria to Slovakia. The third group is the "recently industrialized" market economies, Spain

Table 2. Continued

Origin Countries Country of residence of applicant		Destination Countries HU	RO	RU	PL	SK	ES	GR	IE	IL	KR	PT	AR
AT	Austria	62	2	54	29	42	203	86	80	8	51	96	14
AU	Australia	12	1	56	12		112	86	68	13	72	55	12
BE	Belgium	20	3	77	22	13	200	98	90	20	63	116	16
CA	Canada	14	4	51	20	5	176	106	114	15	94	119	14
CH	Switzerland	98	7	222	69	67	819	374	379	52	325	451	66
DE	Germany	433	23	586	361	182	4,451	1,190	1,154	192	1,217	1,563	82
DK	Denmark	15	3	75	26	8	188	122	113	22	76	116	10
FI	Finland	19	1	101	39	11	198	110	121	3	51	148	2
FR	France	146	7	301	88	66	2,234	726	703	73	584	939	99
GB	United Kingdom	78	12	208	49	47	1,261	639	714	167	388	700	53
IT	Italy	53	13	154	37	28	867	391	312	44	196	432	21
JP	Japan	68	9	206	18	7	1,214	421	291	72	10,230	385	26
LU	Luxembourg	3		16	4	7	39	23	23		16	25	1
NL	Netherlands	69	5	106	52	46	558	275	289	30	416	318	31
NO	Norway	11	1	40	15	3	92	65	62	2	23	67	5
NZ	New Zealand			3	1	1	13	7	11	2	4	8	
SE	Sweden	62	4	145	67	15	443	219	206	44	138	225	15
US	USA	365	46	1,041	247	100	4,677	2,368	2,080	823	5,027	2,274	542
BG	Bulgaria			1									1
CZ	Czech Republic	1		5	2	31	3	2	2	1	3	4	
HU	Hungary	300	4	12	4	6	21	14	11	3	5	15	
RO	Romania	1	926				1	1	2		1	1	
RU	Russian Federation	3	2	15,362	2		9	6	5	1	14	5	
PL	Poland	1		6	1,022		5	3	1	1	2	2	
SK	Slovakia			4	1	75	1	1	1			1	
ES	Spain	4		18	7	4	1,843	65	56	6	18	129	24
GR	Greece	2		3		1	12	7	6		1	6	
IE	Ireland	1	7	8	2	1	40	26	248		12	24	1
IL	Israel	2		19	6	1	76	40	36	419	15	42	3
KR	Republic of Korea	5		192	9		56	16	12	5	43,314	12	14
PT	Portugal	1					11	3	3			88	
AR	Argentina	2		1			5	2	1		1	2	155
BR	Brazil			3	5		17	1	1		7	5	16
CN	China			13	1		6				16		
IN	India			2			4				4		
MX	Mexico			2		2	7	2	3			4	
TR	Turkey						1	1	1			1	1
OTH	Others	30	3	415	19	4	203	102	89	6	251	115	17
# of patents granted to Residents		300	926	15,362	1,022	75	1,843	7	248	419	43,314	88	155
# of patents granted to Non-Residents		1,581	157	4,146	1,214	698	18,223	7,591	7,040	1,605	19,321	8,405	1,086
# of patents granted Total		1,881	1,083	19,508	2,236	773	20,066	7,598	7,288	2,024	62,635	8,493	1,241

to Portugal, and the fourth group is the newly industrialized economies, Argentina to Turkey.

Table 3 reports the number of patents obtained in countries in the origin group and in other groups. Two ratios are also reported in parentheses. The first is the ratio of patents granted in the group to origin patents. The second is the ratio of patents granted in the group to destination patents.

The diagonal elements indicate the extent to which patents have markets in other countries in the group. These numbers include all origin patents

Table 2. Continued

Origin Countries Country of residence of applicant		Destination Countries BR	CN	IN	MX	TR	EP
AT	Austria	25	32	9	15	12	
AU	Australia	51	58	31	25	3	135
BE	Belgium	29	24	7	30	32	
CA	Canada	26	40	28	69	22	312
CH	Switzerland	123	164	105	152	70	
DE	Germany	379	492	268	351	231	
DK	Denmark	9	30	28	15	10	
FI	Finland	32	41	10	11	7	
FR	France	202	209	71	209	77	
GB	United Kingdom	125	173	78	124	74	
IT	Italy	119	95	29	59	31	
JP	Japan	170	1,465	99	134	22	7,139
LU	Luxembourg	6	10	13	5	3	
NL	Netherlands	152	120	65	70	79	
NO	Norway	28	14	9	5	5	124
NZ	New Zealand	6	4	2	3		19
SE	Sweden	86	118	24	64	77	
US	USA	1,150	1,127	559	2,324	285	9,151
BG	Bulgaria		2				
CZ	Czech Republic			3		1	5
HU	Hungary	2	4	1	2	5	21
RO	Romania						2
RU	Russian Federation	2	8	10	1	2	15
PL	Poland						7
SK	Slovakia						3
ES	Spain	22	13	1	18	4	
GR	Greece	1	1	4		2	
IE	Ireland	2	1	1	1	6	
IL	Israel	7	14	17	18	8	92
KR	Republic of Korea	6	237	7	29	2	178
PT	Portugal	1	1	2		1	
AR	Argentina	7		1	1		3
BR	Brazil	424	7	1	4	1	18
CN	China	2	3,097	10	3		7
IN	India			633	1		9
MX	Mexico	2			120		8
TR	Turkey					33	1
OTH	Others	23	36	34	36	17	224
# of patents granted to Residents		424	3,097	633	120	33	17,885
# of patents granted to Non-Residents		2,795	4,540	1,527	3,779	1,089	17,473
# of patents granted Total		3,219	7,637	2,160	3,899	1,122	35,358

plus patents granted by other countries in the group to origin patent holders. These numbers confirm the observation that markets in OECD countries are active. Many OECD countries grant patents to inventors in other OECD countries. However, for the Transition (T), Recently Industrialized (RI) and Newly Industrialized (NI) blocks, the within block markets are negligible. Few patents are granted to inventors from other countries in these blocks.

The OECD row in Table 3 shows OECD origin patents granted in the T, RI and NI block countries. The OECD column in Table 3 shows T,

Table 3. Invention flows from origin block to destination block

			Origin Patents Protected In		
Origin Block	Origin Patents	OECD Economies	Transition Economies	Recently Industrialized Economies	New Industrialized Economies
OECD Economies	272,112	607,546 (223) (3.3)	8,930 (49.3)(22.5)	61,216 (133) (5.2)	14,206 (305)
Transition Economies	18,117	902 (5.0) (0.3)	18,235 (100.7)	148 (0.8) (0.3)	72 (0.4) (1.5)
Recently Industrialized Economies	45,919	11,515 (25.1) (4.2)	318 (0.7) (1.8)	46,648 (101.6)	449 (1.0) (9.6)
Newly Industrialized Economies	4,662	841 (18.0) (0.3)	33 (0.7) (0.2)	40 (0.9) (0.1)	4,715 (101.1)

Note: First number in parentheses is Percent of Origin Patents. Second number in parentheses is Percent of Destination Patent

RI and NI origin inventions patented in OECD countries. Note that the OECD countries obtain far more patents in the T, RI, and NI countries than the T, RI and NI countries obtain in the OECD countries. The transition economies obtain only 10% as many patents in OECD countries as they grant to OECD countries. For the Recently Industrialized countries, the grant to receipt ratio is a more favorable 19%. For Newly Industrialized countries, the grant to receipt ratio is only 6%.

These numbers suggest major invention market asymmetry. However, when viewed relative to origin patents the picture is sharply different. Transition economies grant 3.3% of OECD origin inventions to OECD inventors, but protect 5% of transition origin inventions in OECD countries. RI countries grant 22.5% of OECD origin inventions to OECD inventors, but obtain OECD protection for 25.1% of RI origin inventions. NI countries grant protection to only 5.2% of OECD origin inventions but obtain OECD protection for 18% of NI origin inventions.

Thus there are two ways of looking at asymmetry. Most developing countries look at absolute numbers and conclude that high numbers of patent grants to foreigners are contrary to national pride and policies. But, when looked at as percentages of origin inventions, the asymmetry does not hold.

IPRS AND TECHNOLOGICAL CAPITAL

Avila and Evenson (2004) have recently developed the concept of Technological Capital to better understand the processes of economic development. Two indexes are developed. The first is an index of Innovation Capital. The second is an index of Imitation Capital. Both indexes are data-based, and countries can be classified in index classes by using objective data.

The Innovation index is based on two indicator variables, Agricultural Scientists per unit of cropland, and R&D as a percent of GDP. The first indicator is based on data from the International Service for National Agricultural Research (ISNAR); the second is reported by UNESCO. Data for these two indicators allow an objective classification of countries into Innovation Capital classes for 1970 and 1990.

The Innovation Index takes the following values:

Agricultural Scientists/Cropland
1 if value is 0.02 or lower
2 if value is 0.021 to 0.06
3 if value is greater than 0.06

R&D/GDP
1 if value is less than 0.002
2 if value is between 0.002 and 0.006
3 if value is greater than 0.006

The Innovation Capital is the sum of the two indexes.

Figure 4 reports country classification organized by Innovation Capital class. Note that the lowest possible class is 2 and the highest possible class is 6.

The first digit is the Innovation Capital class as of 1970. The second is the Innovation Capital class as of 1990.

The second Technological Capital Index is based on Imitation Capital. This index is also based on two indicators, Agricultural Extension Workers per Unit of Cropland and average schooling of males over 25.

The Imitation Capital Indexes take the following values:

Agricultural Extension Workers/Cropland
1 if value is 0.2 or lower
2 if value is 0.21 to 0.6
3 if value is higher than 0.6

Average Schooling: Males 25 and older
1 if value is less than 4 years
2 if value is between 4 and 6 years
3 if value is greater than 6 years

The Imitation Capital class is the sum of the two values. It also ranges from 2 to 6. In Figure 4, Imitation Class values are shown in parentheses.

In considering the country classifications, it should be noted that IPRs are important to provide incentives for Innovation Capital, but not for Imitation Capital. Actually, IPRs are generally not essential for public sector investment in agricultural research, but they are quite essential for private sector investment. To guide the reader, an asterisk is placed to indicate countries where UNESCO reports no R&D for agricultural research.

Figure 4 shows country classification beginning with the 22 countries in Innovation Class 2 in 1970. Nine countries remained in Class 2 in 1990. Eight of these report zero R&D. Six countries advanced to Class 3 in 1990. Three of these report zero R&D. Seven countries advanced to Class 4 in 1990.

Thirty-four countries were in Innovation Class 3 in 1970. Two actually lost ground. Ten remained in Class 3 in 1990. Seventeen advanced to Class 4 in 1990 and five advanced to Class 5.

Economic performance indicators will be related to Innovation Class, but at this point it bears mention that none of the countries with an Innovation Class level of 2 or 3 in 1990 has an effective IPR system. By contrast, all countries with an Innovation Class level of 5 or 6 have at least partially functioning IPR systems. Those with Innovation Class levels of 4 have mixed experiences with IPRs.

Countries achieving Innovation Class levels of 4 in 1990, as noted, have mixed IPR systems and mixed economic performance. Countries with Innovation Class levels of 5 and 6 in 1990 have partially functioning to strong IPR systems and good to excellent economic performance.

Imitation Class levels are correlated with Innovation Class levels but not perfectly. Improvements in Innovation Class levels are unrelated to Imitation Class levels. That is, for Innovation Class improving countries, Imitation Class levels are as likely to be lower as they are to be higher than Innovation Class levels.

Table 4 provides comparisons of economic performance measure with Innovation and Imitation Classes. The most important performance measure for agriculture is growth in Total Factor Productivity (TFP). TFP growth rates are reported in Avila and Evenson (2004). Tables 4 to 7 compute indicators weighted by the value of agricultural product.

Table 4 provides very limited support for the proposition that investment in agricultural extension produces higher TFP growth. The TFP growth when both Innovation and Imitation classes are lowest (level 2) was 0.775. That was not enough to offset the real price declines in world markets for agricultural commodities. When the Imitation Class was 3, TFP growth was lower. When the

Innovation Classes 2 and 3 in 1970

2 2[1]		2 3[1]		2 4[1]		3 2[1]		3 3[1]		3 4[1]		3 5[1]	
Afghanistan	(2 2)[2]	Benin*	(3 4)	Dominican Republic*	(2 4)	Guinea Bissau*	(2 2)	Chad	(2 2)	Algeria	(2 2)	Guatemala	(3 3)
Angola*	(2 2)	Burundi*	(2 2)	Ecuador	(2 3)	Sudan	(2 2)	Gabon*	(3 2)	Cameroon	(3 4)	Kenya	(4 5)
Cambodia*	(2 3)	Burkina Faso	(4 3)	Guinea*	(3 3)			Haiti*	(3 3)	Guyana*	(4 4)	Malawi	(4 4)
Congo (Zaire)*	(2 3)	Central African Republic	(3 3)	Mali*	(3 4)			Laos*	(3 3)	Indonesia	(2 5)	Peru	(4 5)
Ethiopia*	(2 2)	Rwanda	(4 4)	Nicaragua	(2 3)			Madagascar	(2 2)	Iran	(2 3)	Venezuela	(3 3)
Mongolia*	(3 4)	Somalia*	(2 2)	Togo	(2 3)			Mauritania*	(3 3)	Libya	(3 3)		
Mozambique*	(2 2)			Tunisia	(2 4)			Morocco*	(3 3)	Nepal*	(3 4)		
Namibia*	(2 2)							Myanmar*	(3 3)	Nigeria	(2 2)		
Niger	(2 2)							Paraguay	(2 4)	Panama	(5 6)		
								Zambia	(3 4)	Seneghal	(2 3)		
										Swaziland*	(2 3)		
										Syria	(2 5)		
										Tanzania	(4 4)		
										Uganda*	(3 4)		
										Uruguay	(3 4)		
										Vietnam*	(4 4)		
										Yemen	(2 2)		

Innovation Classes 4 and 5 in 1970

4 3[1]		4 4[1]		4 5[1]		4 6[1]		5 5[1]		5 6[1]	
Saudi Arabia	(2 3)	Bangladesh	(3 3)	Argentina	(4 4)	Turkey	(2 5)	Cuba	(4 4)	Brazil	(2 4)
Zimbabwe	(4 5)	Bolivia	(3 3)	Botswana	(4 5)	India	(2 4)	Costa Rica	(4 4)	Chile	(3 5)
		Colombia	(4 4)	Egypt	(3 5)			Philippines	(4 6)	China	(5 6)
		Cote d'Ivoire	(2 3)	Iraq	(2 2)			South Africa	(4 6)	El Salvador	(2 5)
		Gambia	(2 2)	Malaysia	(3 5)					Pakistan	(2 4)
		Ghana	(3 4)	Mauritius	(5 6)						
		Honduras	(2 4)	Mexico	(3 5)						
		Jamaica	(4 5)	Sri Lanka	(5 6)						
		Jordan	(4 5)								
		Thailand	(4 5)								
		North Korea	(2 2)								
		Sierra Leone*	(4 4)								
		Surinam*	(2 2)								
		Trinidad-Tobago	(4 5)								

[1] First digit is the Innovation Class as of 1970; second digit is the Innovation Class as of 1990.
[2] Imitation Classes for 1970 and 1980 are in parentheses.
* An asterisk indicates countries where UNESCO reports no R&D for agricultural research.

Fig. 4. Country Classifications

Table 4. Growth in Total Factor Productivity (TFP): Innovation Class vs. Imitation Class

Innovation Class	Imitation Class 2	3	4	5,6
2	0.775	0.394	1.172	
3	2.466	1.459	0.131	0.955
4	2.310	1.270	1.665	-0.187
5,6	0.758	0.687	2.582	3.216

Table 5. Adoption of Green Revolution varieties (%): Innovation Class vs. Imitation Class

Innovation Class	Imitation Class 2	3	4	5,6	Mean
2	18	10	30		(78)
3	37	50	37		(44)
4	19	54	57	82	(5-9)
5, 6		62	76	80	(78)

Table 6. Agricultural indicators by Innovation Class

Innovation Class*	Growth in TFP	Adoption of Green Revolution Varieties	Cereal Yields (kg)	Fertilizer per hectare (kg)
2 2	0.55	14	960	6
2 3	1.84	21	928	9
2 4	1.26	45	1733	48
3 3	0.78	44	1393	16
3 4	1.33	62	2368	81
4 5	1.83	79	2922	91
5 6	3.86	81	3760	210

* First digit refers to Innovation Class of 1970; second digit refers to Innovation Class of 1990.

Imitation Class was 4 there is a suggestion that TFP growth is higher. But clearly, the move from Innovation Class 2 to Innovation Class 3 or 4 was the major driver of TFP growth, and once the Innovation Class is 3 or 4, there is no indication that higher Imitation Class levels result in higher TFP growth.

Table 5 shows the relationship for adoption of Green Revolution varieties. It essentially supports the interpretation for Table 4.

Table 7. Economic growth by Innovation Class

Innovation Class*	GDP per Capita PPP$1998	Growth in per Capita PPP$ (1962-92)
2 2	1160	-1.08
2 3	930	1.04
2 4	3203	2.14
3 3	2291	0.60
3 4	2881	2.49
4 5	8430	3.49
5 6	4156	3.67

* First digit refers to Innovation Class of 1970; second digit refers to Innovation Class of 1990.

Table 6 reports several agricultural indicators as they relate to Innovation Classes in 1970 and 1990. They show very low cereal yields and fertilizer levels for the 22 and 23 countries. Cereal yields of less than one ton per hectare are very low. Even with farms of substantial area, these farmers do not produce enough products to earn more than one dollar per day per capita.

Table 7 reports per capita income levels (PPP) and growth rates in per capita incomes. Incomes of the poorest Innovation Class actually declined. Clearly Innovation capital is important for economic growth.

IPRS FOR PLANTS: EXCLUSION PROVISIONS

Box 1 lists the features of three important documents affecting plants.[16] TRIPS Article 27 states that certain items can be excluded from patentability. The European Patent Convention Article 53 (a) and (b) as well as EU Directive Article 4 also state exclusion provisions.

All three of these exclusive provisions appear to be favorable to developing countries seeking the weakest possible Internal Rate of Return (IRR) for plants. But all three have been challenged, and the exact meaning of the exclusion restriction has been given different interpretation by administrative boards.

[16] Box 1 is from F. Yamin (2003) of the Sussex group. This paper is very informative in spite of having a strong bias against industrial biotech firms' interest.

BOX 1 Excludability Provisions

Exclusions from Patentability, TRIPS Article 27

2. Members may exclude from patentability inventions, the prevention within their territory of the commercial exploitation of which is necessary to protect ordre public or morality, including to protect human, animal or plant life, or health or to avoid serious prejudice to the environment, provided that such exclusion is not made merely because the exploitation is prohibited by their law.

3. Members may also exclude from patentability:

   a. Diagnostic, therapeutic, and surgical methods for the treatment of humans or animals;
   b. Plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof. The provisions of this subparagraph shall be reviewed four years after the date of entry into force of the WTO Agreement.

Exclusion Provisions of the European Patent Convention Article 53 (a) and (b)

European patents shall not be granted in respect of:

   a. Inventions, the publication or exploitation of which would be contrary to "ordre public" or morality, provided that the exploitation shall not be deemed to be so contrary merely because it is prohibited by law or regulation in some or all of the Contracting States;
   b. Plant or animal varieties or essentially biological processes for the production of plants or animals; this provision does not apply to microbiological processes or the products thereof.

Exclusion Provisions of EU Directive Article 4:

1. The following shall not be patentable:

   a. Plant and animal varieties;
   b. Essentially biological processes for the production of plants or animals.

2. Inventions, which concern plants or animals, shall be patentable if the technical feasibility of the invention is not confined to a particular plant or animal variety.

3. Paragraph 1(b) shall be without prejudice to the patentability of inventions which concern a microbiological or other technical process or a product obtained by means of such a process.

1. The EPC Exclusions

Non-government organizations and citizens groups have challenged European Patent Office (EPO) rulings giving protection to biotechnology products. The United States and the EPC do have different philosophies on patentability but both the EPO and US Patent and Trademark Office (USPTO) play a harmonizing role. Under the EPC, "plant varieties" are to be excluded from patent protection. However, the fundamental issue is the definition of plant varieties. Specifically, are genetically engineered varieties to be granted exclusion?

The EPO refers the term "plant varieties" to plants subject to protection under the UPOV system. Thus, patents can be given to plants falling outside the UPOV rules. Both the US (in the JEM vs. Pioneer case) and the EPC (in the Novartis case) have addressed the issue of patent eligibility for plant varieties eligible for UPOV protection. The US Supreme Court ruled that plant varieties could be given protection under both patent and UPOV rules. The EPO Enlarged Board of Appeals has ruled that "inventions ineligible for protection under the plant breeders rights system were intended to be patentable under the EPC provided they fulfilled the other requirements of patentability."

The EPC, arguing that transgenic plant varieties do not have a privileged position over other varieties, has so far denied "product patents" for transgenic plant varieties. But the EPO's decision in the Novartis case allows wider protection for plant varieties. This means that the EPO has moved closer to US practice.

2. Biological Processes

TRIPS gives members rights to exclude "essentially biological processes" from patent protection. Non-biological processes and micro-biological processes are not excluded. The term "product-by-process" is used to address the question of whether the process enabled the product. Traditional plant breeders oppose patent protection for transgenic plants and argue that this provided "back-door" protection.

The EU Directive 98/44/EC (the Biotechnology Directive) excludes "plant varieties" from patentable subject matter but defines plant varieties narrowly so that most transgenic plants would be eligible for patent protection.

3. Ordre Public

The patentability of plants has also been challenged under the ordre public clause. NGOs and other interest groups have brought ordre public cases on moral grounds. Several cases have been argued as "public abhorence" grounds. But in all cases the EPO has not accepted these grounds as a basis for excludability.

4. Abridged Excludability (Box 1)

Courts and administrative agencies in both North America and Europe have generally taken an abridged or limited interpretation of the excludability provision in TRIPS Article 27, the European Patent Convention Article 53 and EU Directive Article 64. The implication of this for Asian developing countries is that many processes and products, particularly, genetically engineered processes, products and product-by-process cases will not be excluded from patentability.

CBD IMPLICATIONS

The Convention on Biological Diversity (CBD) has Articles covering *in situ* conservation (8j), access to genetic resources (15) and access to end transfer of technology.

Article 8j encourages *in situ* conservation "to respect, pressure and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles."

Artcle 15 states that:

> *"Recognizing the sovereign rights of states over their natural resources, the authority to determine access to genetic resources rests with the national governments and is subject to national legislation."*

Article 16 states that:

> *"Access to and transfer of technology to developing countries shall be provided and/or facilitated under fair and most favorable terms. In the case of technology subject to patents and other intellectual property rights, such access shall be provided on terms which recognize and are consistent with adequate and effective protection of intellectual property rights."*

The CBD was initiated and supported by developing countries. Article 8j reflects a broad international consensus that *in situ* conservation be supported. Virtually all plant breeding materials are accessible only in *ex situ* collections of seed in a number of genebanks. Article 15 is the critical article in that it defines rights associated with genetic resources in countries that can claim to have been countries of origin. These are often termed "farmers rights." With the development of these rights, the traditional system of free exchange of genetic resources between public international and national plant breeding programs has come under threat.

THE CBD AND THE INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE (ITGRDFA)

ITGRDFA is designed to reconcile conflicts between farmers rights and the traditional free exchange of plant genetic resources in *ex situ* collections in International Agricultural Resource Centers (IARCs) and National Agricultural Resource System (NARS) plant breeding programs. This exchange is vital. The delivery of "advanced" breeding lines by IARCs to NARS programs makes NARS breeders more successful (Evenson 2000).

FAO has led the ITGRDFA discussion. The recognition of both farmers' rights and other IPRs has been at the center of the ITGRDFA negotiations. It appears that a mechanism for payment of Farmers Rights based on "certificates of origin" has been made. The *in situ* language of the CBD has been problematic because breeders generally utilize *ex situ* collections instead of *in situ* collections.

The ITGRDFA establishes a multilateral system to govern access to plant genetic resources for many crops. The legal document for exchanges is a Materials Transfer Agreement which provides for benefit sharing and provides that,

> *"Recipients shall not claim any intellectual property or other rights that limit the facilitated access to the plant genetic resources for food and agriculture in the form received from the multilateral system."*

This wording is ambiguous regarding "material derived from plant genetic resources in the form received." Since plant genetic resources are primarily "landrace" and related uncultivated species, they are not "received" in transgenic form.[17]

POLICY IMPLICATIONS FOR PLANT BREEDERS IN ASIA

Two developments over the past 20 years have changed the nature of plant breeding in Asia in a fundamental way. The first development is the development of rDNA techniques and associated genome mapping. The second is the expansion of patent scope in developed countries to include living plants, specific DNA constructs and rDNA techniques, themselves.

While there are many activist groups (particularly in Europe) dedicated to imposing regulatory bans on Genetically Modified (GM) crops, there is little question that the methods and techniques of plant breeding have changed. Even in countries with a dedicated opposition to GM crops, hence to transgenic breeding, a "modern" plant breeder will be using techniques developed in recent years, particularly marker-aided selection. And the opposition to GM crops in most developing countries is fading as countries recognize that GM crops are of value to farmers.

The expansion of IPRs, specifically patents to plants, genes and techniques, has also changed the way plant breeders operate. The days when a breeder could ignore IPRs and expect costless access to genetic resources are largely gone. Today, virtually all plant breeding initiatives, whether public or private, should begin with an IPR search. This search may reveal IPR-protected materials requiring a licensing arrangement and negotiation over terms. Public plant breeding programs will be under an obligation to obtain IPRs on their products to protect their ownership of the product. This will be the case even when the program does not seek IPR revenues.

The WTO-TRIPS agreement was basically an agreement designed to give better protection to the IPRs of OECD IPR holders. The agreement did not change the fundamentals of technology market asymmetry. Many developing countries are poised to pass stronger IPR laws, but many are

[17] See Alker and Heidhus (2002).

also poised to understaff IPR systems and to use courts to redress what is seen as an "unfair" inclusion of IPRs in the Uruguay Round of the GATT.

As countries develop and invest in R&D, their R&D systems mature. They engage in less adaptive invention and more competitive invention. The old "Asian Tigers" — Singapore, Hong Kong, Taiwan and South Korea — graduated to R&D maturity status some years ago and now have joined the OECD "club" so to speak. They now maintain and enforce strong IPRs.

With changes in IPR systems, particularly as they affect agriculture, the boundary line between countries with a genuine interest in strong IPR systems, i.e., in WTO-TRIPS systems, and countries with an interest in the weakest of possible IPRs has been drifting to lower income levels.

The Technology Capital discussion in this paper demonstrated that Asian countries can and have relied on public sector agricultural research programs for crop and animal genetic inventions. However, that discussion also showed that when some industrial R&D is undertaken, agricultural Total Factor Productivity grows more rapidly.

Most developing countries, including several in Asia, simply do not have industrial R&D capacity. Only a few countries have functioning IPR systems, although this is changing rapidly. The number of patents granted to Asian inventors is low, but these inventors actually have good markets for the few inventions that they do make in OECD invention markets.

The Technology Capital analysis in this paper clearly shows that invention/innovation capital matters for economic growth, and virtually all experiences for the past several decades show that economic growth is essential if poverty reduction is to be achieved.

The Technology Capital analysis also showed that countries can and do rely on public sector agricultural research programs. The system of IARCs and NARS programs have produced important forms of technology for Asian countries. This system produced the Green Revolution, and this system is facilitating the Gene Revolution. But it is also clear that industrial R&D is important to economic growth.

The task of providing incentives for private sector firms to invest in R&D is challenging. The experience of virtually all OECD, Transition and Recently Industrialized countries indicates that IPRs, particularly patent IPRs, are essential if inventive efforts by private firms are to be achieved. In addition, inventive effort is required to produce economic growth.

Developing countries in Asia range from the Asian Tigers who have accepted the value of IPRs, to countries with little or no experience with IPRs. While IPR systems can be modified and tailored to national needs to some extent, there are really no alternatives to IPR systems for industry. In agriculture, the public sector system has served Asian economies well. Yet, even in agriculture, IPR systems can facilitate private sector contributions to productivity growth.

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