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INTELLECTUAL PROPERTY RIGHTS FOR APPROPRIATE INVENTION

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Intellectual Property Rights for Appropriate Invention*

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Intellectual Property Rights (IPRs) are one of the oldest means by which "failures of the market" have been at least partially remedied in the United States. They are prescribed in the U.S. Constitution as the institutional means by which the "promotion of progress in science and the industrial arts" is to be achieved.[1] The new U.S. government passed the first Patent Act in 1790 and the Patent Office was one of the most important agencies in the U.S. government in its early years.[2] Over the years patent, trademark and copyright property rights have been sought by both U.S. and foreign inventors and writers.

IPR systems have evolved as institutions over time in response to changing prices, infrastructure and related institutional change. This evolution, however, has been slow and sometimes painful. By the end of the 19th century several international agreements were in place each calling for national IPR systems to provide "national treatment" to foreigners as regards IPR protection. Over the course of the 20th century, however, these international agreements, while nominally in place and binding, are clearly under great stress and conflict by different groups of countries.

Those countries that today constitute the Developed Market Economies, i.e., the OECD countries, have generally been strengthening the scope administration and general strength of IPR systems.[3] Furthermore, the various international agreements are generally respected by member countries and relatively few conflicts have emerged between these countries. This, however, is not the case for developing countries.

Twenty years ago developing countries mounted an effort to attain better terms of technology transfer between North and South countries. In practice this meant better terms for technology purchases by developing countries. Developing countries pursued several efforts to change the existing intellectual property rights framework in their favor. They argued that payments of royalties and license fees to foreign holders of patents and copyrights constituted "unfair" terms of exchange and that the holders of these rights in developed countries had no moral or "natural" rights to protection in developing countries.[4]

No new agreements or conventions regarding IPR's were developed as a consequence of the North-South debate, largely because the North resisted all changes. Many developing countries actually weakened their own IPR laws and the administration of those laws in the intervening years. Ironically, today the countries of the North, who resisted changes in IPR systems in the North-South debate, are now on a virtual "rampage" to force the countries of the South (at least a certain sub-set of them) to strengthen IPR protection for foreign inventors. The U.S. is leading a "war on piracy" using a provision of U.S. trade laws (sec. 301) as its chief weapon. IPR considerations have now become an integral part of the Uruguay round of the GATT.[5]

In spite of the increased demand for stronger IPR's by most developed countries, economists remain somewhat divided and inconclusive as regards this actual economic merit of IPR's in developed countries.[6] There is even less agreement as to their merit in developing economies where these economies have not exhibited a demand for stronger IPR's and have if anything been weakening their IPR systems.[7]

This divergence of interests and downright conflict raises a number of policy questions regarding IPRs. Do we have analytic and/or empirical studies that can explain why both national IPR systems and international agreement have been strengthened within the OECD "club"? Do we understand why this is not the case for developing countries and why there is growing institutional conflict? Should IPR's be strengthened? In which countries? Would global welfare be improved if a strong international system of IPR's were in place and enforced? IPR systems are designed to provide stronger incentives for R&D (than afforded by trade secrets and monopoly) and to facilitate disclosure of inventions, and this disclosure facilitates follow on and inventing around (legal imitation) inventive activities.

In this paper a review of relevant studies is undertaken. The review is undertaken from the perspective of developing countries and particularly the newly industrialized countries in Asia. The review begins with an institutional review of IPR systems (Part I). The usage patterns of IPRs are reviewed (Part II). Part III examines empirical evidence on R&D spending with a view toward assessing whether developing countries are underinvesting in R&D. Part IV reviews studies of IPR incentives for R&D. The empirical literature reviewed in both Parts III and IV unfortunately is too limited to allow strong policy conclusions. The theoretical literature is also of very little policy relevance[8] for most of these questions. A summary of comparative international patterns of investment in R&D and related magnitudes is offered in the final part of the paper as a basis for suggestions for some policy directions and for further work.

I. IPR Systems: An Institutional Review

A. IPR Systems[9]

Legal systems for securing private rights to inventions implement diverse types of protection: (i) seed and breed certification; (ii) copyrights; (iii) trade secret enforcement; (iv) invention patents; (v) utility models or "petty patents"; (vi) inventor's certificates; (vii) industrial design patents; and (viii) plant patent and variety protection. All of these systems provide some type of legally enforceable right to restrict the use of inventions by someone other than the inventors and their licensees/assignees.

The seed and breed certification systems normally require that seed and animals be marketed with sufficient labeling to identify the origin of the seed or animal and give its genetic heritage. Such certification operates like a trademark to prevent others from trading on the reputation that a breeder establishes with a new plant or animal variety.

A copyright prevents unlicensed copying of works of art or an author's writings. The "copyright" is quite literally limited to "copying" the publication and does not preclude the use of the information contained therein. For inventions which can be maintained in secrecy, such as manufacturing processes that are not readily apparent in the marketed product, trade secrets contracts prevent anyone (primarily ex-employees and collaborators) from disclosing secrets of manufacture and the like to competitors.

An invention patent system, which governs the usual type of patent, gives the inventor the right to exclude others from practicing the invention for a certain time period (usually 15-20 years). Invention patent systems traditionally require that an application for a patent must include an "enabling disclosure" which sufficiently describes the invention so that others skilled in the same technical field can reproduce it successfully.

An invention patent is not an exclusive right to practice a particular invention, but rather a right to exclude others from practicing the invention, within the scope of the exclusion defined by the claims which describe the novel contributions made by the inventor.

To be valid, an invention patent must disclose an invention that is novel, useful, and an improvement over the prior art. An invention must be novel in the sense that it has not previously been published, exhibited, or otherwise described, except within the period immediately preceding the application, and then only by the applicant. As to its utility, the invention must be capable of industrial or agricultural application, and not be purely ornamental.

The degree of "improvement over prior art" that an invention must exhibit defines the single most important attribute of a patent system. Also called the "inventive step" or "level of invention" requirement, this increment must be greater than what would be obvious to the average person skilled in the art. The height of this step varies from country to country.

Utility models or "petty patents" are similar to invention patents in that they give the inventor the right to exclude others from practicing the invention for some period of time. They differ from the invention patents in requiring only novelty and utility, without any "inventive step" above the prior art. Thus, petty patents preserve rights to minor variations of known devices rather than to major technical innovations having broad adaptability. Countries usually grant petty patent protection for a much more limited time than is the case for invention patents, and many grant petty patents only to their own citizens. Also, since the existence of an inventive step need not be determined, such systems cost less to administer than do most invention patent systems. In developing countries, minor adaptations of machinery and other inventions may be valuable in the local economy but may not be valuable abroad.

An inventor's certificate is a notice given in socialist countries that entitles an inventor to receive compensation for his invention, which as a matter of property belongs to the state. This non-market alternative to the standard patent aims to reward the inventor whil, removing his monopolistic control over the invention.

Industrial design patents provide protection to designs as opposed to inventions per se. They provide weak protection somewhat similar to that provided by copyrights.

B. The Role of International Conventions

In keeping with the treatment of inventions as "intellectual property," most countries of the world are party to at least one international agreement, the intent of which is to facilitate protection of an inventors rights to their inventions from country to country. The most widely held of these agreements is the International Convention for the Protection of Industrial Property, usually called the "Paris Convention" for the seat of its first 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 as those belonging to its own citizens.

The next logical step in providing uniform protection for citizens of different countries is to create a uniform application system under which a single application may be examined by designated member countries according to their particular laws. An agreement of this type was signed by 35 countries in 1978. Called the Patent Cooperation Treaty, its stated aims are "to make a contribution to the progress of science and technology," "to perfect the legal protection of inventions," "to simplify and render more economical the obtaining of protection for inventions where protection is sought in several countries," "to facilitate and accelerate access by the public to the technical information contained in documents describing new inventions," and "to foster and accelerate the economic development of developing countries through the adoption of measures designed to increase the efficiency of their legal systems...."

About half of the parties to the Patent Cooperation Treaty are developing countries: Algeria, Argentina, Brazil, Egypt, Iran, Israel, Madagascar, Malawi, North Korea, the Philippines, Sri Lanka, Syria, along with the following members of the African Intellectual Property Organization: Cameroon, Central African Republic, Chad, Congo, Ivory Coast, Senegal, and Togo. The remainder comprises Western Europe, North America, Japan, and half of Eastern Europe. With the exception of the Philippines, North Korea, and Sri Lanka, underdeveloped Asia is missing entirely. Latin America, too, has few participants. We may ascribe the relatively strong rate of participation by African countries to the formation of the African Intellectual Property Organization (open to any country but presently comprising former French colonies), a group of countries which binds its members by a modern agreement modeled on French patent law.

Two other treaties have a more direct bearing on agricultural inventions: the International Convention for the Protection of New Varieties of Plants, and the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purpose of Patent Procedure. The first of these, the Plant Variety Convention, was amended most recently in 1978 and provides for patent or patent-like protection to breeders of new plant varieties who belong to member countries. 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). At present, no developing country belongs to this treaty, and only one, Argentina, has passed a law to give protection to new varieties.

The Budapest Treaty on Microorganisms was signed in 1977. It provides for an "international depository authority" in several nations, which keeps samples of patented microorganisms. This special arrangement takes the place of the usual written and/or graphic description that regular patent documents employ.

The treaty aims to lower the cost and reduce the inconvenience of trying to deposit multiple samples in each country in which the inventor desires protection.

The treaty does not grant patent protection *per se*, but merely commits states to the system of recognizing deposits made in other countries as equally valid with those made in its own. Thus, the treaty leaves a considerable degree of freedom in the hands of the individual countries to decide what constitutes a patentable microorganism. Among developing countries, only Senegal, Korea and the Philippines belong to this agreement; the only other non-Western participant is the Soviet Union.

C. Comparative Summary of IPR's in Developing Countries and the U.S.

In order to summarize concisely the scope of protectable subject matter in the various countries assume a hypothetical Amalgamated Research Corporation (ARC). ARC's research program covers the entire spectrum of research and development activities. For the purpose of this discussion, we assume that all of these research results were obtained exclusively by ARC using ARC funds, were never before existent or described anywhere in the world, and were in fact better than the state of the art.

Mechanical/Electrical Inventions

1. ARC Machine I: a basic innovation in machines.
2. ARC Machine II: a minor modification in machines.
3. ARC Chemical: a new chemical compound.
4. ARC Insecticide: a new and useful chemical compound insecticide.
5. ARC Herbicide: a new and useful chemical compound herbicide.
6. ARC Pharmaceutical: a chemical compound pharmaceutical.

Biogenetic Inventions

7. ARC Soybean: a new improved soybean variety developed in a plant breeding program.

8. ARC Corn: a new hybrid corn seed variety developed in a plant breeding program, with AARC retaining control over the hybrid parents.

9. ARC Rose: a new variety of asexually reproducible ornamental rose.

10. ARC Beef Cattle: a new pure breed of beef cattle developed in a selective breeding program.

11. ARC Bacterium: a new and improved nitrogen-fixing strain of bacteria developed using recombinant DNA techniques.

12. ARC Live Virus Vaccine: a new strain of virus to be used as a vaccine for animals, developed using recombinant DNA techniques.

Other Inventions

13. ARC Computer Program: a new and improved computer program that determines the optimal mix of chemicals in a production process.

14. ARC Accounting System: a new and improved accounting system used for optimally allocating resources.

Table 1 shows the availability of patent or variety protection available to ARC in different countries. From the table one can see immediately that the degree of protection given to intellectual property varies considerably among countries. Of particular interest are those entries that denote that the device in question is specifically prohibited from being patented.

Several countries ban the patenting of chemical substances and the processes for making them; others ban only the substances; still others permit chemicals in general to be patented but do not allow chemical vaccines to be patented because they are medicines. Among Asian countries, India, Korea, and Taiwan do not allow chemical patents of any kind; Thailand excludes only chemical medicines. (Thailand is currently changing it laws.) As a group, Asia falls midway between Latin America and Africa in allowing chemical patents. In Latin America, half of all countries ban patents on chemicals of any type, and three-fourths of them ban patents on chemical medicines. By contrast, all the African countries permit some kind of chemical patent, and only two exclude chemical medicines from protection. In the Middle and Near East, all countries allow non-medicinal chemical patents, but most forbid patents on medicinal chemicals.

For minor mechanical-electrical inventions (those which do not meet the "inventive step" requirement of a regular patent, but which contain some adaptation or modification of existing technology), five semi-industrailized countries provide protection via a utility model system: Brazil, Uruguay, Korea, the Philippines, and Taiwan, as well as the parties to the African Intellectual Property Organization.

As to biogenetic inventions, most countries specifically exclude plant varieties and animal species from protection, either as such or by excluding foodstuffs. Among developing countries, only Argentina and Korea make provision for plants of any kind to be patented, and only Argentina permits

TABLE 1
Availability of Patent or Variety Protection for Different Categories of Inventions in Selected Countries

	Mechanical/Electrical		Chemical				Biogenetic						Other	
	Machine Major	Machine Minor	Fertilizer	Insecticide	Herbicide	Chemical Vaccine	Soybean	Corn Hybrid	Rose	Beef Cattle	Nitrogen Fixing Bacteria	Live Virus Vaccine	Computer Program	Accounting Systems
Australia														
NORTH AMERICA														
Canada														
USA														
EUROPEAN COMMUNITY														
France														
Netherlands														
U.K.														
West Germany														
ASIA														
Bangladesh 1,2	no	no	no	no	no	no	no[a]	no[a]	no[a]	no[a]	?	?	no[a]	no[a]
China														
India	no[a]	no	no[b]	no[b]	no[b]	no[b]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no	no
Indonesia 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Korea (South)	yes	yes	no[b]	no[b]	no[b]	no[a]	no[a]	no[a]	yes	no[a]	yes	no[b]	no	no
Malaysia 1,2	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no[a]	no[a]
Nepal 4	yes	no	yes	yes	yes	yes	See footnote						no	no
Pakistan 3	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	yes	yes	yes	no[b]
Philippines 5	yes	yes	yes?	yes?	yes?	no	no	no	no	no	yes	yes	no	no
Singapore 1,3	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no[b]	no[b]
Sri Lanka 3	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no	no[b]
Taiwan	yes	yes	no[b]	no[b]	no[b]	no[b]	no[a]	no[a]	no	no[a]	no	no[a]	no	no
Thailand	no[a]	no	yes	yes	yes	no[b]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no
LATIN AMERICA														
Argentina	yes	no	yes	yes	yes	no[a]	yes	yes	yes	no	yes	no[a]	no[a]	no[a]
Bolivia	yes	no	no[b]	no[b]	no[b]	no[b]	no	no	no	no	no	no[a]	no	no[a]
Brazil	yes	yes	no[b]	no[b]	no[b]	no[a]	no[a]	no[a]	no	no[a]	no[a]	no[a]	no[a]	no[a]

Chile	yes	no	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no	no[a]	no	no[a]
Colombia	yes	no	no[b]	no[b]	no[b]	no[b]	no[a]	no[a]	no	no[a]	no[a]	no[a]	no[a]	no[a]
Costa Rica	yes	no	yes	yes	yes	no[a]	no	no	no	no	no	no[a]	no	no
Dominican Rep.	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no[a]
Ecuador 7	yes	no	yes	yes	yes	no[a]	no[a]	no[a]	no	no[a]	no	no[a]	yes	no[a]
Guyana	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Haiti 3	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Jamica	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Mexico	yes	no	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]
Nicarague	yes	no	no[b]	no[b]	no[b]	no[b]	no	no	no	no	no	no	no	no
Panama 5	yes	no	yes	yes	yes	no[a]	no[a]	no[a]	no	no	no	no[a]	no	no
Paraguay	yes	no	yes	yes	yes	no[b]	no	no	no	no	no	no[a]	no	no
Peru	yes	no	no[b]	no[b]	no[b]	no[b]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]	no[a]
Surinam	yes	no	no[b]	no[b]	no[b]	no[b]	no[a]	no[a]	no[a]	no[a]	no[a]	no	no	no
Uruguay	yes	yes	no[b]	no[b]	no[b]	no[b]	no	no	no	no	no	no[a]	yes	no[a]
Venezuela	yes	no	no[b]	no[b]	no[b]	no[b]	no	no	no	no	no	no[a]	no	no[a]
NEAR AND MIDDLE EAST														
Aden 1	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no[a]	no[a]
Bahrain 1	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no[a]	no[a]
Egypt	yes	no	yes	yes	yes	no[b]	no	no	no	no	no[a]	no	no	no
Iran	yes	no	yes	yes	yes	no[b]	no	no	no	no	no	no	yes	no
Iraq	yes	no	yes	yes	yes	no[b]	no	no	no	no	no	no	no	no[a]
Israel	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	yes	yes	no	no
Jordan	yes	no	yes	yes	yes	yes	no	no	no	no	yes	yes	yes	no
Kuwait	yes	no	yes	yes	yes	no[b]	no	no	no	no	no	no[a]	no	no[a]
Lebanon	yes	no	yes	yes	yes	no[b]	no	no	no	no	no	no[a]	no	no[a]
Syria	yes	no	yes	yes	yes	no[b]	no	no	no	no	yes	no[a]	yes	no[a]
AFRICA														
African Intellectual Property Organization 3,6	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no[a]	no[a]
Algeria 3,7	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no	no
Botswana, Lesotho 3	yes	no	no	no	no	no	no[a]	no[a]	no[a]	no[a]	no	no	no[a]	no[a]

(Continued)

TABLE 1 (Cont.)

	Mechanical/Electrical			Chemical			Biogenetic						Other	
	Machine Major	Machine Minor	Ferti-lizer	Insect-icide	Herb-icide	Chemical Vaccine	Soybean	Corn Hybrid	Rose	Beef Cattle	Nitrogen Fixing Bacteria	Live Virus Vaccine	Computer Program	Account-ing Systems
Burundi, Rwanda, Zaire 5	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Ghana 3	yes	no	yes	yes	yes	no[b]	no[a]	no[a]	no[a]	no[a]	no	no[a]	no[a]	no[a]
Kenya 3	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no[a]	no[a]
Liberia	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Libya	yes	no	yes	yes	yes	no[b]	no	no	no	no	no	no[a]	no[a]	no
Malawi, Zambia, Zimbabwe	yes	no	yes	yes	yes	yes	no	no	no	no	yes	no[a]	yes	no
Nigeria 3	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no	no
Sierra Leone 3	yes	no	yes	yes	yes	yes	no[a]	no[a]	no[a]	no[a]	no	no	no[a]	no[a]
S.W. Africa 5	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Sudan	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Tanzania	yes	no	yes	yes	yes	yes	no	no	no	no	no	no	no	no
Tunisia	yes	no	yes	yes	yes	no[b]	no[b]	no[b]	no	no	no	no	no	no

+Biotechnology based product, developed using recombinant DNA technology. (where in table?)

[a]This invention is specifically excluded from patent protection by national law.

[b]Although this chemical substance is specifically excluded from patent protectionby national law, the process used to produce the substance is not excluded.

NOTES: This table sumarizes the dates that record principal constituents of each country's patent laws.

1. British patent law is assumed to hold in this country, owing to the provisions in its laws. British patent applications (whether or not by British citizens) have priority. In practice, a prior British patent is routinely granted approval in this country at the applicant's request. See Chapter 37 of the Patents Act of 1977 of Great Britain. The U.E. prohibits the patenting of microbial processes or products for use on humans or animals. Ghana independently prohibits patents as pharmaceutical and medical substances.
2. This country has no patent act of its own.
3. "Microbiological processes and the prodcuts of each processes" are patentable. Whether this protection exceeds to microorganisms per se is not

known and will depend on the interpretations of the domestic courts. In the absence of specific indications to the contrary, we have assumed that the nitrogen-fixing bacteria and the live virus vaccine are not patentable under these considerations.

4. A patent is granted to a foreign inventor if he has obtained a patent in his own country and any three other countries. Presumably, patentability standards in those countries apply.
5. Other than meeting public standards of health and morality, no other criteria for patentability are cited. In general, we take mechanical, chemical, and electrical inventions to be patentable, and others to be unpatentable. In this Philippines, U.S. law is assumed.
6. The following countries are signatories to the Libreville Agreement of 1962, which establishes the African Intellectual Property Organization: Benin, Cameroon, Central African Republic, Chad, Congo, Gabon, Ivory Coast, Madagascar, Malagasy Republic, Mauritania, Niger, Senegal, Togo, and Burkina Faso. The revised agreement of 1977 has been signed by Cameroon, the CAF, Gabon, Ivory Coast, Mauritania, Niger, Senegal, and Togo. In the absnece of laws to the contrary, we apply the revised standards to the other countries as well.
7. The Inventor is entitled to state indemnification for the rights to some or all of these inventions. In this case, he does not own the rights himself.
8. Food and chemical patents require mandatory licensing.

Source: Evenson and Putnam (1989).

sexually-reproduced plants to be patented. The U.S. has until recently not provided plant variety protection for the hybrid corn--presumably because such protection is not needed, since corn breeders can effectively maintain control over the hybrid parents, and thus they already have so-called "genetic" protection. However, recent strengthening of the U.S. system allows the patenting of plants including hybrid corns.

As to microorganisms, the U.S., Argentina, Korea, and Israel specifically allow the patenting of microorganisms not occurring in nature; Argentina and Korea disallow the live-virus vaccine on the grounds that it is a medicine.

India forbids the patenting of "a method of agriculture or horticulture"; "any process for the medicinal, surgical, curative, prophylactic, or other treatment of human beings or any process for a similar treatment of animals or plants to render them free of disease or to increase their economic value or that of their products"; or any substance "intended for use, or capable of being used, as food or medicine or drug" [Article 3(h)), (i); Article 5(a)]. Furthermore, "medicine or drug" includes "insecticides, germicides, fungicides, weedicides and all other substances intended to be used for the protection or preservation of plants" [Article 2(1)(iv)].

The Indian law illustrates a general pattern in developing countries. The argument for such laws is that food and medicine products are "basic needs" and that citizens in less developed countries should not be vulnerable to the monopoly pricing associated with patents. This argument suggests that a country like India would lower the total cost of producing technology were it to abandon its patent system.

In recent years the developed countries have taken steps to broaden and strengthen the protection afforded to intellectual property generally and to biotechnology in particular. The so-called "Chakrabarty decision" of the U.S. Supreme Court overruled the U.S. Patent Office by permitting microorganisms to be patentable subject matter. Ex Parte Hibbard, an Appeals Court decision allowed plants to be patented even when they were subject to plant variety protection. Ex Parte Allen similarly allowed the patenting of animals.

Differences between the developed and developing worlds regarding IPR's parallels that which has emerged in many other contexts, notably in the Conference on the Law of the Sea Treaty, in which the developing countries took the position that the ocean seabeds represent part of "the common heritage of mankind." The developed countries generally favor the possibility for private exploitation of resources on efficiency grounds and point to the public benefits that result. In more traditional areas of patent protection, developing countries are much more likely than developed countries to exclude medical and agricultural inventions from protection, on similar grounds.

Events indicate, however, that the developed world is prepared to press hard for protection in cases where piracy is a possibility, either because of indigenous adaptive capacity or because of infringing products exported to the market from other developed countries. For example, the United States recently completed a so-called "Section 301" action against Korea, in which it threatened trade sanctions if South Korea did not undertake an extensive revision of its intellectual property laws (covering copyright and well as patent laws). Among the results of the subsequent bilateral consultations was Korea's announced intent to accede to the Budapest Treat on the Protection of Microorganisms and to grant and enforce protection for agricultural chemical and pharmaceutical patents. Under recently enacted amendments to U.S. trade laws, patent infringement is deemed a per se "burden or restriction on commerce" and sets in motion a series of events that culminate in trade retaliation. More generally, intellectual property protection has become a central issue at the current Uruguay Round of talks of the GATT. The emerging conflict appears to be between advanced developing countries with significant adaptive capacity, such as Brazil and India, who argue that GATT is an inappropriate forum for the debate (they prefer WIPO), and the developed countries who claim to be losing billions of dollars a year to pirates.

II. IPR Use

A. Invention Patents

Tables 2 and 3 summarize the use of the invention patent in a number of countries for certain periods. Table 2 reports the number of patents granted to national (i.e., domestic) inventors, the number granted to foreign entities and the number obtained by nationals in other countries. Patent grants to foreigners are reflecting various forms of technology purchase by the granting country. The motives for obtaining a patent in a developing country include the use of the IPR to license technology in some form of technology sales contract. Most sellers of technology seek IPR protection in the buying country to prevent copying by competitors (although IPR's are not the only form of protection from competition). If the technology owner seeks to sell the invention in the form of a product he will also usually seek IPR protection against domestic copying and manufacture.

Table 2 indicates that some developing countries are significant markets for IPR protected technology. Of course, industrialized countries are also significant markets for technology. Indeed for most types of inventions - these are the largest technology markets. This is borne out in Table 3 which shows patent trade data.

Technology buyers (perspective of the granting country) purchased most of their technology from industrial countries (with the U.S. being the major supplier). The Latin American countries do purchase a significant amount of technology from semi-industrailized and developing countries (also from Latin America). South Korea and Brazil, however, purcha e 97 percent of their imported technology from industrial countries.

TABLE 2
Invention Patent Summary

Country	Patents Granted to Nationals 1967	1976	1986	Patents Granted to Foreigners 1967	1976	1986	Patents Granted to Nationals Abroad 1967	1976	1986
USA	51,274	44,162	37,152	14,378	26,074	24,675	73,960	90,273	54,360
Japan	13,877	32,465	38,032	6,896	7,582	8,074	6,843	20,246	20,663
RECENTLY INDUSTRIALIZED									
Spain	2,758	2,000	1,485	6,827	7,500	7,739	627	766	1,180
Israel	178	200	305	935	1,200	1,419	219	145	316
Greece	975	1,343	1,114	2,302	1,285	942	61	81	691
Portugal	84	46	95	1,045	1,319	2,200	53	50	50
NEWLY INDUSTRIALIZED									
South Korea	207	1,593	2,580	152	1,727	1,161	20	50	50
Singapore	5	50	50	26	550	548	5	5	5
Brazil	262	450	349	684	1,500	3,494	63	88	50
SEMI-INDUSTRIALIZED									
Turkey	30	35	34	438	588	424	–	–	–
Philippines	16	108	82	498	767	755	–	–	–
Argentina	1,244	1,300	1,264	4,488	2,800	2,843	81	102	133
Mexico	1,981	300	174	7,922	5,000	1,831	149	181	171
Chile	80	60	60	1,237	514	514	–	–	–
DEVELOPING									
Egypt	48	16	10	873	511	317	–	–	–
India	428	433	500	3,343	2,062	2,000	72	73	57
Sri Lanka	7	9	5	148	156	36	–	–	–
Venezuela	41	50	55	954	514	408	–	–	–
Colombia	49	30	36	851	600	808	–	–	–
Uruguay	165	46	41	351	110	236	–	–	–
Kenya	1	5	–	104	98	–	–	–	–
Morocco	28	23	21	391	334	330	–	–	–

TABLE 3
Patent Balance Data 1980

Country	Patents Granted to Foreigners	U.S.	Perspective of Granting Country Percent Form Industrial-ized	Semi-Industrialized	Devel-oped	Planned	Patents Granted Abroad	U.S.	Perspective of Origin Country Percent In Industrial-ized	Semi-Industrialized	Devel-oped	Planned
USA	24,675	.49	.94	.02	.01	.03	54,360	.35	.853	.098	.016	.033
Japan	8,074	.49	.91	.01	.00	.04	20,663	.35	.882	.093	.003	.022
RECENTLY INDUSTRIALIZED												
Spain	7,739	.25	.96	.01	.01	.02	1,180	.028	.893	.084	.016	.007
Israel	1,419	.46	.98	.001	.001	.01	316	.377	.930	.070	.000	.000
Greece	942	.21	.93	.02	.001	.05	691	.006	.982	.004	.000	.003
Portugal	2,200	.23	.93	.05	.01	.01						
NEWLY INDUSTRIALIZED												
South Korea	1,446	.26	.97	.002	.01	.02						
Brazil	6,228	.36	.97	.01	.01	.01	113	.204	.627	.336	.027	.009
SEMI-INDUSTRIALIZED												
Turkey	427	.29	.97	.01	.01	.01						
Argentina	4,479	.50	.97	.01	.01	.01	133	.211	.505	.412	.068	.015
Mexico	2,389	.62	.91	.02	.07	.01	171	.275	.701	.094	.176	.029
Chile	1,224	.46	.94	.04	.01	.01						
DEVELOPING												
Uruguay	236	.24	.83	.15	.01	.01						
Venezuela	408	.47	.88	.09	.02	.01						
India							57	.175	.737	.176	.069	.018

Technology sellers (perspective of the origin country) sell the bulk of their technology to industrial countries, although developing countries do find significant downstream markets in semi-industrial and developing countries. These markets are also significant for industrialized countries and for recently industrialized countries.

The data in Tables 2 and 3 then portray the general features of international technology markets. Developing countries are primarily buyers of technology. Their IPR systems enhance technology purchase but do not stimulate large numbers of domestic inventions. As countries move up the scale they become larger purchasers of technology but they also begin to achieve more domestic invention. As they reach the recently industrialized stage they become significant sellers of technology and they find significant downstream markets for their technology.

B. Other IPR's

Table 4 reports a summary of the use of utility models, industrial design patents and trademarks in the countries of concern. The utility model or petty patent is utilized only in Spain, Portugal, South Korea, Brazil and the Philippines (as well as in Japan and West Germany). As the table indicates, most utility models are granted to domestic inventories and it does appear that they stimulate domestic invention, primarily of the adaptive type (see below for industrial patterns).

Industrial design patents are also provided primarily to national inventors and probably also serve to stimulate domestic invention. They are not used extensively in the older industrialized countries.

Trademarks are also used quite extensively in developing and early industrializing countries. They are granted to foreigners in large numbers. Brazil granted huge numbers of trademarks in 1980 reflecting rapid growth in numbers of products in its rapid growth phase (since abated). Even countries

TABLE 4
Other IPRs: Summary 1980

Country	Utility Models To Nationals	Utility Models To Foreigners	Industrial Design Patents To Nationals	Industrial Design Patents To Foreigners	Trademarks To Nationals	Trademarks To Foreigners
USA			3,056	892	17,319	1,566
Japan	49,468	533	30,696	593	41,577	5,290
RECENTLY INDUSTRIALIZED						
Spain	3,845	1,131	2,239	407	11,119	12,822
Israel			266	56	255	863
Greece					1,260	1,800
Portugal	159	25	355	228	1,035	581
NEWLY INDUSTRIALIZED						
South Korea	1,315	438	3,917	154		
Brazil	500	13	136	81	136,808	42,821
SEMI-INDUSTRIALIZED						
Turkey					1,129	1,181
Philippines	465	3	151	19	1,125	1,031
Argentina			2,426	159	12,428	2,032
Mexico					8,637	8,292
Chile					1,986	1,735
DEVELOPING						
Egypt			166	27	145	408
India			723	29	3,019	640
Sri Lanka			8	10	160	376
Venezuela			77	16	2,360	1,961
Colombia			11	5	584	672
Uruguay					6,41[illegible]	541
Kenya					443	747
Morocco					541	443

with weak invention patent systems utilized trademark IPR's.

III. R&D and Returns to R&D

A. An International Comparison of R&D Investments

OECD and UNESCO data on the scale of investment in R&D and basic science around the world show ratios of R&D to GDP in the 2 to 3 percent range in the industrialized countries (see Table 5). Among the more recently industrialized countries only Israel and South Korea approach this level; semi-industrialized and new industrialized economies generally fall within the 0.3 to 1 percent range. Among the developing economies India stands out with a relatively high ratio. Most middle- and low-income developing economies have R&D investment ratios of less than 0.3 percent. Expenditures on basic science are even more concentrated in the industrialized countries.[10]

Available estimates usually put the public sector as accounting for more than 80 percent of formal R&D expenditures in developing economies. An important exception to this pattern in South Korea, where in 1976 approximately 80 percent of R&D investments were financed by the public sector. By the late 1980s a complete reversal had occurred, and the private sector is now responsible for funding 80 percent of the total (Dahlman, 1989:14). Estimates for Brazil suggest that the public sector is responsible for 70 to 90 percent of R&D-related expenditures. In the cases of Argentina, Mexico and India, comparable figures for 1982 were around 95, 90, and 86 percent, respectively. It should be noted, however, that some publicly funded research in these countries may, in fact, be conducted by industry. For further details see CNI (1988), Psacharopoulos and Saliba (1989), Evenson (1990b), and Deolalikar and Evenson (1990).

These statistics cover only formal R&D, that is R&D explicitly organized as such. Most firms, however, engage in informal invention activity, including "blue collar" R&D (meaning that workers and managers develop product and process improvements on the shop floor). Few estimates of the magnitude of such informal R&D exist.[11]

Developing countries are investing a higher share of GDP in agricultural than in industrial research (Table 5). This can largely be explained by the fact that agricultural R&D has traditionally been performed in public-sector institutions, as few farms have been large enough to undertake, and profit from, effective R&D programs. The lack of protection for improved plants and animals in developing countries has contributed to the paucity of private R&D. In addition, studies have concluded that agricultural technology is highly location-specific (Evenson and Kislev, 1975).[12]

B. Social and Private Rates of Return on Research Investments

Social returns accrue to the society at large, that is, to both producers and consumers. Private return is that portion of the social return captured by the producing firm.

Industrial R&D in Developed Countries

Surveys on returns to private R&D in developed countries show that investments in R&D, when evaluated _ex post_, yield returns to firms that are at least as high as returns to other investments (Griliches, 1984). Mansfield et al. (1977) report on 17 case studies of innovation for which the median private rate of return was 25 percent. Griliches (1984) reports returns to R&D for large industrial firms in the United States ranging from 30 to 50 percent.[13]

Mairesse (1990) reviewed statistical estimates of the impact of research on a firm's productivity. He reviewed five economy-wide and four sector studies using cross-sectional, firm-level data to estimate research productivity elasticities (which approximate rates of return). His review covered seven U.S., five French, and four Japanese studies. All showed positive R&D elasticities of high statistical significance ranging from 14 to 42 percent, with a median of 27 percent. Through another set of firm-level

TABLE 5
R&D Indicators

Countries	Applied R&D/GDP (x 100) All Sectors		Applied R&D/ Value Added (x 100) Agriculture		Scientists & Engineers Engaged in R&D in 1986		Basic Science/ GDP (x 100)
	1970	1986	1970	1986	Total	Per 1,000 Workers	1986
Industrial Economies							
United States	1.65	1.85	1.96	2.16	785,000	6.56	0.42
United Kingdom	1.56	1.71	3.95	5.27	86,500	3.32	0.31
France	1.58	1.94	0.78	1.52	72,889	3.09	0.46
Federal Republic of Germany	2.03	2.60	2.94	2.83	128,162	4.62	0.50
Japan	1.84	2.75	3.28	2.54	531,612	8.80	0.37
Centrally Planned Economies	2.60	3.00	0.75	1.00	—	—	—
Recently Industrialized Economies							
Spain	0.2	0.5	0.21	0.81	15,299	1.19	0.07
Greece	0.2	0.2	0.32	0.63	3,000	0.77	0.06
Portugal	0.2	0.4	0.89	0.61	3,475	0.71	0.08
Israel	1.1	2.5	2.93	4.47	3,350	2.32	0.90
Newly Industrialized Economies							
Korea, Republic of	0.5	1.8	0.38	0.56	32,117	2.05	0.19
Singapore	0.1	0.5	—	—	2,401	1.95	0.15
Middle-Income Developing Economies							
Venezuela	0.2	0.4	1.95	1.18	4,568	0.97	0.08
Argentina	0.5	0.4	0.68	0.44	10,500	0.87	0.08
Mexico	0.2	0.6	0.11	0.63	16,679	0.76	0.10
Brazil	0.2	0.7	0.50	0.95	32,508	0.75	0.06
Chile	0.1	0.4	0.89	1.21	1,600	0.43	0.10
Colombia	0.0	0.2	0.61	0.64	1,083	0.12	0.02
Turkey	0.1	0.2	0.44	0.41	7,747	0.49	0.04
Thailand	0.3	0.3	0.91	0.60	n/a	n/a	0.06
Egypt	0.8	0.2	0.39	0.40	19,939	1.61	0.04
Philippines	0.2	0.2	0.41	0.18	4,816	0.23	0.03
Low-Income Developing Economies							
Indonesia	0.1	0.3	0.29	0.45	24,895	0.45	0.06
Pakistan	0.2	0.3	0.05	0.31	9,325	0.41	0.03
Kenya	0.1	0.1	1.34	0.81	n/a	n/a	0.02
India	0.4	0.8	0.16	0.35	28,223	0.12	0.12
Bangladesh	0.1	0.2	0.15	0.34	n/a	n/a	0.20

SOURCE: Evenson, 1990

studies in which rates of return were directly estimated, Mairesse confirmed his conclusion that for the three countries in question (including Japan during its imitation phase) private rates of return to R&D were at least as high as for other investments.

Social rates of return may be considerably higher than private rates, because the individual firm is incapable of appropriating, or capturing, completely the benefits from conducting R&D. Even with strong intellectual property protection, the private firm's rent from licensing or product sales generally represents only a fraction of the real value of the invention to the economy that is, of the invention's social return. In a study conducted by Mansfield et al. (1977), the median social rate of return from major innovations was 56 percent; the median private rate of return was 25 percent.

Industrial R&D in Developing Countries

Few studies have estimated returns to industrial R&D in developing countries. Pack (1990) has computed potential returns from productivity-enhancing R&D based on data for Philippine textile firms. He has shown that more than 80 percent of the firms in the industry would realize higher returns of R&D on factor demand but stopped short of computing returns to investment. Two studies of agriculturally related industrial R&D (see below) reported high rates of return as measured by their impact on agricultural productivity.

Agricultural R&D

On the basis of a review of 159 estimates of returns to agricultural R&D (Table 6), most undertaken for developing countries, Evenson (1990b) concludes that returns to agricultural research are higher than those resulting from other public-sector investments and generally higher than from industrial R&D. These returns are inherently "social" and should be higher than private returns because they measure the full impact of agricultural research on productive efficiency, not just gains captured by farmers.

TABLE 6
Rates of Return Estimates in Agricultural Research and Extension Studies

Scope of Study	Range of Estimated Returns on Investment (in %)		
	0-20	30-50	50+
Returns to Public Research			
Developed Countries	3	28	23
Developing Countries	8	28	37
International Research[1]			12
Returns to Private Research[2]			
Developed Countries			3
Developing Countries		1	1

SOURCE: Evenson, 1990
NOTES:
1 Studies on CGIAR international research centers.
2 Research on agricultural machinery and agricultural chemicals.

It is of interest to note that the distribution of rates of return reported in these studies is approximately the same for the 54 estimates reported for developed countries and the 73 estimates reported for developing countries. Returns to research conducted in the International Agricultural Research Centers within the Consultative Group for International Agricultural Research (CGIAR) are also high, reflecting the high degree of adaptation potential or location specificity of most agricultural inventions. Crop varieties, animal breeding gains, and agronomic practices are affected by soil and climate factors. Specific crops can only be economically produced over a specific range of sites, and many are strictly tropical crops where there is little or no scope for invention in developed countries. Accordingly, experiment stations, even with limited resources and research skills, can produce improved technology tailored to local conditions (Evenson and Kislev, 1975).

Five of the studies of which focused on developing countries (Brazil and India), report social returns to private-sector R&D in agriculture. These studies estimated the benefits realized on inventions in the input-supplying industries (chemicals, machinery, veterinary medicine). Interestingly, these benefits remained largely "uncaptured" by the supplying firms.

Despite the widespread pattern of high returns to agricultural R&D, the connection between underinvestment in agricultural R&D and the presence or absence of intellectual property protection is difficult to establish (even in the OECD countries), precisely because the field in question is agriculture. The bulk of agricultural research is publicly funded; moreover, in developing countries patents have not been used to appropriate returns to research, except in the area of agricultural implements and agricultural chemicals.

IV. Determinants of R&D: Does Protecting Intellectual Property Stimulate Inventive Activity?

Studies that attempt to determine the incentive effects of intellectual property on the decisions to innovate and imitate fall into two categories: (1) studies of behavior, either of firms holding patents or firms that conduct systematic R&D and may choose patenting as one option for appropriating returns, and (2) studies that try to establish for different sectors the intrinsic value of a patent (in comparison to the value of other rewards and incentives driving private R&D efforts).

How Firms Value Patents

Few studies have directly measured the incentive effects of intellectual property protection in industrial countries. Watanabe (1985), in a 1979-1980 survey of 2,390 Japanese firms found that patents were viewed most often as the foremost incentive to industrial invention. Of these firms, 20.7 percent cited the patent system as the most important incentive, followed by 13.5 percent citing other financial incentives. With respect to the motivation of individual researchers within those firms, the possibility of patent protection was the third most important stimulus to invention, with 11.6 percent of researchers surveyed pointing toward it. This percentage trailed competition with other firms (22.9 percent) and academic or technical interest (16.8 percent).

A 1981 survey of United States firms in the chemical, drug, electronics and machinery industries (Mansfield, Schwartz and Wagner, 1981) elicited related data and found that these firms would not have introduced about one-half of the patent innovations that composed the sample without the benefit of patent protection.

Economy-wide the evidence suggests that the benefits of a patent system are difficult to measure and vary widely across industries. Considering the issue historically, no evidence was found that the Netherlands or Switzerland were hampered economically during their patentless years (1869-1912 and

1850-1907, respectively; Schiff, 1971:122).[14] A survey in Canada, a major technology importer, concluded that patents were not greatly important to the decision to invest in a Canadian subsidiary (Firestone, 1971:chaps. 7 and 10). Other surveys also rank patents as a low component of R&D investment determinants (reviews in Scherer, 1986:446; Nogues, 1990a:5-6). Greif (1987), however, shows that for the Federal Republic of Germany, R&D investments and patent applications are closely correlated, suggesting a role for patents in stimulating investment.

At the level of individual industries, the results are more supportive of patents, especially for pharmaceuticals. Taylor and Silberston (1973; chap. 14) attempted to stimulate the effects of a weakened patent law in the United Kingdom. Their results indicated that the more affected industries would be pharmaceuticals and specialty chemicals, the two industries that use patents more intensively.

Despite the importance of patent protection implied by these results, there is also strong evidence that patents do not effectively deter imitation by rivals for very long. In part, this is because patents carry, in Schumpteter's words, "the seeds of their own destruction," in the sense that they disclose to rivals the means to reproduce the invention. A random 1985 survey of 100 U.S. firms (Mansfield, 1985) in 13 major manufacturing groups yielded an estimate of the average time period between a firm's decision to commit to a new process or product and the point at which the detailed nature and operation of that new product or process is known to its rivals. According to the firms in the sample, such information with regard to products is in the hands of rivals within roughly one year; with regard to processes it generally becomes available in less than 15 months. These firms listed patents as one of the chief conduits through which this knowledge spreads.

Levin et al. (1987) interviewed over 600 R&D managers in major U.S. firms, asking about the relative efficacy of patent rights in appropriating the returns to R&D. The survey was conducted by "line of business". In most lines of business, patents were rated as being less effective than trade secrets and effective sales and service as a mechanism for securing the returns from R&D. The survey confirmed Mansfield's 1985 results in showing that imitation, even in the presence of a patent, occurs rapidly and the patents disclose a significant degree of information to competitors. Results varied by line of business, with pharmaceuticals and scientific instruments attaching particular importance to patent protection, whereas in most electrical and mechanical fields, patents were deemed less important.

Furthermore, it does not appear from Levin's research that patent protection prevented competitors from entering the market. Except in certain chemical-related areas, it is generally not difficult to devise a functional substitute for a successful new product that does not actually infringe the original inventor's patent. Firms participating in Mansfield's 1985 survey believed that for about half of the sampled innovations patent protection postponed imitation by a matter of months only. Within four years of the introduction of the innovations in the sample, some 60 percent of those patented and profitable had been imitated. For just 15 percent of the sample did patent protection delay imitation by more than four years. And although patents increased imitation costs across the board, these costs were not so substantial as to markedly affect the speed with which imitators entered the market.[15]

The studies discussed to this point do not allow us to draw meaningful conclusions for the behavior of firms in developing countries. There are two important sides to R&D; the discovery of new products and processes and the capability to quickly assimilate and modify results of rivals' esearch (Cohen and Levinthal, 1989). It is this latter capability that is particularly important, yet lacking in developing countries.

Studies on the incentive effects of intellectual property in developing countries are few, and their approach appears to be narrowly focused. One survey that traces the interlocking nature of patent rights with other rights, as well as the possible role that stronger intellectual property protection might play, was conducted by Sherwood (1990a:115), who reported that in Brazil approximately 80 percent of 377 firms surveyed declared that they would invest more in internal company research and would improve training for their employees if better legal protection for trade secrets were available.

More recently it has been argued that because developing countries have a comparative advantage in adaptive invention - that is, in assimilating and modifying the inventions of developed-country firms - they require intellectual property systems that facilitate access to foreign inventions and stimulate adaptive or imitative domestic invention. An important element in such a system, is the utility model (or "petty patent") because it is well suited to stimulating adaptive invention. Table 5 reports registration of utility models in 1986 for several countries with this property right.

This point is corroborated by two studies of the agricultural implements industry in Brazil (Dahab 1986) and in the Philippines (Mikkelson, 1985) which concludes that the utility model stimulated adaptive inventions in these countries and enabled domestic firms to increase their competitiveness with multinational firms whose inventions they imitated. Another study by Otsuka, Ranis and Saxonhouse (1988) reports similar conclusions for textiles in Japan and India. All three studies reported that much of this R&D was of the "informal" or blue-collar" type. Ranis (1990) discusses the relevance of informal, blue-collar R&D in improving industrial productivity.

V. Synthesis of International IPR Data

Table 7 provides a comparative summary of the data reviewed in previous sections. Qualitative ratings for strength of IPR's, piracy, reverse engineering capacity and economic growth potential are indicated . (These are the judgments of the authors.) Quantitative measure of investment intensities (GDP ratios) and patent ratios are also summarized. The groupings of countries is designed to reflect technological stages of development. Most developing countries are middle income developing countries (see World Bank tables). The distinction between newly industrialized and semi-industrialized is based on technical capacity and sophistication of industries but also reflects recent growth rates.

The fact that strong correlations between investment intensities and development success within the group of less than fully industrialized countries has been noted earlier. This is further illustrated in Table 7 which shows that when the data are aggregated a somewhat more regular relationship between investment in R&D and development success exists. Table 7 also brings out several other differences between the newly and semi-industrialized countries and developing countries. Two of these are qualitative. The reverse engineering capacities are noted to be much stronger in the NIC's than in the developing countries. The extent of piracy is similarly distributed. Three additional quantitative measures are pertinent as well:

First, technology purchase rises with the stage of development. Second, technology sales do not. Third, patents per scientist and engineer rise rapidly with development stage.

Technology purchase and sales are estimated from the proportion of foreign patents and the proportion of patents obtained abroad. (Data from India and the Philippines were used to scale foreign patents to reflect the R&D content of domestic patents. This is probably misleading for the patents obtained

TABLE 7
Comparative Summary of Type by Economy

		Industrialized	Newly Industrialized	Semi-Industrialized	Developing	Planned
I. Qualitative Rankings (1-5)						
Strength of IPRs		4-5	1-3	1-2	1	3
Degree of Piracy		1	4-5	3-4	2	1
Reverse Engineering Capacity		4-5	4-5	3-4	1-2	2
Economic Growth Potential		3	4-5	3-4	1-3	2
II. GDP Ratios						
Science						
Applied R&D	1986	.40	.15	.08	.05	n.a.
Industry	1971	2.27	.56	.31	.15	2.61
	1979	1.96	.43	.30	.20	3.29
	1985	2.15	.50	.40	.25	3.10
Agriculture	1960	.68	.29	.29	.15	.45
	1970	1.37	.54	.57	.27	.75
	1980	1.50	.73	.81	.50	.73
Forestry	1970	.28	.10	.05	.02	.17
	1984	.27	.07	.06	.02	.15
Agriculture (Extensive)	1960	.38	.29	.60	.30	.29
	1970	.57	.51	1.01	.43	.33
	1980	.62	.59	.92	.44	.36
Technology Purchase	1970	.67	.66	.37	.45	.27
	1984	.95	.67	.53	.75	.08
Technology Sales	1970	1.95	.04	.02	.01	.13
	1980	1.23	.08	.06	.02	.10
III. Patent Ratios[a]						
$P_N/P_N + P_F$	1967-1971	.53	.25	.17	.11	.76
	1983	.27	.20	.12	.93	n.a.
P_A/P_N	1967-1971	1.79	.28	.10	.10	.15
	1981-1983	1.71	.47	.17	.10	.10
$P_N/S+E$	1967	.238	.998	.380	.053	.269
	1971	.258	.876	.337	.066	.218
	1976	.201	.494	.185	.055	.187
	1979	.200	.550	.154	.052	.243
IV. World Shares (1983)						
Invention Patents		.615	.033	.010	.044	.336
Industrial Designs		.918	.046	.017	.010	.029
Trademarks		.556	.309	.092	.036	.007

[a] P_N = patents granted to nationals; P_F = patents granted to foreigners; P_A = patents granted abroad to nationals; S+E = scientists and engineers engaged in R&D.

Source: National Science Board, Science Indicators, Washington, D.C.: National Science Foundation.

abroad.)

This rough evidence offers an explanation for piracy.[16] Pirates have high reverse engineering capacity, high technology purchases and low technology sales. Their domestic R&D, while adaptive and reverse engineering in character, is nonetheless highly productive - particularly - as compared to less developed countries. When pirating countries begin to sell large volumes of technology abroad they join the Paris Convention "club".

The notion that technology markets exist has been challenged by some. The terms purchase and sales as used here are meant to measure actual exchanges. This is not to suggest that these markets are perfect. Nor does it suggest that the IPR systems are optimal. Piracy would probably not be an issue if they were.[17]

The treatment of technology as a marketable product is useful, however, even if markets are not perfect. The general principle of comparative advantage, for example, can be fruitfully applied to the data presented here. It should not be surprising that the big technology markets are in the industrialized economics. It should also not be surprising that firms (and individuals) located in these economics have a comparative advantage in producing technology for these markets. The "economic laboratories" for potential inventory outside these countries are best suited for the discovery of adapted or derivative inventions.

This adaptive and derivative invention (as reflected in the low patenting abroad and in the downstream patenting) suggests a kind of technology "drafting" phenomenon. Countries such as Korea have developed the capacity to copy and reverse engineer recently developed inventions from industrial countries. They are thus able to achieve technology that is of high value to them at low cost. An increase in investment upstream is quickly reflected in increased technology purchase (and pirating) and own R&D for firms in the draft.[18]

Most poorer countries are not in the draft. Their product (and process) markets are such that the value of slightly modified technology from the leaders is not high. They also lack the skills and experience to draft effectively. Indeed, many find that they must purchase technology in "turn-key" form, i.e. in large interlinked contract form. Their failure to be pirates is not for lack of will to pirate, but for lack of capacity.

The returns to R&D evidence for the NIC's and for the poorer developing countries is quite limited. However, standard growth accounting calculations suggest that for the NIC's investments in technology acquisition, including the investments required to pirate, i.e. to imitate illegally (from the U.S. perspectus) as well as to imitate legally (pirating is probably hugely overstated because the changes cover both legal and illegal imitation) have been very high. They would have to contribute only a small part of realized productivity growth to generate very high returns.

For the "out of the draft" developing countries, the returns to R&D evidence is practically nil. These countries probably fall into two broad categories. Most poor countries simply have not created viable institutional infrastructures for technology exchange as a general basis. They do not have IPR systems of much relevance. They often do not have good construct enforcement systems. Many have very small and primitive industrial sectors. Some rely on "turnkey" type technology contracts with multi-national firms. These contracts are usually "inter-linked" and entail payments for IPR's and a number of other services. The returns to these purchase investments are probably quite variable, but in many cases are probably high and this investment enables some of the countries to develop improved institutions and infrastructures.

A number of "out-of-the-draft" developing countries--notably India, but probably a few other countries--have developed institutions and infrastructure to support significant investment in industries. They have not managed the package of institutions to achieve the high volume importation of technology at lower cost that characterize the NIC's. They usually do not have strong IPR's and they are usually obsessed with "dependency fears," vis-a-vis foreign technology . They have not developed incentives to achieve strong domestic R&D-pirating-imitations capacity. They invest little in R&D but it is probably highly productive. They are often characterized by tariff-protected and regulation-protected industries where competitive pressures are weak.

VI. Further Research

The returns to R&D evidence, while scanty, indicates that there is probably widespread underinvestment in R&D and related activities in developing countries. For the NIC's, returns to R&D, including imitative and adaptive legal and illegal (piracy) inventive activities are probably very high. The NIC's are all expanding R&D investment rapidly. The out-of-the-draft developing countries generally do not have the institutional and incentive environments to invest in R&D optimally. For the poorer countries some of the problem is simply a basic problem of incentives and institutions working at cross-purposes.

This paper has argued that the imbalance between buyers and sellers of technology promotes such a severe free-riding problem that Paris Convention rules will not prevent piracy. Is there an argument for alternative agreements? Do current pirates have a case for improved tariff treatment in exchange for giving stronger IPR's to foreigners? Can new IPR's instruments be developed to "tilt" incentives in favor of domestic technology activities in LDC's?

These matters all require analytic and empirical investigation. More return studies would be helpful. Empirical studies of domestic investment in technology activities (own R&D, technology purchase, even pirating imitation) and their responsiveness to international invention flows (i.e. to potentially imitables and adaptable technology) will be useful.

Modeling of invention and IPR's is less promising than empirical studies. This is a field where most theoretical models, while suggestive in many ways, have not had good testable implications that can guide empirical work. Returns to R&D empirical studies, for example, have not benefited greatly from theoretical models. R&D investment studies have benefited more. International studies have been even less informed by technology modeling, in part because the "foundations" of international trade modeling set aside technology. Nonetheless, there is much scope for further work. The policy relevance of technology transfer and of IPR's is not likely to decline.

FOOTNOTES

1. Article 9 is...

2. The Patent Office introduced the first public research activities in the U.S. and its statistical division was a fore-runner to the U.S. Department of Agriculture.

3. The 1985 ex parte Hibbard and the 1986 ex parte Allen divisions following the 1980 "Chakarbarty" decision are the major judicial changes in the U.S. These decisions opened the door to the patenting of multi-celled plants and animals.

4. See Viatsos (1976), Stewart (1977), OECD (1982), and Ranis (1979) for discussion.

5. See Bradley (1987), GAO (1986), Good (1985), IPO (1987), and Zalik 1986 for discussions.

6. U.S. Congress (1986), and 1984.

7. See Siemsen (1987), and Obach (1987).

8. See Walker and Bloomfield (1988), especially chapters 9-13, for a sampling.

9. Dixit (1985) has an interesting application. Arrow (1969), Nelson (1951), and Schmookler (1966) offer general analyses.

10. This section draws extensively on Evenson and Putnam (1986).

11. Outside the OECD, definitions of scientists and engineers engaged in research and development are not standardized across countries. Caution is necessary because in some countries only scientists having Ph.D. and M.S. degrees are counted; in others, those with B.S. degrees may also be counted; similarly, an "engineer" may have graduate training or only a technical degree.

12. Mikkelsen (1986) reports the manufacturers of agricultural implements in the Philippines undertake a significant level of informal R&D. Evenson (1983) reports similar findings for Indian manufacturers of agricultural implements. See also Dahab's (1986) study of Brazil.

13. The extension of intellectual property protection to biological and biotechnological discoveries in the developed world has been followed by an increase in private investment in agricultural research. See Chapter 6, section D. Private-sector R&D has been important in the fields of agricultural chemicals and implements. See Table 2 for estimates of returns to the investment.

14. Alam (1985) and Nogues (1990a) question the relevance of these results for R&D in developing countries.

15. It should be noted that conditions for invention may well have differed substantially in these periods from the contemporary setting.

16. Evenson 1983 provides a discussion of piracy and IPR's in developing countries.

17. See Stewart (1979).

18. The metaphor of auto racing where a vehicle drafts on a vehicle ahead of it is suggestive ot technology drafting.

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