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Intellectual Property Rights in Agriculture and the Interests of Asian-Pacific Economies

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1. INTRODUCTION

Agricultural trade policy continues to be at the forefront of international controversy at both the multilateral level and on various regional fronts. Meaningful agricultural trade liberalization is likely a necessary condition for any significant multilateral agreements in the ongoing Doha Development Round at the World Trade Organization (WTO). Within the Asia-Pacific region, a number of bilateral trade agreements implicate agricultural support and trade policies in varying degrees. It is evident that Japan, Korea, and other East Asian economies remain relatively closed to trade in food, while protection is also high in certain agricultural products in the United States, Canada, and Australia.

An important, and sometimes overlooked, feature of farm policy is that agriculture is a technologically dynamic sector. Agriculture is in the midst of two ongoing technological revolutions -- crop genetics and livestock industrialization -- and is in the early stages of a third -- gene modification through recombinant DNA. These technological changes have a number of implications. First, the evolution of large agro-business firms devoted to life science has generated substantial industrial concentration and vertical integration in the sector. Second, while research in agricultural product development is increasingly undertaken in the private sector, the relationships between public research agencies and private firms in establishing basic scientific results are growing in complexity. Third, there is increasing product innovation through the

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development of new plant and animal varieties, biologically based inputs for agriculture, and crop-based nutritional and pharmaceutical goods.

Taken together, these factors mean that the industry places growing reliance on formal means of protecting new technologies, including intellectual property rights (IPRs), and there are strong interests pushing for further strengthening and international harmonization in this regard. There are three major forms of IPRs that affect such protection and the willingness to invest in agricultural technologies. These are patents on life forms, plant variety rights, and geographical indications.[2] Also relevant is competition policy, including the treatment of exhaustion (parallel imports).

Put briefly, the growing application of science and industry to agriculture makes the sector increasingly globalized, as new technologies and agriculturally based multinational enterprises (MNEs) push to extend markets across borders. This trend clearly raises some difficult questions for policymakers in Asia and elsewhere. For example, to what extent can restrictive trade policies and agricultural supports be sustained in this environment? What would reducing such supports imply about the ability of firms to invest in agricultural technologies, given other basic determinants of comparative advantage in this sector? What set of IPRs standards would be appropriate for nurturing agricultural development and would such IPRs have the potential to offset the competitive pressures arising from trade liberalization? To what extent would IPRs need to be supplemented by additional policy support? How should innovation policies be established in light of difficult international controversies regarding sanitary and

[2] Also important are trade secrets protecting confidential information or know-how, trademarks, certification marks, and protection of confidential test data. But these policies are not much under debate.

phytosanitary standards and issues of environmental use and biodiversity? It is evident that such policies exist in a second-best world.

In this paper, I offer a largely qualitative analysis of such issues. While paying some attention to the interests of developing countries in East Asia, the emphasis is on the main players in Asia-Pacific trade and production in agricultural goods: the United States, Canada, Japan, China, the Republic of Korea, and Australia. In the next Section, I discuss essential technological changes in agriculture and some basic issues they raise. In Section Three I explain the nature of IPRs in agriculture, including the policy environment in major countries. In Section Four I look at the economic interests of these countries by considering information on endowments, technology, production, and trade. In Section Five I conclude by taking up the question of linkages between IPRs and other supports, including trade policy and agricultural subsidies. Included are observations about the scope for regional policies and reforms in the WTO.

2. TECHNOLOGICAL CHANGE IN AGRICULTURE

It is remarkable that standard international trade and investment models view agriculture as a competitive industry with constant returns to scale and static technologies. In fact, each of these characterizations is inadequate in many ways, at least outside the poorest developing countries. Modern agriculture is subject to considerable technological change, rising concentration among farms and agribusiness firms seeking economies of scale and scope, and is the beneficiary of massive public research subsidies and output or price supports. These characteristics matter in the formulation of trade policies and IPRs.

To see that agriculture is technologically dynamic, consider the research-intensive nature of many globally marketable crops. Technological progress arises from efforts to improve breeding and growing methods, develop new seed varieties, and engineer plants and animals to display such beneficial traits as pest resistance, higher yields, and nutritional gains. Thus, hybridization of plant strains involves selecting and combining desirable characteristics across species through cross-fertilization and asexual reproduction. Maize, sorghum, and potatoes, among other crops, long have benefited from this research. Breeding techniques based on sexual propagation characterize many other forms of plant varieties, including produce and ornamental flowers and trees.

Agricultural biotechnology goes beyond this stage to injecting genetic material (recombinant DNA) from other, perhaps unrelated, plants and animals into particular species in order to develop new varieties with specific characteristics. Major crops now produced with bioengineered technologies include soybeans, cotton, rice, and potatoes. Animals are also increasingly the subject of biotechnological applications, with the greatest progress existing in dairy production and fish farming. The newest manifestation of agricultural biotechnology involves field testing of so-called nutriceutical plants, the products of which are designed to arrive at the consumer's table with a built-in combination of nutrition and medical benefits.

Agricultural production is characterized also by two further forms of technological change. First is the increasing industrialization of livestock production, involving the concentration of large numbers of animals into specific locations and the application of antibiotics to sustain animal health and hormones to promote rapid growth. Such industrialization is increasingly common in beef, pork, poultry, and fish farming.

Second is the increasing tendency of crops to be differentiated in terms of appearance, quality, and production characteristics (including organic foods) in order to generate higher value added per unit produced. This trend is especially prevalent as regards processed foods and beverages, and particularly in the increasingly globalized wine industry.

Each of these activities involves the application of extensive research funds and scientific personnel to both basic science (such as biogenetic research tools) and applied agriculture (such as seed varieties, livestock antibiotics, and extension services). In consequence, there is a complex mix of public research support and private development work in all areas of agricultural technology. This mix, and the attendant gains from investments in technology, vary considerably across countries and affect the economic interests that nations have in international trade and technology policy. Further, the types of IPRs used in each of these areas are different across products and countries, generating pressure for further policy reform and harmonization. To illuminate these facts the discussion turns next to a deeper discussion of technological change, competition, and IPRs in the Asia-Pacific region.

a. Agricultural Technology in the Asia-Pacific Region

Traditional agricultural methods involves farmers selecting and cultivating the most successful plant strains from natural landraces and then exchanging seeds in informal markets. This tradition remains in place in rural regions of the poorest countries but is not much in evidence among the middle-income and high-income economies of the Asia-Pacific region. Rather, these economies are characterized by the purposeful application of science to the selection and improvement of crops in order to achieve the massive productivity gains that have benefited rising populations.

The development of high-yielding modern crop varieties dates from the late 19^{th} century with the advent of scientific breeding technologies in North America and Europe (Evenson, 2004). Hybridization methods in maize spread through these areas relatively quickly and later were applied to sorghum, millet, and rice varieties (Griliches, 1957). Hybridization techniques were adopted successfully by the private sector in the absence of legal intellectual property protection because hybrids produce a one-generation "heterosis" effect that precludes the germination of saved seeds, forcing farmers to pay for new seeds each season (Goeschl and Swanson, 2000). Other forms of breeding that generated new varieties of wheat, other grains, flowers, and produce did not carry their own technological protection of this kind, leading to industry pressures within the United States for the Plant Patent Act of 1930 and the Plant Variety Protection Act of 1970 (Watal, 2001). Other countries in the region followed later, as noted below.

The international diffusion of modern crop varieties into Asian developing economies is most closely attributed to the Green Revolution, under which rice and wheat varieties bred for stability and strength by public agricultural institutions were introduced and improved in various regions, beginning in the 1960s. Diffusion of new varieties continued to grow through the 1990s and, by that decade, modern strains had dominated agricultural production in Asia (Evenson, 2004). Thus, by the 1990s over 80% of area planted in wheat and over 60% of area planted in maize, rice, and other cereals were of modern varieties in Asia. Much of this increase may be attributed to significant transformation of Chinese agriculture into widespread use of scientifically developed plant strains.

The major countries of the Asia-Pacific region are enthusiastic adopters of plant varieties developed by breeding techniques. While the United States has the oldest legal system for protecting such investments, seed industries flourish in Canada, Australia, Japan, Korea, and China as well. Outside China these industries are largely made up of private enterprises, though all rely on significant research support from their governments and on learning from international information sources and reverse engineering. In 2002 the United States had the largest internal commercial market for seed and planting materials at $5.7 billion, followed by China at $3.0 billion, and Japan at $2.5 billion.[3] Canada and Australia were also large markets for exchanging seeds. The United States was the largest gross exporter of commercial seeds, at $799 million. Other export figures included Canada ($122 million), Japan ($105 million, almost completely in horticultural varieties), Australia at $43 million, China at $30 million, and Korea at $16 million, though some of these nations were presumably net importers. Thus, the exchange of plant materials is a large and globalized industry.

In recent years the reliance on plant genetics for breeding new varieties has been complemented by the use of transgenic methods for developing new plants that achieve certain technical or aesthetic characteristics. Biotechnology, or the so-called Gene Revolution, differs from plant genetics chiefly in accelerating the development of new varieties, and even new species, by operating at the cellular level to engineer specific traits. Crops have been genetically modified (GM) primarily to increase herbicide

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[3] Data from World Seed Trade Statistics at www.worldseed.org/statistics.html.

tolerance and insect resistance (James, 2003), permitting significantly lower use of chemicals and generating higher yields. For example, research in China suggests that Bt cotton has reduced per-hectare costs by 82 percent, owing to lower pesticide and labor use, while raising yields by up to 15 percent (Huang et al., 2002).

There are four major GM crops in commercial production today, including soybeans, maize, cotton, and canola, though trials are under way in many other products. The global diffusion of such crops, at least in terms of area planted, has been remarkable. From a base of zero hectares in 1995, the global area of transgenic crops grew to almost 70 million hectares in 2003 (James, 2003). However, this has taken place in only 18 countries and only ten have devoted more than 50,000 hectares to GM crops. In the Asia-Pacific region, the United States is by far the largest producer, followed by Canada, China, and Australia. China in particular has been a recent and enthusiastic adopter of GM technologies. It is anticipated that Chinese farmers will have a 92 percent adoption rate of Bt cotton and a 95 percent adoption rate of GM rice by the year 2010 (Huang et al., 2002).

For well known reasons, however, this enthusiasm is not shared by Japan and Korea. Like their counterparts in Europe, consumers and environmental groups in these countries are concerned about the food safety aspects of GM crops and the implications of widespread adoption for biodiversity and environmental stability. While these concerns have yet to be shown to have scientific validity, they resonate with policy makers, who pursue a mix of regulatory delays and labeling requirements to slow the local adoption and imports of GM foods. Moreover, these concerns may be employed to limit the spread of new technologies into Japanese and Korean farming, which remain reliant on smaller farms and higher-cost techniques.

As noted earlier, a final form of major technological change in agriculture has been the industrialization of animal husbandry through the development of large feedlots, poultry farms, and fish and crustacean farms. The ability to concentrate the raising of animals in single locations generates substantial economies of scale in producing protein, which itself has spurred growth of consumption standards in Asia-Pacific economies. In itself, this trend relies relatively little on science and IPRs. However, to make such industrialization feasible, agribusiness firms have developed antibiotics, vaccines, and scientifically balanced feeds to promote growth and control disease. These technologies are central to the transformation of livestock husbandry from a pastoral and gathering occupation to an industrial activity. This activity is well advanced in the United States, Canada, and Australia, while it is emerging quickly in the Asian countries. China in particular is adopting industrialized techniques, while the prevalence of fish farming in Vietnam and Thailand is well established.

b. Industrial Implications

The succeeding application of new technological knowledge and techniques to agriculture has generated at least three important and interrelated outcomes for competition and market structure. First is the establishment of large life science companies that organize the production of biologically based inputs for farming, including seed varieties, hybrids, agricultural chemicals, genetic technologies, feeds, and animal medicaments. There are economies of scope in developing multiple product lines because of synergies in research and the need to engage in extensive technology licensing.

There are also economies of scale arising from the research intensity of these activities. Like other intellectual property-intensive sectors, there may be high fixed costs of developing a new biogenetic plant or animal vaccine but the marginal costs of production and distribution are low.

Most prominently this concentration has emerged from the acquisition of seed companies by agricultural biotechnology firms. Thus, for example, Monsanto (an American company) acquired six large seed firms by 2000, including DeKalb, Holden, and Cargill International. DuPont (USA) acquired Pioneer, while Aventis (France and Germany) bought four companies. The entry of pharmaceutical companies into the industry is illustrated by Syngenta (Switzerland), which is a merger of Novartis and AstraZeneca, a company that had acquired numerous large seed firms. These four merged corporations, along with Dow Agrosciences (USA), constitute the bulk of global suppliers in biological agricultural inputs (Dhar 2002).

There are other important suppliers in Asia, including the Beijing Seed Corporation (China), Mitsubishi (Japan), Takii (Japan), and Charoen Pokphand (Thailand) (Kuyek, 2001). However, the science-based agricultural inputs industry is dominated by corporations from the developed countries. Asian developing countries, including China and Korea, lag considerably in the development and registration of new technologies in this area and remain net importers.

A second feature is that R&D in the agricultural life sciences is increasingly undertaken by private firms, rather than public research institutes, in the developed market economies. To be sure there is a substantial role played by governments in the United States, Canada, and Japan in funding basic research in genomics, genetic tools, and recombinant technologies. However, the U.S. biotechnology industry has been built on applications undertaken by private firms, often spun off from university laboratories under terms of the Bayh-Dole Act of 1980. Successful technologies developed in this fashion generally have been gathered into the ambit of larger corporations through acquisitions. Indeed, the U.S. government considers the privatization of even basic research results to be a valuable form of international competitive advantage (Barton and Maskus, 2004). Thus, the fruits of its research subsidies ultimately find their way into private channels of production, trade, and investment.

This privatization of agricultural research raises concerns in some quarters about potential impacts on costs for farmers in poor countries and on sustainable development (Dutfield, 2000). These concerns are compounded by the diminished relative presence of national research services and international agricultural research centers (IARCs) in developing new agricultural technologies (Evenson, 2004). Nonetheless, Korea and Japan have moved toward greater reliance on private firms for commercializing agricultural research, and China actively has sought to establish quasi-private biotechnology enterprises associated with government laboratories and universities (Maskus, 2004).

The third feature of the technology intensity of modern agriculture is the growing reliance on intellectual property protection to ensure the appropriability of returns to investment in R&D. Both plant varieties (other than hybrids) and biotechnological inventions are extreme cases of technologies on which it is extremely difficult to practice technical exclusion. This is obvious in the case of new plants, for harvested seeds automatically embody the technology for future propagation. Thus, without legal protection of some kind, the introduction of new plant varieties quickly generates a large pool of potential free riders (farmers), thereby diminishing up-front incentives for research. For their part, many biotechnological products are easily reverse engineered through the application of genetic techniques. IPRs are so central to competition in these industries that it is important to review the main forms of protection.

3. THE PROTECTION AND REGULATION OF INTELLECTUAL PROPERTY IN AGRICULTURE AND FOOD

a. The Role of IPRs

With this complexity of technological change, participants, and demand patterns, a complicated set of public policies is required to support the movement of technologies from laboratories to embodied products on the market. A central and critical policy is the set of IPRs, which set out the boundaries within which their owners have exclusive rights to produce, sell, and license a technology or product. For an economy seeking to develop and benefit from its agriculture, biotechnology, and agribusiness industries, IPRs provide the framework for balancing several objectives.

First, costs of inventing and marketing new seed varieties and bio-engineered plants and foods are high, because of research expenditures, uncertainty of outcomes, and costly and lengthy testing and approval procedures. In order for inventors to recover these R&D costs, there must be some form of market exclusivity because appropriability of market returns is an acute problem. Biotechnologies have a natural appropriation problem because they have qualities that make imitation by others feasible at relatively low costs. This problem is easily seen in the agricultural sector. Innovative plant varieties, as embodied in seeds, may be readily reproduced in identical qualities simply by virtue of cultivating the plants. Thus, new plant varieties may face competing production and sales simply by being placed on the market in the first place, an act that carries an implicit license for replication and production without enumerated rights (Swanson, 2002). Intellectual property rights (IPRs), primarily in the forms of patents and plant variety protection, therefore provide the exclusivity needed to earn returns to invention and innovation. Patents are critically important for this purpose in the biotechnology sector (Barton, 2002; Maskus, 2000).

A second purpose of IPRs is to provide incentives to bring new technologies and products to the market in order to achieve consumer and industrial benefits. While public research programs may be effective at developing new knowledge, universities and public laboratories in the past have been ineffective at commercializing it through embodied products, a situation that remains true in much of the developing world and transition economies, including China (Maskus, 2004). In recognition of this difficulty, the United States enacted the Bayh-Dole Act in 1980, permitting universities to assert patent rights over inventions developed with their facilities and encouraging licensing of those rights. This approach has been central to the development of the biotechnology-based agricultural sector (Thursby and Jensen, 2001). It facilitates allocation of rights in a complex contracting game in order to move technologies through to the production and marketing stage. This ability to encourage transfer of knowledge through licensing of rights is perhaps the most significant, if under-appreciated, pro-development aspect of IPRs.

A final objective of IPRs is to promote diffusion of knowledge into the broader economy. In part, this happens automatically as products are commercialized, making them available for inspection, reverse engineering, and development of competing new technologies. More directly it happens through publication and disclosure requirements in patents and plant variety protection.

Despite the potential dynamic economic gains from protecting intellectual property, IPRs are limited in duration and scope order to prevent anti-competitive abuses by rights holders. These limitations are discussed in the following sub-section, which briefly explains the major types of protection for agricultural technologies. That IPRs are limited, however, indicates clearly that interest in the strength of protection varies naturally over time and across countries. Protection in the United States, Canada, and Japan is far stronger now than it was 20 years ago, reflecting their status as major developers and net exporters of intellectual assets. Standards in middle-income economies and poor countries tend to be weaker, for they perceive few interests in protecting the rights of foreign technology developers and may see weak IPRs as a form of industrial policy to promote local firms (Maskus, 2000). Nonetheless, China and Korea have adopted strong intellectual property protection in anticipation of developing sophisticated technology.

b. Forms of Intellectual Property Protection

The IPRs of most relevance to agriculture and agribusiness include patents, plant variety rights (PVRs), trade secrets, and geographical indications, which we describe briefly here. A patent provides its owner the right to exclude all others from making, selling, importing, or using the product or process named in the patent without authorization for a fixed period of time. It provides exclusive rights to the physical representation, in the forms of goods, formulas, and designs, of ideas with industrial applicability.

For an invention to be patentable it must meet three criteria: it must be novel (that is, previously unknown), it must contain an inventive step (that is, a step that is non-obvious to one skilled in the area of technology it represents), and it must be useful or have industrial utility. Novelty and non-obviousness are important for they set the technical bar that patent examiners must certify has been met in order to award protection. The utility standard is also important because it essentially determines the dividing line between basic research discoveries, which are generally unpatentable outside the United States, and applied inventions.

Patents are provided for a fixed length of time, a minimum of 20 years from the filing date under the TRIPS agreement. The breadth or scope of the patent may vary. Inventors make claims about the protectable novelty of their inventions but examiners may narrow the claims or modify or reject them. While the claims recognized in a patent grant establish the literal terms of protected subject matter, patent scope may be complemented by a legal "doctrine of equivalents". This doctrine permits patent owners to litigate against competing products and technologies that may be shown to rely on techniques that are essentially equivalent to those in the patent grant.

The market power associated with patents may impose social costs even as it encourages invention and commercialization. Accordingly, patents are limited in duration and breadth. They carry disclosure requirements and, in many nations, must be worked in order to sustain protection. The severity of these limitations varies across countries. Moreover, the potential for abusing the market power inherent in patent grants is recognized in national competition policies. Attempts to extend protection beyond the patent grant are considered anti-competitive and may be subject to antimonopoly remedies.

Surveys performed of corporate research managers in the United States tend to find that patents are less important than other factors in decisions about whether to undertake R&D in technologically complex products, though they are useful for encouraging technological rivals to cross-license (Cohen et al., 2000). However, the major sectors in which the promise of patents is relied upon for undertaking R&D and attracting capital are pharmaceuticals and agricultural chemicals, including the biotechnology components of both industries. One prominent observer claims that without patents the biotechnology industry could not develop (Barton, 2002).

While patents may also be available, new plant varieties are protected by special systems designed for that purpose. PVRs permit developers of new plant varieties to control their marketing and use. These rights operate much like patents, being provided for fixed terms. However, rather than requirements that new plants be non-obvious and have industrial utility, a weaker stipulation exists that plants be distinctive from earlier varieties and genetically stable. They differ also from patents in that they permit certain fair-use exceptions that are not available in patents. Under some systems a research exception is provided in which a protected plant variety may be used by competitive rivals as a parent in a breeding program to develop improved plants. More important is the farmer's privilege, whereby individual farmers may retain enough seeds from each year's crop for re-planting in the following season. Such re-planting rights are not often invoked in the developed economies, where farmers typically find it advantageous to purchase new seeds on the market each year in order to benefit from newer technologies. The exception is often employed in developing economies, though many such economies do not yet have systematic plant variety protection systems in place.

The TRIPS Agreement in Article 27.3 of the TRIPS Agreement requires that WTO members protect plant varieties either with patents or an effective *sui generis* system of exclusive rights (or both). The de facto standard for a system of PVRs is the International Convention for the Protection of New Varieties of Plants (the UPOV Convention), which first came into force among mainly European nations in 1968. Revised UPOV Acts in 1978 and 1991 now determine the scope of protection from which countries may select. The 1978 Act retains the research exception and the farmer's privilege, while these standards were tightened considerably in the 1991 Act. Specifically under the terms of the later act, breeders must develop new varieties that are not “essentially derived” from protected parents, and farmers may only retain seed for use on their own land and no marketing or exchange of protected seeds is permitted. Even this latter privilege needs to be affirmatively established in national laws. Only the 1991 Act is open for accession at this time and countries joining UPOV therefore commit themselves to restricting the freedom of research institutes, breeders, and farmers to operate in this realm. As might be expected, in negotiating bilateral trade arrangements with developing countries the United States generally demands that its partners join UPOV 1991 or conform with its standards. This has been the case with Chile and Vietnam, among other countries.

Trade secrets provide protection for any information (whether patentable or not) that has economic value and is prevented from disclosure by firms through reasonable efforts. Trade secrets may be critical for biological materials that are not sold, but rather used in production. Examples include a microorganism used to make a drug or a parent line used to make a hybrid. The commercial advantage of trade secrets in these cases is that the inventor is not required to publish the protected information. TRIPS requires countries to set out laws defining the nature of unfair competition in this area, with the intention of raising the costs of learning technical business secrets through permissible reverse engineering and encouraging labor mobility.

Geographical indications (GIs) are a final form of IPRs of interest to agriculture. A geographical indication is a name, word, logo or other mark that identifies a product as having originated in a particular region, locality, or country, where reputation or some quality characteristic of the good is essentially attributable to that origin. GIs most readily attach to wines and spirits, though they are relevant for foods, food products, tobacco products, or other agriculturally based goods. By providing enterprises located within a region the exclusive rights to display the regional name on their products and marketing, GIs offer incentives to improve or safeguard these inherent quality characteristics. In turn, such products should command a price premium on the marketplace, generating larger value added per unit sold. Many see this as a mechanism for raising incomes in agriculturally based developing economies, though the major users at present are European nations.

There is a dual structure of protection for GIs in the TRIPS Agreement. The most general obligation is that countries must permit interested parties to use legal means to prevent the identification or presentation of a good that would mislead consumers as to its true geographical origin and to prevent acts of unfair competition in this regard.[4] WTO Members also must provide for refusal or invalidation of trademarks containing misleading geographical indications. These general requirements must be afforded any

[4] See "WTO Mandated Negotiations on Geographical Indications (TRIPS)" available at www.intracen.org/worldtradenet/docs.

product for which GI protection might be sought. However, terms that are generic within a territory need not be awarded GI protection and countries are not required to recognize GIs that are not protected in their country of origin or have fallen into disuse there.

TRIPS calls for a higher level of protection for GIs for wines and spirits. The Agreement requires WTO Members to prevent the use of GIs identifying wines and spirits that do not originate in the place indicated, even where the true place of origin is indicated or the GI is used in translation or accompanied by such expressions as “kind”, “imitation”, or the like. Further, it mandates negotiations concerning the establishment of a multilateral system of notification and registration of GIs for wines eligible for protection in those Members choosing to participate in the registration system. Ongoing negotiations at the TRIPS Council seek to determine whether to extend this stronger protection for wines and spirits to GIs for other products.

c. Related International Obligations

While IPRs are the focus of this paper, it is important to note that other international obligations affect international trade and investment in agriculture. Most prominent are food safety rules, with WTO members obliged to meet terms of the Agreement on Sanitary and Phytosanitary (SPS) Measures. In essence this agreement requires importing nations to demonstrate that their food safety laws are not disguised restrictions on trade and are based on scientific testing and risk assessment. It also effectively sets internationally recognized food standards (generally set through Codex Alimentarius) as minimum safety levels that exporters must meet, though importing nations are free to set more rigorous norms. It is evident that adherence to SPS places some limitations on the ability of governments to use food standards as means of protecting domestic agriculture from trade competition.

A second important area is the application of safety principles to genetically modified foods. The United States, Canada, and China are enthusiastic producers of GM foods but subject firms to meeting bio-safety rules as regards nutrition and the environment. Japan and Korea do not produce GM foods and subject imports to rigorous rules governing maximum share of GM inputs and labeling requirements. They may choose to follow the European Union in asserting rules for tracking the separation of GM products and non-GM products. Thus, such rules significantly affect the prospects for economies to expand exports of bio-engineered foods. Indeed, the Cartagena Protocol (2000) to the Convention on Biodiversity recognizes the right of countries to exclude imports of GM foods under the "precautionary principle". At this time, among East Asian and North American economies the Protocol has been ratified only by Japan, Vietnam, Cambodia, Malaysia, and Mexico, none of which produces GM foods.[5]

d. An Overview of Policy Approaches

A brief review of policy stances in the major Asia-Pacific countries in the area of IPRs is in order. For this purpose, the laws of each country are summarized in Table 1.[6] As might be expected, the United States has the strongest protection regime for agricultural IPRs. It provides patents on higher-order life forms and, within the area of biotechnology, permits broad patent claims on genetic discoveries (such as genetic

[5] Mexico has a small amount of land under experimental cultivation (James, 2003).

[6] Readers should note that there are exceptions and modifications in such laws, and these characterizations are not always entirely valid.

sequences and specific genes) and research tools in addition to exclusive rights on GM products. The United States permits both patents and PVRs on new plant varieties, including those developed from genetic engineering, though patents apply only to plants that reproduce asexually. Moreover, its plant variety law conforms to UPOV 1991 and therefore significantly restricts the ability of rival breeders to use protected plants in research as breeding stock or germplasm. As for geographical indications, the United States offers no specific protection for these devices. Rather, companies within a region are free to register certification marks, which certify origin with no necessary relationship to quality characteristics. Indeed, the United States is opposed to their extension beyond wines and spirits at the WTO, believing that trademarks and certification marks offer sufficient incentives for the development of niche foodstuffs.

Japan's system of IPRs in agriculture is close to that of the United States, reflecting the recent convergence in its laws with American laws and the general strengthening of the Japanese regime (Maskus, 2002, Nagaoka, 2005). Japan strongly protects plant varieties with both PVRs and patents (on both sexually and asexually reproducing plants), reflecting the interests of its horticultural industry. However, it relies on trademarks and unfair competition laws to prevent misleading application of geographical names to products. Korea's system has also converged on that of the United States, especially as regards certification marks for protecting place names. Korea does not yet award patents to genetic discoveries.

China's regime is designed to encourage innovation in agricultural biotechnology, while retaining strong regard for follow-on competition. Thus, China does not offer patents for genetic methods, though it does do so for GMOs. Plant varieties are protected under the weaker terms of the 1978 UPOV Convention, permitting a breeder's research exemption and the farmer's privilege. Finally, Canada and Australia follow similar regimes. Canada does not patent plant varieties but does offer patents on novel and inventive plant cells. As befits its high-quality wine industry, Australia protects geographical indications in wines, largely as a result of a bilateral arrangement on this subject with the European Union.

Overall, while there are noteworthy differences in these approaches to protecting technology in agriculture, the various regimes in these countries offer strong protection for inventors and plant developers. In this context, differences in IPRs per se are not likely to be significant distortions to trade and investment in foods and food products in the region.

4. ECONOMIC INTERESTS OF ASIA-PACIFIC ECONOMIES

a. Production and Trade

Some basic perspective on the agricultural economies of major Asia-Pacific economies is provided in Tables 2 and 3.[7] As may be seen in Table 2, rice is grown in large quantities in all of the seven countries listed. Thailand and Vietnam devote the largest land areas per capita to rice paddy and are major producers, trailing only China with its massive scale. Despite its large allocation of land to rice cultivation, Korea produced on average only 6.9 million metric tons of rice. Japan produces larger quantities, but rice farmers in both Korea and Japan evidently display lower productivity

[7] I exclude Canada, which has a comparative advantage structure similar to the United States and Australia, in order to bring in Thailand and Vietnam.

than do farmers elsewhere. This is borne out by the figures on international trade in Table 3, which show that those two countries are major net importers of rice, despite the extensive protection and support for rice producers (Table 4). Korea and Japan also produce virtually no maize, wheat, soybeans, and cotton, procuring their needs from imports.

In contrast, the United States is a significant net exporter of grains, cotton, and beef (Table 3), though it retains extensive producer subsidies for wheat, maize, and rice. The United States is a net importer of sugar, which is heavily protected, fruits and vegetables, and fish and seafood. Thailand and Vietnam are large net exporters of fish and seafood, much of it to the United States, a factor underlying recent U.S. antidumping actions in catfish and shrimp. The growth of production and exports in this sector in Vietnam since the late 1990s has been extraordinary.

China is a large producer of all the commodities listed except cotton, and that product has grown rapidly since the introduction of Bt cotton (Huang et al., 2002). China's trade picture in agriculture is mixed across commodities, with surpluses in rice, maize, fruits and vegetables, and fish and seafood, while experiencing deficits in wheat, sugar, soybeans, cotton, and beef. Rapid economic growth since 2002 presumably has increased China's net import positions, particularly in wheat and soybeans.

With the exception of China, the countries in Tables 2 and 3 present a picture of decided comparative advantage and disadvantage in agricultural products. Among the richer countries, the United States and Australia demonstrate net export positions in most commodities. This is especially true for Australia in wheat, cotton, and beef. Australia's extensive comparative advantage in wine, a technology-intensive good dependent on intellectual property protection, is demonstrated clearly in Table 3. However, Japan and Korea are net importers of most products, including wine. Thailand and Vietnam display similar net export positions in agricultural goods and have particular comparative advantages in rice, sugar, fruits and vegetables, and fish and seafood.

It is impossible to discuss agricultural trade without recognizing the extensive protection from imports and production subsidies that affect production and exchange. Tables 4a through 4c provide recent computations of various measures of protection. In Table 4a are producer subsidy equivalents (PSEs) for OECD members in the group studied here. These are made up of market price supports and payments based on outputs or area planted as a percentage of total farm income. Japan and Korea provide the most extensive support, ranging up to 89 percent for Korean oilseeds producers and 86 percent for Japanese wheat and rice farmers. The United States and Canada offer significant support as well, most of it tied to production. Within this group of countries only the United States pays export subsidies, an element of central concern in the Doha Round negotiations.

The figures in Table 4b reflect estimates of average border protection in different crops. These figures are bound tariff rates averaged across tariff lines, incorporating both primary and processed products. Measured this way, protection in the United States, Canada, and Australia is slight, with the exception of sugar. Korea has high bound tariff rates in wheat, cereals, oilseeds, and fruits and vegetables, though its applied tariffs are presumably lower. Thailand has bound tariff rates in agriculture that range from 17 percent in cotton to 49 percent in sugar. Finally, the estimates for China are based on actual price wedges from a variety of interventions (Anderson et al., 2004) that combine to form nominal rates of protection. These estimates suggest that China strongly protects sugar, cotton, and oilseeds but penalizes rice, meats, and fruits and vegetables slightly. It should be noted that China intends to move toward a tariff-rate quota system that is likely to raise the average nominal protection for these commodities by 2007 (Anderson et al., 2004).

The bound tariffs in Table 4b are misleading about true levels of protection because they fail to account for the tariff-rate quotas (TRQs) that abound in agricultural tariff lines. Thus, in Table 4c, I list average in-quota and over-quota tariff rates for products subject to TRQs in North America and the Asia-Pacific region. It is evident that within-quota rates seem moderate in North America, ranging from two percent in cotton to 28 percent in sugar, but import levels beyond the quota restraints encounter significant increases in tariff rates. Both in-quota and over-quota rates tend to be higher in the Asia-Pacific area. Whether the higher over-quota rates matter depends on the fill rates for specific quotas, though it is likely that the higher over-quota taxes act as a deterrent to actual fulfillment.

Overall, this review of trade restrictions suggests that agricultural production and trade remain subject to significant distortions from government policy. Negotiating reductions in these barriers is likely to be extremely difficult without some offsetting gains in other aspects of trade regulation, one candidate for which is intellectual property protection.

b. Innovation and Intellectual Property

Each of the major countries considered in this paper has extensive public research programs in place in agriculture, ranging from basic genetic and biotechnological research activities to applied extension services. Japan, for example, has a public agency, the National Agricultural and Bio-oriented Research Organization, which manages five regional research institutes and six specialized research institutes. Research centers at Nagoya University, University of Tokyo, and other institutions work on developing agricultural technologies and methods of transferring technology to industry and farming, including through the registration and licensing of IPRs. China has established linkages among its public research laboratories and universities in order to develop agricultural and medical biotechnologies and to improve biosafety regulations. In the past Chinese public research agencies have been ineffective at commercializing their inventions (Maskus et al., 2004), but in recent years their ability to transfer technology has improved.

The United States has devoted the most resources to agricultural technology development and has a deep innovation system ranging from research-intensive land-grant universities to government extension services and research laboratories and on to farmers, agribusiness firms, and agro-biotechnology companies. This broad approach to developing knowledge and applied agricultural technologies implies that the sector is R&D intensive and employs far more labor and capital than a straightforward listing of numbers of farmers would imply. It also implies that the United States remains the major source of agricultural technologies on a global scale.

To appreciate the relative success of major Asia-Pacific economies in agricultural innovation, consider the figures in Tables 5 and 6. The first two columns in Table 5 show the numbers of plant variety certificates in place in 1998 and 2002. As noted above, the United States permits plant developers to choose plant variety protection or patent protection (or both) on new strains. There was a sharp increase in the number of both forms of protection granted in the United States over this period. U.S.- resident developers filed far more applications, and received more certificates, than foreign developers. It is interesting to note, however, that the number of applications fell in this period, while the number of patent applications rose sharply, especially on behalf of non-residents. Indeed, in 2002, more patents were issued to non-residents than to residents, attesting to the global nature of this industry. Japan awards the largest number of plant variety certificates of all the countries in the list, the great majority of which go to Japanese inventors. However, there was a large increase in certificates issued to non-residents.

The plant variety protection laws in China and Korea are relatively new but both have attracted significant increases in applications and registrations. China as of 2002 had not issued any certificates to foreign residents, who experience some difficulties in application procedures (Maskus, 2004). Korea saw a dramatic increase in applications for PVRs between 1998 and 2002 by non-residents. Canada and Australia have also witnessed significant increases in non-resident applications and grants. The overall impression from Table 5 is that there is significant growth in innovative activity in developing new plant varieties, including biotechnological strains, and in protecting those inventions within the Asia-Pacific region. Japanese developers are especially active in registering for protection at home.

The figures in Table 6 relate patent grants awarded over the period 1997-2001 in the United States for those patent classifications most relevant to agriculture. Also listed is a measure I call "revealed technology advantage", which is defined as:

$$RTA = \{(P_{ij}/P_{iw})/(P_j/P_w) .$$

This ratio calculates the share of country j's patents in classification i of global patents in classification i, divided by the share of country j's patents in global patents (where global means all patents taken out in the United States). The measure is precisely analogous to the standard measure of revealed comparative advantage in trade and is designed to find out if a country tends to register a disproportionately higher share of patents in a particular technology classification than it does overall in the United States. A ratio greater than one suggests a technological specialization in that category.

Patent classification 047 is plant husbandry and is the closest (though narrower) category to the plant variety patents listed in Table 5. The United States received by far the greatest number of patents in this category over the period and has a revealed advantage in it. Japan registered 69 plant husbandry patents, which was the largest number of any foreign country, but its RTA suggests that Japanese inventors tend to specialize in non-agricultural technologies.[8] Similar comments apply to China and Korea, which together registered only one patent. In contrast, Canada and Australia display large RTAs in plant husbandry. The situation across countries is the same in category 119, animal husbandry.

Category 424, bio-affecting drugs, involves agricultural drugs as a component but is broader than just farming. Japan again registered a large number of patents but did not achieve an RTA. In contrast, China's RTA demonstrates a significant specialization in this area as regards technological resources. Also interesting in this context is category

[8] Listed for comparison purposes is classification 438, which is semiconductor device manufacturing processes. Japan had a revealed advantage in this area, as did Korea, pointing to the specialization of R&D in those countries in electronics over agriculture.

800, multicellular living organisms. While these organisms are generally not patentable outside the United States and Japan, all countries considered have registered patents in the former nation. While the number is small, China's RTA suggests also a relative specialization in this area of technology, as do those of Canada and Australia. Again, Japan and Korea display technological disadvantages in developing new organisms.

The picture supported by this review of innovation data is the following. Japanese inventors are active in all areas of agricultural technology, including biotechnology, and register large numbers of plant variety certificates in particular. However, in the aggregate Japanese invention is not specialized in these areas, at least as far as registration of patents in the United States is concerned. Korea has become more active in developing new plant registrations but has not achieved a specialization in new agricultural technology. Canada, Australia, and the United States, as nations with significant comparative advantages in agricultural commodities, have specialized their invention resources in developing agricultural and biotechnological inventions. Australia also has moved forcefully into registration of geographical indications in wine. Finally, China is emerging as a producer of new agricultural knowledge and drugs.

On this basis it is sensible to infer that all the countries in this sample share an interest in protecting intellectual property, though Korea and China remain more in the form of technology followers in these areas of knowledge. As a result, these countries may have greater interests in limiting the scope of patent protection in order to enhance access to newer technologies. At the same time, China has decided to promote biotechnology in agriculture as a means of achieving rapid productivity gains and food security. Attracting these technologies from abroad and moving them from public laboratories to the marketplace presume the existence of well specified IPRs.

5. LINKING IPRS TO TRADE POLICY

The point of assessing the state of trade protection and IPRs in agriculture in this paper is essentially to bring out some relationships between them that are relevant for agricultural trade liberalization in the region. Significant pressure exists to open markets in Japan, Korea, and China while reducing the scope of farming subsidies in the United States and Canada in order to increase market access for efficient agricultural exporters. Similar liberalization commitments may be expected of the poorer economies, including Thailand and, assuming its WTO accession procedure is fruitful, Vietnam. Indeed, the Doha Round is likely to be defined by its progress on this basic question of agricultural liberalization.

At the same time there are negotiations at the WTO and WIPO on extending or modifying the global IPRs regime, some of which is directly relevant for agriculture. Most prominent are discussions about extending the reach of GIs to new products and countries. However, the issue of patentability of life forms and of protection for plant varieties (Article 27.3 of TRIPS) may be revisited, while deliberations at WIPO seek to establish a global harmonization of patent standards and practices. Finally, questions of biosafety and the treatment of biotechnological products and labeling in international trade loom large in the agricultural arena. It is useful, therefore, to conclude the chapter by considering the forms in which such discussions may evolve and the interests of the major Asia-Pacific economies.

a. IPRs and Trade Policy

The inherent ambiguity in interests about IPRs poses the interesting question of whether the use of intellectual property protection can be complementary to trade liberalization in agriculture. The conventional wisdom among economists seems to be that stronger patents or PVRs would reduce the access of local farmers and agribusinesses to seeds, fertilizers, biogenetic inventions, and other technologies by raising the costs of reverse engineering and imitation (Commission on Intellectual Property Rights, 2002). Strong IPRs offer market power to R&D-intensive agribusiness firms, which as noted above, are heavily concentrated on a global scale. These firms may use their protected positions to raise seed costs and segment technology markets. Thus, tariff cuts and strengthened IPRs both would be sources of pressure on inefficient and technologically lagging farming sectors. Put differently, countries cutting tariffs might be expected to weaken intellectual property protection in order to sustain the competitive position of domestic farmers (Zigic, 2000).

The risk is real that farmers in high-cost economies with lagging technologies will suffer greater competitive pressures from both trade liberalization and tight IPRs. While this description may most readily describe the current situation in such low-income economies as Vietnam and China, it applies as well to Japan and Korea, where farms tend to be small and inefficient. The latter countries have few options in terms of limiting intellectual property protection and, as a result, may be even more resistant to opening up to imports. In contrast, the major agricultural exporters are also net developers of technology, as noted in Table 6. The United States, Canada, and Australia presumably have strong interests in greater market access for agricultural goods within the region to complement their gains from exploiting intellectual property.

While this analysis suggests a sharp difference of interests in the region, in truth the situation is more complex. After all, the essential purposes of protecting IPRs are to encourage domestic innovation, promote market development and licensing to enhance information diffusion, and to increase access to domestic and foreign technologies. To the extent these outcomes emerge, a country's farming sector should become more competitive over time, even if there are short-run costs as a result of higher costs of imitation and technology purchases. A significant variant is the need for productivity growth in agriculture in order to sustain incomes (even as the number of farmers diminishes) and to improve nutrition and food security. China, in particular, envisions such gains emanating from extensive deployment of agricultural biotechnologies, the development of which is increasingly dependent on IPRs. Patents, trademarks, and trade secrets have significant potential to increase flows of technology transfer to countries that are open to trade and investment (Maskus, 2000). Seen in this light, there is some scope for IPRs to improve domestic productivity growth prospects in agriculture, even in the presence of trade liberalization.

The challenges posed by this mix of incentives for Asia-Pacific economies are significant and the outcomes of joint trade liberalization and IPR strengthening are difficult to predict. For Japan and Korea to sustain a farming presence in the face of tariff liberalization and reduced farm supports, these countries would need to rationalize their agricultural incentives while encouraging more innovation. Much has been written about the need for rationalization, including especially improving investment incentives and reducing impediments to transacting in farmland. That rationalization in itself should increase investment in new technologies and shift more agricultural innovation into the private sector. However, there remains a need for effective systems of public and private agricultural innovation, with improved processes for moving public technologies into domestic use. In this context, a policy emphasis on keeping the results of basic agricultural research, performed by public institutions, largely in the public domain can be beneficial for productivity growth. Note also that research subsidies would have some ability, albeit limited, to substitute for reduced farm income supports and liberalized border restrictions.

Many Asian economies recognize the scope for innovation that is provided their farmers through the implementation and registration of geographical name protection, whether through certification marks, collective marks, or geographical indications. Just as one essential purpose of plant variety rights is to increase the return to differentiating products in ornamental plants, produce, and trees, value can be created for specific localities through the use of such names. Australia gains from a system of GIs in wines, permitting entrepreneurs in that country to trade on such names as Coonawarra and Barossa (Anderson, 2000). The United States remains opposed to extending the GI system globally, in part because of the current use in its market of names that could become reclaimed property in such a world. It would seem, however, that developing countries, including China, and even Japan and Korea would have little to fear from extending such protection in order to encourage innovation and product development among their own farmers.

A final related challenge must be to rationalize the use of food safety standards and technical requirements in order to increase market access and expand market opportunities abroad (Maskus and Wilson, 2001). It is likely that regional economies rely at times on arbitrary product standards to limit import competition in food and agriculture, a charge frequently leveled at Japan in particular. While such standards may have a protective impact, they are impediments to rationalization and the introduction of more globalized technologies. The most glaring example is the EU ban on imports of GM foods, mirrored by the rigorous labeling and tracking standards in Japan and Korea. Such restrictions tend to limit investments in exporting countries and limit the spread of technology. Indeed, a potential ban on GM trade in Northeast Asia would have significantly negative impacts on Chinese welfare while limiting consumer choice in Japan and Korea (Anderson and Yao, 2001).

b. Global IPR and Trade Negotiations

What might be said about the interests of the major Asia-Pacific economies in the intellectual property area, in light of potential regional and global agricultural trade liberalization? A number of conclusions seem sensible from the foregoing analysis.

First, there is a broad similarity of intellectual property policies and objectives among the richer economies of the region. While there is a sharp distinction in comparative advantage in agriculture, and therefore differing interests in pushing for cuts in border measures and farm supports, each of these countries the United States, Canada, Australia, Japan, and Korea – sees advantages in promoting technological progress in the rural sector. For Japan and Korea the challenge may be particularly acute as regards modernizing and rationalizing its farm sizes and agricultural practices. However, IPRs, especially plant variety rights and some forms of geographical name recognition can assist the transition. Indeed, given Japan's presence in developing new plant varieties, a significant export opportunity could be provided by stronger global protection.

For its part, the government of China stresses the importance of modern agriculture for food security and rural development, supporting its encouragement of biotechnology adoption. China and the United States share a mutual interest in reducing international resistance to genetically modified agricultural products. In that regard they may wish to coordinate efforts in making sure that potential labeling requirements in major world markets are not onerous even as they push for greater market access.

However, there are significant differences within the region. The United States has gone far beyond the rest of the region in awarding patents to plants, multi-cellular organisms, non-traditional breeding methods, and genetic research technologies. There is legitimate debate even within the United States about the wisdom of such strong protection, which reflects in part the capture of the patent system by corporate inventive interests in agribusiness and biotechnology. U.S. negotiators in the Doha Round would like to re-open TRIPS Article 27.3 in order to widen the scope of patent eligibility requirements on a global scale. However, such requirements could be ultimately damaging to the prospects for domestic innovation and technology diffusion in such countries as China and Vietnam, while limiting the scope for dynamic competition in Japanese agriculture.

Where such pressures could come to a head quickly is in the ongoing negotiations at WIPO concerning a global Patent Law Treaty, which aims to harmonize patent eligibility and examination standards in all WIPO members (Barton, 2004). The announced goal of those discussions is to reduce patent transactions costs through harmonization of procedures and concentration of patent examinations in a small number of national or regional offices. However, both the United States and the European Union seek aggressively to export their patent standards to other economies. In this context, it would be inadvisable for the developing economies of East Asia, including China, to accede to an agreement that established such standards. Even Japan, Korea, and Australia could be disadvantaged by the increasingly broad scope of patent protection it would bring to key agricultural technologies.

Overall, then, while there is some scope for making tradeoffs between agricultural trade liberalization and intellectual property reform, the nations of the Asia-Pacific region do have somewhat separate interests as regards linking these areas. Significant thought needs to be devoted to these issues as negotiations proceed.

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TABLE 1
Comparison of Agricultural IPRs in Major Asia-Pacific Economies

Country	Patents on Biotechnological Methods	Patents on GMOs	Plant Variety Patents	Plant Variety Rights	Geographical Indications
United States	Yes	Yes	Yes	UPOV 1991	Certification marks
Japan	Yes	Yes	Yes	UPOV 1991	Unfair competition laws
China	No	Yes	No	UPOV 1978	Unfair competition laws
R. of Korea	No	Yes	Yes	UPOV 1991	Certification marks
Canada	No	Yes	No	UPOV 1978	Certification marks
Australia	No	Yes	No	UPOV 1991	Yes for wines

Sources: various

TABLE 2
Basic Agricultural Production Data (Average 1999-2003)

Product	*Measure*	*US*	*Japan*	*China*	*Korea*	*Australia*	*Thailand*	*Vietnam*
Rice Paddy	Area per capita (ha)	4540	13579	22836	22511	6930	166461	95937
	Production (1000 mt)	9274	11125	182696	6878	1186	25828	33017
Maize	Area per capita (ha)	99491	1	18879	360	3795	19273	9802
	Production (1000 mt)	243720	0	116878	68	372	4341	2275
Wheat	Area per capita (ha)	71851	1530	19594	31	619014	20	0
	Production (1000 mt)	56848	714	96756	5	21171	1	0
Sugar	Area per capita (ha)	3369	714	1268	0	21653	14816	3990
	Production (1000 mt)	59143	5264	92979	0	35473	59796	16197
Soybeans	Area per capita (ha)	102429	1069	6987	1759	1965	3400	1865
	Production (1000 mt)	73314	253	15693	115	77	296	179
Cotton	Area per capita (ha)	18306	0	3303	0	18172	526	372
	Production (1000 mt)	9975	0	14211	0	1396	45	32
Fruits &	Area per capita (ha)	4854	3487	14566	8600	4409	5811	7369
Vegetables	Production (1000 mt)	37912	12485	344669	11616	1871	3141	6958
Oil Cakes	Production (1000 mt)	38635	4558	27251	1191	508	1026	164
Wine	Production (1000 mt)	2385	103	1063	0	1052	0	0
Beef	Production (1000 mt)	12210	521	5250	241	2028	179	99
Fish & Sea	Production (1000 mt)*	5405	5521	44063	2282	236	3606	2010

Notes: * = 2001 production. Source: faostat.fao.org/faostat.

TABLE 3
International Trade in Agricultural Goods, 2002 ($ millions)

Product	*Measure*	*US*	*Japan*	*China*	*Korea*	*Australia*	*Thailand*	*Vietnam**
Rice	Exports	775.3	0.3	392.2	0.1	86.3	1632.0	624.7
	Imports	162.3	213.6	110.0	44.9	27.5	0.4	0.7
	Balance	613.0	-213.3	282.2	-44.8	58.8	1631.6	624.0
Maize	Exports	5127.6	8.0	1167.3	0.0	7.8	27.5	4.5
	Imports	137.2	1993.3	592.0	982.2	0.5	3.3	7.0
	Balance	4990.4	-1985.3	575.3	-982.2	7.3	24.2	-2.5
Wheat	Exports	3631.9	2.3	70.1	0.0	1272.4	0.0	na
	Imports	266.2	1120.9	299.5	542.7	0.0	151.6	101.1
	Balance	3365.7	-1118.6	-229.4	-542.7	1272.4	-151.6	na
Sugar	Exports	52.0	0.2	84.3	75.8	31.4	684.3	32.9
	Imports	559.7	273.9	306.0	284.8	2.8	0.0	21.3
	Balance	-507.7	-273.7	-221.7	-209.0	28.6	684.3	11.6
Soybeans	Exports	5623.6	1.3	76.7	0.1	2.7	0.3	11.0
	Imports	27.5	1223.1	3019.0	318.0	0.4	324.3	1.9
	Balance	5596.1	-1221.8	-2942.3	-317.9	2.3	-324.0	9.1
Cotton Lint	Exports	2049.2	0.1	172.3	1.5	680.2	0.2	0.0
	Imports	19.9	250.3	509.7	370.9	0.1	461.9	124.0
	Balance	2029.3	-250.2	-337.4	-369.4	680.1	-461.7	-124.0
Fruits &	Exports	8169.4	0.0	4471.2	315.0	897.1	1293.5	321.5
Vegetables	Imports	10166.5	5586.0	1206.5	694.4	512.0	157.5	55.2
	Balance	-1997.1	-5586.0	3264.7	-379.4	385.1	1136.0	266.3
Beef	Exports	368.9	0.0	0.4	0.0	76.3	0.0	0.0
	Imports	225.5	9.7	16.5	385.4	0.1	0.9	0.0
	Balance	143.4	-9.7	-16.1	-385.4	76.2	-0.9	0.0
Fish & Sea*	Exports	3356.3	779.6	6267.5	1160.1	901.2	4053.5	1783.4
	Imports	10315.1	13487.0	4132.4	1639.0	553.7	1059.9	31.9
	Balance	-6958.8	-12707.4	2135.1	-478.9	347.5	2993.6	1751.5
Wine	Exports	527.0	2.3	5.0	0.0	1272.4	2.1	0.0
	Imports	2654.6	800.4	46.8	29.4	76.5	7.5	6.6
	Balance	-2127.6	-798.1	-41.8	-29.4	1195.9	-5.4	-6.6

Notes: * Figures for Vietnam are for 2001. Figures for fish and seafood are for 2001.

TABLE 4a
Producer Subsidy Equivalents for Agricultural Support Programs, 2001 (percent)

Product	*United States*	*Japan*	*Rep. of Korea*	*Canada*	*Australia*
Wheat	40.0	86.2	na	18.0	4.2
Maize	26.4	na	na	15.5	na
Rice	46.8	86.4	81.2	na	5.3
Oilseeds	25.5	56.1	88.5	19.6	2.9
Refined sugar	48.4	40.8	na	na	10.4
Beef & veal	4.7	31.9	59.7	8.3	3.3

Source: www.oecdnt.ingenta.com

TABLE 4b
Estimated Border Protection in Agriculture, 1999-2001 (Average Bound Tariff Rates)

Product	*United States*	*Japan*	*Rep. of Korea*	*Canada*	*Australia*	*Thailand*	*China**
Wheat	1.3	na	101.0	12.0	1.3	32.3	12
Cereals	2.7	16.3	191.0	3.3	2.0	37.3	20
Rice	na	na	na	na	na	na	-3
Oilseeds	10.0	2.0	60.5	3.0	2.5	36.0	32
Sugar	4.5	70.7	27.0	8.0	15.0	49.0	40
Cotton	5.7	3.0	9.3	7.0	10.3	16.7	27
Meats	6.0	12.0	31.0	5.0	2.0	35.0	-15
Fruits & Vegs.	5.5	10.0	91.0	5.5	5.0	39.0	-4

Notes: *Data for China are estimates of nominal rates of protection. Data for other countries are averages across primary and processed products. Sources: Anderson et al., (2004), and WTO (2003).

TABLE 4c
Average In-quota and Over-quota Tariff Rates by Major Region, 2001

	North America		*Asia-Pacific*	
Product	*In-quota*	*Over-quota*	*In-quota*	*Over-quota*
Cereals	25	80	12	321
Oilseeds	10	148	19	485
Sugar	28	109	27	61
Cotton	2	15	na	na
Meats	17	164	60	62

Source: http://www.ers.usda.gov/db/Wto/WtoTariff_database

TABLE 5
Statistics on UPOV Plant Variety Certificates

	Plant Certificates in Force		*Applications by Residents*		*Applications by non-Residents*		*Issued to Residents*		*Issued to non-Residents*	
Country	1998	2002	1998	2002	1998	2002	1998	2002	1998	2002
US	3207	4037	406	257	53	30	66	345	2	32
(Patents)	6169	8094	346	454	374	690	245	518	316	615
Japan	4071	5465	793	799	241	269	869	1035	148	286
China	19	216	271*	299	1*	8	19*	92	0*	0
Korea	na	323	234	260	0	342	na	76	na	0
Canada	425	936	62	62	296	412	53	34	92	194
Australia	947	1578	107	121	115	208	95	127	123	159

Notes: * = 1999. Source: http://www.upov.int/en/documents

TABLE 6
Cumulative US Patents Awarded in Agricultural Technologies and Revealed Technology Advantages, 1997-2001

	United States		*Japan*		*China*		*Rep. of Korea*		*Canada*		*Australia*	
Code	Grants	RTA	Grants	RTA	Grants	RTA	Grants	RTA	Grants	RTA	Grants	RTA
047	636	1.31	69	0.38	0	0.00	1	0.05	46	2.42	24	5.65
071	137	0.97	27	0.51	1	5.27	4	0.73	17	3.09	10	8.13
119	1381	1.39	48	0.13	0	0.00	8	0.21	71	1.83	24	2.77
424	19865	1.08	3057	0.44	54	2.17	192	0.27	955	1.32	266	1.65
426	2298	1.12	385	0.50	3	1.08	28	0.35	74	0.92	24	1.34
435	12316	1.24	1591	0.43	12	0.89	98	0.25	529	1.36	165	1.89
504	486	0.77	188	0.80	2	2.35	8	0.33	12	0.49	10	1.82
800	1820	1.40	74	0.15	3	1.71	11	0.22	85	1.67	23	2.02
438	7604	0.80	3874	1.09	3	0.23	1512	4.08	39	0.10	11	0.13
ALL	398581		149642		538		15564		15604		3484	

Notes: 047 = Plant husbandry; 071 = Chemistry: fertilizers; 119 = Animal husbandry; 424 = Bio-affecting drugs; 426 = Food or edible material; 435 = Molecular biology and microbiology; 504 = Plant protecting compositions; 800 = Multicellular living organisms; 438 = Semiconductor device manufacturing: process. Source: http://www.uspto.gov/go/taf/tecstc