UNCTAD-ICTSD Project on IPRs and Sustainable Development



Nutrition and Technology Transfer Policies

By John H. Barton
Professor, Stanford Law School, USA

ICTSD
International Centre for Trade and Sustainable Development

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For details on the activities of the Project and all available material, see http://www.iprsonline.org/unctadictsd/description.htm

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FOREWORD

The present paper dealing with nutrition and technology transfer policies is one contribution of the joint UNCTAD-ICTSD Project on Intellectual Property Rights (IPRs) and Sustainable Development to the ongoing debate on the impact and relevance of intellectual property to development.

It reviews the transfer of nutritional technologies to developing nations, seeking to identify the most important contemporary policy issues at both the national and international levels. The paper considers both the traditional public sector programs to transfer agricultural technologies efforts and the more recent private sector efforts. The technology transfer issues are substantially different for farmers in the market sector and for those in the subsistence/small-holder sector, so the analysis proceeds in a matrix pattern, looking at the policy issues in each of the four quadrants of the matrix (private/market; public/market; private/small-holder; and public/small-holder). The paper recognizes that nutrition is shaped not only by agriculture but also by food distribution systems and technologies and attempts to take into account the rapid changes in the developing world food distribution process. In this respect, the study concentrates on plant agriculture and food-procession; it does not consider fisheries, but does give some coverage to animal agriculture. The paper considers the variety of policies affecting the transfer of technology in the nutritional area, including intellectual property, competition law, biosafety, international trade, and public sector research issues. In some areas, it poses specific policy issues; in others it calls for further policy-focused research.

Intellectual property rights have never been more economically and politically important or controversial than they are today. Patents, copyrights, trademarks, industrial designs, integrated circuits and geographical indications are frequently mentioned in discussions and debates on such diverse topics as public health, food security, education, trade, industrial policy, traditional knowledge, biodiversity, biotechnology, the Internet, the entertainment and media industries. In a knowledge-based economy, there is no doubt that an understanding of IPRs is indispensable to informed policy making in all areas of human development.

Intellectual property was until recently the domain of specialists and producers of intellectual property rights. The TRIPS Agreement concluded during the Uruguay Round negotiations has signalled a major shift in this regard. The incorporation of IPRs into the multilateral trading system and its relationship with a wide area of key public policy issues has elicited great concern over its pervasive role in people's lives and in society in general. Developing country members of the World Trade Organization (WTO) no longer have the policy options and flexibilities developed countries had in using IPRs to support their national development. But, TRIPS is not the end of the story. Significant new developments are taking place at the international, regional and bilateral level that build on and strengthen the minimum TRIPS standards through the progressive harmonisation of policies along standards of technologically advanced countries. The challenges ahead in designing and implementing IP-policy at the national and international levels are considerable.

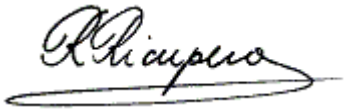
Empirical evidence on the role of IP protection in promoting innovation and growth in general remains limited and inconclusive. Conflicting views also persist on the impacts of IPRs in the development prospects. Some point out that, in a modern economy, the minimum standards laid down in TRIPS will bring benefits to developing countries by creating the incentive structure necessary for knowledge generation and diffusion, technology transfer and private investment

flows. Others stress that intellectual property, especially some of its elements, such as the patenting regime, will adversely affect the pursuit of sustainable development strategies by raising the prices of essential drugs to levels that are too high for the poor to afford; limiting the availability of educational materials for developing country school and university students; legitimising the piracy of traditional knowledge; and undermining the self-reliance of resource-poor farmers.

It is urgent, therefore, to ask the question: How can developing countries use IP tools to advance their development strategy? What are the key concerns surrounding the issues of IPRs for developing countries? What are the specific difficulties they face in intellectual property negotiations? Is intellectual property directly relevant to sustainable development and to the achievement of agreed international development goals? Do they have the capacity, especially the least developed among them, to formulate their negotiating positions and become well-informed negotiating partners? These are essential questions that policy makers need to address in order to design IPR laws and policies that best meet the needs of their people and negotiate effectively in future agreements.

It is to address some of these questions that the joint UNCTAD-ICTSD Project on Intellectual Property and Sustainable Development was launched in July 2001. One central objective has been to facilitate the emergence of a critical mass of well-informed stakeholders in developing countries - including decision makers, negotiators but also the private sector and civil society - who will be able to define their own sustainable human development objectives in the field of IPRs and effectively advance them at the national and international levels.

Ricardo Meléndez-Ortiz
ICTSD Executive Director



Rubens Ricupero
UNCTAD Secretary General

EXECUTIVE SUMMARY

The most important policy issues in the context of nutrition and technology transfer are related to intellectual property rights; competition issues in the seed, food processing and marketing sectors; biosafety questions; and trade and macroeconomic considerations.

Humans obtain food through two fundamentally different ways. One is relatively self-sufficient subsistence farming in which a small economic unit, typically a family, produces its own food. The other is production of food for a market and the consumption of purchased goods.

The task for technology transfer in a smallholder economy is to improve the subsistence farmer's standard of nutrition. In a market economy, technology transfer has a double objective: first, to enable the production of larger quantities of marketable products; and second, to improve the movement of food from the farm to the consumer. Reflecting the increasing degree of urbanisation worldwide, subsistence farming is steadily losing ground to the market economy. This trend poses serious challenges for nutrition and technology transfer policies. Recent World Bank figures show that current food production levels are clearly too low to satisfy the Millennium Development Goal of halving the proportion of people suffering from hunger by 2015.

Technology Transfer Processes in Nutrition and Agriculture

There are two economic mechanisms of supporting the development and transfer of agricultural technology, one based on the public sector and the other on the private sector.

With respect to public sector agricultural research, the lead institutions in breeding new varieties during much of the last three decades were those of the Consultative Group on International Agricultural Research (CGIAR), which co-ordinates a series of research centres throughout the world to meet developing world agricultural research needs. Middle-income developing countries have also established their own national agricultural research institutes.

With public sector budgets shrinking, private sector agricultural research is becoming increasingly important in developed and middle-income developing countries. Only a small part of this research is currently spent on developing country needs, although huge markets such as Brazil, China and India might receive increasing attention in the future. As yet, the poorest nations have not been able to benefit from private sector research and related technology transfer.

Key Policy Issues

The market/small-holder production patterns, and the private/public technology transfer patterns define a two-by-two matrix, as shown below.

		FORM OF TECHNOLOGY TRANSFER	
		PRIVATE	PUBLIC
FORM OF AGRICULTURE	MARKET	Private sector, market agriculture quadrant	Public sector, market agriculture quadrant
	SMALL-HOLDER	Private sector, small-holder quadrant	Public sector, small-holder quadrant

The private sector and market agriculture quadrant

Policy issues may arise in particular in the contexts of intellectual property (IP), competition, biosafety and trade and macroeconomics.

With respect to IP, the primary challenges exist in the seed sector. The main question is whether the UPOV Conventions provide sufficient incentives for private sector research for field crop varieties, or whether such research is better accommodated through the regular patent system. Under UPOV, plants into which a gene has been introduced through genetic engineering may be used by third parties for breeding purposes. This possibility may be denied under patent law. Depending on national implementation, it would be a patent infringement to insert a patented gene into another plant or to use such a transgenic plant for breeding purposes. This stronger form of monopoly right arguably enables private sector researchers to better recoup the costs of their investment, as illustrated by the significant increase of private sector research in the developed world after the introduction of patents to the biotech sector in the late 20th century. Therefore:

- Based on factors such as market size and research capability, a developing nation should decide whether to adopt a UPOV style system in minimal compliance with TRIPs or instead to adopt a stronger biotechnology-oriented patent system.

- Depending on their attitudes toward biotechnology, poor nations should consider ways to make themselves more appealing to private biotechnology research, for instance through integrating the seed markets of several nations followed by adoption of appropriate intellectual property rights.

- Research is needed on how major a role will be played by intellectual property rights in the global agricultural export sector and in the supermarket revolution, and on what might be the reasonable response for the developing world.

With respect to *competition issues*, the main challenge arises from the possible concentration of multinational biotech companies in developing countries and consequent negative price effects. On the other hand, such companies are likely to provide considerable technology transfer to the host country. Therefore:

- Nations with limited private sector competition in the seed industry should ensure that public sector varieties are available in competition with private sector ones.

  Middle income developing nations should develop appropriate competition law principles and bureaucratic structures for reviewing multinational acquisitions of local firms.

- These nations should also seek to participate effectively in international competition law negotiations in order to ensure that they are not harmed by global-level declines in competition.

In the area of *biosafety*, developing countries are concerned about losing European export markets if they engage in research and production of genetically modified food. Therefore:

- Developing nations should seek a way in which the biosafety uncertainties of genetically modified agriculture can be resolved, so that these nations can make appropriate decisions to encourage or regulate the private sector's interests in using these technologies.

As to *trade and macroeconomics*, developing countries should ensure that at the national level, tax regimes and investment policies are conducive to the transfer of agricultural technology from abroad. In the international context, developed countries' agricultural subsidy schemes pose a considerable challenge to exporting developing countries. Therefore:

- Developing nations should carefully consider their positions vis-à-vis international negotiations on agricultural trade and agricultural product standards, with the goal of ensuring that their agricultural sectors face competition conditions that encourage the adoption of economically-desirable new technologies.

The public sector and market agriculture quadrant

Generally, there is only a limited need for public means of technology transfer in an efficient market-based agricultural sector. Nevertheless, the public sector should remain available as a

counter-balance to anti-competitive moves in the private sector. In addition, certain broad societal needs are not addressed by the private sector and thus require basic public sector research. Therefore:

- Public sector research institutions should seek ways to carry out and support basic research of value to both people and the environment in developing countries and to co-operate with the private sector in a way that encourages the application of this research as new requirements affect world agriculture.

The private sector and small–holder agriculture quadrant

Private sector research is almost irrelevant for subsistence farmers, because the latter are unlikely to have the financial means to purchase private research products. One major challenge subsistence farmers are exposed to in the area of private sector research is plant breeders' rights. Under the 1991 UPOV Convention, seed saving may be permitted, but seed exchange is prohibited (Article 15). However, such prohibition is not mandated by the TRIPs Agreement. Therefore:

- In the developing world, seed law and plant breeders' rights law should be tailored to take into account the needs of small-holder farmers.

On the other hand, the private sector does offer important opportunities to small-holder farmers. It could, for instance, make advanced seed varieties at low cost available to subsistence farmers, while recouping its expenses through sales to market-economy farmers at market prices. Therefore:

- The public and private sector should co-operate to develop public-private licensing arrangements and partnerships designed (a) to bring new technologies to subsistence farmers under terms that allow them to reap benefits from research while permitting the private sector to obtain appropriate economic compensation in the market sector, and (b) to help small farmers enter the agro-industrial sector.

The public sector and small–holder agriculture quadrant

In this quadrant, it is important to define the appropriate tasks for public sector research:

- How should public sector agricultural research be refocused to deal effectively with the now highly diverse areas of rural poverty? What should be its relation to the private sector? Should the public sector commit itself to biotechnology research?

Another challenge for public research consists of the increasing patenting of "research tools", possibly causing researchers to be held liable for patent infringements. This leads to the following questions:

- How serious is the research tool patent problem in agriculture and can it be resolved? Are the various proposed collaborations likely to be successful? How might their likelihood of success be improved?

Finally, with respect to contextual and macroeconomic conditions needed for farmers to use new technologies, the following issues will have to be addressed:

- How much does the adoption of new agricultural technology depend on the broader matrix of rural economic policy? Should those policies, including subsidy policy and support for agricultural extension services, be modified to contribute to adoption of new technologies? If they should, then how? And lastly, how should the agricultural policy analysis/decision-making and the broader economic development policy-oriented analysis and decision-making be brought into dialogue with each other?

General implications for developing nations

Many of the issues highlighted above arise not only in the particular context of one of the four quadrants, but also in a more general sense. In particular, more expertise and research is needed in the areas of:

- agricultural technologies and IP issues;
- competition law;
- biosafety and biotechnology;
- trade law; and
- the future design of public sector activity and research policy.

1. NUTRITION AND AGRICULTURAL TRENDS

Humans have sought to satisfy their nutrition needs in two fundamentally different ways. One is relatively self-sufficient subsistence in which a small economic unit, typically a family, produces its own food. The other is production of food for a market and consumption of goods procured on such a market. There are, of course, intermediate patterns in which some goods are produced locally and others procured on the market, based either on earnings from labour or on sale of a portion of the local product. Because so many subsistence farmers must sell some of their crop in order to obtain cash, this paper uses the term small-holder to describe farmers who participate in only a very limited way in the market economy.

1.1 In a subsistence/small-holder economy

In a subsistence/small-holder economy, a family is limited to what it can produce itself. There may be some trade, as to enable the family to buy fertilizer. The need in technology transfer is then to make available to that family the various technologies that are needed to improve its standard of nutrition. This may be a matter of better seeds, especially seeds adapted to the local agronomic conditions or of better livestock or better feed for the livestock; it may also be a matter of better food-processing capabilities, such as storage procedures or more fuel efficient cooking capabilities or of access to micronutrients such as Vitamin A. And, in some cases, improvement may be a matter of enabling the family to enter the market sector.

It is in this rural subsistence sector (and in smallholder sectors generally) that the likelihood of malnutrition is highest. The largest share of malnourished children are in Sub-Sahara Africa (where the numbers are growing) and South Asia (where they are shrinking slightly).[1] Globally, the total absolute numbers of undernourished (including all, not just children) have been falling very slightly, from about 815 million in 1990/92 to 776 million in 1997/99, meaning that the proportion of the world suffering from malnutrition is, overall, shrinking.[2] Only sometimes is this malnutrition a result of the lack of adequate technology or of a failure in the national extension process to bring known technologies to the individual farming family. Sometimes, it is a result of weather, or lack of access to adequate land or water, or to the lack of complementary inputs such as credit or fertilizer that may be needed to make the available technologies effective. And sometimes, instead, it is a result of other kinds of factors such as war or HIV.

1.2 In a market economy

In a market economy, the technology transfer task is to enable the family to produce a larger quantity of marketable products, again in the plant agricultural sector, typically through better seeds or other inputs, or through better breeding stock or feed in the case of animal agriculture. But there is also a further technological need of improving the movement of food from the farm to the consumer. This may involve transportation and storage capabilities; it may involve packaging capabilities; and it may involve food-processing capabilities, including value-added processing.

The absorption of technology in this area is also affected by non-technological factors. At the national level, there are issues of access to credit, access to complementary inputs such as fertilizer and pesticides, availability of roads and transportation systems to bring products to market, and the role of national policies affecting agricultural prices. Moreover, this area will be heavily affected by the hyper-rapid spread of supermarkets and national and international vertical integration of the food chain.[3] And the incentives of farmers at this level are further affected by the economic effects of agricultural subsidy programs in the developed world.

1.3 Trends

The global trend is toward nutrition through a market economy, as is essential to support the world's increasing degree of urbanization. This is also a normal effect of success in economic growth. Moreover, the long-term global trend is of successful technology development and transfer.

But this success is falling off. Thus, agricultural yields per hectare are still increasing, but at a declining rate.[4] The growth rate in yield for cereals was 2.5% per annum in the 1961-99 period, but only 1.4% in the 1991-2001 period.[5] And the average calorie consumption per person has increased from 2,360 kilocalories per person per day in the 1960s to 2,800 currently. The rate of fall of under nourishment mentioned above is clearly unable to satisfy the Millennium Development Goal of halving the proportion of people who suffer from hunger by 2015. Moreover, in Sub-Sahara Africa, per capita food consumption is not increasing. As the World Bank puts it, "if China is excluded, the number of food insecure *increased* in the rest of the developing world in the 1990s."[6]

2. TECHNOLOGY TRANSFER PROCESSES IN NUTRITION AND AGRICULTURE

Just as there are two economic mechanisms of obtaining food, so there are two economic mechanisms of supporting the development and transfer of agricultural technology, one based on the public sector and one on the private sector.

2.1 Traditional public sector approaches

The traditional mechanism of supporting nutritional research, both in the developed world and in the developing world, was through public sector support for agricultural research, including, in some cases, food-processing research as well as seed and breeding research. At one time, for example, new seed varieties in most developed nations came from national or public university breeding institutions.

For the developing nations, the institutions which have led in breeding new varieties during much of the last third of the last century are those of the Consultative Group on International Agricultural Research (CGIAR), which coordinates a series of research centres throughout the world to meet developing world agricultural research needs. (Even seeds developed for the developed world may still need to be adapted to deal with the different agronomic and photo-period conditions.) These centres are responsible for the enormous success of the Green Revolution during the 1960s and 70s, under which approximately 60 % of the rice and wheat of Asia and Latin America was replaced by high-yielding dwarf varieties able to use fertilizer more effectively.[7] These were varieties developed afresh for the developing world rather than being based on developed-world technology. Beyond any doubt, this investment in agricultural research has been one of the highest-benefit forms of public expenditure ever undertaken.[8]

During this period, the financial role of national agricultural research institutes has grown much more rapidly. These institutions include, for example, Brazil's Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), China's Chinese Academy of Agricultural Sciences, India's Indian Council of Agricultural Research, and Kenya's Kenya Agricultural Research Institute. Although these institutions are typically not as strong in the poorest nations as in the middle-income nations, the developing nation institutions as a whole now have budgets totalling over $ 11 billion, far more than the CGIAR system, whose budget is on the order of $ 300 million.[9] The developing world institutions frequently have scientists trained in the developed world and are in contact with research institutions in the developed world. In some cases they have provided the conduits to bring CGIAR technologies to farmers as well as to bring their own technologies. In the future, they will almost certainly develop their own technologies. But, it should be noted that the research levels for Sub-Sahara African institutions are growing more slowly than those for anywhere else in the world.

2.2 Private sector roles

With the rise of hybrid maize in the United States in the mid-20th century and the development of genetic engineering in the late 20th century, the developed world seed industry has become a source of significant advanced technology, both through traditional breeding and through biotechnology. As of 1995, it provided about a third of all agricultural research investment, globally.[10] It has found significant markets in the developed world and has transferred technology and conducted significant agricultural research specifically for the middle-income developing nations, and for those, such as Brazil and Argentina, that export agricultural commodities to the developed world. But its efforts rarely reach the poorest. This industry also changed in the 1990s from a broadly decentralized seed industry to become a highly centralized one of roughly five major firms.[11]

An additional change has taken place, most rapidly in the last decade of the 20th century, with the spread into the developing world of large supermarket chains, franchising operations, together with large-scale food

processing and vertically-integrated poultry production and dairy operations.[12] This global agro-industrialization is even reaching some low-income and Sub-Saharan nations.[13] There are two related phenomena. First, developing-world consumers are buying much more of their food in supermarkets – the percentage of purchases in such shops in Latin America, for example, has gone from 10-20% in 1990 to 50-60% in 2000.[14] And, second, more and more of the food is sold in processed form or is acquired through direct or vertically integrated arrangements among retailers, processors, and consumers. Again, as an example of the rate of change, UHT (ultra-high-temperature treated) milk has gone from 0% of the Brazilian market in 1988 to 92% of the formal fluid milk market (which is 60% of all milk) in 2000.[15]

These changes derive in part from the rise in the developing world of an urban class able to afford a broader range of food products and interested in the convenience and quality control of supermarkets. Moreover, the last decade has been marked by openness to foreign direct investment in both the retail and the processing sectors, not just by developed nations into developed nations but also by middle income developing nations such as South Africa into lower-income developing nations such as those of Sub-Sahara Africa.[16]

These trends, which, of course provide technology transfer to the nation as a whole, have important positive effects. The emerging system probably provides higher-quality food to the consumer. It also provides technology transfer to farmers, for purchasers in these sectors require their suppliers to use specific varieties and are prepared both to impose quality-control standards and to assist farmers in meeting those standards. And this sector provides the economies of trade, for the agribusiness firms will not necessarily procure products in the same nation in which they market them.

But there are also negatives. Some of the new agro industries may have negative environmental effects, as exemplified by high-density animal feeding.[17] The new technologies, like any new technologies, will displace some producers, in this case farmers who may not be able to afford the agronomic changes needed to meet the new industries' quality control standards or may not be as efficient as suppliers from other areas. Finally, many of these industries are global oligopolies. This market structure is bound to have a major effect on the character of technology used by farmers, as well as on international trade in agricultural products.

2.3. Trends

The trend is for more and more agricultural research, including that for developing nations, to be done in the private sector. Public sector budgets are shrinking under general economic pressure. Private sector budgets increased substantially during the 1990s, based on the promise of agricultural biotechnology, but, for at least some companies, have stopped growing or even shrunk more recently, presumably in response to fears that markets will be affected by concerns about genetically modified plants and animals. The amount of this research focused on developing world needs is still small, although it can be expected that markets such as China and India will receive increasing attention along with markets such as Argentina and Brazil.[18] Thus, the International Seed Federation lists China as a $ 3 billion commercial seed market second only to the United States.[19] And it remains to be seen what kind of research will be done by the vertically integrated and marketing organizations.

3. KEY POLICY ISSUES

The two kinds of production pattern and the two kinds of technology transfer pattern define a two-by-two matrix. The following sections describe the key policy issues arising in each quadrant of the matrix, which is shown here:

Figure 1: Agriculture/Technology Transfer Matrix

		FORM OF TECHNOLOGY TRANSFER	
		PRIVATE	PUBLIC
FORM OF AGRICULTURE	MARKET	Private sector, market agriculture quadrant	Public sector, market agriculture quadrant
	SMALL-HOLDER	Private sector, small-holder quadrant	Public sector, small-holder quadrant

3.1 Private sector & market agriculture quadrant of the matrix

Although there are many other policy issues, those most deserving attention include intellectual property questions, competition issues (in both the seed and food processing and marketing sectors), biosafety questions, and trade issues.

Intellectual property issues

a. In the seed sector

The private sector is the major source of technology for market agriculture, and the agricultural sector is one where proprietary incentives have been extremely significant and effective in the developed world. Historically, the strongest incentives have been those arising from the marketing of hybrid seeds. Such seeds are often especially valuable to farmers by providing higher yields. They also have the commercial benefit to the seed marketer that the seeds of the offspring cannot be used by the farmer because these seeds do not breed true-to-type. The farmer is therefore compelled to return each year to procure new seeds from the private seed marketer. This form of "biological protection" provided the market incentive for the private sector research under which the maize yield in the United States "corn belt" increased by a factor of 5 over the period 1930 to 1990 – the yield growth resulting from genetic improvement has been estimated to be 56 kg/hectare/year.[20]

Traditionally, this form of biological protection worked only with certain crops where hybrids provided a biologically reasonable and effective method of propagation. For crops where such biological protection has not worked, the developed world created the Plant Variety Protection (or Plant Breeders' Rights) systems, now adopted in many nations in accordance with the provisions of the International Union for the Protection of New Varieties of Plants (UPOV in its French acronym). Although the economic evaluations leave room for some doubt, and these laws may well have been effective for ornamental and some horticultural varieties, it is not clear that the laws provide an adequate incentive for encouraging private sector research for field crop

varieties.[21] The investment in private breeding for wheat, for example, where hybrids are not generally used, has not been as great as for maize, where they are available and provide a form of proprietary protection (and regular patents are being used for soybeans).

With the development of sophisticated agricultural biotechnologies during the 1980s, the regular patent system intruded into this area. The key reason was the concern of breeders to obtain stronger protection than available under UPOV-type laws, and particularly to protect their investment in introducing new genes by genetic engineering. Under a UPOV approach, a plant into which a gene had been introduced by genetic engineering could be legitimately used as a breeding parent. By crossing with the transgenic variety, a competing breeder could transfer the new gene to other material and market this new variety in competition with the initial transgenic variety. Thus, the initial breeder would be less willing to invest in identifying new genes, inserting them, and ensuring their biosafety. In contrast, under a regular patent system, patents would be available, depending on the details of the particular national law, on the use of the new gene to transform a plant, on the transformation process, and most significantly on the transformed plant itself. With this last right, in which the patent covers any transgenic variety containing the genetically-engineered gene, the genetic engineering firm can be more confident of obtaining the fruits of its research, because it would be an infringement of the patent to transfer or insert the patented gene into another plant.[22] This stronger form of intellectual property protection has become extremely significant in the developed world, and has contributed to the explosion of private-sector agricultural research during the 1990s.

In a further twist that has become politically controversial, there is the possibility of "GURT" (genetic use restriction technology) or "terminator" technology under which a plant is genetically engineered in such a way that the seeds it produces will be sterile, so that farmers cannot reuse them. This could provide the same kinds of incentives provided by hybridisation and avoid the various restrictions of intellectual property law. The technology has been strongly attacked politically, and whether firms will actually use it is not clear.

For the developing nation, the question is whether any of these forms of protection will be useful in encouraging a national seed industry and in the adaptation of developed-world technologies to developing-nation needs. Certainly, they will be valuable only to the extent that a national industry is feasible – i.e. only in nations in which there is or can be a substantial commercial market for seeds. The chances are, that for a poor nation, neither a UPOV nor a regular patent approach will actually encourage private-sector research. Hence, such a nation is probably best-off adopting minimum compliance with TRIPS, which requires at least some form of *sui generis* protection for plants – although there is the possibility that a number of nations with similar agricultural conditions could combine their markets in some way that encouraged private investment. Moreover, use of UPOV-style laws might help in commercialising varieties developed by the public sector.

For middle-income countries, however, it seems likely that the same incentives that have been effective in the developed world will be effective in the developing world as well. Research is needed in order to adapt the crops optimised for one climate and agronomic region to another. For these middle-income countries that are interested in biotechnology-based improvements, it is almost certainly, then, the regular patent system that is more significant. (As will be noted below, the system should be adapted to developing nation needs.)

b. In other sectors

The intellectual property issues look quite different for a private firm seeking to export to the developed world, e.g. an industry exporting grain or one exporting a speciality tropical crop. Here, it is essential to ensure that the exported product infringes no intellectual property rights in the developed-world market – and it is also possible to use intellectual property rights to protect a market, conceivably through patents or UPOV protection, or, more likely, through trademarks to build up a product identity. Some developing nations, for example, would benefit substantially from the use of geographic indicators to identify their products, and are seeking to change international trade law to protect these indicators on new products.[23]

The intellectual property issues associated with the supermarket revolution are not yet clear. Clearly, these firms are in a position to bring in new technologies and

can be counted on to assure that the technologies are protected and comply with intellectual property rules. In some sectors, such as poultry production where breeding stock is carefully controlled, they will protect their technologies through trade secrecy. And they will be heavy users of trademarks. These entities will probably contribute to improved food quality for the community, e.g. through their quality control efforts and possibly their reduction of waste in the distribution chain. They will certainly force out of the market a number of existing producers and distributors, but this is more likely to be through their economic power as purchasers than through any use of intellectual property rights. Whether the agro-industrial firms will bring intellectual property litigation against one another and against new entrants into the agro-industrial area is not yet clear.

c. Consequent policy issues

- Based on factors such as market size and research capability, a developing nation should decide whether to adopt a UPOV style system in minimal compliance with TRIPS or instead to adopt a stronger biotechnology-oriented patent system.
- Depending on their attitudes toward biotechnology, poor nations should consider ways to make themselves more appealing to private biotechnology research, as through integrating the seed markets of several nations followed by adoption of appropriate intellectual property rights.
- Research is needed on how major a role will be played by intellectual property rights in the global agricultural export sector and in the supermarket revolution and on what might be the reasonable response for the developing world.

Competition issues

Important competition issues are posed both in the global seed industry and in the supermarket/vertically integrated food sector. The seed industry has become concentrated during the biotechnology revolution, and the global biotechnology firms have frequently grown by acquisition of seed companies, even in developing nations. The new food sector firms are often concentrated within the developed world, and have also purchased developing-world firms. And both sectors can force out of business existing developing-nation competitors or suppliers who have inadequate quality standards.

Concentration does not *necessarily* imply high prices, but at very small numbers of firms, it is extremely likely to do so. Moreover, the poorer or smaller the nation, the more likely that only a few of the multinational firms will be marketing in the country, implying higher concentration and potentially higher prices. There is a more complex issue with respect to quality and technology. Almost certainly, an international firm will bring in technology and products of higher quality than those that previously existed in a developing-world economy. At the same time, however, where there is little competition, there is little incentive to do research and develop or bring in new technology.

A developing nation has to face two issues here. One is to protect its people from high prices due to lack of competition. This can be done through price control, although this approach raises problems because of the difficulty of determining prices fairly and because of the risks of corruption. Hence, the alternative approach of ensuring a reasonable degree of competition is generally preferable. This can be done, for example, by making sure that there are several dairy or supermarket chains in the country. The global consolidation of these industries is unlikely to be resolved by global antitrust law, at least at this time. There are discussions of such global antitrust law as part of the Doha Round, but the issues to be considered will almost certainly be initially at the level of blatant price-fixing and cartel agreements.

In some cases, competition may have to be created by providing a competitive public sector alternative. Where only a very small number of private sector competitors are available, and the public sector can provide an alternative, as in the case of seed varieties, doing so can be very effective. The public sector variety creates a competitive price against which the private sector varieties must compete. The private sector may be able to charge more than the public sector price, but only to an extent corresponding to the increased value

of its seed to the farmer. This strategy should be adopted in spite of the argument that the public sector is competing unfairly with the private sector – it is, in fact, the most practical response to the industry's global consolidation.

Not only must developing country competition law deal with the number of competitors; it must also deal with acquisitions of local firms by multinationals. This is an issue that will normally arise most strongly in middle-income nations that have a sophisticated national seed or food sector. Suppose a multinational wishes to buy a major local seed firm. Should this be allowed? The positive factor is that the multinational is likely to provide substantial technology through its local affiliate. The negative is that the degree of competition in the local seed industry may be reduced. These positive and negative factors must be balanced in the individual case, and the nation needs an antitrust entity able to make a reasonable balance. Note that even a joint venture raises some of the problems because in addition to the positive technology transfer provisions, such an agreement is likely to include marketing provisions under which the two parties agree not to compete with one another. Somewhat similar issues will arise as large food firms force local firms or suppliers out of business through competition or the quality demands they place on the suppliers. Again, there must be a balance reflecting the efficiency brought by the large firm as well as the competition that may be brought by the small indigenous firm – and it is important in making this balance to recognize that a certain degree of institutional change is an unavoidable implication of adopting new technologies.

The consequent policy issues are:

- Nations in which there is limited private sector competition in the seed industry should ensure that public sector varieties are available in competition with private sector ones.
- Middle income developing nations should develop appropriate competition-law principles and bureaucratic structures for reviewing multinational acquisitions of local firms.
- These nations should also seek to participate effectively in international competition law negotiations in order to ensure that they are not harmed by global-level declines in competition.

Biosafety issues

One of the most important policy issues confronting developing nations is whether or not to use biotechnology-based agriculture. Some, particularly in Europe, fear that such technologies will be dangerous for either the consumer or the environment. Others view the technologies as ways to meet the needs of an expanding global population while saving the environment.[24] The developing nations are caught in the middle of this controversy; sometimes, as in the case of Zimbabwe in 2003, persuaded that the genetic modification technologies are bad; sometimes using the technologies, as in the case of Argentina; and sometimes concerned that they will lose European export markets if they use the technologies.[25] Thus, they face uncertainty, although that uncertainty might be partially resolved by some form of U.S.-European understanding on labelling of genetically modified foods.

- Developing nations should seek a way in which the biosafety uncertainties of genetically modified agriculture can be resolved, so that these nations can make appropriate decisions to encourage or regulate the private sector's interests in using these technologies.

Trade and macroeconomic issues

There are two types of trade and macroeconomic issues that affect the transfer of nutritional technology into developing nations, those at the national level and those at the international level. At the national level, there are the obvious questions of hospitability to foreign investment, and the question of whether tax and pricing policies favour the acquisition of technologies. For example, it is hard to encourage farmers or their national or international suppliers to adopt new technologies if the prices of agricultural products are forced below a market-clearing level. Nations should also carefully consider the design of tax regimes that affect agriculture, considering whether the particular regime is the most effective way of gaining

necessary government revenue in light of its possible harm to the agricultural sector.

At the international level, the key issue is the impact of the developed world's agricultural subsidy schemes. These schemes impose enormous costs on developing world agriculture, primarily because they make uneconomical the export of competitive crops by developing nation farmers. Moreover, where the developed world imposes tariffs that discriminate against processed goods (as it does with respect to coffee processing), it directly discourages the developing world from obtaining the technology to do the processing. And subsidized exports from developed nations may make otherwise competitive agriculture unprofitable even in the developing nations. At the same, the subsidized exports from the developed world may bring benefits to poor food-importing nations. Thus, the net negative effect of the developed world subsidy programs is greatest for certain exporting developing nations; the programs may, on net, benefit some of the poorest nations.[26]

With the rise of agro-industrialization, an additional trade issue will be posed for many developing nations – the task of satisfying product quality standards for exports to the developed world. There are certainly cases in which these standards are used as forms of protection for local producers, and there are also cases in which legitimate standards are difficult for developing nation exporters to satisfy. This will be an increasingly important international trade issue.

Therefore:

- Developing nations should carefully consider their positions vis-à-vis international negotiations on agricultural trade and agricultural product standards, with the goal of ensuring that their agricultural sectors face competition conditions that encourage the adoption of economically desirable new technologies.

3.2. Public sector & market agriculture quadrant of the matrix

In general, the public sector is not needed where there is an efficient private sector, and there is likely to be an efficient private sector where there are markets, at least in the larger developing nations. Hence, the role for the public sector is limited with respect to market agriculture. However, there are at least two important issues that need to be considered. The first, already discussed above, is the need to maintain availability of a public sector variety where there is limited competition. Clearly this need depends on the actual level of competition – and is significantly less where there are many private firms or where the varieties are being marketed for production for export.

The second is new, and much more complex. This is the choice of research goal and strategy to be emphasized by the international and developing-world public agricultural sector. Naturally, the major focus of this sector has been the needs of the subsistence farmer. It has also, however, contributed significantly to the needs of market farmers and is likely to continue to do so in many nations. Moreover, it in general currently finds itself downstream of the private sector, looking to take technologies being developed by the private sector and to adapt them to developing world needs.[27]

There are grounds for serious question whether this is a suitable long-range strategy, because there are important research needs that are not met by the private sector. The obvious example is the need for basic research on the environmental aspects of agriculture and on developing the technologies necessary to make agriculture more environmentally sound. And, if the projections of water shortage are correct, there will be further demands on agricultural research.[28] Such areas are unlikely to be researched significantly by the private sector, because the pay-off is too far in the future and the needed research is still at a very basis level.

Hence, the public sector should explore ways in which it can get upstream of the private sector and do more basic research on these particular issues (much as the U.S. National Institutes of Health, the U.K. Medical Research Council, and the university researchers they support are upstream of the pharmaceutical industry). This implies a change in the collaboration pattern between the public and private sectors, and may involve the CGIAR, the developing-world public sector research institutions, and possibly developed-world research institutions. The need is to support basic

research that offers only a long-run and uncertain benefit for industry, but is crucial for society, and then to work with the private sector to integrate that research into products whose final research and development and manufacture are carried out by the private sector. (It is, of course, essential that the allocation of research funds to this goal be balanced with allocation to the goal of helping subsistence farmers.)

The consequent new policy issue is:

- Public sector research institutions should work to find ways to carry out and support basic research of value to the developing world society and environment and to cooperate with the private sector in a way that encourages the application of this research as new requirements affect world agriculture.

3.3 Private sector & small-holder agriculture quadrant of the matrix

Almost by definition, the private sector is irrelevant to small-holder agriculture, for small-holder farmers are unlikely to be able to purchase significant inputs. Yet, it is important for such farmers to have access to the best breeding material possible, and at least some will choose private-sector varieties if they can afford them and believe they are better. This may even be part of a transition for the particular farmers from the subsistence to the exchange sectors. Hence, where small-holder farmers choose to buy private-sector materials (with the choice informed by the ability to buy an alternate reasonably-priced public sector variety), they should be encouraged to do so, and national agricultural credit institutions should take this possibility into account (should the farmers sell enough that credit is feasible). In addition to maintaining appropriate credit institutions, national policy can also help here through appropriate seed legislation to ensure that the varieties are marketed with adequate quality control. This is typically a matter of seed law.

Plant breeders' rights systems typically make no allowance for subsistence farmers to exchange seed at the local level. Under Article 15 of the most recent version of UPOV, seed saving can be permitted (by national law), but seed exchange is not permitted. It does seem likely, however, that a *sui generis* intellectual property protection system for seeds could be developed that permitted exchange, and still be consistent with TRIPS. This exchange is important[29] – and it is, of course, true that the market losses to seed companies of exchanges among the poor are unlikely to be so great as to lead to actual legal action. Nevertheless, this is an issue that should be clarified, and it may be appropriate to make responsive changes in UPOV.

But there is also an opportunity in this area – are there not ways that the private sector can provide advanced varieties to the poorest at near the marginal cost of reproducing the seeds, recognizing that there is no economic loss in doing so, since there would be no significant commercial sales anyway? The private sector would still provide the varieties to market sector farmers at higher prices that would allow recovery of its research expenses. Such an allocation is envisioned in the public-private collaborations designed to help make new varieties available to the poorest farmer – the private sector providing its advanced varieties and genes and the public sector providing the necessary skills and investment to adapt the material to subsistence use. In these arrangements, it is typically intended that the benefits of the collaboration be marketed at near cost to subsistence farmers, while the private sector remains free to distribute products deriving from the research to market-economy farmers at prices it chooses. Depending on the circumstances, the markets might be distinguished on the basis of different crops (few firms see a commercial market for cassava; many see one for maize), on the basis of different nations (rich versus poor), or on the basis of relative poverty at the point of sale. This is a model that could certainly help bring significant technological improvement to the poorest in developing nations.

Finally, there may be opportunities for partnerships to help subsistence farmers enter the trading sector – and these opportunities are growing as a result of agro-industrialization. An example is the Hortex program described in the World Bank's Asian rural strategy report under which a large partnership reflecting a variety of institutions is helping a group of Bangladesh farmers export fresh fruits and vegetables to Europe.[30] Public sector subsidies can play an appropriate role in initiating such efforts, demonstrating their feasibility, and providing a portion of the training. But the models will be sustainable only if they provide a return adequate to attract private investment.

The policy issues then are:

- In the developing world, seed law and plant breeders' rights law should be tailored to take into account the needs of small-holder farmers.
- The public and private sector should cooperate to develop public-private licensing arrangements and partnerships designed (a) to bring new technologies to subsistence farmers under terms that permit the subsistence farmers to afford the benefits of the research while permitting the private sector appropriate economic recompense in the market sector, and (b) to help small farmers enter the agro-industrial sector.

3.4. Public sector & small-holder agriculture quadrant of the matrix

For subsistence agriculture, the national and international public sector has been the traditional primary source of technology and technology transfer. As noted above, such research has been found to be among the most cost-effective forms of research ever undertaken publicly. At the same time, this research faces several special concerns in the evolving task of assisting developing-nation subsistence-level farmers.

Defining appropriate research tasks

The obvious one is to define the correct research tasks. What are the priorities that will be most beneficial to the poorest? The Green Revolution that was beneficial in Asia and Latin America was based on a specific concept – the introduction into wheat and rice of a dwarfing gene that enable the crops to use fertilizer more effectively. The breakthrough proved applicable in a variety of growing regions. The international research institutions are finding it very difficult to duplicate that breakthrough. They have, of course, been struggling with ways to focus their research, especially with respect to Africa – but the diversity of local agro-ecosystems has been part of the problem in Africa, where a solution that works in one situation is hard to apply in others, and it is not clear that the approach that was so successful in the rest of the world will also be successful here.

A second group of priority issues is associated with the increased role of private sector breeding and the related move toward genetic engineering. Should the public sector institutions attempt to work independently from the private sector and develop new versions of traditional varieties? When should they attempt to get upstream, for example to understand tropical agriculture better than the private sector and then to offer technology to the private sector in the expectation that products can be marketed to the poor at concessional prices as suggested in the previous section? When should they choose to remain more down-stream and attempt to adapt technology from the private sector in order to apply it in the developing world? And, in the face of the widespread belief that genetic engineering is the way to bring sustainability to developing-world agriculture and the widespread doubts about genetic engineering, how much should the public sector research rely on genetic engineering?

Finally, how should factors other than yield improvement be taken into account? What about long-term environmental effects? What about the interplay between agronomic patterns and family structure? What about farming in marginal areas where agriculture is likely to produce serious environmental damage? Might there be situations in which it is better to encourage farmers to become part of the urban workforce or at least to participate in the market agricultural economy rather than to continue farming in a marginal area?

Thus the important new policy issues are:

- How should public sector agricultural research be refocused to deal effectively with the now highly diverse areas of rural poverty? What should be its relation to the private sector? Should it commit itself to biotechnology?

Intellectual property and access to technology

Whether or not the international public sector cooperates closely with the private sector, it must deal with intellectual property rights. As a result of the private sector's move into agricultural biotechnology, the basic tools for biotechnology-based agriculture are now widely patented. For example, widely used basic promoters to encourage gene expression are patented, as are many specific genes and ways to place genes into plants.[31] In the United States, even traditional varieties are patented in order to prohibit their use as a source of variation for further breeding.

This poses a severe issue for public sector research institutions, which fear that they will infringe the patents. It is clear that these institutions use much patented technology.[32] There may often be no technical infringement, because the technology may be patented only in the developed nations, and the research may be done in developing nations. Patents apply only territorially so the direct impact may be only on research in developed nations and on exports to those nations. This naturally reduces the effects of the patents.[33] Nevertheless, there may still be political pressures on research institutions to avoid conducting such research out of fear that they will offend donors or firms with whom they hope to collaborate.

The general fear about the patenting of "research tools" is that the number of patents on such tools will become so great as to create serious complications in research.[34] Researchers avoid this problem in a number of ways: through use of a research exemption (available in some nations, but recently held generally unavailable in the United States[35]), through doing the research abroad, through simply ignoring the patent, or through negotiating a specific license. The most recent careful study (in the pharmaceutical industry) found no cases of lines of research that were actually terminated as a result of these patents, but did find evidence that research goals were chosen with patent concerns in mind and that the various evasive devices just described were commonly used.[36] Licenses are expensive to negotiate and may not always be available.

There are proposals for various kinds of intellectual property intermediaries to deal with this issue. For example, the Rockefeller Foundation has created a patent intermediary for Sub-Sahara Africa, the African Agricultural Technology Foundation.[37] The planned arrangements reflect the private sector's desire to avoid backflow of seed into its profit-making markets, a concern that can be overcome in Sub-Sahara Africa, but will be hard to overcome in other areas of poverty in the world. The arrangements also reflect industry's desire to obtain protection against liability for unsafe use of genetically modified materials – it wants to make sure the licenses are granted under conditions that ensure responsible use of the materials. And developing nations can also help deal with this issue by designing their patent systems appropriately, with, for example, broad research exemptions. (This will reach some, but by no means all, of the relevant patents – patents on the inserted genes would still be infringed by the final seed, for example.) Moreover, it is clear that this problem is much less serious for the subsistence sector, where the private sector sees little possibility of a commercial market, than it is for the market sector.

The consequent policy issues are:

- How serious is the research-tool-patent problem in agriculture and can it be resolved? Are the various proposed collaborations likely to be successful? How might their likelihood of success be improved?

The contextual and macroeconomic conditions needed for farmers to use the technology

It is abundantly clear that making technology available does not mean that the technology will actually be used. Otherwise the industrial revolution would have occurred much earlier and much more broadly. There must be economic incentives available to use the technology; there may have to be complementary inputs, and there must be a cultural framework within which use of the technology is acceptable. These concerns can be seen in the original adoption of the Green Revolution varieties, where there were significant bureaucratic battles and where the introduction of the new varieties had to be accomplished by a major program for appropriate credit arrangements and by new mechanisms to distribute fertilizer and pesticides. Almost certainly, there were subsidies, at least, in areas such as credit.[38]

In general, although the agricultural research institutions may study and be concerned about these

implementation issues, the issues are not within the control of the research institutions. Rather they are within the control of national ministries, and, at least, indirectly, of the strategies of the International Financial Institutions in their assistance to and policy conditionality for the poorer nations, within which subsistence farmers are especially likely to be found. The issues include subsidy and marketing programs, as for fertilizer, water and the crops themselves, they include land tenure structure, and support for the extension services needed to bring the new technologies to the small farmers and to give those farmers the information they need in deciding whether to use the new materials and in actually making the materials effective.

These issues are recognized in the World Bank's rural development strategy papers.[39] The heart of the strategies described in these papers is to remove bureaucratic barriers and perverse economic incentives that stand in the way of creating new firms and entities and applying new technologies, but the papers, both for Africa and South Asia, also point out that new technologies are essential, recognize the need for significantly greater support of technological development, and also recognize the need for support for better mechanisms of agricultural extension. The tension is reflected in issues such as whether there should be subsidies. As an environmental and macroeconomic matter, subsidies on fertilizer, for example, are generally unwise – yet they may be essential if farmers are actually to adopt advanced varieties.[40] And there may be special difficulties in encouraging use of nutritionally fortified materials, such as those with beta-carotene.

The results of the actual policy balances and agricultural yield improvement programs are reasonable impressive in South Asia, but less so in Africa. The reasons in the African case are not clear: they may be the broader perverse incentives, which are still being removed, they may be the varieties themselves that are offered,[41] or they may be that the research is not focused on solving the correct problems.

This issue is, of course, not new, and the CGIAR system has just been questioned for its shift in research focus away from agricultural production research and towards policy and environmentally oriented research.[42] Obviously, there is need both for technological research and for research on whether this technology will be beneficial to the poor and, if it is, on how to create the conditions that the technology can be spread more effectively. There must be a balance between these forms of research. It is also essential that the economic analysis (generally microeconomic) carried out in the agricultural community and by agriculture ministries be integrated with the policy analysis (generally macroeconomic) carried out in the broader development community and by treasury and development ministries.

The policy issues are significant:

- How much does the adoption of new agricultural technology depend on the broader matrix of rural economic policy? Are there ways those policies, including subsidy policy and support for agricultural extension services, should be modified to contribute to adoption of new technologies? How should the agricultural policy analysis and decision-making and the broader economic-development policy-oriented analysis and decision-making be brought into dialogue with each other?

4. GENERAL IMPLICATIONS FOR DEVELOPING NATIONS

The above analysis leads to an agenda for further research and action. Since many of the analytic and action areas arise in several of the matrix quadrants, this section will be organized by area rather than by quadrant. For each area, the issues will be reviewed, as will the state of international negotiations, and the consequent needs for expertise and research.

4.1 TRIPS and intellectual property issues

Four important intellectual property issues are identified above. The first is the use of UPOV-style or regular patent protection for agriculture. In general, it is unlikely that any system will be beneficial to the poorest nations (nor, save for the costs of staffing the system and the question of subsistence-farmer exchange of seeds, will any system be particularly harmful to them). On the other hand, middle-income nations will want to use advanced systems in order to encourage biotechnology-based research. But this point certainly requires analysis, and it is important for the middle-income nations to develop understanding of how best to design a national patent system to encourage biotechnology-based research at as low an economic cost as possible. The key task in doing so is to provide effective protection for transgenic crops themselves (including the transgenes included in those crops), while leaving as many research tools as possible available for open use.

Second, since public sector research plays an important role in middle-income nations, it is essential to supplement the patent legislation and implementation with arrangements for patenting by the public research establishment (which in turn requires arrangements for the employees of these institutions) and with arrangements for licensing out the public sector inventions to the private sector. Some of the middle-income nations have attempted to copy the U.S. Bayh-Dole model under which government laboratories and government grantees gain control of the intellectual property derived from publicly funded research and then license it for their own benefit. This is especially appealing as a way to provide financial support for research institutions under budgetary pressure. Yet, the actual level of economic return is often small, the risk that the intellectual property rights will become barriers to research by others is substantial, and the risk that the institutions will shift their research agendas away from the needs of the poorest (or impose a cost on the poorest) is also substantial. Hence, although intellectual property arrangements are needed here, they should be designed carefully.[43]

The third issue identified is that of subsistence-farmer exchange of seed. Here, there is still need to determine how substantial the issue is – i.e. how much exchange there actually is and whether the private sector is in fact likely to exercise its rights to control that exchange. (It is, nevertheless, never a good idea to have a law that is regularly ignored in an important category of cases.) For those nations for whom such exchange is an issue, it is wise to define an appropriate exception in the national plant breeders' rights legislation. Such an exception is not permitted by UPOV; it is permitted by TRIPS. Assuming this issue is in fact a serious one in many nations, it would be wise to attempt to negotiate a special exception in UPOV, possibly restricted to developing nations. There is virtue in uniformity of law in this area; it would be good if developing nations could be able to participate in a version of UPOV that made the appropriate exception.

The final issue is that of research-tool patents. Here the responses are difficult. One group of responses is to design the patent system so that as few research tools as possible are patentable. This is done by maintaining a high non-obviousness/inventive step standard and an application-oriented utility/industrial applicability standard. A second is to create a research exemption that will permit use of at least some research tools – there are many possible ways to do this, reflecting different balances between the interests of the research tool developed and the research tool user. Considering that much research of significance to developing nations is carried out in developed nations, these patent principles (which are followed in some nations but not in others) should be followed in both developed and developing nations.

None of these legal accommodations is inconsistent with TRIPS. At this point, nations must protect plant varieties, but they have full flexibility in choosing whether to do so by a UPOV system, a modified UPOV system (which could allow for subsistence-farmer exchange of seed), or a patent system. And the exceptions involved in subsistence-farmer seed exchange and research exemptions are certainly consistent with TRIPS.

It should be noted that there is another important negotiation on Patent Harmonization, ongoing at WIPO. This negotiation is intended to lead to common standards for patentability, which will probably require coverage of plants and will attempt to set common standards for non-obviousness and utility. The current negotiations will not cover the research exemption, although that issue may be negotiated at WIPO in the future. There is political question as to the approach developing nations should take to the Patent Harmonization negotiations – arguably they should allow the developed nations to harmonize as those nations choose and then adopt different systems themselves. But the wiser approach may be to push for an acceptable treaty (which may, of course, lead to deadlock), on the grounds that any developed world treaty will ultimately be imposed on them anyway.[44]

These are areas in which developing nations need stronger policy-making capability. And, in spite of the fact that there has already been much study of these areas, there is definitely need for further study. Of the several areas, the one least thought out and that probably needs the most analysis is that of defining a model patent law and associated licensing legislation that faces the biotechnology and research tool issues for middle-income nations as well as the management of intellectual property derived from public-sector research. The tendency is otherwise for these nations to adopt laws close to those of the developed world, both for patents and for commercialisation of public sector research – and this is not necessarily the right direction for these societies.

4.2 Competition law

Two groups of competition law issues were noted above: those arising from the global oligopolization of the international seed industry and the much less well defined issues arising from global agro-industrialization. The international seed industry is now dominated by a small group of oligopolists. And many of the agro-industrial firms are themselves members of global oligopolies. This poses obvious risks of higher prices to developing nations, especially to those with markets so small that only one or two of the oligopolists are participating in the national economy. But it also poses benefits – these firms are, in many cases, sources of important agricultural and food processing technology. And they would be unable to invest in research were they not able to gain some form of super-competitive profit.

Partly, these oligopolies raise issues at the global level. If two of the remaining global seed firms were to seek to combine, there is little that the developing nations could do about it. The issue is rather one for U.S. and European antitrust authorities, who are more likely to consider competitive impacts in their own markets than to consider such impacts in developing-world markets. There is obvious need here for a global antitrust policy that considers competitive impacts in *all* markets. And there is a deeper legitimate concern for the developing nations here – as multinational industries, such as the seed industry, shrink into oligopolies, and control entrance to the oligopolies through use of strong intellectual property positions, what should developing nations that wish to start their own industries do? If they attempt to compete with the oligopolies in the developed world market, they may be sued for patent infringement (even though the members of the oligopoly are unlikely to sue one another). Hence, are they forced either to sell out to the multinational or to find only niche markets within which to compete? In short, the thinking about global antitrust policy must take into account developing nation competitive and intellectual property concerns along with traditional developed-world competitive concerns.

The competition issue over which developing-nation regulators have the most control is that of deciding whether or not to approve an acquisition or joint venture between a multinational and a local firm, as in the seed industry. The balance is between the technology import benefits of the acquisition/venture and the competition benefits of resisting the merger. This issue

is most important in middle-income countries; and it has a link with the traditional concerns of the 1970s about technology transfer agreements. Never-theless, the issues are generally quite different in today's open trade world than they were in the old import-substitution world of the technology transfer discussions of the 1970s. In general, today's corporate transferors of technology are interested precisely in reaching a global market and will therefore seek to use the most efficient ways to produce for that market. But, in much seed and agro industrial technology, the issue is like that of the older debates, for the relevant market is the local market. Thus, depending on the rate at which competition evolves, the private-sector incen-tives for importing the best appropriate technology may not be as strong as desired. This is one of the factors national regulators must take into account as they review particular acquisitions or joint ventures.

Regulators will also be asked what to do about the people and firms which are marginalized by the entry of global agro industrial firms into the local market? There will be displaced seed producers and displaced dairy farmers etc. As a formal economic matter, efforts to maintain these producers (unless they are strong enough to provide serious competition) are likely to lead to inefficiency, and may well impose much greater costs on the rest of society than are posed by the plight of the displaced.[45] At the same time, there may or may not be alternative opportunity available to these people.

None of these particular competition law issues are a current subject for negotiation in the international system. The competition law discussions in the Doha Agenda are almost certain to reach only the most blatant issues of competition law such as price-fixing cartels. The issues of balancing antitrust and intellectual property are extremely difficult theoretically; it is a long time before they will be reached at the international level, even though the competition issue described above is fundamentally global. And when it is faced, the discussions will be significantly affected by national concerns about technological competitiveness.

The first key need here for developing nations is to be able to develop reasonable positions in the global negotiations on competition law. At this point, the developing nations have not been particularly receptive to these negotiations – and it will be difficult for them to find ways to press these negotiations in ways that help open the global oligopolies to new entrants from the developing world and that ensure as much competition as possible in the developing world markets. But this is one of the areas that might offer great long-term benefit to developing nations – so it is crucial to think out and present reasonable proposals for ensuring openness in the existing world industrial structure.

The second key need is for developing nation regulators to be able to deal effectively with the acquisition questions, i.e. to find appropriate balances between the technological benefits brought by an acquisition and the loss of competition derived from losing the competitor. Based on what is now known about the global rise of agro industries, this will be an issue for many poorer nations as well as for middle-income nations. Yet, few developing nations have competition law entities – and fewer still have entities with adequate economic analysis expertise. This is an area for training, and possibly for international cooperation to help in making appropriate regulatory decisions.

To support this, three kinds of studies are needed. One would look at the global oligopolies and the associated global competition law issues, in order better to understand the competitive position of developing nations. The second would look specifically at agro industrialization in order to identify the key competitive problems for developing nations, both middle-income and poorer. The phenomenon is so new that its implications have not been adequately analysed. And the third would look at ways to achieve effective implementation in developing nations – are there ways, for example, that the economic expertise needed to apply competition law well can be shared among several nations?

4.3 Biosafety and biotechnology

In addition, it is essential to resolve the conflict that now exists over genetic engineering and biotechnology. Many believe that use of genetically modified plants represents the best way to assist the poor and to resolve long-term concerns over the effect of agriculture on the environment. And many strongly fear such genetic modification. The fact of uncertainty leaves international and developing-world agricultural researchers in a dilemma, for investments in biotechnology may be wasted in the absence of confidence. Indeed, as noted above, there is now evidence that some developing-world nations are slowing the introduction of genetic engineering out of fear that they will otherwise be unable to export agricultural products to Europe.

This is an issue that will not be fully resolved for at least a generation. Many of the negotiations have taken place largely within the environmental community, as in the negotiation of the Cartagena Protocol on Biosafety by the parties to the Convention on Biodiversity. This protocol entered into force in September 2003. It covers only a portion of the issues involved, and does not have universal membership. In the trade context, this issue of genetically modified food is likely to be examined by a World Trade Organization panel, which has been established following requests by Argentina, Canada and the U.S. in the course of dispute settlement proceedings against the EC.[46] However, there is a strong possibility that the resulting panel report will deal more with legal procedural issues than with scientific issues – and it will certainly not resolve the basic underlying political differences. And beyond the environmental and trade communities, there have been many efforts to seek consensus among unofficial groups of scientists or of scientists together with a broader community. The most likely interim working resolution will be one based on a labelling system.

There are two needs for developing nations. One is to combine the expertise, analytic capability, and institutional capability to make decisions about genetic engineering on behalf of the nation's own agriculture. This has already been done, for example, in Argentina and Brazil, albeit the decision-making process is under legal attack in the latter nation. It is clear that such decision-making must involve the public. The other need is to participate appropriately in the global biosafety and biosafety/trade debate in order to ensure market access for its products. This may be in large part a matter of ensuring that developed world requirements such as the European labelling regulations can actually be met by developing nation agricultural exporters. But it is likely also to require much broader discussions that deal with both the various environmental and consumer concerns about biotechnology and the potential nutritional and environmental benefits of the technology.

4.4 Trade law

As noted above, the developed world's agricultural subsidy programs impose significant costs on developing world agriculture and create incentive barriers to the adoption of new technologies by developing-world farmers. This leads to inefficiencies that hurt the global and the developing-world consumer, and probably the environment as well.

These subsidy programs are at play in the Doha Round of international trade negotiations. It is clear that the efficiencies and budgetary concerns in the developed world will be the primary focus of attention, along with broader access of developing-world farmers to the developed world markets. The developing-world consumer will probably receive relatively little attention. And, it is not at all clear that there will be significant progress during that round.

The major developing-world agricultural exporters, such as Argentina, are already well informed about the economics and politics of this issue and seeking to play an important role through the Cairns group. The area where further study and expertise would be useful from the nutritional technology transfer perspective is to identify the specific incentive impacts of the developed world subsidy programs for developing world farmers. Might such a specific analysis help in identifying particular proposals that might benefit developing world nutrition and also be acceptable to the developed world? This may be more feasible with respect to food

aid than with respect to other forms of subsidy. Here, there have been principles developed for the management of food aid in ways that are least disruptive to local agricultural incentives, while still attempting to benefit those at risk. These are the FAO Principles of Surplus Disposal and Consultative Obligations of Member Countries, and there are proposals to include strengthened arrangements as part of the Doha Round.

4.5 Public sector activity and research policy

The final area of focus – and one of the most important – is that of public sector activity and research policy. What kinds of research should be undertaken and how should the research institutions link with other institutions? These are important for both the national agricultural research groups and the CGIAR.

Several points about focus on agricultural technology research have been made above, primarily in response to the increased role of the public sector in agricultural research. They include the need to focus on the concerns of subsistence farmers, particularly in the remaining areas of serious poverty in Africa and South Asia, and the need to find new ways of working with the private sector, both for achieving long-term goals such as responding to climate and environmental change and for achieving more short term goals such as bringing the benefits of commercial technologies to subsistence farmers.

These needs will require several important changes. First, the agricultural public sector will have to become more sophisticated on at least some issues – it is in large part not now upstream from the private sector (as is the NIH). Thus some part of the research done by the international and developing world public sector should be at a much more basic level than that now done – certainly including the basic science involved in environmental and biosafety analysis. In many other research areas, such as medicine, the public sector funds research that is too basic to interest industry; in the nutrition sector, it has tended to fund applied research for applications to communities that are too poor to interest industry. Some of both kinds of research will be needed.

Second, the public sector will have to cooperate more closely with the global private sector, for that sector now has much more of the most important technologies. This will require new kinds of partnerships, and the negotiation and conduct of these partnerships to be both fair and effective will be an important issue. This is happening already in the medical sector, with the creation of partnerships addressed to research on specific diseases. These partnerships are, so far, primarily funding promising early research; it is an issue for the future whether they will be able to raise the larger sums and organize the broader cooperation to achieve production and distribution of useful products. It is not at all clear that this pattern should be followed in the agricultural sector – but different patterns should certainly be explored.

Third, there may be a need to coordinate the public research institutions more effectively. At one time, this could be done by the CGIAR system, but, as noted above, that system is now conducting only a rather small portion of the research being done globally for the benefit of developing nation agriculture. More results could probably be achieved if there were significant efforts to coordinate the activities of different national agricultural research establishments.

Finally, there needs to be more consideration of the national-level institutional and economic factors that contribute to the adoption of new agricultural technologies. These may be crucial; they certainly include, but are much more far-reaching than the adequacy of extension systems. They involve a nation's basic economic strategies, including its subsidy strategy, and its choice between efforts to improve the lot of subsistence farming communities while leaving them as such communities or alternatively attempting to find other opportunities in the economy for the members of such communities. How the world moves from subsistence farming to urbanization and market farming will depend on macroeconomic issues as well as on land tenure and farm size, and there will be unavoidable change in the rural economic structure. Understanding and dealing with these areas is essential and will require including the international financial institutions in the discussion along with the traditional agricultural biological and social scientists.

END NOTES

[1] See Figure 2 of Rosegrant, Paisner, Meijer, and Witcover, "2020 Global Food Outlook; Trends, Alternatives, and Choices", International Food Policy Institute (IFPRI), August 2001.

[2] Food and Agricultural Association of the United Nations, "World Agriculture towards 2015/2030" (2003) at page 15. [Hereinafter FAO 2015/2030.]

[3] See Reardon & Berdagué, "The Rapid Rise of Supermarkets in Latin America: Challenges and Opportunities for Development", *Development Policy Review*, 2002, 20(4): 371-388; Reardon & Barrett, "Agroindustrialization, Globalization, and International Development: An Overview of Issues, Patterns, and Determinants", *Agricultural Economics* 23 (2000).

[4] Box 1, Pardey & Beintema, "Slow Magic; Agricultural R&D a Century After Mendel", IFPRI, Oct 26, 2001.

[5] FAO 2015/2030.

[6] World Bank, Operations Evaluation Department, "The CGIAR at 31: An Independent Meta-Evaluation of the Consultative Group on International Agricultural Research, Volume 1: Overview Report", p. 2 (May 9, 2003).

[7] Id.

[8] Alston, Chan-Kang, Marra, Pardey, and Wyatt, "A Meta-Analysis of Rates of Return to Agricultural R&D: Ex Pede Herculem?", IFPRI Research Report 113 (October 2000); Evenson and Gollin, "The Green Revolution at the End of the Twentieth Century", Paper prepared for TAC's Standing Panel on Impact Assessment, TAC Secretariat, Food and Agriculture Organization of the United Nations, SDR/TAC:IAR/01/12 (April 2001), also published as "Assessing the Impact of the Green Revolution, 1960 to 2000", *Science* 300:758 (2 May 2003).

[9] Pardey & Beintema at pp 4 and 8.

[10] Id.

[11] This paper does not explore such other important private sector industries as the agricultural machinery industry and the agricultural chemical industry.

[12] See Reardon & Berdegué and Reardon & Barrett, as well as FAO 2015/2030, Chapter 10. And see also the important symposium volumes: "Agriculture, Globalization, and International Development", *Agricultural Economics*, 23 (2000) (September); "The Rapid Rise of Supermarkets in Latin America", *Development Policy Review*, 2002 20(4) (September); "Agroindustrialization, Globalization, and the Environment", *Environment and Development Economics*, 6 (2001) (October); and "Agroindustrialization and Globalization", *International Food and Agribusiness Management Review*, 3 (3/4) (2001).

[13] Weatherspoon & Reardon, "The Rapid Rise of Supermarkets in Africa: Implications for Agrifood Systems and the Rural Poor", *Development Policy Review*, 21:333 (May 2003).

[14] Reardon & Berdegué.

[15] Reardon & Berdegué.

[16] Weatherspoon & Reardon.

[17] Barrett, Barbier, and Reardon, "Agroindustrialization, globalization, and international development: the environmental implications", *Environmental and Development Economics* 6 (2001): 419-433.

[18] Note that the costs of developing a new seed variety are much lower than those of developing a new medicine – the economics of agricultural research for the developing world are therefore dramatically different from those for pharmaceutical research for the developing world. For a comparison of the two sectors, see Barton, Intellectual Property, Biotechnology, and International Trade: Two Examples, in Cottier and Mavroidis (Editors), "Intellectual Property, Trade, and Sustainable Development", p. 285 (World Trade Forum, Vol. 3) (2003).

[19] International Seed Federation, Seed Statistics, available at http://www.worldseed.org/statistics.html.

[20] Duvick, "Genetic Contribution of Advances in Yield of U.S. Maize", *Maydica* 37: 69 (1991).

[21] The evidence for incentives to breeding research for crop plants is rather limited. See the discussion in UK Intellectual Property Rights Commission, "Integrating Intellectual Property Rights and Development Policy" at pages 60-61 (September 2002); and also the anecdotal data presented in Janis & Kesan, "U.S. Plant Variety Protection: Sound and Fury . . .?", 39 *Houston Law Review* 727 (2002).

[22] In some nations' laws, such plants might not be explicitly patentable, but might still be effectively protected because they would infringe a product patent as the product of a patented process.

[23] See Escudero, "International Protection of Geographic Indications and Developing Countries", TRADE Working Papers No. 10, South Centre (2001). See also Rangnekar, "Geographical Indications. A Review of Proposals at the TRIPS Council: Extending Article 23 to Products other than Wines and Spirits". Study prepared for the UNCTAD-ICTSD Capacity Building Project on IPRs and Sustainable Development, available at *http://www.ictsd.org/iprsonline/unctadictsd/docs/rangnekar_may2003_final.pdf* . For an economic assessment of the protection of geographical indications in European countries, see Rangnekar, "The Socio-Economics of Geographical Indications. A Review of Empirical Evidence from Europe", available at *http://www.ictsd.org/iprsonline/unctadictsd/projectoutputs.htm#casestudies* .

[24] For a review of the debate, reflecting the pro-biotechnology side, but also noting opposing sources, see Falck, Zepeda, Cohen, Meinzen-Dick, and Komen, "Biotechnology and Sustainable Livelihoods–Findings and Recommendations of an International Consultation", ISNAR Briefing Paper 54 (September 2002).

[25] Cohen & Paarlberg, "Explaining Restricted Approval and Availability of GM Crops in Developing Countries", AgBiotechNet, 2002 Vol 4, October.

[26] FAO 2015/2030, Chapter 9.

[27] For general discussions of these interactions, and case examples, see Spielman: Thematic Working Paper, "International Agriculture Research and the Role of the Private Sector", prepared for World Bank Operations Evaluation Department, *The CGIAR at 31: An Independent Meta-Evaluation of the Consultative Group on International Agricultural Research* (2003); Pray, "Public-Private Sector Linkages in Research and Development: Biotechnology and the Seed Industry in Brazil, China and India", *American J. of Agricultural Economics* 83(3): 742 (August 2001).

[28] See Rosegrant, Cai, and Cline, "World Water and Food to 2025: Dealing with Scarcity" (2002).

[29] See the cases described in Lettington, "Small-scale Agriculture and the Nutritional Safeguard under Article 8(1) of the Uruguay Round Agreement on Trade-Related Aspects of Intellectual Property Rights: Case Studies from Kenya and Peru" (International Centre of Insect Physiology and Ecology, Nairobi, Kenya) (publication available at http://www.iprsonline.org/unctadictsd/projectoutputs.htm#casestudies).

[30] World Bank, Rural Development Sector Unit, South Asia Region, "South Asia; Strategy and Action Plan for Rural Development", July 11, 2001.

[31] See, for example, Kryder, Kowalski, and Krattiger, "The Intellectual and Technical Property Components of pro-Vitamin A Rice (Golden Rice™); A Preliminary Freedom-To-Operate Review", ISAA Brief No. 20 (2000).

[32] Salazar, Falconi, Komen, and Cohen, "The use of Proprietary Biotechnology Research Inputs at Selected Latin American NAROs", ISNAR Briefing Paper 44, October 2000.

[33] See Binenbaum, Nottenburg, Pardey, Wright, and Zambran, "South-North Trade, Intellectual Property Jurisdictions, and Freedom to Operated in Agricultural Research in Staple Crops", *Economic Development and Cultural Change* 51(2) (2003) (in press).

[34] See Heller and Eisenberg, "Can Patents Deter Innovation? The Anticommons in Biomedical Research", *Science* 280: 698 (1998).

[35] Madey v. Duke Univerity, 307 F.3d 1351 (CAFC 2002).

[36] Walsh, Arora, and Cohen, "Working Through the Patent Problem", *Science* 299: 1021 (14 February 2003).

[37] See www.aftechfound.org; and also see "Public Sector Collaboration for Agricultural IP Management", *Science* 301: 174 (July 11, 2003).

[38] See, e.g. Kohli and Singh, "The Green Revolution in Punjab, India: The Economics of Technological Change", presented at conference on Agriculture of the Punjab, Southern Asian Institute, Columbia University, April 1, 1995, revised September 1997, and available at *http://econweb.rutgers.edu/vellan/EOI/greenrev.pdf*.

[39] E.g. World Bank, Rural Development Operations, the Africa Region, "From Action to Impact; The Africa Region's Rural Strategy" (July 2002); World Bank, Rural Development Sector Unit, South Asia Region, supra.

[40] In at least one case, it has been said that the removal of subsidies on fertilizer made it harder for farmers to use high-yielding varieties. See World Bank, *Tanzania-Participatory Agricultural Development and Empowerment Project*, Updated Program Information Document, Report No. AB38, May 27, 2003.

[41] Evenson & Gollin, supra suggest that the varieties offered by the international agricultural research establishment may not have been adapted to local environmental conditions. And Lettington, supra, describes situations in which farmers reject improved varieties in preference to traditional varieties.

[42] World Bank, Operations Evaluation Department, supra.

[43] See UK Intellectual Property Rights Commission, supra, Chapter 6.

[44] See Barton, "Issues Posed by a World Patent System", presented at conference on *International Public Goods and Transfer of Technology after the TRIPS Agreement of 1994*, Duke University School of Law, April, 2003.

[45] This type of argument was used in the United States and Europe against the use of Bovine Somatotrophin as a way to enhance dairy productivity.

[46] See WT/DS291/24; WT/DS292/18; WT/DS293/18 of 5 March 2004.

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