INTERNATIONAL TRADE, INTELLECTUAL PROPERTY RIGHTS AND TRADITIONAL KNOWLEDGE
The Case of Plant Genetic Resources

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Grant E. Isaac and William A. Kerr

ABSTRACT

The research, development and commercialization focus of genetically modified (GM) crops is undergoing a shift from production-trait characteristics — such as herbicide tolerance and insect resistance — to output-trait characteristics — such as nutraceuticals/functional foods and plant-made pharmaceuticals. It can be expected that, unlike the former focus, the latter focus will increasingly rely upon traditional knowledge to identify plants with characteristics beneficial to human health. These plants will then be subject to the techniques and procedures of modern biotechnology in order to isolate and extract those characteristics for the development of products (by mostly multinational corporations) that are protected by intellectual property rights (IPRs) and likely to be extensively traded across national boundaries. To proponents, this represents bioprospecting: a critical component of the innovative process of bringing human health benefits to all and not just those fortunate enough to benefit from the traditional knowledge because they live in a particular geographic or cultural zone. Yet, to critics, this represents biopiracy: a disingenuous repackaging of traditional knowledge in order to secure monopoly rents for the biopirate while excluding the original innovator from a claim to these rents. The objective of this paper is to examine the bioprospecting — biopiracy debate in the context of traditional knowledge as an important component in an aboriginal economic development strategy. It is concluded that in order to maximize the economic development

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potential of traditional knowledge, several amendments to the way in which the international trade regime administers intellectual property protection are required.

Key Words: indigenous knowledge, traditional knowledge, intellectual property rights, international trade, TRIPS Agreement, World Trade Organization (WTO), biotechnology, genetically modified crops, bioprospecting, biopiracy

INTRODUCTION

Since 1996, nearly 98% of the total acreage devoted to the commercialization of genetically modified (GM) crops has been composed of crops that exhibit production-traits (James, 1997–2001); that is, crops that exhibit production characteristics of value to the grower in the intensive agricultural system (e.g., herbicide tolerance and insect resistance), while exhibiting end-use characteristics that are substantially equivalent to conventionally produced crops such that they offer no additional value to the consumer (Isaac, 2002; Gaisford et al., 2001).

While dominant at the moment, this dominance of production-trait GM crops is expected to decline as plant developers increasingly focus on output-trait GM crops that exhibit characteristics of value to the end consumer (Isaac, 2002). The targets include nutraceuticals (functional foods and supplements with enhanced nutritional composition) and pharmaceuticals [such as plant-made pharmaceuticals (PMPs) using plant photosynthesis instead of the current methods of chemical synthesis]. The 2001 global market for nutraceuticals has been valued at $140 b with an expected annual growth rate of between 5% and 10% for the next 10 years, driven by an increased demand for "alternative" and "natural" products (Nutrition Business Journal, 2001). The 2001 global market for pharmaceuticals has been valued at $410b with an expected growth rate of between 7% and 8% over the next five years (<http://www.eac.gov.pk/pharmweb/global.htm>).

As product developers set out to identify genetic material with beneficial characteristics — which can then be isolated and extracted from the original plant for use in either nutraceuticals or pharmaceuticals — they will increasingly rely upon traditional knowledge built up over thousands of years to point them in the right direction. At first glance, there appears to be a real economic development opportunity for traditional knowledge holders to link with functional food and drug companies in order to access the large and growing global markets for nutraceuticals and pharmaceuticals.

However, this potential economic development opportunity is limited by the rules of intellectual property rights embodied in the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property (TRIPS Agreement). These rules have been, for the most part, designed to promote knowledge-creation and innovation on a global scale where knowledge and innovation are defined in terms of sophisticated scientific procedures and techniques not traditional knowledge. In practical terms, traditional knowledge is deemed a "global common good" ineligible for intellectual property protection, while contemporary and sophisticated scientific knowledge is deemed an inventive-step eligible for intellectual property protection. As a result, the techniques and procedures of modern biotechnology are applied to traditional knowledge in order to isolate and extract the beneficial characteristics for the development of nutraceutical or pharmaceutical products which are then eligible for intellectual property protection and the monopoly rents that accrue.

To proponents, this represents *bioprospecting*: a critical component of the innovative process of bringing human health benefits to all and not just those fortunate enough to benefit from the traditional knowledge because they live in a particular geographic or cultural zone. Yet, to critics, this represents *biopiracy*: a disingenuous repackaging of traditional knowledge in order to secure monopoly rents for the *biopirate* while excluding the original innovator from a claim to these rents. With these two very different perspectives, it should come as no surprise that the debates around plant genetic resources, intellectual property rights and traditional knowledge have become quite polarized; proponents of *bioprospecting* generally argue that all genetic material should be subject to intellectual property protection while critics of *biopiracy* generally argue that no genetic material should be subject to intellectual property protection.

Acknowledging the polarized *bioprospecting-biopiracy* debate and the seemingly inequitable relationship that exists between contemporary intellectual property rights and traditional knowledge and folklore, Article 19 of the *Ministerial Declaration* from the Doha Ministerial Conference of the World Trade Organization (WTO) calls for a review of this relationship with an objective of ensuring economic development opportunities for holders of traditional knowledge (World Trade Organization, 2001). Moreover, it can be expected that developments in this multilateral regime will significantly influence regional regimes such as the North American Free Trade Agreement (NAFTA) and the Free Trade Area of the Americas (FTAA).

Therefore, the objective of this paper is to examine the *bioprospecting — biopiracy* debate with an aim of clarifying the rules of intellectual property protection in a manner that maximizes the economic development potential of both traditional and contemporary, scientific knowledge. The thesis is that neither polarized position — either categorically for or against intellectual property protection for genetic material — is optimal in terms of an economic development strategy for traditional knowledge. Instead, there exist conditional circumstances for protection which have the advantage of simultaneously enhancing the economic development potential of both traditional *and* contemporary, scientific knowledge. The goal, then, is to ensure that the international trade rules reflect these circumstances.

The structure of this paper is as follows. In the remainder of this section, the issues associated with plant genetic resources, knowledge and intellectual property rights are more clearly specified in the context of traditional knowledge. In the next section, the arguments for and against the protection of plant genetic resources are examined. The final section discusses this analysis and draws some important conclusions on how trade rules may be better structured to appropriately account for traditional knowledge and folklore.

Plant Genetic Resources

Plant genetic resources have been chosen as an illustrative example of the complicated relationship between intellectual property rights and traditional knowledge because they embody a panoply of concerns about the scientific modification of nature (and the human, animal and biodiversity impacts of such modifications) and about the control over natural resources (for both food and pharmaceutical use) by multinational corporations (Low, 2001; Shiva, 1999; van Wijk et al., 1993). That is, examining the relationship between intellectual property rights and traditional knowledge with respect to plant genetic resources provides a broad-based assessment of these sensitive and complicated debates.

The role of plants in the food supply and for medicinal purposes should not be underestimated. Of course, any benefits that they provide come from their genetic resources. Land races of plants refer to the staple crops such as wheat, rice and maize, modified over thousands of years through the inter-generational accumulation of traditional knowledge (and which now may have been modified over perhaps a hundred years through the use of scientific knowledge) in order to express quantity and quality characteristics valuable for human use. Much has also been learned about the medicinal properties of naturally occurring plants. Yet, despite the accumulated knowledge, it has been estimated that less than 0.1% of all plants have been assessed for their beneficial properties for either food or medicinal purposes. Given the enhanced ability to identify and isolate economically useful genetic material that underlies biotechnology, the result is an aggressive search for these plants and the new benefits they may yield — either *bioprospecting* or *biopiracy*, depending upon one's perspective.

Traditionally, plants — and, consequently, their genetic material — have been considered as "global common goods" provided by nature for the benefit of all such that ownership could not be assigned to any individual or group, implying that no one could secure intellectual property rights over the plants. This designation has facilitated their international movement, which has taken place since the dawn of commerce (Kerr and Yampoin, 2000; Gollin, 1998). Increasingly, however, the definition of plants as global common goods has been blurred in order to promote innovation in plant development. That is, naturally occurring plants themselves are still considered global common goods, but identifying the genetic sequences coding for the particular proteins that provide the desired benefit is considered to be an intellectual endeavour eligible for intellectual property protection. Understanding this distinction requires specification of knowledge and of intellectual property rights, which are examined below.

Knowledge

At the heart of the conflict between intellectual property rights and traditional knowledge are differing definitions of what constitutes knowledge eligible for protection. To capture the range of these differing definitions, three categories might be considered: knowledge source, knowledge type and knowledge provider/innovator. It is important to note that there are crucial linkages between these categories.

The source of the knowledge can be either traditional knowledge or western scientific procedures and techniques. In the case of plant genetic resources, traditional knowledge would refer to the accumulated learning — often across many generations — that has enabled certain peoples to know, for instance, that a particular plant, harvested under particular conditions and processed in a particular way provides a remedy for a particular ailment. Due to the accumulated inter-generational nature of the learning process, ownership of the knowledge and the benefits that it brings are not given to any one individual but instead are shared as "common goods". Scientific knowledge — which emerges from the foundation of the accumulated, inter-generational traditional knowledge — nevertheless differs from traditional knowledge in a key respect. Scientific knowledge tends to explore beyond the serendipity of the traditional knowledge to understand both *why* and *how* a particular plant provides a remedy for a particular ailment. Sophisticated techniques and procedures of modern genetic sciences play an increasingly important role in this investigation.

The distinction between traditional and scientific knowledge, gives rise to the second important category — knowledge type. Here, two types may be distinguished: discoveries and inventions. The former are outcomes of nature that do not require a human intervention while the latter are those outcomes that are not possible without a human intervention. For example, it can be argued that the traditional knowledge of the benefits of a particular plant is a discovery because there was no real human intervention required to extract the benefit from the plant; the benefit was always there and the human intervention only maximized the beneficial characteristic. Yet, the scientific knowledge of how and why the plant provides the benefit that it does is not possible without a human intervention in the form of highly sophisticated scientific procedures and techniques. Moreover, extracting the beneficial aspects and incorporating them into a product certainly requires human intervention. Hence, under these definitions traditional knowledge is considered a discovery while a product emerging from scientific knowledge is an invention.

In the third category, the aim is to identify the knowledge provider or the innovator. In the example above, the primary/original innovator is the indigenous peoples who accumulated the knowledge inter-generationally. Certainly, it is undeniable that some innovation has occurred in the form of identifying the plant, and the conditions under which the plant has beneficial properties for particular ailments. Assigning "ownership" to the primary/original innovator is, however, very difficult. Of course, this problem disappears if the traditional knowledge is considered to be common property. On the other hand, the secondary innovator — extending and refining the traditional knowledge through the use of sophisticated scientific techniques and procedures in order to develop a product — is much easier to identify. Moreover, if the use of modern science is considered to be a human intervention, then the secondary innovator is the one actually providing an invention — beyond simply being a discovery.

Intellectual Property Rights: A General Introduction

In general, intellectual property rights (IPRs) are legal instruments that simultaneously promote innovation and the public dissemination of knowledge. To promote innovation, they extend to the innovator monopoly protection in the marketplace for the use of their intellectual property. In return for the monopoly protection, the innovator must fully disclose the scientific knowledge to the public in order promote knowledge dissemination. The rationale for IPRs lies in an economic argument of market failure (Machlup, 1958; Nordhaus, 1969; Gallini, 1992; Cornelli and Schankerman, 1999).

According to the economics literature, the market failure that the granting of rights to intellectual property is targeted at removing is free riding by non-inventors (imitators) who can garner the benefits of the science-based innovation without incurring the costs associated with innovating. Imitators are able to capitalize on the public good characteristics of knowledge (i.e., that once created it is impossible — or very costly — to exclude others from its use in the private market and that its "consumption" by one user does not preclude its consumption by another) and produce goods that compete in the market place with those of the innovator. As imitators have lower costs (they have not incurred the research and development costs) than innovators they are able to price their goods below the price that the innovator requires to recoup his full costs. The result is that the prospective innovator has no potential profitable opportunity if they commit resources to research and development activities. The outcome is underinvestment in the development of new knowledge.

This market failure justifies a public policy response. The problem for governments is how to reward innovation. In theory, an innovator should only require a normal rate of return on their investment in research and development. This could be done by providing subsidies but the innovation process is neither linear nor deterministic (i.e., that expending funds will yield an innovation of sufficient value to justify the expenditure required for its development). Research and development expenditures often fail to produce an innovation. Hence, to provide sufficient inducement for firms to engage in research and development activities subsidies would have to cover a firm's failures as well as innovative successes. This, however, would require governments to assess the prudence of research and development expenditures of firms. Given the non-linear, non-deterministic nature of the innovative process this is an impossible task and governments have, instead put in place a second best policy option — the granting of intellectual property rights. Granting intellectual property rights creates a government-sanctioned temporary monopoly on the innovation or its products. Monopolies, however, impose a social cost due to the market distortion they allow (i.e., they allow the holder of the monopoly to produce less quantity and to charge a higher price than is the case in a competitive market). Thus, governments have purposefully accepted the introduction of monopoly distortion to overcome the market failure that leads to underinvestment in innovative activities (Gaisford et al., 2001). Governments recognize the public good nature of new knowledge by limiting the life of the government sanctioned monopoly. Patent lengths are crude attempts at providing a balance between the two distortions.

As there is no relationship between the costs of research and development and the monopoly benefits firms receive, innovative firms bear the risks associated with invention. The monopoly benefits of some successful innovations will, however, be very large, in part because they may have to offset the costs associated with failed investments in research and development. Firms that engage in ongoing research and development must expect that monopoly rewards will be large on some innovations, otherwise they would not commit funds to research and development given the positive probability that some will fail. Of course, the high returns (and high prices charged) for the winning invention are, when viewed in isolation, very contentious and bring forth questions of equity.

Controversy: Bioprospecting v. Biopiracy

Under international trade rules, intellectual property rights for plant genetic resources have typically been given for western science inventions by a secondary innovator rather than for traditional discoveries by the primary/original innovator. This has given rise to *bioprospecting* whereby scientists can extract plant genetic resources from the primary innovators/traditional users because land races and natural plants are considered global common goods and subsequently extend and refine the traditional knowledge using modern science and claim an invention which is eligible for intellectual property protection. Moreover, supporters of these rules argue that all genetic material to which the inventive step of scientific knowledge has been added should be eligible for protection.

Yet, critics of the current relationship between intellectual property rights and plant genetic resources argue that this is simply *biopiracy* where the role of human intervention in discovering that a particular plant, harvested at a particular time and processed in a particular manner has desirable characteristics is discounted as an innovation and simply labelled as a discovery. It is argued that the role of modern science is elevated such that identifying a gene sequence using procedures and techniques of modern biotechnology is patentable because of the human intervention required to identify the sequence despite the fact that, in the most pragmatic sense, identifying this sequence is not an invention; it is only a discovery of a genetic resource that has always existed albeit at a more micro-level than before. The result is the argument that IPRs should not be allowed for plant genetic resources at all — regardless of whether the source of the knowledge is traditional or scientific.

TRADE, IPRS AND PLANT GENETIC RESOURCES

Given the discussion above it is now possible to disentangle the complicated arguments for and against the use of intellectual property rights over plant genetic resources, which are summarized in Table 1 — Matrix of Arguments. The arguments may be read vertically down the five columns and are specified with respect to the rationale of the argument and an assessment of the benefits and costs of the various positions.

In a general sense, the arguments for and against IPRs for plant genetic resources represent a clash between market efficiency and social equity-based arguments. The former, founded in economic arguments, posit that innovative activities that create knowledge face important classic market failures that hinder allocative efficiency. IPRs target innovative activities (where the priority is typically given by governments) and are structured to overcome market failures and inject greater allocative efficiency into the market system. In fact, while the classic market failure arguments previously discussed are present, the issue of plant innovation gives rise to two more market failure arguments: geographic and cultural excludability. The former is the failure that occurs when a plant with beneficial characteristics for all human health is only made available within a geographic proximity that shares the traditional knowledge. The failure is, of course, that global human health cannot benefit. Similarly, the latter market failure occurs when the benefits accrue only to those who share a cultural proximity, while the global human health is excluded. Therefore, to correct these excludability failures and increase allocative market efficiency, IPRs are granted for plant genetic resources, predicated on the notion that without an assurance of protection, firms will have no incentive to innovate to create market-oriented products that overcome the classic (i.e., free-rider problem) and the specific (i.e., geographic and cultural excludability) market failures.

The market efficiency-based arguments are generally seen to be in contrast to the social equity-based arguments, which tend to view IPRs as being predatory instruments of scientifically advanced countries that, in fact, create exclusions themselves. Namely, they exclude traditional knowledge, the primary innovator and the role of discovery from the monopoly economic rents. In the extreme, these arguments reject the granting of intellectual property rights on plant genetic resources at all. These arguments will be examined first.

Arguments Against

In the left hand column is an assessment of the argument for disallowing any intellectual property rights for plant genetic resources. The rationale for this argument is that identifying the beneficial properties of a plant — either at the holistic, traditional knowledge level or at the more precise genetic level of scientific knowledge — remains only a *discovery* of a global common good, not an *invention* worthy of intellectual property. That is, neither the primary innovator nor the secondary innovator should be granted monopoly rights over the exclusive commercial marketing of the benefits. Further, from this perspective, it is argued that IPRs create an economic distortion in the form of a "western" scientific hurdle to innovation that cannot be overcome by many traditional innovators.

The benefit of this position is an equity-based benefit, that plant genetic resources remain global common goods for all and cannot be exclusively controlled. Without an ability to secure monopoly rights, it is argued that predatory, rent-seeking behaviour by those with the capacity to overcome the scientific hurdle will be prevented.

The costs of this position tend to lie with efficiency-based arguments. Disallowing the possibility of securing intellectual property rights over plant genetic resources stems innovation by not overcoming the classic market failures nor the specific market failures of geographical and cultural excludability. It is argued that the primary innovator often does not have the capacity to transform the beneficial plant to a commercial product available on a global scale. Yet, without the assurance of protection over their intellectual investment in this transformation, secondary innovators would be reluctant to dedicate the resources required. The cost is the failure to bring to market products that may have considerable social benefit even accounting for the costs of the monopoly distortion.

TABLE 1
Matrix of Arguments

NO (IPRs Disallowed)	*YES (IPRs Allowed)*			
	Conditional			*Unconditional*
	Land Races	*Natural Organisms*		
		With Known Beneficial Properties	*With Unknown Beneficial Properties*	
Rationale PGRs are *discoveries* of "common good", not true *inventions* IPRs create an economic distortion in the form of a "western" science hurdle to innovation that cannot be achieved by many indigenous innovators	**Rationale** Quantity and/or quality improvements to established food crops beyond the "common good" variety developed by the "primary/original innovator" Improvement linked to a western scientific intervention	**Rationale** Extending indigenous knowledge of beneficial attributes through a western scientific intervention Typically, a "primary/original innovator" can be identified	**Rationale** True BioProspecting: discovering new organisms with potential benefits: •Immediate benefits •Derivative: requiring an inventive step either indigenous or western science No "primary/original innovator"	**Rationale** IPRs to all innovators where innovation connotes both: •Discovery •Invention Innovation may be either •Indigenous knowledge •Western science
Benefits Equity-based: Prevents predatory "rent-seeking" by those with scientific capacity for innovation	**Benefits** Efficiency-based: Promotes innovative improvements to food crops already part of the agricultural system, correcting both: •Classic market failures •Specific market failures	**Benefits** Efficiency-based: Promotes innovation beyond what the primary/original innovator is willing to do or capable of by correcting both: •Classic market failures •Specific market failures	**Benefits** Efficiency and Equity-based: Promoting the discovery of new beneficial processes and products by overcoming •Classic market failures •Specific market failures	**Benefits** Efficiency and Equity-based: Promoting the discovery of new beneficial processes and products by overcoming •Classic market failures •Specific market failures
Costs Efficiency-based: Fails to address both: •Classic market failures •Specific market failures	**Costs** Equity-based: Scientific hurdle excludes "primary/original innovator"	**Costs** Equity-based: BioPiracy arguments Secondary innovators securing IPRs due to some western scientific step	**Costs**	**Costs** Equity-based: rejects Global Commons Goods arguments Efficiency-based: "primary/original innovator" may lack capacity to innovate to the next level

Arguments For

While the arguments against allowing intellectual property rights over plant genetic resources tend to be very straightforward, the arguments for are much more complicated (the remaining four columns from the right in Table 1). Indeed, there are two broad categories — conditional protection and unconditional protection — where the former is itself sub-divided into three categories.

Prior to discussing the differences, it should be noted that the arguments for all share a focus on efficiency-based benefits through correcting both the classic market failures of innovation and the specific market failures of plant innovation. Here the notion is that intellectual property rights over plant genetic resources promote the maximum innovation of plants, beyond what the primary innovator is willing or capable of doing.

The conditional arguments for allowing intellectual property rights over plant genetic resources are all predicated on the notion that while the promotion of innovation is the ultimate goal, only some types of knowledge qualify for protection. Consider first the second column from the left entitled land races. As previously mentioned, land races refer to plants already modified for use in the agricultural system where innovations to these plants target improvements to quantity and/or quality characteristics beyond the modifications of the primary innovator. Indeed, with most varieties of staple agricultural crops it is extremely difficult to identify a sole primary innovator. Therefore, some type of hurdle must be established to identify innovations that are worthy of protection as well as the innovators responsible for the innovation. The hurdle that has emerged is one of scientific definition, where an innovative improvement to a crop must be from a sophisticated scientific technique or procedure. That is, the *condition* upon which intellectual property protection is granted to plant genetic resources is that the innovation be scientific in nature. The rationale is that the use of advanced science results in crop innovations more like inventions that are eligible for protection. The benefit according to this conditional argument is that it promotes innovative improvements to food crops already part of the agricultural system and that the protection corrects both the classic and the specific market failures of cultural and geographic excludability. Unsurprisingly, the cost of this argument is that it essentially excludes the primary innovator from intellectual property protection if a satisfactory level of science is required to shift the innovation from a discovery to an invention. The primary innovator will also be subject to the prices associated with the monopoly distortion along with all other consumers. Of course, the primary innovator would only chose to purchase and employ the products of the scientific innovation if they were sufficiently superior to existing land races to offset the cost.

Conditional arguments for allowing intellectual property rights over plant genetic resources also involve not already modified land races, but what might be called natural organisms (or wild varieties and closely related weeds): plant varieties with either known or unknown beneficial properties that have not been systematically modified for human use. Consider first natural organisms with known beneficial properties. This argument is very similar to the previous conditional argument on the protection of land races. The rationale is that intellectual property rights are necessary to promote innovation extending the traditional knowledge of the beneficial attributes to others who may not have access to the traditional knowledge due to cultural or geographical constraints. To qualify, protection is conditional upon the secondary innovator demonstrating an inventive-step beyond the primary discovery. Again, the inventive-step is best demonstrated through the use of modern scientific techniques and procedures. Benefits — like those in the land race argument — are that intellectual property protection promotes innovation extending the access to the beneficial properties of the natural organisms beyond what the primary innovator is capable or willing to do. With respect to costs, this conditional argument for intellectual property protection differs from the examination of land races because, typically, the primary innovator can be identified, or at least the primary innovators may be identified. This raises the spectre of biopiracy whereby representatives of scientifically advanced secondary innovators use the traditional knowledge of primary innovators to identify natural organisms with beneficial properties, extract the plants as global common goods, apply modern scientific techniques to identify why and how the plants work to alleviate ailments, patent this scientific knowledge and thus have monopoly rights over the commercial use of this knowledge. Yet, those in favour respond that as long as the secondary innovator does not use the legal instruments of

IPRs to prevent the primary innovator from using the traditional knowledge in the traditional way, then there is no harm to allowing protection extending the benefits on a global scale.

Now consider natural organisms with unknown beneficial properties. This is the classic case of bioprospecting and is motivated by the estimate that less than 0.1% of all plants have been assessed for the beneficial potential. The rationale is that in order to encourage innovators to discover plants with immediate benefits and to invent the subsequent large-scale derivative products, assurances that intellectual property investments will be protected are required. In this sense, allowing intellectual property protection is conditional upon the novelty of the discovery and invention. The benefits of this argument are that IPRs promote frontier exploration for new products and processes and prevent classic and specific market failures. Furthermore, there seems to be very little cost to this argument. Given that the exploration is for plants with yet unknown beneficial properties, there is no predation of the traditional knowledge of the primary innovator by a secondary innovator who has the capacity to overcome a scientific hurdle and secure monopoly rights over the commercial use of the knowledge.

Finally, consider the argument for allowing *unconditional* intellectual property rights over plant genetic resources, summarized in the right hand column in Table 1. This argument differs from the conditional arguments because there is no distinction made between what type of knowledge qualifies for protection. Essentially, all *discoveries* and *inventions* whether of traditional knowledge or scientific knowledge are eligible for intellectual property protection. The rationale is that unconditional intellectual property protection over plant genetic resources does not discriminate between traditional and scientific knowledge, treating both equally and providing the opportunity for the primary innovator to profit from the traditional knowledge if desired. Essentially, it allows all innovators to protect their knowledge and does not establish any arbitrary or exclusionary hurdles to legitimate protection. Similar to the other arguments for allowing intellectual property rights over plant genetic resources, the efficiency-based benefit of this argument is that it promotes innovation by correcting the classic market failures and it overcomes the specific market failures of cultural and geographic excludability. There is also an equity-based benefit with this arguments and that is the eligibility of traditional knowledge discoveries under IPR protection. Yet, there are three crucial costs to allowing the unconditional protection of plant genetic resources. The first cost is that this, of course, differs significantly from the spirit and intent of the contemporary intellectual property rules and would require significant restructuring to many national and international regimes. The second cost is that this argument rejects the notion of global common goods and instead accepts that ownership can be assigned to everything — discovery or invention. The third cost is that simply granting ownership to the primary innovator does not imply that further innovation will occur. Indeed, the primary innovator may simply lack the capacity to develop a global scale product, yet a secondary innovator may not be interested in investing in this transformation when the intellectual property resides elsewhere. Alternatively, the secondary innovator may pay the primary innovator for the use of his intellectual property, raising the cost of secondary innovation and, hence, reducing the incentive for innovation (Kerr and Yampoin, 2000). Given that intellectual property rights are artificial constructs of government put in place solely to induce innovation, granting IPRs to discovery appears counterproductive.

DISCUSSION AND IMPLICATIONS

The arguments for and against allowing intellectual property rights over plant genetic resources are very complicated and diverse. Often the issue is dealt with as a highly polarized debate, yet, as Table 1 reveals there are several important variations of the arguments for allowing protection.

The variation that tends to be favoured by international trade rules is found in Table 1 under conditional arguments for allowing protection. That is, international trade rules tend to impose a hurdle of protection eligibility that supports scientific knowledge as creating inventions and discounts traditional knowledge by suggesting that this knowledge is essentially in the discovery category. From the examination of the benefits and costs it is clear that the conditional arguments for allowing protection reflect a clash between efficiency-based arguments of promoting innovation and correcting market failures and equity-based arguments of allowing monopoly protection to true innovators even if they are not consistent with the scientific knowledge definition.

Of course, this raises some important questions about what can be done to more appropriately deal with traditional knowledge within the international trading system. The benefit that arises from granting intellectual property rights is innovations. The reward for innovating is the opportunity to collect, for a time, the monopoly rents available from devising a successful innovation. There should be no grant of intellectual property rights without the promise of additional innovations. In particular, the granting of intellectual property rights to discoveries can only act to reduce innovations. Granting intellectual property rights to discoveries will not induce additional discoveries and adds to the cost of innovation. Thus, the international trading system should act, in the first instance, to ensure that there is the widest possible access to the products of innovation through low trade barriers and strong competition policy disciplines on private restraint of trade in those industries that produce and distribute innovations derived from genetic material. In other words, strong efforts should be made to ensure that firms are not able to use the monopoly granted as a reward for innovation to generate additional opportunities for monopoly rents through practices such as tied sales, input bundling, failure to disclose crucial information to patent authorities, etc.

There also needs to be a clear distinction in international patent law between those scientific innovations that enhance the process of discovery and those that use the information derived from discovery to innovate. Given that the information that arises from discovery has strong public good characteristics — they are *non-rivalrous* because the use of a gene with identified commercial potential in one innovation does not restrict its use in another and exclusion is not possible due to the ease of reverse engineering (Kerr and Yampoin, 2000). The development of gene isolation technology should have been publicly funded and made freely available. This would have increased the rate of innovation. In the absence of the foresight to publicly fund this research, property rights have been extended to the technologies that facilitate discovery and/or the discoveries arising from these processes. The United States, the European Union and Japan all have legislation granting IPRs to gene isolating technology and the genetic material discovered. Given the potential size of the distortion relative to the costs of isolating genetic material, granting IPRs in this area may not have been wise.

One suspects that if no property rights were granted to gene isolation processes and/or the genetic material subsequently discovered, firms interested in innovating using discovered genes with commercial potential would have sufficient incentive to directly search for those genes so that they could reap the benefits from owning intellectual property rights in final products. Their techniques and discoveries would not receive IPR protection. This would preserve the public good aspect of discovery by allowing others access to the technology/discovered genetic material. If the costs of developing genetic isolation technologies are large, one would expect the private sector open access gene isolation technologies to be developed by private sector consortiums so that the cost of development could be shared. If governments think that the private sector is providing too little genetic isolation technology and/or genetic discoveries, then they could encourage this activity through offering prizes. Prizes would both remove the distortions associated with granting intellectual property rights and reduce the incentive to keep discovery enhancing innovations secret. For similar reasons, prizes could be used to induce those who have traditional knowledge regarding the value of natural organisms to share that knowledge. Encouraging the sharing of traditional knowledge through prizes would thus provide a solution to the problem of biopiracy.

If the international conventions on intellectual property continue to extend IPRs to technologies that enhance discovery or the discoveries themselves, then they should also extend IPRs to traditional knowledge. It does not matter whether a discovery has arisen as a result of experience-based traditional methods or through the use of modern scientific methods. The innovation inhibiting distortion is the same in each case and to endow one with intellectual property rights while excluding the other cannot be justified on grounds of equity. If societies with a high degree of scientific capability are willing to "live with" the distortions associated with extending IPRs to scientifically enhanced discoveries then they should not be able to deny societies with little scientific capacity but large amounts of traditional knowledge to extend IPRs to that knowledge. Clearly both inhibit innovation and are counter productive to the original intent of the artificial creation of rights in intellectual property by governments. Both should be public goods but if IPRs can be extended to one method of discovery, it would not be equitable to exclude the other.

Countries with a high degree of scientific capacity and enforceable IPR systems should also ensure that their domestic patent laws do not allow the granting of intellectual property rights to what are traditional discoveries that have been acquired through biopiracy. There have been a number of high profile case in the United States and Japan (e.g., Mexican beans, bitter gourd Plao-noi (Kerr and Yampoin, 2000)) where the patent office has granted a patent to an unaltered landrace or natural plant. The problem appears to lie within patent offices which either have too few resources to deal effectively with question relating to living organisms or the technical capacity to make an informed judgement regarding them. As a result, the courts are left to sort out disputes. Of course, using the court system is not costless. As those who have discovered traditional knowledge are either no longer identifiable or tend to have limited resources, recourse to the courts is inequitable. If societies that have a high degree of scientific capacity want cooperation from developing countries in protecting their intellectual property through the TRIPS, then they need to ensure that their own IPR systems provide good models.

The real equity question, however, relates to scientific capacity. The major (but by no means the only) reason why the protection of intellectual property rights is contentious is that the capacity to use science for the development of innovations is not distributed evenly among societies. Traditional societies typically have little scientific capacity and, hence, have no opportunity to participate in the rents that arise from innovation. Hence, the solution to inequity lies in increasing the scientific capacity of members of societies. Raising scientific capacity is a complex and resource intensive activity and how it can be accomplished is not transparent. However, until the capacity of traditional societies to undertake scientific innovation is increased considerably, they will not be able to share equally in the benefits associated with the "knowledge economy". No amount of tinkering with property rights can remove this fundamental cause of inequity.

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