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Intellectual Property Rights for Traditional Knowledge – Economic Analysis of an Incentive System

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Abstract

The current interest in Traditional Knowledge in the context of Intellectual Property Rights is largely on account of its importance as a valuable resource base to future innovations and growth in emerging sectors such as biotechnology and genetic engineering. The Convention on Biological Diversity (CBD), 1992 mandates that countries develop national systems to regulate access to and ensure sustainable use of biological resources and associated traditional knowledge, particularly in the context of their commercial utilization. In order to implement this, the CBD further provides for the recognition and reward of indigenous and local communities for their role in conservation and use of biological resources through equitable sharing of benefits arising out of the commercial utilization of their knowledge, innovations and practices. Intellectual property rights (IPR) systems are a means to define the rights of the holders of traditional knowledge and to transfer a share in the benefits from commercial innovations developed from their existing knowledge. Over the last decade, the debate on IPR protection for traditional knowledge has been mired in several political, legal and ethical issues, but there has surprisingly been, very little economic research in the area, especially, given that conflicts in intellectual property can be resolved using guidelines from economic theories of incentives for innovation. In this paper, such a framework is drawn up using the theory of cumulative innovation so as to obtain guidelines for designing IPR systems for encouraging innovations based on traditional knowledge and establishing mechanisms for equitable sharing of benefits arising thereon.

Keywords: Traditional Knowledge, Intellectual Property Rights, Cumulative Innovation.

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All errors are, of course, my own.

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I. The Background

In today's knowledge-based economy, the debate surrounding intellectual property rights (IPR) has taken on new dimensions. The products of the core sectors of the knowledge-based economy, such as digitally distributed products, biotechnological processes and genetic sequences are widening the scope of what constitutes intellectual property and are also raising a specific set of issues in the design of IPR systems to cater to the requirements of intellectual property protection of these 'knowledge goods.' Digital technologies are expensive to produce but are easily copied at low costs. Biotechnology and genetic engineering have directed focus on ownership of biological and genetic resources, as they constitute the sources of raw material for these sectors. Thus, the delineation of rights over these resources and the rules governing their access and use assume tremendous significance. Innovations for protection under IPR systems cover a wide range that now includes, plant varieties, genetic sequences, life forms, digital codification of facts and software programs.

As the debate revolves around the design of IPR systems for these new technologies, there is yet another knowledge-based sector that has received a lot of attention over the last decade relating to requirements for intellectual property protection. While, the technology is definitely not a new-age technology, new uses of the existing technology have brought it increasingly under the focus of IPR systems. However with the advent of biotechnology and pharmacogenomics, traditional or indigenous knowledge associated with the biological resources has become the essential stock for future innovations and growth in these sectors. Even prior to this, there was considerable interest[1] in traditional knowledge (TK). TK is not merely a relic from the past. The Commission on Intellectual Property Rights states in its report (2002) that TK has played and still plays a vital role in the daily lives of a vast majority of people. According to the World Bank[2], TK is an underutilized resource in the development process and its dissemination can help to reduce poverty. The WHO estimates that in developing countries close to 80% of the population depend upon traditional medicine for their health needs. The Government of India set up under the Ministry of Health& Family Welfare, a Department exclusively for the promotion of Indian Systems of Medicine and Homeopathy. In 1982, the World Intellectual Property Organization (WIPO) along with the UNESCO adopted the Model Provisions for National Laws on the Protection of Expressions of Folklore Against Illicit Exploitation and Other Prejudicial Actions. The FAO introduced the concept of Farmers' Rights including protection of their TK and a right to a share in the benefits from commercial utilization of genetic resources into the revised International Undertaking on Plant Genetic Resources in 1989. It is estimated that around 75 per cent of the genetic resources in the world are to be found in countries where most indigenous people live[3].

Several agencies, national and international have been undertaking efforts for the promotion of TK in different sectors. However, it was the Convention on Biological Diversity (CBD), 1992 Agreement that provided a common international platform for countries to address the issues of recognition and protection of TK and a framework for to develop legislation for regulating access to and use of biological resources and associated TK. Recently, the World Trade Organization (WTO) in its last Ministerial Conference at Doha in 2001, mandated[4] that as part of the agenda of the Trade Related Intellectual Property Rights (TRIPS) Agreement, in the course of the review of Article 27.3 (b)[5], the relationship between the TRIPS Agreement and the Convention on Biological Diversity (CBD) and protection of traditional knowledge (TK) & folklore is examined.

Thus, it has been with the growth of biotechnology and pharmacogenomics, and the search for new plant-based resources by companies that has led to the focus on systems for regulating access to biological resources and TK and promoting their use in a sustainable manner. Intellectual property rights (IPR) have been granted for uses of plants, which form part of traditional knowledge systems in agricultural, health and environmental fields. Traditional designs, songs and dances have been used by the entertainment and fashion industries to create works, which are protected by intellectual property. Discussions about uses of genetic resources, traditional knowledge and folklore have linked the protection of intellectual property to policy objectives as diverse as food security and agriculture development, biotechnology innovation and regulation, the promotion of free trade, biodiversity and environmental conservation, cultural diversity, etc. (WIPO 2001)

As with the knowledge intensive sectors, IPR is an incentive mechanism that can be used to protect rights over intellectual property in TK. Further, IPR systems can be designed in a manner so that incentives are directed towards achieving the CBD objectives of conservation and sustainable use. The objectives contained in Article 8j, provide the case for protection and sustainable use of biological resources and local knowledge associated with it. It provides that subject to their national legislation, member States:

"…respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity"…and that States "…promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices."

Article 15 further provides *"…Recognizing the sovereign rights of States over their natural resources, the authority to determine access to genetic resources rests with the national governments and is subject to national legislation."*

The objective of IPR protection for traditional knowledge is twofold – (a) To reward the holders of the knowledge for their efforts in conservation and continuation of the TK and practices and (b) to promote further innovations based on TK by ensuring equitable sharing of benefits based on such commercial exploitation.

The recent increase in attention on IPR for protection of TK can also be attributed to the numerous cases of incorrect grant of patents over TK in the public domain. Patent laws require innovators to establish novelty of their innovations to qualify for a patent. However, there have been instances, where patents have been granted for TK already in the public domain or where, knowledge of the communities was used without any provision for sharing of benefits from commercialization (e.g.: cases of patents granted over wound healing properties of turmeric, fungicidal properties of neem, appetite suppressing element of Hoodia Cactus etc.). An issue of growing concern this prompted several countries to initiate measures, such as documentation of biodiversity and TK and developing legislation for protection of rights over TK. Another related objective of IPR is thus, (c) the prevention of misappropriation of traditional knowledge.

The WIPO established an Intergovernmental Committee on Intellectual Property Rights and Genetic Resources, Traditional Knowledge and Folklore in the year 2000. From the point of view of intellectual property, these three themes are taken up together, as they share the same characteristics of a common heritage, of innovations that are constantly evolving, that are beyond individual creativity and cover both spheres of formal and informal innovations. The issue is essentially that of protection of collective rights using IPR systems. These issues relating to intellectual property protection are in fact not peculiar to TK alone, but to any class of information goods that are collectively held. An interesting parallel can be drawn in the case of protection of software products also. IPRs are exclusive rights awarded to innovators for encouraging investment in the production of commercially useful knowledge. However, the rapid development of information technology in the last decade can be largely attributed to the cumulative and collective process of production and sharing of scientific / technological knowledge.

Only recently have economic theories of IPR incorporated the dynamic models of innovation – i.e. IPR protection in the context of cumulative and rivalrous nature of innovation. Recent research on cumulative innovations, for instance, focuses on design of IPR systems in providing incentives for basic research that may be of no commercial value but facilitates important innovations in the future. This is precisely the issue in the case of IPR protection for TK – commercial utilization of TK involves innovations developed using leads from the existing stock of knowledge. Further, the rights over TK are held in common and the knowledge is transferred and preserved through a process of cumulation and interaction. In developing IPR systems for TK in the context of commercial utilization of the knowledge, IPR systems developed must focus on rewarding collective efforts in preservation of the knowledge and their contribution in promoting cumulative innovations based on the existing stock of knowledge.

II. Intellectual Property Protection in Knowledge Goods

There are specific issues that arise protection of intellectual property in knowledge goods, given their peculiar characteristics. In an age, where information technologies and knowledge-based services are rapidly evolving and spreading their impact in the working of a number of sectors, the design of IPR systems must also change to cater to specific requirements of these knowledge goods.

In this section, the characteristics of knowledge goods and the issues relating to intellectual property protection of these gods are briefly described. Subsequently, a parallel to these characteristics and issues in the context of TK is also established. David (1993) describes the peculiar characteristics of knowledge when classified as a commodity and how it differs from other commodities for the purposes of intellectual property protection.

Once a piece of knowledge / information has been obtained, there is no value to obtaining it a second or a third time. The information once obtained can be used repeatedly but the stock of knowledge does not get depleted with use.

Knowledge can be possessed and enjoyed by several persons at a time. It is what is known as a non-rival good.

There are private and social costs to creating and transmitting, filtering, interpreting and utilizing information. For instance, in order to use technological knowledge contained in patents, scientific papers etc. access to the information alone is not sufficient to implement the technology; complementary know-how is also required.

What really sets knowledge apart from any other public good is that the complete attributes of the information good are not known beforehand. There is asymmetry in distribution of information about costs and benefits of innovations among the agents involved. Administrators and researchers do not have identical information about the potential social value of the inventions and the expected costs.

Innovation is often cumulative and interactive in nature. Each advance builds on an earlier innovation or existing sock of knowledge. Knowledge evolves and acquires new utility through cumulation and interaction.

Traditional Knowledge as a Commodity – A Parallel Situation

It is immediately apparent that the characteristics of knowledge listed above apply just as well to 'traditional' knowledge also. This brings up the question: 'what is traditional knowledge?' Different policy goals entail delineating the scope of the term differently. There is a wide range of terms related to TK in use today, in various national and international fora. Yet, there is no single definite and exhaustive definition for TK and nor does this seem desirable. In the context of intellectual property definitions for TK, the approach is to define the subject matter in more general terms and leave the distinct interpretation and application to the governments at the national level (WIPO, 2002 (a)).

The CBD uses the term '*traditional knowledge, innovations and practices'*: "Traditional knowledge[6] … is a term used to describe a body of knowledge built by a group of people through generations living in close contact with nature. It includes a system of classification, a set of empirical observations about the local environment, and a system of self-management that governs resource use."

A WTO proposal for intellectual property (IP) protection in this context describes Traditional knowledge as consisting "largely of innovations, creations and cultural expressions generated or preserved by its present possessors, who may be defined and identified as individuals or whole communities, natural or legal persons, who are holders of rights."

There is no single clear definition of traditional knowledge. However, for the purposes of analysis of intellectual property protection, all the characteristics of knowledge goods listed out earlier can be analyzed in the context of TK.

Once a piece of traditional knowledge / practice is made available outside the community or group that holds it, there is no additional value generated to obtaining it a second or a third time.

The stock does not deplete with increasing use or spread of the knowledge. TK has been preserved and handed over from one generation to another through oral transfer and use. TK is seldom documented and in fact, in the absence of such inter-generational transfer and continuation of the knowledge and practices results in the loss of some of the knowledge.

An important characteristic that is clearly borne out is the collective nature of the rights over TK. It is relevant here, to understand the relation between the knowledge and the community from within which it originates. Often, there is a resistance to the concept of ‘ownership’ of the intellectual property of TK. This is in the sense of ‘private’ or ‘individual’ ownership. But there does exist the concept of collective or community ownership. In fact, what sets TK apart are the cultural dimensions and the social context. The knowledge is defined by the identity and the tradition of the community that preserves, develops and transfers it. The senses of responsibility for protection and custodianship may be seen in a positive and a negative sense. A positive sense of responsibility on the part of the community or collective group directs them to preserve TK and to use it in certain defined, appropriate ways; A negative sense implies that where there is misuse or misappropriation of TK, it constitutes offense or harm to the community or a set of collective values.

There are costs incurred by communities and holders of TK in preserving and transferring the knowledge from one generation to another. The CBD provisions in Article 8j essentially provide for the recognition and reward for this contribution of the local communities in preserving the knowledge and practices associated with biological resources. The World Bank describes Indigenous knowledge (IK) as local knowledge and that, which is tacit and therefore, difficult to codify. It is embedded in community practices, institutions, relationships and rituals. There is a need to understand, validate and use the TK associated with resources. Correspondingly, there are costs attached to filtering, transferring, using and validating the knowledge and whether this knowledge lends itself to such public disclosure and further use depends on the costs and benefits associated with each action. Not all TK is in the public domain, also, not all of it is produced collectively and nor is it always inter-generational. The use and application of TK requires complementary know-how and an understanding of the interaction of TK systems with the social context and cultural dimensions.

However, even before incurring costs to validate, protect and promote the use of TK, there is the basic problem of asymmetry of information even about the value of TK itself. Therefore, in developing policies for TK, incentives may have to be provided even for the initial identification of valuable traditional knowledge and practices. As with the biological resources, TK is also characterized by use, option and intrinsic values. Apart from use of TK as leads in biotechnology and pharmaceutical prospecting, it is valuable in a number of other fields. The potential for use of TK associated with natural dyes as substitutes for harmful chemical dyes in textiles and leather products is as yet not fully explored. Also, the need for IPR protection does not arise in all cases. Therefore, it is important to determine what kinds of incentives are required for TK in each sector and accordingly design system for implementing the incentives. There exists asymmetry of information between the holders and potential users of TK about the social and commercial value of innovations based on TK and the costs and benefits involved in undertaking the required R&D.

An essential characteristic of TK is that it is cumulative in nature. It can be described as cumulative in two senses. TK handed down from one generation to the next has involved improvements and additions to the stock. On the other hand, further commercial utilization of TK are also essentially cumulative innovations as they constitute improvements or applications based on the existing stock of knowledge.

"Local and indigenous knowledge systems are not static. They evolve, adapt and transform dynamically with time. New materials are incorporated, new processes are developed, and sometimes new uses or purposes are evolved for existing knowledge besides the acquisition of knowledge…(t)he contemporary knowledge could build upon traditional knowledge but may also be developed autonomously."[7]

It should be noted here, that the above characteristics do not define the characteristics of TK so much as describing the nature of the methods of its preservation, transfer and use[8]. In conclusion, it is not necessarily the content in itself of knowledge that makes it 'traditional,' but rather the context, method and qualities of the intellectual processes that create the knowledge, including the community and cultural context.[9] "In the context of knowledge, innovation is a feature of indigenous and local communities whereby tradition acts as a filter through which innovation occurs. Practices should therefore be seen as the manifestations of knowledge and innovation."[10]

For the purpose of designing incentives for TK, it may neither be essential nor desirable to establish a definition for TK. There cannot be a single all-inclusive definition for TK. In fact, it is preferable to allow the system to possess sufficient flexibility so that incentives can be directed for specific ends as the requirements of TK relating to different sectors vary.

III. Institutional Arrangements for Protection of Knowledge Goods

The institutional arrangements discussed in relation to allocation and production of knowledge and information goods are similar to solutions to the problem of allocation of public goods. In the case of public goods there are three kinds of solutions - subsidies, governmental production and regulated monopoly. Similarly, in relation to knowledge commodities, there are three kinds of institutional arrangements, often classified as prizes, research contracts (including government procurement) and intellectual property rights. Each of these systems has particular advantages and shortcomings as incentives for R&D and specific conditions under which one may be chosen.

Several international and national agencies have proposed and undertaken different kinds of institutional arrangements for intellectual property protection of TK. IPR legislation and rewards are experimented and implemented by different governments. Apart from IPR laws, contractual agreements for benefit sharing as envisaged by the CBD, *sui generis* systems, resource rights, licenses and documentation are some of the instruments that are used in relation to protection and use of TK and practices. The objectives, costs imposed and suitability to the local context determine the choice of a specific approach used. There are several instances from different countries where one or a combination of the above systems have been adopted and implemented. In the following sections, the issues in and experiences from different countries that have adopted these systems are briefly described through specific examples.

i. Intellectual Property Rights

IPR systems for TK are developed by adapting existing IPR laws for prevention of misappropriation of TK and/or by developing new legislation for recognition and registration of rights and establishing a reward system for sharing of benefits with the holders of TK. Under the TRIPS Agreement, IPRs are classified under seven major types: patents, copyrights, industrial designs, geographical indications, layout-designs of integrated circuits and undisclosed information or trade secrets. Patents and trade secrets protect the original invention; copyrights protect the original mode of expression, trademarks, industrial designs and geographical indications (GI) are commercial rights that protect a name, word, symbol, mark or design. Layout designs are also used to protect original designs and integrated computer circuits.

Adapting existing IPR systems involves amending legal provisions either by providing a wider interpretation of the subject matter for protection to cover TK products and processes or by introducing new provisions specifically for protection of TK. For example, trademarks and industrial designs are used to protect traditional names and designs. Countries like China and Vietnam have been taking efforts at amending their patent laws for protection of pharmaceutical products based on TK. Recently, at the 5^{th} WTO Ministerial Conference at Doha, it was mandated that Geographical Indications protection be extended to products other than wines and spirits. This, of course can be interpreted to include TK products also, where such protection can be particularly suited to protect TK products and processes. The following examples illustrate experiences of some of the countries that have adapted their existing IPR systems to provide for protection of TK.

In Australia and Canada, indigenous arts and crafts, such as products with indigenous symbols, images, paintings, etc are identified and promoted by their existing national system of trademarks. A wider interpretation of the trademarks laws to include indigenous arts and crafts helps to prevent unauthorized reproduction of traditional art and imagery on items such as T-shirts. In a case, Bulun Bulun v Nejlam Investments and Others (1989), the unauthorized reproduction of the paintings of the artist Bulun Bulun on T-shirts was contested. The court granted interlocutory injunctions and the dispute was settled for the sum of $150,000.

In Canada, Aboriginal artists, composers and writers of tradition-based creations use the Copyright Act widely for protection of their works and products. Trademarks are also widely used for identification of Aboriginal artwork and products.

Decision 486 of the Commission of the Andean Community rules that signs… "when they consist names of indigenous, Afro-American and local communities, denominations, words, letters, characters or signs used to distinguish their products, services, or the way in which they are processed, or constitute the expression of their culture or practice"… may not be registered except when the application is filed by the community itself or with their express consent. As evidenced by a case in Colombia, this helps to preserve and maintain TK and cultural practices of the communities. In Colombia, a case for the application for registration of the expression Tairona, as a mark was rejected as the name coincides with the name of an indigenous community that inhabited Colombia, and the relics of which, still exist. Thus the title that distinguished them was protected as part of the heritage of the country.

France uses Geographical Indications and Appellations of Origin to protect some of its traditional knowledge as protecting the use of a particular name is also associated with the know-how specific to the place of origin of the product. Under the French law, "the name of a country, region or locality serving to designate a product originating therein the quality or characteristics of which are due to the geographical environment, including both natural and human factors" constitute an appellation of origin. Traditional local production methods associated with the product are included under the human factors.

Under the TRIPS Agreement, until recently, protection under geographical indications was available only for wines and spirits. At the 4th Ministerial Conference at Doha in 2001, it was decided to establish a multi-lateral system for registration of geographical indications and also extend the protection for products other than wines and spirits. Geographical Indications protection can be very useful in identifying, preserving and promoting traditional products and crafts that are specific to a region or a country.

In India, the potential for the application of Geographical Indications (GI) protection for TK products and techniques came to be discussed as a result of the "Basmati" rice case during 1997-98. Subsequently, the Government of India also passed the Geographical Indications Act in 1999. 'Basmati' refers to slender, long grain variety of aromatic rice originating from India and Pakistan. In 1997, a U.S. rice breeding firm, Rice Tech Inc. applied for registration of the trademark, 'Texmati' in U.K. claiming that the term 'Basmati' was generic. This was successfully opposed and U.K. established a code of practice for marketing rice, in which it has been established that authentic Basmati rice is obtained only from northern regions of India and Pakistan. However, in a contrasting case in the U.S. in 1998, on the same subject, the U.S. Federal Trade Commission and the Department of Agriculture established that 'basmati' is indeed generic. Consequently, the efforts that had been undertaken by several organizations to prevent U.S. grown rice from being labeled as basmati were rejected[11]. The implications of the absence of any kind of protection for the name 'basmati' are borne out clearly. The debate was followed up with interest as it has huge implications for the export markets of Basmati for both India and Pakistan. It is interesting to note that while Basmati can be protected under GI, neither country can exclusively own the rights as, it is generic to northern regions of both countries. There is a need for wider interpretation of the provisions, so that it is may be extended to regions and not just a single place within a country. However, both trademarks and geographical indications are rights that may be held collectively and the length of protection may be extended indefinitely. These make it particularly suitable for protection of TK. Though the GI Act has been passed in India, in four years, the Rules to the Act are yet to be framed, thereby rendering the legislation without much effect.

The use of trade secrets is another possible method of protection of knowledge that is not in the public domain. It is specifically used for protecting inventions that are not patentable, too expensive to patent or are just more valuable if kept secret[12]. This may be particularly useful in the context of some traditional medicinal practices or art works. Indonesia, Norway and the United States are some countries that have emphasized the relevance of Trade Secrets laws in the context of protection of TK[13].

A related point in this context is the preparation of databases and registers of TK, usually pertaining to biodiversity by several countries. These represent a record of rights for TK. Primarily are being developed in response to instances of incorrect grant of patents over TK. These databases may be used as non-patent literature databases to establish 'prior art' in the process of examination of the patent applications by the patent offices. The issues relating to these databases will be discussed in detail in a later section of this paper.

ii. Sui generis systems[14]

Apart from modifying existing IPR laws, TK can also be protected under specific *sui generis* legislation. In implementing CBD provisions (Article 15) and the TRIPS provisions (Article 27.3 (b)), several countries such as Brazil, Philippines, Costa Rica, Peru and India are developing *sui generis* systems for protection of biodiversity and associated traditional knowledge. Though existing IPR systems are being adapted, there are problems in implementing the provisions in the context of protection of TK. Also, establishing these systems involves considerable resources. *Sui generis* systems, as they can be tailored to meet the specific requirements, provide an alternative mechanism that can be developed to provide for specific requirements TK and biological and genetic resources.

Philippines enacted the Indigenous Peoples Rights Act, 1997 that guarantees indigenous communities rights over access to ancestral lands, biological and genetic resources and associated traditional knowledge. Further, there are specific provisions for prior informed consent and equitable sharing of benefits on use of these resources and knowledge by any other parties outside of the community.

The Costa Rican Biodiversity legislation establishes provisions for community rights in traditional knowledge and also for a mechanism for registration and protection of TK associated with biodiversity.

Following another approach, Guatemala amended its Cultural Heritage Protection National Law, which provides for protection of TK from a cultural heritage approach. TK and expressions such as music, performances, symbols etc. are protected by the State as expressions of national culture and heritage. It is therefore recorded and preserved by the State for the future benefit of the society.

Debates ensue with regard to respecting and incorporating customary law in developing systems for protection of TK. The Conference of Parties to the CBD, in its Sixth meeting in 2002 makes a specific mention (Decision VI/24 C 3(b)) for further consideration of the role of customary laws and practices relating to the protection of genetic resources, traditional knowledge, innovations and practices and their relationship with Intellectual Property Rights[15]. Australian Courts have exhibited instances where, customary laws have been considered in awarding equitable relief to indigenous communities in cases of copyright infringement[16].

In *Bulun Bulun & Milpurrurru v R & T Textiles Pty Ltd (1998) 41 IPR 513* the Court found that an Indigenous person had a fiduciary duty to his community. It was based on evidence of the customary law of the Ganalbingu people that the judge established that Mr. Bulun Bulun owed two fiduciary obligations to his community and also further declared circumstances under which, equitable relief may be granted in favour of the tribal community in cases of copyright infringement in a work embodying ritual knowledge. It was declared that the artist, Mr. Bulun Bulun had an obligation not to exploit the painting in a manner contrary to his community's customary law and further that in case of third party infringement, he was to take reasonable and appropriate action to restrain and remedy infringement of the copyright in the painting.

iii. Benefit Sharing Contracts

Pharmaceutical companies have often used benefit sharing arrangements for biological prospecting in developing new drugs. Even before the CBD, pharmaceutical prospecting was touted as an incentive mechanism for conservation of medicinal plants. Widespread ethno botanical research and high returns from trade in plant-based medicinal drugs led pharmaceutical companies to invest in bioprospecting in expectation of high revenues from drugs developed thereon. The debate on whether pharmaceutical prospecting generates sufficient revenues for conservation of medicinal plants has gone a full circle starting from the 'Magic Well' picture that changed drastically as studies[17] showed 'vanishingly small' values derived from prospecting of medicinal plants. Currently, the debate is again at a more optimistic lead, as studies indicate that traditional knowledge led searches for active compounds in medicinal plants (as opposed to random searches) lead to result in higher 'hit rates' and lower search costs in drug discovery[18]. With the rapid development of biotechnology and bioinformatics, interest in bioprospecting and traditional medicine is high. As Mathur (2003) explains, with forty percent of the pharmaceutical patents due to expire by 2006 and with the advent of biotechnology and pharmacogenomics, biotech firms are trying to discover and develop new active ingredients from traditional medicine. The choice of an appropriate method for estimating the value of medicinal plants and the lack of empirical evidence are problems, which are as yet unresolved. There is another significant factor that has not received much attention in the literature on valuation of medicinal plants. Most valuation studies calculate the value of medicinal plants by focusing on the contribution of TK as useful leads in reducing search costs of pharmaceutical prospecting. An important factor that is often overlooked is the growing market worldwide for traditional medicine and medicinal practices itself. The global market for traditional therapies stands at US $60 billion a year and is steadily growing. New models, based on the value of medicinal discoveries for alternative markets, will be particularly useful for developing policies and legislation governing access to and use of medicinal resources for traditional or complementary and alternative medicine.

The CBD suggests that benefit sharing arrangements are another mechanism that can be used to implement provisions of prior informed consent and equitable sharing of benefits from use of biological resources. However, evidence from experiences of the benefit sharing models experimented with so far show that they have not been successful in fulfilling the CBD objectives. The reasons for the same are analysed below.

Over the last decade, several pharmaceutical companies involved in pharmaceutical prospecting also developed models for benefit sharing from drug development with the indigenous communities. Some of the well-known cases are the Costa Rican INBio-Merck & Co. case; the Shaman Pharmaceuticals model; benefit sharing arrangements developed by Government sponsored programs like the International Cooperative Biodiversity Groups (ICBG) program of the U.S. Government and research institutes like the Tropical Botanical Gardens Research Institute (TBGRI), India. Except for the case of TBGRI, commercial drugs are yet to be completely developed from any of the other initiatives, though several leads have been obtained. In fact, the extremely high costs, and the risk and time involved in clinical trials and R&D in drug development resulted in the bankruptcy and closure of Shaman Pharmaceuticals. In the one successful case of the early nineties, the Kani-

TBGRI case in Kerala, India, there were several problems after the drug 'Jeevani' was developed. There were problems in terms of access to the plant resource, market establishment, in balancing competing claims of representation for benefit sharing and calculation of shares in distributing the benefits from royalties and license fees. Some of these issues are yet to be resolved.

A common result that these cases show is that using leads from TK reduce search costs related to identifying potential samples. However, there are also very high transaction costs in obtaining consent and collection of samples from indigenous peoples and in further clinical trials for R&D. Though the government-sponsored programs are in a better position in terms of availability of funds, they face other problems regarding valuation of the monetary benefits after drug development and in identifying and compensating the beneficiaries. One of the most important issues in the implementation of the benefit sharing models is the identification of the beneficiaries. This is a problem faced while awarding IPR rights also. There is seldom a single beneficiary. As the rights over the resources and knowledge are held collectively, questions revolve around how the communities are defined (for instance, geographically, ethnically or politically etc.) for the purpose of sharing the benefits.

iv. Prizes and Awards

Another system of incentives used for promoting local and traditional knowledge based innovations is through identifying and awarding prizes for outstanding innovations. SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions), an organization based in Ahemadabad has been involved in scouting, documenting, registering and exchanging thousands of grassroots innovations. A local innovations database established through the Honey Bee network, SRISTI's popular knowledge-pooling network collects information on contemporary innovations and outstanding examples of the use of traditional and local knowledge in the sustainable management of natural resources. These innovations are shared with local communities and individuals in over 75 countries through the Honey Bee newsletter, which is issued in seven different languages. In 2000, the National Innovation Foundation (NIF) was set up, with funding from the Department of Science & Technology, Government of India. NIF[19] documents innovations from all over the country, by organizing countrywide competitions. NIF further declares awards for outstanding local grassroots innovations in the competitions conducted every year, under different categories. They are currently involved in developing a system to ensure that prior informed consent of the innovator is obtained before sharing the innovation and are further exploring the possibilities of using petty patents for the IPR protection of the local innovations.

Each of these incentive systems has specific advantages and shortcomings. According to the suitability to and requirement of the situation in different countries, one or usually, a combination of the above systems is used for protection and promotion of TK. However, there is very little economic analysis on the choice of the incentive systems and their effectiveness in relation to the objectives of the CBD. This paper attempts to review the IPR system as an incentive mechanism for protection and promotion of use of TK in the context of commercialization of the knowledge. The objective of this paper is to draw up a framework for analyzing the design of IPR systems for TK. In the following sections such a framework is developed using relevant economic theories of IPR.

IV. Economics of Intellectual Property Rights

The principal economic theory underlying analysis of intellectual property is grounded in utilitarianism – intellectual property rights have historically been justified as incentives ‘to Promote the Progress of Science and Useful Arts’ through the creation of exclusive rights of limited duration so as to balance the social welfare loss due to monopoly exploitation (Menell 1999). North (1973, 1981) attributes the rapid pace of technological development and innovations during the Industrial Revolution to the existence of a systematic protection of rights over intellectual property. However, there were also opposing views (Plant, 1934) regarding the usefulness if IPR as it was argued that innovative activity is largely spontaneous and there was no need for IPR to stimulate such activity. This issue was resolved in the seminal analysis of the markets for information. Arrow (1962) describes that any information, for e.g. on a new method of production, available free of charge ensures optimal utilization of the information, but provides no incentive for investment in research. IPR, through the creation of property rights, thus basically serve as incentives to direct *investment* into innovative activity, rather than innovation per se. Patents provide a means of bringing the private rate of return closer to the social rate of return, thereby encouraging investment in innovation and its spread.

Economic analysis of patents primarily focuses on the tradeoff between the benefits accruing from increased innovation against the deadweight loss imposed due to granting temporary exclusive rights to innovators over their innovations. Nordhaus (1969) formally analyses this trade-off by providing a framework for designing the optimal IPR policy. In the classic Nordhaus model, only one policy instrument was considered in the design of the optimal policy - the duration of the patent. He argues that the patent life can be adjusted to provide optimal duration of protection such that it balances the incentives provided for innovation against the deadweight loss due to monopoly exploitation. However, there are several problems with this. In the first place, only if the patent life can reflect the R&D costs and benefits, is it possible to choose the efficient research firm and grant a patent long enough to cover the costs. If so, the optimal patent duration would be the shortest one that gives the inventor enough incentive to invest. Secondly, there is usually, asymmetry of information about the costs and benefits of R&D. The patent authority does not have the same information about the costs and potential benefits of an invention, as does the researcher or an innovating firm. Thirdly, there is an ex ante uncertainty about costs and benefits. Making patent length depend on R&D costs would lead innovators to overstate their costs, while a system that rewards only successful innovations would reduce the incentives for investment in research. This problem could again be addressed under the patent system if the patent life could reflect R&D costs and benefits or alternatively, the authorities use some mechanism by which, agents reveal private information about their strategies and costs.

Subsequent studies have focused on another policy instrument; the patent breadth or the scope of the protection as a variable affecting per-period profit of the patent. Broadening a patent will result in higher per-period profit. Then the patent life can be made shorter so that the loss due to monopoly exploitation is reduced, without discouraging R&D. So, what is patent breadth? Gilbert and Shapiro (1990) take the flow rate of profit available to the inventor (determined by the patentee's ability to raise the price of the patented product) as a proxy for patent breadth, while Klemperer (1990) in an alternative approach defines it as the product space covered by a patent. This difference in interpreting patent breath correspondingly produces different results in designing the patent policy. Gilbert and Shapiro, in their model, argue for narrow patents of infinite duration, because broad patents, as per their definition are more costly in terms of deadweight loss. In Klemperer's model, the source of deadweight loss arises due to substitution to alternative products. Increasing the breadth in this case would mean that non-infringing substitutes are made less attractive to the customers and thus, the patent life could be shortened without discouraging R&D.

With the analysis of patent breadth as an alternative instrument to address the Nordhaus trade-off, theories of IPR started incorporating the dynamic aspects of innovation, not considered earlier in the models. Inventive activity is rarely undertaken in isolation. There are usually, several inventors or research firms working simultaneously, often towards the same patent, but with different research strategies and expectations of the costs and benefits involved. Under such dynamic models of innovation, Green and Scotchmer (1995) interpret patent breadth as the minimum improvement required to avoid infringing a prior patent.

While, patent length or patent breadth can be used as instruments for patent policy, there are some additional issues that have to be dealt with in designing an optimal policy. David (1993) explains that in order to secure benefits from the increasing stock of knowledge, it is desirable to promote full and prompt disclosure of new findings, so that they may be disseminated, verified by replication and put to use by others engaged in intellectual pursuits. This in turn implies that rewards are based on some criterion of priority, such as, the first to invent or first to register for a patent. This gives rise to patent races and inefficiencies due to duplication of inventive effort. Excessive inventive effort could be avoided under a contract system if all the agents are fully aware of the potential costs and social value of the findings of all the innovators.

An important feature of innovative activity that until recently was not incorporated in the economic theories of IPR is the cumulativeness of innovations. The design of IPR incentives takes on new dimensions when we consider that the social value of an invention is compounded by the fact that it facilitates future innovations. Given this, the incremental value accruing from such future discoveries must also be incorporated into the social value created by the initial invention (Scotchmer 1991). Cumulativeness in innovations implies that inventions of one inventor become a foundation for subsequent innovations by other inventors. These could largely be of four types - improvements over earlier products; cost reductions for producing earlier products; applications of basic technologies and enabling technologies, such as, research tools. The basic problem with cumulative innovations is the division of joint profits from the cumulative innovations between the original and subsequent innovators. In order to provide incentives for investment in innovation, the first inventor must be able to appropriate a share of the profits from subsequent innovations facilitated by his/her original invention. Simultaneously, it must be ensured that the incentives are designed so that this sharing of profits with the original inventor does not reduce incentives for the subsequent innovators to undertake R&D.

To summarize, the main issues in intellectual property protection of knowledge goods can be classified into three sets. First, the basic issue is of designing incentives for encouraging investment in innovation in a way, such that the benefits from increased innovation balance the dead weight loss imposed due to the grant of monopoly rights. Second, the problems in designing the IPR incentives, in turn arise due to two basic reasons: (a) asymmetry of information about costs and benefits of innovation among the agents involved (i.e. innovators or firms and the patent authority or government) and (b) due to cumulative nature of the innovations. The third set of issues deal with the policy instruments available in designing the IPR policy. The two main variables involved are the duration of protection and the scope of protection. The forms of IPR available are patents, copyrights etc. Different forms of governance structures, such as licensing and contractual arrangements, complement the IPR systems. All of these together are used to determine the optimal IPR policy.

In order to direct IPR incentives for TK, there is a need to identify all the stakeholders involved in preservation, validation and further use of TK. There are several stakeholders involved at different stages in the preservation and use of TK associated with biological resources. There are at one end, the communities and indigenous people who have been preserving, transferring and using the knowledge from one generation to the next; and at the other end, the companies and research organizations interested in developing TK based innovations and products. Then there are the intermediary agencies, such as NGOs that mediate between the communities, the companies and the government agencies. The Government often acts as a coordinating agency that consolidates the property rights of the different parties and establishes a system for the protection and sustainable use of TK.

The variables involved in the design of incentives are scope and length of protection. Another related aspect that must be incorporated is the subject matter of protection. This is an important issue that has to be clarified while designing IPR systems for TK. Apart from the types of IPR such as patents, geographical indications, copyrights etc., there are other complementary measures such as licensing and contractual agreements that are often used as instruments to resolve conflicts in intellectual property.

The CBD objective of equitable sharing of benefits is essentially the same issue as that of cumulative innovations- division of joint profits with subsequent innovators. Economic theories of IPR incorporating cumulative nature of innovations are germane to the analysis of the design of incentives for intellectual property protection of TK. In order to provide incentives for the preservation and continuation of TK and practices, the holders of TK must be able to appropriate a share of the profits from the innovations facilitated by their existing knowledge and practices. In designing these incentives, it must be ensured that while providing a share in the rewards to the original holders of TK, it doest not discourage R&D by the subsequent innovators. There are also divergences in the context of TK as cumulative innovations. There does not usually exist a patent on the original invention nor is there a single innovator. Often, the original innovator(s) are not identifiable. Models of cumulative innovation sometimes assume that the original and subsequent innovations take place contemporaneously. Obviously, this assumption does not hold for TK. These issues are studied in detail in the subsequent sections as a framework is developed using cumulative innovation theory for a formal analysis of IPR incentives in the context of TK.

V. Cumulative Innovation Theories

The cumulative nature of innovation was incorporated into models of intellectual property protection with the policy debate on alternative instruments, such as, patent breadth in addressing the Nordhaus tradeoff. In the earlier models, innovation is often represented as a single, stand alone inventive effort that is seldom improved upon. However, in reality, this is rarely the case. There exist very few pioneering innovations, while most innovations build on earlier works. When there are positive externalities from innovations, there arise issues of contracting between the original and subsequent generations of innovators. The cumulativeness of innovations and the extent of the breadth of the patent have implications for incentives to innovators, both original and subsequent to invest in R&D to develop the innovation.

As seen earlier, Gilbert and Shapiro, 1990 and Klemperer, 1990 introduced the patent breadth dimension into the policy debate. Scotchmer, 1991 extended it further to incorporate cumulativeness of innovation by providing for possibilities of ex ante agreements between innovators in designing optimal patent breadth. As explained earlier, the cumulative nature of innovations has implications for the social value of the innovation, which is compounded by the value of subsequent innovations facilitated by the original innovation. This therefore, brings up the possibilities of contractual arrangements between the innovators involved in the original and subsequent research. Innovations are essentially improvements over a stock of knowledge and the optimal patent must provide for claims over future research (Green and Scotchmer, 1995; Chang, 1995 and O'Donoghue, Scotchmer & Thisse, 1998). These models interpret patent breadth as the minimum improvement required to avoid infringing a prior patent. A solution provided in these models to the problem of designing incentives is through ex ante contracting. However, there are positive transaction costs associated with such contracting and different alternative forms of governance structures in each case.

Another view of patent breadth in the context of cumulative innovation is provided from the legal approach – litigation in enforcing patents determine the boundaries of protection available to the firm. Merges and Nelson, 1990 for instance, explain that judicial practices like reverse equivalence determine the effective patent breadth. In a further analysis, Llobet, 2002, establishes that patent breadth is determined by litigation technology by relating the concept of breadth to the probability that the patent holder succeeds in court and the size of the future innovator.

The specific problems in the cumulative innovation models are briefly described below. An example of cumulative innovation is the case of 'basic' and 'applied' research. Transferring profits from the second-generation product to the first innovator, so as to provide the original inventor with sufficient incentive to undertake basic research is difficult. Denicolo (1997) explains that if the second product is made patentable, it transfers profits from the first innovator to the second, thereby reducing the incentive to invest in the first innovation but increasing incentive to invest in the second. Subsequent products, that are improvements over the original products or technology may displace the original products from the market. This reduces the incentive for the initial inventors to undertake research.

Establishing an optimal patent length or patent breadth or a combination of both provides a solution to this problem. Designing IPR policy for cumulative innovations first involves determining if the subsequent product developed from the original innovation infringes the patent on the original product; whether the second product is itself patentable; and if so, the lengths of the first and second patents. The other related factor is regarding patent breadth. Patent breadth can be construed to mean the minimum improvement required to avoid infringing the first patent. If the initial inventor is provided with a broad protection, he/she can earn profits through licensing. This might have an adverse impact though, on the second innovator's incentive to undertake further R&D on the basic research. For instance, if small improvements were patentable then firms might become too modest in their aspirations relative to the social value of improvements. When small improvements are not patentable, firms aspire to larger ones (O' Donoghue, 1998). *Ex ante* agreements to share both costs and profits can bring about a balance but the characteristics of these arrangements would depend on the bargaining positions of the two sets of innovators.

Recent models[20] of cumulative innovation also consider infinite sequences of improvement, where each inventor will both license from the earlier innovator and license to the next. In this scenario, the difference between original and subsequent innovators will fade eventually.

In the case of infinite sequence of quality improvements, the effective patent life largely depends on the patent breadth. The patent on the first product ends when a non-infringing better product is introduced in the market and replaces the original innovation. Thus increasing the effective patent life by increasing the breadth will have a positive impact on the profits of the innovators. However, in that case, just as an innovator may earn more profits through license fees, similarly, he/she will also have to pay more in terms of license fees to the preceding inventors.

Another important factor is the determination of the subject matter of patentability. Patent law establishes the conditions under which, the second-generation product infringes on the first patent and when the second-generation product itself is patentable. While, whether a product infringes a patent is determined by the breadth of the first patent, patentability is established by the novelty (inventive step) requirements. Scotchmer explains that if infringing applications of basic innovations are patentable, then, patentability is unnecessary to protect profits and an exclusive license on the prior patent would be sufficient. Patentability of the subsequent product improves the second firm's bargaining power for an exclusive license and undermines the profit of the initial innovation. When the second product is both infringing and patentable, then both the firm could end up with blocking patents *ex post*.

While there are several theoretical models in relation to cumulative innovation theory, there is as yet, very little empirical evidence in this area.

VI. A Cumulative Innovation Model For Traditional Knowledge

Traditional knowledge and innovations developed from it are cumulative in nature. The social value of TK is compounded by the value of future innovations facilitated by the existing stock of TK. The theory of cumulative innovations (CI) provides a framework for analysing the central issues of the design of IPR protection (length and scope of protection) for TK and an appropriate mechanism (licensing and contractual arrangements) for sharing with the holders of TK, joint profits arising from TK-based innovations developed. In designing incentive systems for TK, it must be established if subsequent innovations based on TK are in fact patentable (or qualify for any other form of IPR protection) and if so, the requirements for the same. There is no patent on the original TK; the IPR provisions developed must therefore establish the level of quality improvements required for patenting of the second-generation TK-based innovations or in other words, the breadth or scope of protection. Another important issue is the length of protection. The protection for the original innovation represents an infinite period of time. The length of protection for the subsequent innovations however, must be established.

The knowledge regarding the particular characteristics and specific uses of the medicinal plant species in an area, held over generations by the local communities or groups of individuals, is the original stock of knowledge. In CI theory, this is known as basic research. For pharmaceutical companies and biotechnological firms, this is an important resource base for future innovations. Leads obtained from TK considerably reduce search costs involved in prospecting and result in higher 'hit rates' in identifying active compounds from plant species for drug discovery. The leads obtained from TK are also useful in developing products that are applications of or improvements over the existing knowledge.

As already pointed out, there are some divergences in cumulative innovation in scientific and technological research from that in TK. The holders of TK do not own patent rights or any other form of intellectual property rights over their knowledge. There is rarely only a single inventor; the rights over the knowledge are held collectively, which raises issues in sharing of joint profits from subsequent innovations. Another problem is that of asymmetry of information about the value of TK. However, these issues can be addressed through contractual and licensing arrangements. Further, the Traditional Knowledge Digital Library (TKDL), a database enabled with features of search and retrieval of TK pertaining to medicinal plants addresses to an extent, the problem of asymmetry of information about value of TK. Though, the TKDL has been prepared by the Government of India as non-patent literature database to prevent the incorrect grant of patents over TK, it is also an important source of valuable TK that will serve as the basic research for subsequently developing useful TK-based innovations. Licensing arrangements developed for the database act as the vehicle to transfer profits from future innovations. This database is a means to both preserve and promote the use of valuable TK. The need for developing a mechanism to resolve potential conflicts in intellectual property rights from use of the knowledge in the database is imminent, but guidelines for regulating access to and use of the database are yet to be established. CI theory provides guidelines for developing an appropriate mechanism for regulating the access to and use of TKDL. The application of the theory to TKDL is examined in detail in the final section.

There are two basic questions that arise on the commercial utilization of TK outside the context of the community that holds and preserves it. First, under what conditions, will there be an incentive to invest in R&D to develop TK-based innovations? Second, what kind of a mechanism should be developed to ensure sharing of joint profits from commercial products derived from the basic TK, with the holders of the knowledge? These issues are central to CI theory. The solutions to the above question basically lies in designing the optimal IPR policy by establishing the optimal length and scope of IPR protection, given the cumulative nature of TK-based innovations. This in turn determines, how the rights of the different parties are defined and their bargaining positions in a licensing agreement.

VII. The Model

A formal analysis of the design of IPR systems for cumulative innovations in TK can be developed using a simple formulation of a cumulative innovation model provided in Scotchmer, 1999.

As explained earlier, TK is a form of basic research, which on its own commands no commercial value, but in turn, derives its value from the value of future innovations facilitated by it. There are two notions of value[21] in this context: market and non-market values. One is the value of TK derived from the traditional use of the resource and associated knowledge within the local context of the community and the other is derived from its use outside the local context of the community. These may be broadly classified as the non-market and market use of the TK relating to biological resources. The market value of TK is determined when members outside the community that traditionally own the rights over TK, use the knowledge to develop further products or cost-reducing processes. Commercialization of the TK, closely held within a community may involve a loss to the community in terms of changes in access to and the traditional use of the resources and knowledge. It no longer remains as TK embedded within the social and cultural context of the community. However, given the declining use of TK and practices in some cases, such commercialization of TK can also prove to be beneficial as it translates to the community the viability of preserving the tradition.

Let the commercial value of the TK be equal to zero.

$x(t)$ = per period market value of TK, which at $x(0) = 0$.

The time period just prior to commercialization of TK is referred to as t=0. The market value of TK at this point is equal to zero. But TK is also a form of basic research and it derives its market value from future innovations that are applications of the basic TK. This is included in what is known as the social value of the basic innovation.

The knowledge regarding the particular characteristics and specific uses of the medicinal plant species in an area, held over generations by the local communities or groups of individuals, is the original stock of knowledge. In CI theory, this is known as basic research or the original set of innovations. For pharmaceutical companies and biotechnological firms, this is an important resource base for future innovations. Leads obtained from TK considerably reduce search costs involved in prospecting and result in higher ‘hit rates’ in identifying active compounds from plant species for drug discovery. The leads obtained from TK are also useful in developing products that are applications of or improvements over the existing knowledge.

$\pi(x, T)$ = market value of the basic TK innovation for a given number of years of protection, ‘T’.

$p(x, T) = f(x, T, c_1\ r)$
$x = x(t)$ = per period market value of the TK innovation
T = duration of protection
c_1 = costs undertaken in preserving and transferring TK
r = rate of discount

The market value of the basic TK innovation for a given period of time $p(x, T)$ is a function of the value of the basic research (x); the duration of protection (T); the costs undertaken in developing the basic research (c_1) and the discount rate (r). As explained above, prior to commercialization of TK, the market value of the basic research is equal to zero.

The well-known Kani Tribes-TBGRI[22] case can be used here, as an illustration. The anti-stress and immuno-stimulating properties the fruit of the plant, *arogyapaacha* (*Trichopus zeylanicus travancoricus*) was known only to the members of the *Kani* Tribes[23] of Kerala. This knowledge served as the basis to the TBGRI scientists for detailed scientific investigation and chemical screening to identify the active compounds and develop a restorative, immuno-enhancing, anti-stress and anti-fatigue drug, '*Jeevani'*. With the potential for development of a pharmaceutical drug, there emerged, a commercial value of the TK for the tribe. Thus, '*x'* represents the market value of the basic TK, i.e. the knowledge about the medicinal use of a plant species or a method of production etc. This is the original TK 'innovation' that facilitates future innovations. In this case, the basic TK innovation is the knowledge about the medicinal properties of the fruit of the plant *arogyapaacha,* which was held only within the community. Within the Kani tribes, the rights of transfer and practice of certain traditional medicinal knowledge customarily rests with tribal healers (known as Plathis). The market value of the TK innovation was initially zero till the potential for developing a pharmaceutical drug from the knowledge was discovered.

In case of a modern scientific or technological innovation protected by a patent, '*T'* represents the length of the patent protection, which, as per the requirements of the TRIPS Agreement, is currently for 20 years. The market value of the innovation increases with an increasing *T*. A longer duration patent results in higher profits to the innovation, but also increases the dead weight loss to the consumers due to monopoly exploitation. In the case of TK, of course there exists no such patent protection. Yet, the knowledge is preserved and transferred through customary systems by the holders of the knowledge for generations, as is done by the traditional healers of the Kani tribes. Hence, '*T*', can be interpreted to represent an infinite term of protection, in the case of the TK innovation.

The costs incurred in developing the basic research are given by c_1. The solution to the classical Nordhaus model is that the optimal duration of IPR protection should be such that it covers the costs of the innovation. In the case of cumulative innovations, as the basic innovation is of no commercial value, the first innovator must be able to appropriate a share from the profits of the future innovations, so as to recover the costs incurred in developing the basic research. Otherwise, there will be no incentive to invest in basic research. While TK exists over generations, the communities or group of individuals involved continue to incur costs in preserving and transferring the knowledge. The objective of benefit sharing provisions envisaged in Article 8j of the CBD, 1992 is to reward the holders of TK for incurring costs for their efforts in conservation and sustainable use of biological resources.

p(x, T) is actually the present market value of the basic innovation for a given time period T. A suitable rate of discount 'r' has to be determined to calculate the present value of the TK innovation.

Given the cumulative nature of TK innovations, the value of TK is compounded by the value of future innovations that are developed based on the initial stock. The traditional medicinal knowledge, once obtained by pharmaceutical companies becomes the base for developing further marketable drugs. The concept of social value of innovation captures this additional value generated from cumulative innovations. The social value of innovation is represented by W(x, T).

$W(x,T) = f(x, T, c_i, r, a)$

where, c_i refers to costs of both basic and applied research, where i=1,2 (the original and subsequent innovators, i.e. the TK holders and the pharmaceutical company, respectively)

a = per period market value of the application, which is the pharmaceutical drug developed.

Thus, in addition to the market value of the basic innovation, the social value of TK includes the market value of the subsequent innovation (i.e. the pharmaceutical drug developed from application of the TK innovation) and the costs involved in developing the application. Hence, c_i refers to the costs of both sets of innovators: the original innovators, i.e. holders of TK and the subsequent innovator i.e. the pharmaceutical company that develops a marketable drug based on the TK. Using the same earlier example, the social value of the traditional medicinal knowledge of the Kani tribes is compounded by the value of the drug 'Jeevani' developed by the TBGRI based on the TK associated with the *arogyapaacha* plant. Thus the social value of the innovation $W(x, T)$increases with the market value of the application 'a' developed from the basic innovation.

In this case, we consider only one application developed from the TK. In reality, there is usually a sequence of innovations based on the original innovation. The medicinal properties of the drug 'Jeevani' could in turn serve as the basic knowledge for further improved drugs or cost reducing processes. This system of sequential innovations, which include several stages of innovation over the basic research, is common in the information technology and biotech industries. The computer chip and several software programmes that undergo regular successive improvements are examples of sequential innovation. Pharmaceutical and bioengineered products also undergo a series of improvements with time. This is described as a "quality ladder", in which, the difference between the basic and applied research, or the first and second innovators fades eventually. Correspondingly, the social value of the original innovation will also reduce with time, as its contribution to future applications is also lower at the later stages of innovation.

$W(x, T)$ for any basic innovation protected by a patent reduces with increased length of protection, as a longer patent implies a greater deadweight loss. In case of sequential innovations, the classic Nordhaus trade off appears as the effective length of the patent has to be long enough to cover the research costs but must also ensure that incentives for subsequent research are not reduced.

$W(x, T) > p(p, T)$. The social value of the basic TK innovation is greater than the private market value of the knowledge as it is compounded by the value of subsequent innovations also. The social value of TK further includes any costs borne by the community due to its loss of TK on commercialization. Similarly, it also includes any gains to the community that accrue from sharing of the profits from subsequent innovations developed. Thus the social value of the innovation, can be represented as $W(x, T)$ where, in case of a two stage innovation of basic and applied research, $i=1,2$. The first innovator is the entire community[24] or group of individuals holding the rights over the basic TK and the second innovator is the pharmaceutical company interested in developing the drug. In case of a quality ladder, $i=1,2,3....n$, where there are n-1 stages of innovation and one company at each stage interested in developing the application.

This brings up the question, "Under what conditions will investment in subsequent R&D to develop applications based on traditional medicinal knowledge take place?" This question is directly addressed by the design of incentives to promote TK based innovations. The design of a suitable IPR policy, determining the length, scope and subject matter of protection and the mechanism for sharing of joint profits will determine the incentives for TK based innovations.

Let us first consider the case of a two-stage innovation of basic and applied research, where there is only one innovator interested in developing the application. The firm developing the application has an idea, (a, c_2) where,

a = per period market value of the application

c_2 = cost of developing the application

$p(a, T)$ = Market value of the application for a given T (length of protection)

$p(a, T) = f\,(a, T, c_2, r)$

Unlike the case of the basic TK innovation, the application developed based on the TK innovation, has a market value that can be determined as it is sold in the market. '*a*' is the market value of the pharmaceutical drug developed from application of the basic TK innovation.

Likewise, the application can also be protected under a patent. With a longer patent life, the market value also increases. Simultaneously, the patent breadth must also be established. The subject matter of protection under the patent system must ensure that there is sufficient inventive step in the application of the original TK and is not merely a repackaging of what is already known. This includes, determining whether the application is patentable at all in the first place, and if it is, the degree of novelty requirement in order to qualify for a patent and the specific conditions under which a patent is granted.

The IPR system must also ensure that the costs incurred by the firm in developing the application are covered. Else, there will be very little incentive for investing in subsequent R&D. As in the case of developing a pharmaceutical drug, there are huge costs involved in clinical trials, tests, standardization and validation before the drug is developed. This often takes several years apart from requiring large amounts of investment. Unless the firm is able to recover the costs incurred through a patent or any other system, it will not have the incentive to invest in developing the drug at all.

In multiple stages of innovation based on TK, $W\,(a, T)$, the first application developed based on the original TK innovation, is compounded by the value of further innovations facilitated by it. This raises the questions of patent length and breadth for the subsequent innovations. O' Donoghue et al., 1998 explain two types of solutions for determining the effective patent life in the case of a quality ladder. One solution is to provide long a statutory patent with limited breadth, while the other, is to provide patents of a finite length and unlimited breadth. In the first case, the longer the patent length is, the greater is the deadweight consumer loss due to consolidation of property rights. In the second case, where the patent breadth is very large, there might occur wastage of R&D resources; for it requires, subsequent innovations to be in the nature of large improvements. In the absence of an existing patent on TK, suitable licensing arrangements can be designed so that holders of TK can stake their claims over future innovations developed based on their TK. In order to provide incentives for investing in subsequent R&D, the effective patent life awarded for the applications must be such that it covers the costs of the innovation and adds to the joint profits of both sets of innovators.

Returning to the original question, "Under what conditions will investment in subsequent R&D to develop applications based on traditional medicinal knowledge take place?" The result that is already obvious from the above discussion is that, there is incentive to invest in developing the application, whenever it adds to joint profits and the costs of the innovation can be recovered fully.

If $p(a, T) - c_2 > 0$ then, the investment in subsequent R&D to develop the application based on the original TK innovation will take place.

If the market value of the application exceeds the costs involved in developing it, then, there is an incentive for the subsequent innovator in investing in R&D to develop the application. In order to ensure this, the effective patent life has to be determined so that the costs of developing the innovation 'c_2' are recovered. If $p(a, T) - c_2 < 0$, there is no incentive for investing in subsequent research as the market value of the application is lower than the costs involved in developing it. This could occur, if the costs of the innovation are too high or the effective length of the protection available does not cover the costs. For instance, a relatively minor improvement over TK may require large amounts of investment. As in the case of pharmaceutical drugs developed from traditional medicinal knowledge, substantial resources are devoted to clinical tests, standardization and R&D. the value of the drug developed eventually, may be relatively small in comparision to these costs incurred. Put in other words, if the IPR system for the protection of the application does not enable the innovator to recover the costs incurred, then, there is very little incentive to develop the application. Either, the length of the patent (T) should be long enough for the innovator to recover the costs or in the case of a finite patent life the patent breadth must be larger, so that returns can be earned through licensing.

However, it should be remembered that the application is developed from the existing stock of knowledge and though, there exists no patent, the TK holders have a claim to the profits from the application. In the absence of a share of benefits from future innovations, there is no incentive for the community holding the TK to share their knowledge with the pharmaceutical company or in some cases, where there is declining use of TK and practices within the community itself, to continue its preservation. Licensing arrangements enable the profits from the marketing of the TK-based application to be transferred to the TK holders. The rights of the parties involved and their bargaining positions determine the terms of the licensing arrangement. The novelty requirements of the patents for the subsequent innovations can determine if the applications are 'infringing' on the existing TK. The cases of incorrect grant of patents over TK essentially present this problem. There is no patent on TK to prove that the subsequent innovations are infringing. Patent laws establish that patents cannot be granted over 'prior art', i.e. knowledge already known or in use. Thus, patent laws for subsequent TK-based innovations can clearly define the novelty requirements so that the innovator demonstrates sufficient inventive step over TK, in order for the application to qualify for a patent.

Now, if the entire surplus is transferred to the original inventor, there is very little incentive for the subsequent innovator to undertake investment in R&D. Even if the condition $p(a, T) - c_2 > 0$ is satisfied it might still be unprofitable for the pharmaceutical firm to invest in the innovation, for the surplus from the application is transferred to the TK holders. Following are different types of licensing arrangements that determine relative shares of profits for the innovators and their incentives to invest in innovations.

Scheme 1: Ex post licensing of innovations

Licensing arrangements to share profits from cumulative innovations can be developed ex post, i.e. after the costs in developing the application are sunk. Given this situation, where the firm has already invested in R&D to develop TK-based innovation, the bargaining surplus available to be shared between the innovators is the entire surplus from the application, which is otherwise, the market value of the application.

$p(a, T)$ = Bargaining surplus.

k and $1-k$ are the respective shares of the TK holders and the pharmaceutical firm in dividing the bargaining surplus

The licensing arrangement divides the bargaining surplus $p(a, T)$ into non-negative shares of k and $1-k$ between the TK holders who provide the basic research and the pharmaceutical firm that develops the drug based on TK.

$p(a, T) - c_2 > 0$ is the condition for the pharmaceutical form to undertake the investment for developing the application. However, in an ex post licensing arrangement, we find that even if the above condition that the application is developed every time it adds to joint profits is satisfied, investment by the firm may not be profitable. The firm will expect to cover the costs of innovation with the profits it earns from the marketing the application. This may not take place as explained with the help of the licensing arrangement described below,

$(k)p(a, T) - c_1$ = anticipated profit for the holders of TK

$(1-k)(p(a, T) - c_2)$ = anticipated profit for the pharmaceutical firm

Thus, even if $p(a, T) - c_2 > 0$, it might still be unprofitable for the firm to invest in the application, as costs of innovation may not be covered fully. Only if $(1-k)$ $p(a, T) - c_2 > 0$, will it be profitable for the firm to invest in the application. One way to ensure this is to increase the life of the patent available to the pharmaceutical firm, but as seen earlier, this increases the deadweight loss to the consumers. $W\,p(a, T)$ decreases with a longer T.

Under the scheme of ex post licensing, the condition that the application is developed every time it adds to joint profits does not hold. Even if the application adds to joint profits, the share of firm investing might not be sufficient to cover its costs and the entire costs sunk in developing the application is borne only by the firm. While profits are shared, the costs are not.

Scheme 2: Ex ante contracting

Ex ante contracting i.e., before the costs c_2 are sunk, can ensure that the application is produced whenever it adds to joint profit. But it cannot ensure that the entire profit surplus is transferred to the original innovators as in the previous case.

$p(a, T) - c_2$ = Bargaining surplus

$k(p(\mathrm{a}, \mathrm{T}) - c_2) - c_1$ = Anticipated profit to the TK holders
$(1 - k)(p(a, T) - c_2)$ = Anticipated profit to the pharmaceutical company

Thus, the entire surplus $p(a, T)$ is not transferred to the holders of TK. While, this ensures that investment in the application takes place whenever, $p(a, T) - c_2 > 0$, it also splits the costs of innovation between both sets of innovators. Ex ante contracting can help to increase social welfare as it ensures that the application is developed. Considering that the value of TK is derived from future innovations, ensuring that applications are developed adds to the profit earned from commercialization of TK. However, the share in the bargaining surplus is reduced for the TK holders as the costs of the application are also shared and the entire surplus from the application is not transferred. This problem can be addressed by providing a longer duration of protection. As it is, there is no fixed term of protection for TK; *T* is interpreted to refer to an infinite time period. Licensing arrangements or *sui generis* systems developed for TK can ensure that profits from subsequent innovations are transferred to TK holders for a time period that rewards them for their efforts and compensates them for costs incurred. In other words, the condition $k(p(a, T) - c_2) - c_1{}^3\ 0$ must hold. This is a stronger condition and as explained above requires a longer term of protection.

Thus, ex ante contracting arrangements can arranged in a manner such that it is beneficial to both sets of innovators and adds to joint profits. As opposed to ex post licensing, this ensures that the condition for investment in the application holds. The design of an appropriate licensing arrangement depends on the bargaining positions of the parties involved and the terms for sharing the joint profits. A coordinating agency such as the government, for instance, acting on behalf of and with the consent of the community holding TK, can make available to a pharmaceutical firm, an exclusive license over TK. Through a system of ex ante contracting, terms of the licensing arrangement can be determined in advance so that corresponding shares in the joint profits for the holders of TK and the firm with the license to produce and market the TK application are calculated and implemented.

Scheme 3: Ex ante contracting with several subsequent innovators

I have indicated earlier that there can be several stages of cumulative innovation over the basic stock of knowledge. However, there can also be several innovators interested in developing TK applications at one stage. Ex ante contracting ensures that the application is developed whenever it adds to joint profits and provides a means for sharing of joint profits. However, there is rarely only a single firm interested in developing an application. Several firms can compete for an exclusive license over TK to develop the application. In such a situation, problems arise from asymmetry of information between the original and subsequent innovators. The firms interested in developing the application all hold private information about their costs and benefits of innovation.

The condition for investment in the application is:

$p(a_i, T) - c_i. > 0$

There are several firms with the idea (a_i, c_i) where,

i = 1…n; the number of firms interested in developing the TK application

a_i = per period market value of the TK application to the i^{th} firm

c_i = cost of developing the TK application to the i^{th} firm

$k(p(a_i, T) - c_i)$ = profit for the TK holders

$(1 - k)(p(a_i, T) - c_i)$ $(1 - k)(p(a_i, T) - c_i)$ = profit to the i^{th} firm that procures the ex ante license

The problem is in assimilating the information on all (a_i, c_i). This problem may be addressed by a mechanism design. The government, any other agency or a representative of the community itself can act as the principal on behalf of the group of individuals holding the rights over TK. The pharmaceutical companies are the multiple agents interested in developing TK-based applications. These companies hold private information regarding the different (a_i, c_i).

Again, ex ante licensing arrangements can ensure the development of the application and a suitable system for the sharing of joint profits. As in the mechanism design game, the government, for example, as the principal chooses a mechanism based on the agent types. A system, such as a fee for the exclusive license to use the TK or the number of licenses that will be auctioned to the companies has to be determined and announced. The pharmaceutical firms interested in developing the TK based innovation can then choose to accept or reject the mechanism. Accordingly, the firms that accept the license fee or the auction system play the game as specified by the mechanism and reveal their true types. Once this information is collected and the game played, the bargaining surplus can be divided as per the guidelines of the ex ante licensing agreements.

These forms of contractual arrangements already exist in case of TK databases where, ex ante licensing arrangements are announced. The access to and the use of the database are regulated through these licenses. Apart from licensing systems, certain types of IPR can be used to redefine the rights over TK in the changed context of its commercial utilization outside the community. These rights also help to better determine the bargaining position of the TK holders in a licensing arrangement. *Sui generis* systems can be developed to define the rights of the communities over their knowledge. Some examples of countries that are developing *sui generis* systems have already been described earlier in this paper. These systems enable the government and the communities holding TK to regulate access to and use of biological resources and the associated TK. While patents may not be a suitable mechanism, alternatively, forms of collective IPR may be developed and used. For instance, neighborhood rights provide moral and remunerative rights to performing artists and record publishers in authorizing copies of an artwork or a musical performance. A similar system that guarantees rights of the community over the TK and establishes a mechanism for controlling access to and use by parties outside the community will determine the bargaining positions of both parties in a licensing or contractual agreement and help to develop an optimal policy for protection and use of TK.

VIII.Application to TK Policy

There already exist, specific examples of use of the two different types of licensing arrangements described above: ex post and ex ante licensing. The benefit sharing models attempted by the pharmaceutical companies in the process of biological prospecting represent a form of ex post arrangements.

Benefit Sharing Models

As in the Kani-TBGRI case, the Shaman pharmaceuticals case or the InBio – Merck case in Cots Rica, costs to develop pharmaceutical drugs from prospecting of biological resources and using leads from traditional knowledge had already been invested. Licensing arrangements to divide any joint profits arising from the sale of the pharmaceutical drugs developed are made only after the product has been developed. So far, it is only in the Kani tribe case that a drug has been developed successfully. However, the division of profits thereon has been fraught with complications. A major problem was in the identification of the beneficiaries. One of the drawbacks with benefit sharing models has been that there are no clear guidelines in identification of communities and methods for calculating shares of the beneficiaries in dividing the benefits. The CBD also only states that there should be ‘equitable’ sharing of benefits, with no guidelines on how this can be implemented. In the above case, the TBGRI licensed the technology of production of the drug ‘Jeevani’ for seven years, to an ayurvedic pharmaceutical company, Arya Vaidya Pharmacy for a license fee of rupees ten lakhs and two percent of the sales as royalty. The TBGRI transferred fifty percent of the license fees and the royalty it received to a Trust Fund for the Kani tribe. The discovery of the medicinal property of the plant was made in 1987. Since then, it took up to 1999 for the entire process of the development of the drug, patent application, licensing of technology, marketing of the drug and sharing of returns with the transfer of benefits to the Kani Trust fund. There are also questions regarding claims of members of Kani tribes in other parts of the State of Kerala, who also possess the same knowledge about the properties of the plant. There has also been some objection to the methods of calculation of the share in the license fees transferred to the Kanis. Recently, at the first meeting of the fund members, it was decided to reward the three tribes people, who originally shared the information about the plant with the scientists. The use of the remaining funds in the Trust is yet to be discussed. The bargaining positions and the property rights are not well defined. In this case, though the drug is making profits to cover the costs, the mechanism of transfer of benefits to the community is not clear. In the case of Shaman pharmaceuticals, though several leads were acquired, no marketable drugs were developed. However, the company had developed a model for sharing of the profits from any successful drugs developed. But on account of the huge costs in drug discovery, the company went bankrupt and it resulted it its closure. As already seen, in case of ex post licensing, there is no sharing of cots of innovation with the original innovators.

Digital Databases for Traditional Knowledge

Ex ante licensing is a better means to address problems in sharing of joint profits. These can be used in the future for designing contracts for use of TK. In case of databases on TK, a mechanism designed ex ante determines, the rules of access to and use of the database and sharing of profits arising out of drugs developed from the application of the TK contained in the database. On account of increasing cases of biopiracy, several countries, following the CBD guidelines, initiated efforts to prepare databases for recording information about known properties, uses and practices relating to different biodiversity species and traditional knowledge. The WIPO particularly, is encouraging and trying to coordinate national efforts at developing digital databases for TK. The Indian initiative - the Traditional Knowledge Digital Library (TKDL) was selected by the WIPO for a pilot study across a hundred and seventy countries as a model for developing digital databases. Ex ante contracting will be particularly useful in determining how the database will be made available and used. The database in turn, is a record of rights over TK and serves as a means for regulating access to and sustainable use of TK and biological resources.

The TKDL initiative developed by the Department of Indian Systems of Medicine and Homeopathy (Dept. of ISM&H) and the Council for Scientific and Industrial Research (CSIR) is a database of traditional knowledge pertaining to medicinal plants. The first phase of the database that is complete now, is the documentation of TK from the existing literature on Ayurveda available in the public domain and has been translated into six languages[24]. The web version of the TKDL includes a web-based search interface with an innovatively structured classification system, the Traditional Knowledge Resource Classification (TKRC). The TKRC enables retrieval of information relating to 5000 subgroups, in contrast to the single group available under the international patent classification (IPC) system for medicinal plants. The database enables searches on known uses for botanical species, disease conditions, proven methods of preparations etc. Further, the TKRC has been linked to the international patent classification and thus the patent examiner can identify the relevant IPC also for each entry. TKDL was developed in response to the need for the creation of easily accessible non-patent literature databases so as to address the problem of incorrect grant of patents for non-original inventions relating to TK. Patent literature, for instance, is usually available in distinct databases with easy search and retrieval features. In creating the TKDL, it is hoped that it may be included in the official list of international search authorities (ISA) relating to non-patent literature and that patent examiners may easily be able to establish 'prior art' while examining patent applications.

However, it is also obvious that databases such as, the TKDL are of immense commercial potential. Though, as of now, there are no specific guidelines prescribing the access to and the use of the database, it is imperative that safeguards are established before the database is released. Otherwise, the TKDL, in the absence of sufficient safeguard mechanisms would defeat its own purpose by facilitating further piracy of valuable TK. Also, these databases are often claimed to serve the CBD objectives of benefit sharing from subsequent commercial use of the TK contained in them.

The TKDL is in a sense, similar to scientific databases like the gene banks. Databases containing information on genetic sequences are particularly useful for R&D in the biotechnology industry. Information contained in the TKDL will be particularly useful for developing further TK-based innovations in pharmaceutical and biotechnology industries. Substantial amounts have already been spent in creating the database; a little over a quarter of a million dollars (approx. Rs. 1.5 crores) has been spent so far. It is therefore, important to ensure that there is either statutory protection, such as copyrights or *sui generis* legislation for database protection and/ or technological safeguards, such as encryption or password to ensure that the information contained in the database is not misappropriated or the entire database itself copied. It must also be remembered that the constituent parts of the database, the ayurvedic medicinal knowledge is not protected otherwise through patents, copyrights etc.

The information contained in the TKDL and the subsequent innovations developed from it are essentially a case of basic research and applied research. The information contained about known uses of particular species or treatment for disease conditions form leads for pharmaceutical companies to develop marketable drugs. In providing incentives for subsequent innovations to be undertaken and also enable the government to earn a share in the profits to recover the costs undertaken in compiling the database, ex ante licensing arrangements may be established to ensure that applications are developed, whenever, it adds to joint profits. In this case, the government is not the original innovator but the owner and compiler of the database and must be able to earn a fair return in recovering costs incurred in creating the database. In order for potential users to access the database and invest in innovations based on information in the TKDL, they must also be able to earn a high enough share in the joint profits to cover their costs of innovation.

There are several arrangements possible for governing the use of the database. There can be several potential users of the database. The data from public databases like the Genbank are made available without charge to end users and creators of derivative databases. Access to private databases is sold at high licensing prices[25]. Some databases charge a fee per item downloaded, and usually the fee varies according to the item. Similar to licensing a patent, access to the use of a database could thus be licensed to potential users for a fixed fee or a royalty (possibly non-uniform) or a combination of both. Licenses can be sold to potential users or a limited number of licenses auctioned. The choice of a particular licensing arrangement will depend on the one that maximizes return to the database owner. Any of these options may be applicable to the TKDL. The Government, using the mechanism design game can first collect information about the different agent types, i.e. of the pharmaceutical, biotech firms and other potential commercial users of the TKDL and accordingly announce the most suitable form of licensing arrangement for the use of the database.

The information contained in the TKDL has been compiled from literary Ayurvedic texts and Sanskrit verses. The Government owns the database and licensing arrangements with subsequent users may be easy to establish in this context. However, in cases of future databases created by compiling information from the communities or traditional medical healers etc., the problem of consolidating the property rights of the holders of TK is an important and complicated issue with direct implications for the sharing of joint profits. Already, several non-governmental agencies and government organizations are involved in preparation of biodiversity registers by collecting from communities in different regions, local knowledge pertaining to biodiversity in their regions. The guidelines relating to the ownership of these registers, the rules regarding their availability and use are still vague. There is a need to coordinate the various documentation efforts across the country and it is important to develop systems in consultation with the local communities for determining the access and use of their knowledge. To sum up, these databases are potential sources of valuable information for facilitating innovations in the rapidly growing biotech, genetic, pharmaceutical and related industries. Access to the information in these databases is also directly related to the protection and sustainable use of biological resources. This is one of the central concerns of the CBD, 1992 agreement. The CBD suggests developing national systems of legislation and/or benefit sharing arrangements to regulate access to and use of biological resources and associated TK, essentially to ensure that the resources are not over exploited in the context of their commercialization and to provide sufficient incentives for their preservation and sustainable use by the parties involved. The TK databases are one means of access to TK and biological resources in the country. Legislative systems for protection of the database and licensing arrangements to regulate access and ensure sustainable use of the knowledge contained in the database and associated resources through equitable sharing of benefits can in fulfilling the CBD objectives.

IX. Conclusions

In this paper, a framework for economic analysis of the design of IPR for traditional medicinal knowledge has been drawn up using a model of cumulative innovation. TK is also a form of cumulative innovation; it serves as the basic stock of knowledge for developing future innovations that are improvements or applications of the existing knowledge. Given this framework, the question of equitable sharing of benefits is essentially that of division of joint profits arising from innovations based on TK, between the communities that share their knowledge and the firms that develop innovations based on this knowledge.

This involves designing IPR incentives to encourage investment in innovation to develop an application based on TK. For this, not only does the application developed have to add to joint profits, the firms developing it must also be able to recover their costs of innovation and the holders of TK earn a share in the returns for their contribution in facilitating the innovation in the first place. Ex ante contracting provides a solution in addressing this tradeoff. Ex ante licensing arrangements ensure that applications are developed whenever it adds to joint profits and that both, costs and profits of innovation are shared between communities holding the basic TK and the firms that invest in further TK based innovations. This further involves determining the length, scope and subject matter of IPR protection for subsequent products developed from TK. Simultaneously, existing IPR and/or *sui generis* systems have to be established for regulating access to and use of TK and associated biological resources to ensure that the resources are not over exploited and are used in a sustainable manner. I have also briefly demonstrated in the last section, the application of the CI theory to develop incentive mechanisms in the cases of benefit sharing models and digital databases for traditional medicinal knowledge related to biodiversity.

As already indicated in the CI model, there can be several innovators interested in developing TK based innovations at one stage. Also, innovation based on TK is not restricted to a one time improvement or application; there are several stages of cumulative innovation that is possible and is also undertaken. Thus, the basic CI model can be developed to incorporate both of these aspects – expansion horizontally by including multiple innovators at the second stage and by building the model vertically by analyzing the case of ‘quality ladders’ for TK based innovations. Empirical estimation and evidence would go a long way in supporting these models and will be particularly useful for policy making by the Government. There is in the existing IPR literature for scientific and technological innovations, empirical studies on the impact of patents and other IPR, but these are limited and mostly pertaining to the pharmaceutical industries. Another aspect relates to the methods for estimating the market and social values of TK and innovations developed from it. The values can then be incorporated into the CI models.

As countries are developing national systems of legislation for protection and sustainable use of biological resources and related TK, the guidelines from CI theory are particularly useful in addressing the issues involved and designing incentive systems. The objective of this paper is to highlight the kind of economic analysis that is possible and required in the area. To conclude, I would like to emphasize that there is need to initiate further research along these lines and also to identify alternative approaches to address the central CBD issues of protection of collective rights over resources and knowledge and of equitable sharing of benefits arising from their use.

This paper focuses on IPR for traditional medicinal knowledge. In this area, the IPR concerns are well articulated and recognized. There are several other areas, such as textiles, crafts, architecture, and town planning, irrigation and agricultural practices, etc., where there is a need for protection and promotion of the use of traditional knowledge and practices. In some of these cases, there may be a need for IPR systems, whereas, in some others, for a different approach. A similar framework for economic analysis of the issues involved in these areas is required to first identify valuable TK and then to determine the nature of incentives required in each sector.

NOTES

1 For details, see Sengupta (1995), Proceedings (2001, 2002).

2 www.worldbank.org/arf.ik

3 Helen Fagerlin, *Report from Roundtable Meeting on Intellectual Property and Traditional Knowledge*, WIPO, Geneva, 1-2 November, 1999.

4 Paragraph 19 of the Doha Ministerial Declaration, Document WTO/MIN(01)/DEC/1.

5 Article 27.3 (b) deals with the patentability / non-patentability of plant and animal inventions and the protection of plant varieties. As required by the TRIPS Agreement, Article 27.3(b) is one of the Articles that is being reviewed by the TRIPS Council.

6 Note by the Executive Secretary, Traditional Knowledge and Biological Diversity (UNEP/CBD/TKBD/1/2), paragraph 85

7 Gupta, A., "Rewarding Traditional Knowledge and Contemporary Grassroots Creativity: The Role of Intellectual Property" (Draft), p. 10.

8 This aspect was developed in discussion with Prof. Partha Dasgupta at a SANDEE Research & Training workshop.

9 See the parallel discussion in document WIPO/GRTKF/IC/3/8, from paragraph 12.

10 Note by the Executive Secretary, Traditional Knowledge and Biological Diversity, (UNEP/CBD/TKBD/1/2), paragraph 85.

11 Commission on Intellectual Property Rights, 2002.

12 Menell, 2000.

13 Responses provided by countries contained in WIPO document WIPO/GRTKF/IC/3/7, 2002 (b).

14 Compiled from WIPO document WIPO/GRTKF/IC/3/7, 2002 (b) and Report of the Commission of Intellectual Property Rights, 'Integrating Intellectual property Rights and Development Policy', 2002.

15 Source: www.biodiv.org/decisions/default.asp?lg=0&m=cop-06&d=24

16 For details of these cases, see WIPO Document, WIPO/GRTKF/IC/5/INF/2, 2003.

17 See for instance, Pearce and Moran, 1994, Simpson et al., 1996.

18 See recent studies by Rausser and Small, 2000; Pushpakumara et al., 2002; Kumar, 2002.

19 Sinha, 'Initiatives of the NIF', Excerpts from the Proceedings of Workshop on Traditional Knowledge – Appreciation for Policy Making, New Delhi, 2002.

20 Scotchmer 1999; O'Donoghue, Scotchmer and Thisse 1998

21 I am thankful to Prof. Kanchan Chopra for a very useful discussion on this section.

22 The scientists of the Tropical Botanic Garden and Research Institute (TBGRI), Kerala learnt of the medicinal properties of the plant from the two Kani tribe members who were acting as guides to their team during an expedition in the forests. For details, see Anuradha, 1998 and Gupta, 2002.

23 The members of the Kani Tribes live in the forests of the Thiruvananthapuram district of Kerala, South India. Their current population is estimated to be around 18,000.

24 The formulations contained in the database can be presently decodified in English, Hindi, German, French Japanese and Spanish.

25 For a detailed discussion on issues relating to protection of databases, see Maurer 1999.

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