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Commercialization of Research and Technology

**Nicholas G. Kalaitzandonakes
Department of Agricultural Economics
University of Missouri**

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Foreword

Since Congress established the Development Fund for Africa (DFA) in 1987, the U.S. Agency for International Development (USAID) has been challenged to scrutinize the effectiveness and impact of its projects in Africa and make needed adjustments to improve its development assistance programs. Structural Adjustment programs have been adopted by many sub-Saharan African countries — often with reluctance — and some significant economic development progress has been made.

As donor agencies face severe cutbacks and restructuring, and less assistance becomes available to developing countries (not just in sub-Saharan Africa), new ways must be found to channel declining resources to new institutions their most effective and productive uses. Donor agencies like USAID, therefore, are increasingly looking to institutional arrangements in the agriculture and natural resources management sectors to sharpen competitiveness, with agriculture as the dominant sector of sub-Saharan African economies and the potential catalyst for generating broad-based, sustainable economic growth.

The USAID Africa Bureau's Office of Sustainable Development, Productive Sector Growth and Environment Division (AFR/SD/PSGE) has been analyzing the Agency's approach to the agricultural sector in light of the DFA and recent experiences of sub-Saharan African countries. This publication reflects some of these efforts.

This publication is part of a Sustainable Finance Initiative (SFI) Series.* The intent of this publication series is to make information and lessons more broadly available regarding innovative financing mechanisms and sources. The audience for the SFI series is practitioners in Africa, including USAID Field Missions, African organizations attempting to develop new mechanisms, African funding agents,

and other donors, as well as firms and individuals providing technical assistance to these groups.

The SFI makes available, in traditional print form as well as electronic versions, this publication as well as several others. The primary purpose of this series is to provide those interested in sustainable finance with a set of information resources that:

- describes the principles and tools of sustainable finance;
- provides up to date examination of case examples of sustainable finance;
- reports on meetings that discuss sustainable finance; and
- presents SFI program activities and results.

The SFI is a joint effort of the World Bank, USAID, and two multi-donor bodies — the Special Program for African Agricultural Research (SPAAR) and the Multi-Donor Secretariat (MDS). The SFI aims to help build capacity through focusing on African agriculture and natural resource management agencies. The SFI works with these African agencies to help create new — and more sustainable — mechanisms and sources of funding for national needs and initiatives.

To make this publication series most effective, the documents are written not only to accommodate the point of view of the African institutions undertaking sustainable finance programs, but also from the viewpoint of governments, potential funders, and other stakeholders. Thus these publications can be used as part of the efforts of agriculture and natural resources management unsteadiness to build coalitions and to inform stakeholders about the "art of the possible" in sustainable finance.

David A. Atwood, Chief
Productive Sector Growth and Environment Division
Office of Sustainable Development
Bureau for Africa
U.S. Agency for International Development

* A list of the anticipated publications in this series can be found on the inside front cover of this report.

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Executive Summary

Researchers and administrators of African Agricultural Research & Natural Resource Management (AR/NRM) are increasingly confronted with the challenge of financing agricultural research under tight fiscal realities and declining aid from donors. As such, commercialization of research and technology is being examined as one alternative source of funding. The most apparent benefit from commercialization is the generation of funds from user fees that can be funneled back into research and technology transfer activities. The benefits from commercialization, however, extend beyond direct financial gains. Research and technology transfer organizations that are more “commercially minded” are more sensitive to demand-pull rather than science-push forces. “Demand-pull” tends to improve technology transfer and overall efficiency in operations.

The potential benefit to the process of technology transfer are not without potential costs. Under commercialization, social groups with little or no commercial orientation could be under-represented in the design of public R&D and technology transfer agenda. Under representation would be unacceptable in the case of Africa and many other LDCs where subsistence farmers dominate agriculture. Furthermore, commercialization of research and technology by public institutions could act as a substitute for private research and transfer activities, effectively leading to socially suboptimal levels of research and technology transfer.

This handbook provides information designed to assist decision-makers to choose and properly manage one or more commercialization schemes if commercialization is deemed relevant and possible. A premise of the handbook is that institutional barriers are the most important block to successful commercialization. Such barriers

reflect inherent difficulties in replicating, adapting and transferring technical knowledge across individuals, organizations, cultures, institutions, and geographical locations.

Public research and technology transfer organizations that consider commercialization of research and technology as a way to sustain their operations will have to learn how to create value from activities that reduce informational gaps in technology transfer. Several case studies presented in this handbook provide examples of such activities used by public technology transfer organizations and technology brokers to capture value in technology markets.

Independent status is necessary for public organizations considering commercialization. The ability of governmental organizations to negotiate and enforce contracts and intellectual property rights, an essential part of commercialization, is typically limited. An appropriate accounting system is also essential and is most often missing from African public research and technology transfer organizations. Pricing of technology products and services and cost allocations among various research and technology transfer activities are not facilitated in the absence of such a well-developed accounting system.

Organizations that are interested in commercialization should be prepared for a prolonged adjustment process. It is unlikely that substantial funds can be generated in the short-run. Slow changing cultures, long gestation periods in the R&D and transfer process, lack of crucial organization knowledge, insufficient enforcement of intellectual property rights and slowly changing relationships between public and private sector are all impediments to quick returns from commercialization.

Glossary of Abbreviations and Acronyms

ARCH	Argone Chicago Development Corporation
ARIPO	African Regional Industrial Property Organization
AR/NRM	African Agricultural Research & Natural Resource Management
BTG	British Technology Group
CETP	Continuing education and training programs
EMBRAPA	Brazilian Agricultural Research Organization
EPC	European Patent Convention
EPO	European Patent Office
EU	European Union
FAO	United Nations Food and Agricultural Organization
FHIA	Fundacion Hondurena de Investigacion
GATT	General Agreement for Trade and Tariff
INBio	Instituito Nacional de Biodiversidad
IPR	International property rights
ISAAA	International Service for the Acquisition of Agri-biotechnology Applications
KARI	Kenya Agricultural Research Institute
LDC	Less developed country
MDC	Moderate developed country
OAPI	Organization Africane de la Propriete Intellectuelle
ODC	Oserian Development Company
PBR	Plant breeders' rights
PC	Paris Convention
PCT	Patent Cooperation Treaty
PRO	Public and non-profit agricultural research and technology transfer organization
RCT	Research Corporation Technologies
SFI	Sustainable Financing Initiative

UPOV International Convention of the Protection of New Variety
USAID United States Agency for International Development
WIPO World Intellectual Property Organization

1. How to Use This Handbook

WHAT IS THE PURPOSE OF THIS HANDBOOK?

The purpose of this handbook is to assist decision-makers in their efforts to:

- assess whether commercialization of agricultural technology is relevant to a particular public technology transfer organization in Africa for a given set of economic, institutional, technical, and organizational conditions;
- choose and properly manage one or more appropriate commercialization schemes, if commercialization is deemed relevant and possible;
- assess the adjustments in institutional, organizational, and economic conditions that must be realized if commercialization is currently not possible but it is desirable in the future.

In this direction, the handbook answers the following key questions: (a) what is the purpose of and benefits from commercialization; (b) what are the general principles for effectively managing commercialization of agricultural technology; (c) what commercialization schemes are available; (d) what are the specific management issues likely to arise for each commercialization scheme and how should they be appropriately dealt with.

WHO CAN USE THIS HANDBOOK?

This handbook has been written primarily for individual researchers and administrators of African (and other developing region) agricultural research systems. As both researchers and administrators confront the challenge of financing agricultural

research and technology transfer under tight fiscal realities and declining aid from donors, commercialization should be examined as one alternative source of funding. Government officials and donors may also find the handbook of interest as they consider their potential funding contributions to agricultural research and technology transfer in areas that are strategically important to the overall sustainable development of African countries but show little promise for commercialization.

WHAT IS IN THIS HANDBOOK?

Part II provides background information on commercialization. It reviews the circumstances under which commercialization is possible, especially as it pertains to public agricultural research and technology transfer institutions, and examines associated benefits and costs.

Part III develops a framework for managing research and technology transfer. The typical stages of technology transfer are reviewed and underlying factors that influence success are identified. Practical rules for management are provided, especially as they pertain to commercialization.

Part IV identifies the main aspects of managing intellectual property rights, an integral element of commercialization.

Part V enumerates various commercialization schemes and identifies management issues likely to arise in each commercialization scheme. Case studies, primarily from developing countries, are used to demonstrate that such management issues may arise and tie-in the rules for successful technology transfer management developed in Part III.

Part VI develops the notion of technology brokers and intermediaries and reviews their role in facilitating commercialization in underdeveloped technology markets. Case studies of technology brokers describe their functions and illustrate key conditions for commercially successful technology transfer.

Part VII provides some concluding comments about the relevance, applicability, and potential commercialization for African countries as a means of financing agricultural research and technology transfer. It should be noted that, depending on the reader's interest, most parts of this handbook can be studied independently.

2. The Case for Commercialization

WHAT IS COMMERCIALIZATION?

Commercialization of technology involves any possible configuration or scheme that allows those who invest in technological innovation (inventors, research systems, private firms and others) to capture some of the economic benefits generated by their innovation. Patent licensing, research grants and contracts, R&D joint ventures, and technical services for a fee, are all examples of commercialization schemes. The focus of this handbook is on **Public and non-profit agricultural Research and technology transfer Organizations (PROs)** and their ability to appropriate economic benefits from the end-users of their technology. This “user-pays” approach can raise funds for sustaining research, development and technology transfer services and for that reason commercialization is part of the Sustainable Financing Initiative (SFI). Compared to most other SFI alternatives, however, commercialization is less focused in the sense that it is an on-going process which involves numerous diverse activities. As a result it may be a less stable funding source since demand for technology transfer services must be continuously secured. However as it is suggested below, the benefits from commercialization are not exhausted in the sourcing funds. Commercialization can also improve the efficiency of developing and transferring technology. Such efficiency gains can be significant and can also assist the long term sustainability of R&D and technology transfer operations of PROs.

IS COMMERCIALIZATION POSSIBLE?

A typical argument about why commercialization of technology may not be possible or efficient is that technical knowledge is a classic public good.

That is, (a) it is non-rival in its consumption (i.e., one’s consumption of technical knowledge does not reduce its availability to others); (b) the cost of making another unit available is trivial; and (c) the cost of exclusion of non-payers is very high. Under such conditions, users often find it difficult to appropriate benefits from technical knowledge and they are not willing to pay for it. Some of these assumptions, however, are often exaggerated. The costs of producing an additional unit of technical knowledge are, in many cases, substantial. For example, extension and technical training are services designed to reproduce and disseminate technical know-how among diverse audiences. As demands increase for sharing know-how, bottlenecks can occur in the form of overextended scientists and extension agents. This is because know-how is not simply embodied in a blueprint. Human factor is also important. Thus, the costs of offering additional units of such services beyond a certain threshold are non-trivial.

Similarly, excludability of non-payers is in many cases possible. Individual and organizational technical knowledge is often tacit in nature. It is accumulated through experience and is not explicitly described or elaborated in print. Acquisition and/or reproduction of such knowledge involves costs that are often significant. In other cases, technology is embodied in products which are difficult to imitate. In such cases, exclusion is easier than usually assumed. Protection of intellectual property through patents, copyright, plant breeders’ rights and others affords owners of technical knowledge further exclusion of free riders. As the costs of making an additional unit of technical knowledge available increases and exclusion of non-payers becomes possible, an effective demand for technical knowledge is formed and opportunities for commercialization arise. Testimonial of the existence of such market

opportunities is provided by the increasing number of technology consultants, private technology transfer organizations, and technology brokers that are involved in the commercialization of technical knowledge today.

ARE PUBLIC ORGANIZATIONS WELL-SUITED FOR COMMERCIALIZATION?

If market opportunities for appropriating technology benefits from end-users exist, the natural question that arises is whether PROs are well positioned to capitalize on such opportunities. Currently, most PROs are not well positioned to commercialize technology. Lack of personal and organizational knowledge of basic commercialization principles, as well as existing culture, incentives and delivery systems are all impediments to commercialization. Most PROs are staffed with scientists and technologists who have spent a good part of their professional careers delivering science in the public domain for societal use and benefit. This “science-push” process of knowledge generation is often considered complete as soon as knowledge has become public (through publications, lectures etc). Thus, most research projects are terminated at proof of concept. Incentive systems are based on disciplinary achievement and peer recognition rather than use and implementation of scientific knowledge. Due to these traditions, PROs normally lack specialized expertise on commercializing technology or developing demand for technical knowledge. Furthermore, moving away from the culture of non-proprietary technology requires a shift in paradigm, and such shift can generate individual and organizational resistance.

Private industry is also reticent about dealing with public organizations. Such attitudes are caused in part by experience in dealing with government as an adversary (e.g. regulatory matters). In other cases negative attitude is due to past experience with government bureaucracies, or can be due to a “corrupt government” perception.

Under such circumstances, significant barriers to communication and commercialization exist.

Some of the barriers to commercialization can be removed through appropriate revision of the incentive system and policies of PROs. Training programs can be used to educate existing personnel on the merits and techniques of commercialization. Use of specialized expertise in commercial technology transfer may also be appropriate. The point that needs to be clarified here is that while PROs are currently not well suited for commercialization, they can become suited. However, the level of commitment to the spirit of commercialization is important. Accumulated experience suggests that organizations attempting to commercialize at the margin do not usually enjoy substantial financial benefits from their ventures.

POTENTIAL BENEFITS FROM COMMERCIALIZATION

The most apparent benefit from commercialization is the generation of funds from user fees that can be funneled back into research and technology transfer activities. Assuming that the costs of commercialization are consistently surpassed by associated revenue, PROs will enjoy a financial inflow which can be used to sustain their operations.

A direct financial gain, however, is only one of the benefits. Commercialization tends to impose market discipline on the research agenda of individual researchers and the organization as a whole. Energy must be spent in examining market conditions, and identifying potential applications and clientele. The pure exercise of economic reasoning and justification of proposed research projects has been found to increase the effectiveness of R&D in private companies and public research organizations in terms of research output and posterior commercial success.

The relevance and effectiveness of PROs’ research agendas will also benefit from

commercialization by way of increased information inflow/ outflow. Frequent contact with end-users, necessitated by commercialization, uncovers technical needs and give rise to additional researchable projects. As a result, lags associated with problem identification are reduced. Similarly, research priorities have become more sensitive to demand-pull rather than science-push forces. Thus, technologies developed are more in tune with the immediate needs of end-users. Furthermore, end-users have a better appreciation of the relevance and potential benefits of the technology as they have greater input in its creation and dissemination. Under such circumstances technologies are adopted faster and to a greater extent, thus having a greater impact on the economy.

POTENTIAL COSTS ASSOCIATED WITH COMMERCIALIZATION

An issue that deserves special attention when considering commercialization is that of research agenda balance. Under commercialization, social groups or commodities with little or no commercial emphasis could be under-represented. This would be unacceptable in the case of Africa and many other LDCs where subsistence farmer s represent a large part of the farming sector. Clearly, governments and donors have the ability to remove such biases by contributing funds for

research and technology transfer targeting specifically non-commercial farmers and “orphan” commodities. Furthermore, full-cost recovery pricing policies for commercial research and technology transfer can be used so that scarce resources are not taken away from research on commodities with non-commercial emphasis.

Another potential cost from commercialization is a possible crowding-out of private R&D which could result in socially suboptimal levels of overall R&D and technology transfer. Traditionally, public R&D has been complementary to private R&D due to the traditional emphasis of public R&D in risky basic research. Commercialization of technology transfer by PROs, however, could act as a substitute for private R&D and technology transfer activities.

Finally, emphasis on commercialization usually implies emphasis in applied and adaptive instead of basic research. It is possible that substitution of adaptive for basic research could result in long run productivity losses as a consequence of lack of scientific and technical advancement. However, such losses are likely to be more relevant to research systems that are close to the frontier of science and technology. For many African PROs, emphasis on adaptive research could in fact be beneficial as much existing knowledge could be adapted and transferred at costs far lower than those necessary for basic research.

3. Technology Transfer: A Framework

In this section, a conceptual framework is developed to describe the dynamics of technology transfer and provide consistent rules for effective management and commercialization.* PROs that hope to develop an effective commercialization program will have to actively manage technology transfer so that the true technical needs of end-users are identified and relevant technical solutions are developed and delivered.

BACKGROUND AND BASIC CONCEPTS

The dominant paradigm of agricultural technology transfer assumes that where scope for an economically beneficial technology transfer exists, such a transfer will in fact occur. Implicit to this paradigm are several rather unrealistic assumptions. First, it is implicitly assumed that both PROs and the end-user possess full information. PROs are assumed to know exactly what the technical needs of the end-user are and the necessary technical solutions to address them. Similarly, the end-user is assumed to fully understand and appreciate the benefits of the new technology. In practice however, information is, in most cases, incomplete and asymmetric. Technical needs are not always well-known or understood. Technical solutions are also not equally well understood and fully appreciated. Informational asymmetries tend to increase uncertainty and hamper the transfer of technology. Actions that facilitate the flow of information from the end-user to the research organization and back tend to increase the likelihood of an effective technology transfer, but they are costly.

* Technology transfer is broadly interpreted here to include research, development, delivery, and use of technical knowledge.

Second, it is implicitly assumed that knowledge is readily accessible and transferable. This blueprint view of technology tends to emphasize the physical matter (e.g., material, substance, and instrument array) part of technology and isolate it from its human element. However, specialized know-how is embodied in humans that produce, operate, and organize technical knowledge. This specialized know-how is often tacit and complete transfer can be achieved only through effective, and in most cases costly, coordination and cooperation between the source and the end-user of the technology.

The basic premise of the framework presented here is that technology transfer is inhibited primarily by informational and knowledge barriers. They reflect inherent difficulties in replicating, adapting, and transferring tacit knowledge across individuals, organizations, cultures, institutions, and geographical locations. Successful management of the technology transfer process involves dealing intelligently with informational barriers and associated uncertainties.

THE DYNAMICS OF TECHNOLOGY TRANSFER

Technology transfer involves three separate phases: (a) opportunity recognition, (b) technology design and generation, and (c) delivery and adoption. Such phases are illustrated in figure 1.

Opportunity Recognition

In this first phase, a need or opportunity for implementation of new technology is identified.**

** The term new technology is used to indicate technology that is new for a particular geographical and

A variety of factors generate opportunities for creation and use of new technology including:

- random occurrences (e.g. a disease outbreak);
- changes in demographics or consumer tastes and attitudes;
- changes in the institutional and regulatory environment;
- advancement in science.

A need/opportunity for implementation of new technology may be recognized and articulated by the end-user (a “demand-pull” situation). Alternatively, a perceived need/opportunity for technology may be articulated by the PRO or the research establishment at large (a “science-push” situation). In this latter case, technology may first be generated and suitable end-users may subsequently be searched for.

Factors that: (a) enhance awareness about the state of the technology-in-use *vis à vis* the state of the art; (b) facilitate the flow of information between the PRO and the end-user; and (c) create pressures for change and innovation tend to improve opportunity recognition. Some of these factors are intrinsic to the end-user and the PRO. For example, entrepreneurial and well informed managers of private firms recognize opportunities for new technologies early on and actively pursue them. Similarly, technology transfer organizations with extensive scientific expertise and in-depth knowledge of the production/distribution systems of potential end-users are likely to readily identify opportunities for technical change as they arise.

Organizational and institutional factors that improve communication between the PRO and the end-user can also facilitate opportunity recognition. For example, cooperatives and producer associations tend to create forums where technical

social setting. It is inclusive of (a) existing technology that may be transferred unchanged to the locale of interest, (b) existing technology adapted to the conditions of the locale of interest, or (c) entirely new technology.

needs/ opportunities are more readily identified, communicated and empowered. Similarly, technology transfer organizations with focused clientele (e.g., commodity research groups) enjoy relatively swift information flows which assist opportunity identification. Competitive market forces, environmental regulation, or compelling societal needs are examples of exogenous pressures that may stimulate active pursue of new technologies and improve opportunity recognition.

Technology Design and Generation

Of course, not all identified opportunities are equally important. The significance of any opportunity identified is in effect determined by the implied degree of technical advancement and socioeconomic impact. The potential impact on such factors as food security, employment, foreign exchange earning capacity, and growth of GDP typically determine the importance of any identified opportunity for technical advancement. Non economic factors, such as the political clout of the end-user, may also impact the importance attached to an identified opportunity.

The aggregate effect of all the factors that influence the process of opportunity identification is expressed by the strength of the signal that arrives at the PRO. Clearly, many different identified opportunities are communicated to, or articulated by, the PRO competing for scarce research and transfer resources. The stronger signals indicate greater opportunity. However, the final decision to turn an identified opportunity into a research project lies within the technology transfer organization. As a result, the organization’s culture and value system will influence this decision.

The value systems of research and technology transfer organizations are typically quite complex. Researchers and administrators tend to be motivated by, among other things: personal and institutional recognition (usually manifested by publications, individual vitae, and institutional prestige); personal and institutional profiting (through salaries, consulting, grants, and

contracts); institutional mandate; scientific curiosity; stewardship to natural resources; and altruism. Hence, any of these factors, especially those nurtured by the culture of the organization, may have a substantial impact on which identified opportunity becomes a research project.

After the decision to proceed with a particular opportunity has been made, designing and generating a technical solution completes the second phase. The constraints and capabilities of the PRO are important in designing and generating a fitting technical solution to the opportunity originally identified. Such constraints include:

- individual and organizational expertise;
- R&D infrastructure;
- organizational forms.

As technology has become increasingly science-based, maintaining sufficient individual and institutional expertise and R&D infrastructure (e.g., labs, computing power) is paramount to research and development capacity. The ways physical and human research resources are organized (e.g., by product, process, and discipline) are also important. While no single organization form is dominant under all circumstances, it is well established that organizational forms can have substantial impact on the R&D and delivery capacity of technology transfer organizations. The second phase is complete when the new technology has been produced and is ready for delivery to the end-user.

Delivery and Adoption

The third phase of technology transfer involves the delivery of the technology and its adoption by the end-user. The relevance of the technology to the end-user's needs is an important determining factor of adoption. New technologies that address real problems are usually well received by end-users. Conformity of the new technology with the end-user's constraints and capabilities is equal important.

Constraints and capabilities which define the capacity of the recipient to use the new technology include:

- management abilities;
- own resource base (e.g., degree of capitalization, labor availability);
- public infrastructure;
- supporting institutions (e.g., markets, credit availability) ;
- culture and traditions;
- collateral assets.

Compatibility of the new technology with existing resource base, public and private infrastructure, culture and supporting institutions reduces the possibility of bottlenecks in implementation and hence it increases the potential of adoption. Collateral assets tend to have a similar impact. Collateral assets are physical and non-physical assets which in reference to a specific technology act as complementary or supporting assets. For example, new technologies that make use of tools and implements already owned by the end-user and a set of skills that requires little adjustment are likely to be well received as they imply little change in the user's production paradigm (i.e., habits, knowledge base etc). On the other hand, technical innovations that require complete change in the skill set and render owned resources obsolete are likely to be met with resistance.

Even when the potential benefits from the new technology are well-understood and appreciated by the end-user, however, the important task of effectively delivering the new technology still remains. A variety of modes and mechanisms can be used to deliver new technology at varying costs and degree of effectiveness. These include:

- Passive dissemination of information
 - technical reports
 - news releases
 - journal articles
 - fact sheets, etc.
- Active dissemination of information

- workshops and seminars
- continuing education
- extension services
- Licensing of technology
- Personnel transfers and exchanges
 - staff transfers
 - staff consulting
- Collaborative research and development
 - cooperative R&D
 - R&D contracts
- Advisory groups
 - technical review groups
 - advisory boards

The varying degree of effectiveness of these mechanisms is due to the tacit nature of technical knowledge. Certain delivery mechanisms can facilitate the way in which people communicate, work together, and learn from each other. Active one-on-one communication is generally superior to passive delivery of information. Furthermore, mechanisms that allow end-user intervention in the design and generation phase (e.g., cooperative R&D and advisory groups) not only facilitate communication but they also improve the relevance of the generated technology.

In addition to costs and effectiveness considerations, various other factors influence the choice of transfer mode, including:

- technology transfer infrastructure;
- incentive and value system of the organization;
- institutions.

Organizations with well-established technology transfer traditions and infrastructure (e.g., extension system) are better suited for active delivery. The value system of the organization is also an important determinant of the choice of delivery mechanism. For example, organizations emphasizing proof of concept and publication in disciplinary journals are likely to opt for passive information dissemination modes. Finally,

institutions can be instrumental in the choice of delivery mode. For example, existence and enforcement of intellectual property laws open up modes of delivery otherwise not available (e.g., licensing).

UNCERTAINTY AND TECHNOLOGY TRANSFER MANAGEMENT

Adequate information exchange between the PRO and end-users in all three phases is critical for effective technology transfer. In an uncertain world, both the PRO and the end-user possess incomplete and asymmetric information while information exchange between them is less than perfect. Information inadequacies create a variety of risks and uncertainties, becoming the main barrier to technology transfer. The following types of uncertainty are of concern: (a) primary, (b) secondary, and (c) behavioral.

Primary uncertainty is a state-contingent type that arises from random acts of nature and unpredictable changes in consumer preferences and market conditions. It includes input and output price uncertainty, output (yield) uncertainty due to weather variation, and technical uncertainty which is always present in the inherently risky process of research. Secondary uncertainty arises from lack of communication as one decision-maker oftentimes has no knowledge of concurrent decisions made by others. Thus, information incompleteness and asymmetries tend to add to such uncertainty. Secondary uncertainty, however, is an “innocent” kind. Behavioral uncertainty on the other hand involves calculated non-disclosure, disguise, or distortion of information. This class of uncertainty is more prevalent when transacting parties are joined in a bilateral dependency.

Individual scientists in technology transfer organizations are generally exposed to all three types of uncertainty. Research and development of new technology are inherently risky processes subjecting scientists to primary uncertainty. Secondary uncertainty arises from the scientists’

lack of understanding regarding technical needs and capabilities of potential end-users and clientele groups. Finally, philosophical differences and interpersonal conflicts among scientists or between scientists and clientele groups obstruct cooperation and coordination and generate behavioral uncertainty.

Scientists may attempt to manage secondary and behavioral uncertainties by devoting much of their energy to disciplinary research. Disciplinary associations and journals then become their main clientele. The response is perfectly rational. Secondary uncertainties are reduced by producing research output for a “clientele” whose priorities are better understood by the scientists. Behavioral uncertainties are also reduced since professional stature is generally improved through disciplinary achievement allowing the scientist to deal with intra- or inter-organizational conflict from a position of greater strength.

In a typical technology transfer process, the end-user is also exposed to all three types of uncertainty. Specifically, the end-user is almost invariably exposed to price and output uncertainties. Adoption of a new technology usually implies secondary uncertainty as well. Lack of understanding of the performance and benefits of the new technology is quite common. Production uncertainty may also increase in the short run until, through learning by doing, new knowledge base is developed by the end-user. In some cases, there is even lack of understanding as to what the need or opportunity the new technology is supposed to address. All such informational deficiencies add up to secondary uncertainty. Further compounding the riskiness of technology transfer is behavioral uncertainty. “What do they know...” and “...they don’t understand my situation...” type of attitudes are typical expressions of mistrust and suspicion toward the technology transfer process or the PRO.

In many cases the sum of primary, secondary, and behavioral uncertainty can completely paralyze the technology adoption process. The risk averse end-user will not adopt the new technology despite

its potential economic benefits thus, (rationally) accepting lower expected returns for lower risks.

Active management of the technology transfer process by a PRO involves dealing intelligently with uncertainty. In many cases, primary uncertainty cannot be eliminated or even reduced since it is inherent in the system and unpredictable. Secondary and behavioral uncertainty can be limited, however, by increasing the flow of information between the source and the end-user while encouraging coordination and cooperation in all three phases. The following basic principles for reducing secondary and behavioral uncertainties generally apply:

- maximize contact between the source and the end-user under appropriate conditions so that information about needs and opportunities is shared, mutual understanding is increased, and trust is established;
- minimize the distance between the technology the source can deliver and the technology the end-user needs so that associated value and benefits are easily understood and appreciated.

A variety of organizational forms and incentives may be used by PROs to maximize informational flows and produce technologies more in tune with end-user needs. Examples of organizational forms of interest include:

- use of scientific and industry advisory boards to maximize inflow of information regarding science and user needs;
- participation of influential individuals from interested organizations (unions, cooperatives, industry associations, etc.) in the technology design process;
- use of technology champions and brokers to actively manage linkages between the organization and potential end-users.

Incentives and associated policies are equally important for encouraging individual and organizational behavior to maximize contact with end-users and technology transfer. Examples of incentives include:

- reward association with clientele groups;
- reward effective team work in addition to superior individual achievement;
- reward transfer and use of technology rather than proof of concept;
- institutionalize rigorous project review and selection process;
- institutionalize the need for market analysis and boundaries of acceptable solutions for proposed research projects.

Establishing clear policies which clarify conflict of interest and acceptable practices as well as a clear reward system reduces secondary and behavioral uncertainty within the organization. As such, it is paramount to effective management of technology transfer.

IMPLICATIONS FOR COMMERCIALIZATION

Under commercialization, securing willingness to pay for technology generation and transfer becomes an important discriminating criterion of opportunity identification, project selection, and delivery mode. In essence, some of the control over the direction of science and technology is relinquished from the PRO to market forces and ultimately to (paying) end-users.

For the end-user, willingness to pay for technology transfer is determined in a fashion similar to any other uncertain investment. For the investment to be economically relevant, the expected return from such investment must be at least equal to a “normal rate” plus a premium that compensates for uncertainty. For promising technical innovations expected profitability can be easily demonstrated. Commitment of funds by the end-user is not guaranteed, however, simply on the basis of high expected profits. The sum of primary, secondary, and behavioral uncertainties faced by the end-user is also important in determining the economic relevance of investment in the new technology. The higher total uncertainty is the higher the required risk premium of investment will be, thus effectively making fewer transfers of

technology economically relevant. Hence, PROs who generate and deliver technology in tune with the needs of potential end-users, and, actively manage uncertainty in all three phases of the technology transfer process are likely to enjoy greater success in commercialization.

PROs who choose to make the transition towards commercialization will be well-served by encouraging interaction and cooperation between their personnel and potential clientele groups. Entrepreneurship among scientists should be coached and promoted while their time should be safeguarded from additional demands associated with commercially-oriented technology transfer. Commercialization increases the level and range of activities in which a technology transfer organization is typically involved. Legal, marketing, and financing activities substantially expand with commercialization. Marketing activities are primarily intended to make the existence of technologies available for transfer known and to demonstrate their value to potential end-users. Hence, their primary purpose is to reduce uncertainty, by means of increased information, and secure interest for technology transfer. Typical marketing activities include:

- evaluation of technical and economic benefits of technologies for transfer;
- search and identification of potential end-users;
- development of promotional material;
- direct or indirect contact with potential end-users.

Financing of technology transfer becomes more complex with commercialization as the financial instruments become more diverse. Grants, contracts, user fees, royalties, profit sharing and other forms of financing commercial technology transfer require additional accounting, data handling and clerical services as well as increased management sophistication.

Legal activities are also broadened with commercialization of technology transfer. The focal points of such activities are securing,

administering, and allocating intellectual property. Legal activities are intended to reduce uncertainty by delineating property rights and associated benefit allocation for all parties involved in the transfer of technology. Typical legal activities of technology transfer organizations with commercial emphasis are:

- technology evaluation and application for intellectual property rights;
- negotiation and administration of licensing agreements;
- negotiation of research contracts and allocation of intellectual property;
- dispute resolution over ownership of intellectual property and infringement;
- liability management.

Increased legal, marketing and financing activities require additional coordination and management and translate into increased

transaction costs. While most benefits from commercialization accrue to the technology transfer organizations, a large part of the associated transaction costs are sustained by individual scientists. Commercialization involves additional demands on their time both in the form of additional activities but also in the form of training and development of new skills not previously required. Thus, provision of adequate professional marketing, legal, clerical, and other support services may be used to minimize personal transaction costs. Mechanisms that redistribute part of the benefits from commercialization to individual scientists may also be introduced to balance personal transaction costs. If individual costs and benefits within technology transfer organizations are not appropriately managed, employees will remain disinterested, or even negative, toward commercial-ization and any such efforts are bound to fail.

4. Management of Intellectual Property

IPR IN AGRICULTURE: What Are They, and Why Do They Exist

Intellectual property rights (IPR) are legal monopolies offered by national governments for a limited time to provide protection to those who incur research costs and expend effort in innovative activity. IPR are offered to reward and encourage investment in technical innovation. In general, the bulk of the benefits from technical innovation accrue to the technology users rather than the inventors. Thus, national governments tend to encourage inventive activities as a matter of policy. IPR allow those investing in such activities the exclusion of free riders and, in turn, improve their chances for capturing some of the economic benefits. In this way, further investment in technical innovation is encouraged. The IPR system also encourages disclosure of invention thus effectively assisting incremental development of technology.

Two types of IPR are of primary interest in agriculture: (a) utility patents and (b) breeders' rights. They constitute the main forms of property rights for products of agricultural and biological research.* A patent is a grant of a property right to

* In the U.S., an additional form of IPR is available to asexually reproducing plants through plant patents. Protection extended through plant patents lasts 17 years but it is usually more limited in scope than that secured by utility patents. Other forms of intellectual property rights that may be of interest in agriculture include petty patents for small mechanical inventions and trade secrets. Trade secrets are not covered in this handbook since they are not relevant to public research organizations. Such form of IPR is used primarily by private businesses with own production capabilities which can safeguard intellectual property and technical

the inventor allowing exclusion of others from using, making or selling a particular invention. This monopoly right is granted for 20 years from the filing date of a patent application. A patent is a national right. Ownership of a patent in one country does not extend protection in another. At this time, there is no uniform international patent system and as a result differences in the legal requirements and interpretation of the law are encountered from one country to another. Treaties and international conventions, however, provide a common basis for national laws. Furthermore, international agreements provide a network by which patent application filings for multiple countries are facilitated. The most important international treaties are:

- Paris Convention for the Protection of Industrial Property (1883, revised 1967)
- Patent Cooperation Treaty (1970)
- European Patent Convention (1973)
- Organization Africaine de la Propriete Intellectuelle (1977)
- African Regional Intellectual Property Organization (1962, revised 1976)
- Budapest Treaty for Deposit of Living Organisms (1977)

Ultimately, a patent application must be filed in every country that protection is pursued.

Plant Breeders' Rights (PBR) are patent-like rights extended to new sexually reproducing plants. A certificate rather than a patent is offered to the breeder securing protection for 17-20 years. PBR were instituted in many developed countries to encourage and provide protection to inventive activity in plant breeding. Substantive differences exist between patents and PBR both in terms of the

know-how from imitation.

scope of protection allowed and the limitations of the rights secured. PBR are more limited in scope. Furthermore, there are two exemptions that weaken PBR protection relative to that afforded by patents. The, so called, farmers' exemption permits farmers to save part of the harvested seed for future crops, and in the U.S. to even sell seed to neighboring farmers. The research exemption allows breeders to use protected material in their breeding efforts and seek PBR for the outcome as long as the protected material is not used repeatedly.

CURRENT INSTITUTIONAL ENVIRONMENT

In considering the potential and relevance of IPR in commercialization, it is beneficial to assess the institutional environment and associated opportunities and constraints. Laws and enforcement of IPR differ substantially from one country to another. An assessment of their status is not within the scope of this section. Of interest, however, are *changes* in IPR that have occurred in the last two decades and will likely shape the future of intellectual property and its exchange in the market place.

Patents Awarded to Living Organisms

Until 1977, patents were not applicable to "products of nature." A US Court of Customs and Appeals decision, however, allowed patents to be claimed for any new form or composition of life. The 1980 U.S. Supreme Court decision in the *Diamond vs Chakrabarty* case to honor the first patent extended to genetically engineered bacteria legitimized patenting of living organisms. In 1985, the US patent office granted the first patent to a plant while in 1988 a patent was awarded to genetically altered mice with increased susceptibility to cancer.

Similar developments were observed in the European Union (EU) over the same period. Despite provisions in article 53(b) of the European Patent Convention (EPC) that exclude plant and

animal varieties from patent coverage, the European Patent Office (EPO) awarded its first patent to a plant in 1989. The award was decided on the basis that the patented material was not considered to be a variety as defined by the Technical Board of Appeals. Genetically engineered mice were awarded a patent in 1992.

The driving force behind changes in patenting practices is biotechnology which has allowed genetic altering of life forms. As the biotechnology R&D race has heated up, claims have become increasingly broad. Agracetus, a U.S. biotechnology company, was awarded a U.S. patent on *all* genetically engineered cotton plants in 1992 and a European patent on *all* genetically engineered soybean plants in 1994. A similar broad patent for transgenic cotton plants was granted to Agracetus in India while similar patent applications are pending in Brazil and China.

Enhanced Plant Breeder's Rights

PBR was also strengthened in the last few years. The International Convention of the Protection of New Variety (UPOV) which administers PBR across a number of developed member countries revised its convention to strengthen PBR in 1991. The previously available breeder's exemption was eliminated in the case of an "essentially derived variety." This provision was designed to protect holders of PBR from appropriation by other breeders, especially biotechnology companies. Under this provision, a party that inserts a single gene into a variety protected by PBR will have to compensate the holder of the right in case where the new variety is marketed. The 1991 convention also extended the protection term of PBR from 15 to 20 years. Further, farmer's exemption—the right of farmers to save seed for future crops—became an optional exemption and was left to be decided by national laws in the country members.

Harmonization of International Intellectual Property Rights

In addition to the general strengthening of IPR for living organisms, harmonization of international

IPR has been pursued at different forums with varying degree of success. In 1984, the World Intellectual Property Organization (WIPO)—the United Nations’ agency that administers most international IPR treaties—initiated its attempt to harmonize certain provisions of national patent laws of several MDCs. Two items have been the focus of the harmonization effort: (a) the period for public disclosure allowed before filing for application and (b) the award of a patent to the “first to file” or “first to invent.” Such harmonization efforts have not been finalized.

For over six years the European Commission has also embarked in an effort to harmonize legislation on biotechnology patents in the EU. Until recently, differences still existed between the council of ministers which supports patenting practices and the European parliament that opposes them. The biotechnology industry has conceded to some conditions demanded by the parliament including a farmer exemption for genetically engineered seed.

Probably the most important efforts towards harmonization have been within the framework of bilateral and multilateral trade negotiations. MDCs were able to link IPR to international trade negotiations in the Uruguay round of GATT. Such a development was important because it linked LDCs’ access to international markets with improvements in IPR protection and enforcement. Furthermore, unlike other international IPR agreements, GATT provides dispute-settlement and enforcement mechanisms in case of violations. The following provisions of GATT are of interest in the present context:

- Member governments are obligated to provide patent coverage consistent with the substantive provisions of the 1967 Paris Convention. Further, a 20 year patent coverage is available to all inventions. Exclusion allowance is provided for plants and animals and essentially biological process for the production of plants and animals. Plant varieties must be protected, however, either by patents or by a *sui generis* system (such as the PBR provided in the

UPOV convention). Because of the last provision, PBR may serve as the minimum international standard in the protection of plants and hence the 1991 UPOV convention takes on greater significance.

- Member governments are obligated to provide procedures and remedies under their domestic law to ensure that IPR can be effectively enforced both by foreign right holders as well as nationals. The agreement provided for the establishment of a Council for Trade-Related Aspects of IPR to monitor the operation of the agreement and governments’ compliance. Disputes are to be handled under the integrated GATT dispute-settlement procedures as revised in the Uruguay Round.
- In terms of implementation the agreement envisaged a one-year transition period for developed countries to bring their legislation and practices into conformity. Developing countries were allowed a five-year transition period and least developed countries eleven years. Developing countries that did not provide patent protection at the time of the agreement were given ten years to introduce such protection. In the case of pharmaceutical and agricultural products, however, they must accept the filing of patent applications from the beginning of the transitional period and though the patent need not be granted until the end of this period, the novelty is preserved as of the date of filing. If authorization for the marketing of the relevant pharmaceutical or agricultural chemical is obtained during the transitional period, the developing country must offer a five-year exclusive marketing right or until a patent is granted, whichever is shorter.

In addition to the GATT agreement, the U.S. and, in few cases, the EU have used “strong arm” tactics to force LDCs to increase their coverage and enforcement of IPR. The Special 301 provisions of the 1988 U.S. Omnibus Trade Act allows retaliatory measures by the U.S. government in cases of IPR violations. China,

Brazil, India and Thailand were some of the countries targeted under these provisions in the past. While such tactics have been often viewed as infringement of national sovereignty by most LDCs, they have been effective in inducing

Property Rights over Plant Genetic Resources

The 1992 Biodiversity Treaty capped the international debate over the ownership of genetic resources that began by the creation of the United Nations' FAO Commission on Plant Genetic Resources in the early 1980s. The Commission's first achievement was the International Undertaking on Plant Genetic Resources in 1983. The concept underlying the Undertaking at that time was the "common heritage principle." Plant resources were considered heritage of the mankind and hence available without any restriction. This principle was interpreted to include special proprietary varieties and lines.

The Undertaking as later developed not only recognized breeder's rights but also two other concepts—national sovereignty and farmers' rights—which became central to the debate over the control and use of genetic resources. The first concept reflects the ideal that sovereign countries have legal ownership of the plant genetic resources found within their borders and hence they can exercise control over their acquisition and use. The concept of farmers' rights was developed to be symmetrical to PBR so that the contribution of indigenous farmers to the development and preservation of plant genetic resources is also recognized.

The 1992 Biodiversity Treaty endorsed the concept of national sovereignty and affirmed that states have the right to exploit their own plant genetic resources. Article 15 of the Treaty determines that access to genetic resources is within the jurisdiction of national governments and legislation. States are required to facilitate access to genetic resources but subject to "prior informed consent." The convention also provides that countries contributing genetic resources should

improvement in IPR legislation or a compromising stand in WIPO and GATT negotiations.

participate in research and development activities carried out with such resources and should share the benefits from commercialization. The Biodiversity Treaty is important because its provisions on national sovereignty, prior informed consent and participation in research and benefit sharing—while not new ideas in that they reflect the basic principles of the FAO Undertaking—are significant advances toward recognizing the interests of LDCs.

Sources and Implications of IPR Strengthening

While property rights for new life forms and genetic resources will continue to be discussed, *all* institutional adjustments that have taken place over the last two decades seem to be pointing towards the same direction: a general strengthening of IPR. The strengthening of IPR in recent years is not coincidental. It has been fueled by:

- the recognition of technological leadership as a primary competitive strategy both at the firm and national levels;
- substantial changes in technology markets characterized by shorter innovation cycles and an associated need for IPR for faster recovery of R&D expenditures;
- an increasing need for R&D collaboration and associated need of IPR for allocation of benefits among collaborating parties. R&D alliances are increasingly used as a strategy for keeping up with ever-increasing specialized scientific knowledge and sharing R&D risks and expenditures;
- an increasing number of technology stakeholders who support IPR protection including:

- public universities and government laboratories which view commercialization of technology as a means for replacing diminishing government funding;
- pharmaceutical, chemical and food processing firms that have found substantial complementarities between their basic operations and biotechnology.

As the number of technology stakeholders and their investment increase, IPR will likely further expand thus increasing the demand for research and technology and making opportunities for commercialization increasingly available.

WHEN SHOULD PROS BE INTERESTED IN IPR?

IPR are negative rights. They prevent use of a particular invention without the consent of the right holder. This implies that unless a practical and profitable use for the invention is identified by the IPR holder such rights yield no private financial benefit. Yet, they are costly to acquire and maintain. As a result, the decision to seek IPR is ultimately a *commercial* one. There should be little interest to secure a costly monopoly over a product or process that nobody is interested in.

When an invention is truly novel and could secure IPR, a series of questions should be answered to document commercial relevance of the resulting new technology before embarking in an IPR application process. The following questions may be posed:

- does the new technology have a substantial profitability advantage over existing technologies?
- is the expected market size for the new technology large or small?
- are there any alternative applications for the new technology?
- are layers of proprietary coverage possible?
- what is the expected economic life span of the new technology?

- is the need for the new technology well recognized among potential users?
- is the new technology easy to use?
- is the new technology compatible with existing skills and assets of potential users?
- does the new technology necessitate substantial capital investment in the initial experimentation stages?

Inventions leading to technologies with substantial profitability advantage and which cover large size or multiple markets possess potential for commercial success. Layers of proprietary protection (e.g., not only the product but also the production process is protectable) and long economic life span extend the value of an invention with commercial significance. Ease of use, low capital investment requirements at the initial utilization stages, and compatibility with existing skills and assets all tend to improve the possibilities of adoption and diffusion which in turn improve the commercial capacity of the new technology.

OWNERSHIP OF IPR

IPR belong to inventors. Accordingly, applications for IPR protection can be filed only by inventors or persons authorized by them. In the case of joint inventorship all inventors become owners of the IPR. Once IPR are granted, each owner can usually sell or assign the IPR to third parties without the consent of the co-owners.

In cases where the invention is developed by an employee of a PRO, the organization may have ownership rights over the invention. The conditions tend to vary from one country to another but typically PROs will have ownership claim over an employee's invention under the following conditions:

- if the employee was "hired to invent";
- when substantial resources of the PRO (facilities, funds, equipment, material, and information) were used in the course of the invention;

- if the employee supervised or directed work with R&D objectives.

Since such conditions are commonly subject to interpretation, many universities and government research organizations have adopted written policies requiring their employees to assign IPR ownership to them by signing appropriate forms. Pertinent laws of contracts govern such agreements. Often, as explicitly specified in such agreements, the employee-inventor may be entitled to a percentage of the income from marketing the invention or resulting technology.

External funding through an R&D grant or contract with a private third party may further complicate the issue of ownership of IPR. If no up front contractual agreement exists, negotiations between the third party and the PRO may be in order. Typically, however, ownership of IPR is resolved within the signed R&D contract.

Oftentimes visiting scientists participate in the research program of a PRO that may yield an invention which could secure IPR. Unless visiting scientists have signed an agreement similar to that signed by the employees of the PRO assigning ownership to the hosting organization, they or their employers may be entitled to ownership rights.

UTILITY PATENTS

Scope of Protection: What Is Patentable and What Is Not

In general, any man-made product, mechanism, composition of matter, and process for making products is subject to patent protection as long as they satisfy three basic conditions: novelty, utility, and nonobviousness. Exclusions to the scope of protection differ among various countries. In most cases, the following are not patentable:

- laws of nature;
- fundamental scientific principles, forces, or phenomena;
- mathematical formulae and algorithms;

- business ideas or methods;
- medical and surgical procedures;
- cooking recipes.

It is a general understanding among nations that ideas or formulas are not patentable. It is important to distinguish ideas from uses of these ideas. Only the latter are subject to patent protection.

In many countries, computer programs, chemicals and pharmaceutical products, food products, and living organisms, are excluded from protection. However, as indicated earlier, living forms that have been modified have been extended patent protection in the U.S., Europe and a few LDCs in the last few years.

Requirements for Patentability

Although the three basic requirements for patent protection—novelty, utility and non-obviousness—are the same in most national systems, meaningful differences still exist. Some of the differences are discussed here. However, parties interested in utility patent protection are encouraged to investigate the requirements for patentability for the individual countries of interest.

Novelty: Most countries have a novelty requirement for patentability. In essence, an invention is not novel if:

- it was previously described in a printed publication anywhere in the world in a manner that enables a person skilled in the art to produce the invention;
- it was previously offered for sale, or publicly used;
- it was previously patented in the country of interest.

The U.S., Canada and the Philippines allow a one-year grace period while Japan permits a six-month grace period. Hence, an invention that was publicized, made available for sale, or publicly used can still be patented if a patent application is sent forward in less than one year (six months)

from the disclosure. For most other industrialized countries disclosure even one day before application voids the right to protection. That is, “absolute novelty” is required. In some other countries, “relative novelty” is required. In such cases, publication anywhere in the world or *local* public use void the right to protection.

A few additional points are of interest here. “Printed publication” should be broadly interpreted as any form of public disclosure (oral presentation included) that made the invention widely known in an enabling form. Sharing results with colleagues is not public enough but a presentation in a professional conference is. In the case of profession journals, disclosure occurs at the day of publication and not the submission date. Information exchanged under confidentiality agreements is not public knowledge and presents no problem. Finally, “offered for sale” should also be broadly interpreted. A completed sale is not necessary for preventing patentability. A sale brochure making the product available is sufficient.

There is an additional critical difference in the interpretation of novelty and the associated right to a patent between the U.S. and Canada and the rest of the world. In the U.S. and Canada, the first to invent is awarded the patent even when another inventor claiming the innovation has filed first. Most other countries give priority to the first to file. This latter provision provides inventors a greater incentive to file an application as soon as possible so that they do not risk losing the rights to a patent.

Utility: An invention is not patentable if it does not work for its intended purpose or if it has no known legal or moral use. Utility is a low threshold. Only one use needs to be reported. Furthermore, such use need not be particularly valuable. While the usefulness of an invention must be reported in the patent application, it does not need to be claimed.

Nonobviousness: An invention is not patentable if at the time the invention was made it would have been obvious to an ordinary person with skill in the art. Nonobviousness questions the contribution to

technology by any particular invention. A trivial improvement over existing knowledge should not warrant a patent.

Judging nonobviousness usually involves answering three questions: 1) what is the scope and content of the prior art? 2) what are the differences between the prior art and the claims? 3) what is the level of ordinary skill in the art? Based on this information, nonobviousness involves determination of whether a person with ordinary skill in the relevant art could reproduce the invention “without undue experimentation.” In general, nonobviousness is the most difficult obstacle to overcome in patent prosecution as it is open to personal interpretation and judgement.

Patent Filing and Prosecution

A patent application, be it original, continuing, divisional, or substitute must be submitted to the patent office and should have the following components: (1) a specification, (2) a declaration or oath, (3) drawings (when necessary) and (4) a filing fee.

Specification of a Patent: The first step in the patent application process is to write the specification which basically demonstrates the three conditions of patentability: novelty, utility and nonobviousness. A specification has two main parts: the disclosure of the invention and the claims. The purpose of the disclosure is to define and describe the invention on how it is made and used. From the written description, any person skilled in the art should be enabled to reproduce the invention. It is crucial that the writing of the disclosure be targeted not only to one, but several different audiences (patent examiner, judge, jury member).

A particular specification format is not rigidly imposed. However, patent offices often provide guidelines on how to prepare a patent application. A typical specification should include:

The Title of the Invention: It is short and specific (but not too specific as to restrict the scope of

protection) placed on the first page of the specification, as a heading.

Cross-Reference to Related Applications: It identifies prior and co-pending applications that are closely related to the invention.

Technical Field: It includes a broad statement of the subject matter (as broad as the scope of the broadest claim) corresponding with the official classification and sub-classification of the invention by the patent office.

Background Information (Prior Art): It is useful for understanding the invention. In most cases the prior art is discussed in great detail here. This is usually the part where it is explained how prior art does not prevent patentability for the invention of interest. The following questions are usually addressed:

- why the invention was made and what is a practical application;
- what deficiency or problem it solves;
- why the invention is important;
- how prior art was unsuccessful in addressing the deficiency or problem approached;
- what was the inventor's thought processes in developing the invention.

It should be noted that whatever the inventor mistakenly specifies as prior art here, it becomes such for the purpose of evaluation even though technically may not be prior art.

Disclosure: It provides a summary of the invention in broad terms. In this summary, the advantages of the invention are outlined, the fashion that the invention solves existing problems is explained, the utility of the invention is demonstrated and the nature and substance of the invention is specified.

Brief Description of the Drawings: If any figures are included they should be briefly described in this section.

Detailed Disclosure of the Invention: It includes description of (1) physical characteristics, (2)

cooperative relationships between structure and operation, (3) functions performed and (4) results obtained.

Because of its contents, detailed disclosure varies from one invention to another. For example, in the case of pharmaceutical inventions the structure, synthesis and utility of the drug may be described. For biotechnology, it may involve experiments to identify, purify, and characterize the material.

From the disclosure, drawings, and the detail disclosure a person skilled in the art should be enabled to make and use the invention without undue experimentation. If biological material is involved and following the specification cannot lead to reproduction of the invention, material must be deposited in a patent depository under conditions specified by the Budapest Treaty. During the prosecution, the examiner may request a sample to verify that the invention is operative. When the patent issues, a sample must be provided to all those requesting one.

Claims: The specification concludes with at least one claim describing with precision what the inventor considers to be the invention. As many claims as are necessary to describe the invention are allowed. Claims are the most important part of the patent application since they define the scope of invention. They strive for both *strength* and *breadth* of coverage. As those qualities often counteract each other, the skill of writing a successful patent is to achieve an appropriate balance of these qualities. A patent application may contain more than one claim, each one varying in scope. The broadest claim should be listed first. Product and process claims should be grouped separately. There are independent and dependent claims. Each dependent claim is read as incorporating all the elements of the claim on which it depends. The rule of thumb is that independent claims should be as broad as justifiable while dependent claims should be strong and narrow.

Abstract of the Disclosure: A single paragraph (no more than 250 words) summarizing the invention and identifying the novelty element.

Declaration or Oath: In the declaration the applicant explicitly states the belief that he/she is the original and first inventor. In the case of joint application, each inventor must sign the oath.

Filing Fee: During the prosecution of a patent, the applicant pays various fees to the patent office. They include filing, application, processing or prosecution, patent issue, reissue, and maintenance fees. Such fees vary from one country to another. An exact schedule can be obtained from the relevant patent office. Individual inventors, small businesses, nonprofit institutions and universities are usually granted "small entity status" and receive a 50 percent discount on some of the fees. Filing fees along with expenses associated with prior art searches and attorney fees can fast grow into substantial sums, especially when international patents are pursued. Practical rules for managing such costs are provided in the next section.

The filing date of an application is when the patent office receives the specification and drawings (if required). The declaration and the filing fee can be included in a later date.

Filing for International Patent Protection

In general, filing for foreign patent protection is an expensive undertaking. While patent applications should eventually be filed in the countries protection is pursued, international conventions may be used to decrease the cost of filing until the commercial potential of the invention becomes more clear.

Most countries are members of the Paris Convention (PC). The Convention allows a one-year grace period. That is, after an application has been filed in any one country-member of the PC, subsequent filings in any other country that take place within a year assume as effective filing date the one of the first filing, also known as priority filing.

Commonly used alternatives for minimizing filing costs while evaluating the commercial capacity of an invention in different markets are multi-country applications through the Patent Cooperation Treaty (PCT), the European Patent Convention (EPC), and the African Regional Intellectual Property Organization. PCT provides a streamlined procedure for preserving the rights to file national applications in all member countries. An application may be filed with the PCT office accompanied by a PCT filing fee. Discounts are offered for multi-country applications. A PCT application preserves the right to a later filing in individual countries specified. PCT also provides prior art searching and a preliminary examination of the application.

Within 16 months from filing date the PCT office usually issues a report listing prior art the examiner perceives as relevant to the claims and after 18 months the patent application is published. Before 19 months from filing, the applicant must file a demand to enter PCT Chapter II or file in individual countries. PCT Chapter II delays the deadline for individual country application by 10 more months. Furthermore, Chapter II provides a preliminary examination of the application that could influence the examination of the patent application in individual countries of interest. Commonly, within 22 months from filing a written opinion on patentability is provided. The prosecution stage of PCT Chapter II is ended within 30 months from filing. At that time, the applicant must decide whether to file application in some or all designated countries or abandoned rights. The principal benefit from filing with PCT is the postponement of the deadline for filing in individual foreign countries while examining the commercial potential of the invention and the deferral of some initial costs.

Multi-country filing procedures are allowed under the EPC. The European Patent Office (EPO) is a regional patent authority representing many

European countries.* A single application is filed with the EPO for all or selected country-members. Applications may be filed either in Munich or in the branch office at the Hague. If national law permits or requires, the application may also be filed in a national patent office. The application may be filed in one of the three official languages: English, French or German. After examination, a European patent may be granted by EPO. However, the patent must be confirmed by and registered in each designated country-member to secure protection. In some cases only a fee payment is involved. In other countries complete translation is required. Once country rights have been secured, annual maintenance fees are required. If patent protection is pursued in only few European countries, the cost of going directly to the individual national patent offices should be calculated and compared with that of an EPO patent application.

Two separate patent unions facilitate multi-country patent application procedures in Africa: the African Regional Industrial Property Organization (ARIPO) and the Organization Africaine de la Propriete Intellectuelle (OAPI). ARIPO is the patent union for English-speaking African nations.** The examination procedure is similar to that for a EPC application. The application for a patent with designation of the countries of interest is filed with the patent office

* The following countries are members of the EPC: Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Liechtenstein, Luxembourg, Monaco, the Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. Latvia, Lithuania, and Slovenia signed extension agreements in 1994 with the EPO and can be designated in European patent applications.

** The following countries are members of ARIPO and have acceded to the Harare Protocol thus allowing them to be designated in an ARIPO patent application: Botswana, Gambia, Ghana, Kenya, Lesotho, Malawi, Sudan, Swaziland, Uganda, Zambia, and Zimbabwe. Sierra Leone, Somalia, and Tanzania are members of ARIPO but have not signed the Harare Protocol and as a result they cannot be designated in an ARIPO patent.

of a member-country. After verifying basic requirements, the local patent office directs the application to the ARIPO central office in Harare, Zimbabwe. A substantive examination follows. Following a favorable examination, the ARIPO office notifies the applicant and each designated country of the decision to grant a patent. Each designated country has six months to examine the decision and notify ARIPO that the patent will have no effect within its territory. After the lapse of the six-month period, ARIPO grants the patent with effect in those designated countries that have not returned an unfavorable decision.

OAPI is a union for protection of intellectual property consisting of French-speaking African countries.*** OAPI is unique in that member-countries have renounced their national sovereign rights to allow a single title protection valid in each country. All other unions require designation of countries of interest and confirmation by these countries. A single registration at OAPI protects the patent in all member countries. Member-countries may require the filing of the application with their national patent office (know as indirect filing), or they may require the patent application be made directly to the common patent office at Yaounde, Republic of Cameroon. Applications are subjected to a mere *per se* examination for form, novelty, unity of invention and patentability.

The Role of Patent Attorneys

The value of an invention is often heavily impacted by the depth and breath of IPR protection. A poorly-drafted patent that provides inadequate coverage diminishes the value of the invention. Patent applications vary both in quality and style according to the skill of the person who drafts them. The role of a patent attorney in the writing of a patent application is essential. A patent application is a complicated legal document. While

*** The following countries are member of OAPI: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Gabon, Guinea, Mali, Mauritania, Niger, Senegal, and Togo.

it is based on science, it is not a scientific document. The common complaint of inventors that they do not recognize their inventions after a patent attorney has completed the patent application is a good indicator of the difference between a scientific document and a patent application.

Patent attorneys must be registered with the patent office. In addition to their legal training, they must have extensive training in science or engineering and tend to specialize in particular fields of science. PROs may utilize patent attorneys for:

- evaluating public disclosures with respect to enablement and potential of patentability;
- performing a pre-filing evaluation of the invention—by means of a prior art search through specialized data bases and evaluation of the potential for satisfying the requirements of patentability;
- assisting with inventorship disputes;
- assisting with negotiations for distribution of property rights in the case of collaborative research with other institutions;
- preparing legal documents in the case of licensing agreements;
- obtaining general information regarding IPR.

A good working relationship between the inventor and the patent attorney is important. The attorney should be provided with all available information and should be advised as to what component of the invention is considered commercially valuable. The attorney can then position the patent application in such a way so that maximum coverage and value is secured.

FILING FOR PLANT BREEDERS RIGHTS

A breeder of any sexually reproduced or tuber propagated plant variety (other than fungi or bacteria) is entitled to plant variety protection if the variety is:

- “new”, in the sense that it has not been sold or made publicly available for more than a year prior to filing for protection;
- “distinct”, in the sense that the variety is clearly distinguishable from any other variety the existence of which is publicly known or a matter of common knowledge at the time of the filing;
- “uniform”, in the sense that any variations are describable, predictable, and commercially acceptable;
- “stable”, in the sense that the variety, when reproduced, remains unchanged with regard to its essential and distinctive characteristics with a reasonable degree of reliability.

An application for a certificate recognizing plant variety rights should contain:

Name of the Variety: A name that characterizes the variety must be provided although a temporary designation suffices until the certificate is to be issued.

Description: A full description of the variety setting forth its novelty and breeding procedure should be included in the application. In particular, the genealogy, including public and commercial varieties, lines and clones used in the breeding should be listed. Details about subsequent stages of selection and multiplication should be provided. Similarly, evidence of uniformity and stability should be presented. The type and frequency of variants during reproduction and multiplication may be identified.

A summary of the variety’s distinctness should also be furnished clearly stating how the application variety may be distinguished from all other varieties in the same crop. In the case where the new variety is most similar to a group of related varieties, such varieties should be identified and the differences should be described in detail. Seed and plant specimens or photographs which clearly indicate distinctness may also be submitted.

Plant Material Deposit: A declaration that a sample of at least 2,500 viable untreated seed or, for tuber reproduced varieties, tissue culture necessary for propagation will be deposited and replenished periodically in a public repository should accompany the application.

Ownership Statement: A statement of the basis of the applicant's ownership should be furnished with the application. The applicant may be the actual breeder, the employee of the breeder, the owner through purchase, etc.

Finally, a filing and examination fee should accompany the application. International conventions for multi-country applications for plant variety protection do not exist. All applications must be filed in the countries of interest that allow breeder's rights.

FINANCING IPR

Filing for IPR involves a variety of fees for services. These include fees for performing specialized prior art searches, attorney fees for preparing the application and other general consultation, as well as filing, reissue, and prosecution fees assessed by the patent office. Such costs vary widely with a number of factors including the country IPR are sought, the type of invention, and the number of claims made. For example, biotechnology inventions are most expensive while mechanical inventions are typically relative inexpensive. Similarly, a larger number of claims involves larger filing and prosecution fees. Patent offices set strict deadlines within which responses to their requests must be provided and fees must be paid. Overrunning such deadlines may result in loss of a patent.

After IPR have been granted, there are maintenance (renewal) that must be regularly paid by the IPR owner. In some countries such fees are paid annually while in others every two or four years. Renewal fees increase toward the final years of protection. If such fees are not paid on time,

penalty fees are assessed. Further delay of payment may even result in loss of a patent. Hence, as PROs prepare to seek IPR for their inventions budgets should be set aside both for filing and prosecution as well as the maintenance of granted IPR. Furthermore, accurate payment schedules must be maintained so that their IPR do not lapse accidentally.

COMMERCIAL EXPLOITATION OF IPR

Commercial exploitation of granted IPR can be achieved through self-production or sale and licensing of IPR to third parties. Since PROs will rarely be interested in self-production as a means for commercializing IPR, this section concentrates on marketing and selling or licensing IPR.

Many PROs will find obtaining IPR cost-prohibitive. Instead, they may attempt to identify a potential licensee before seeking IPR protection for their invention. The potential licensee may agree to bear some or all of the costs of IPR application and maintenance as part of the overall licensing agreement. This section is equally applicable to such cases as it is to situations where marketing and licensing of already secured IPR is pursued.

Marketing Strategies

Marketing is a key element of active technology transfer and commercialization of IPR. In the past, most public research and technology transfer organizations have been content to put their inventions and technologies on the shelf and make known their willingness to transfer. It is now known that such approach is generally ineffective.

Numerous marketing strategies exist for seeking potential licensees with varying degree of effectiveness and implied costs. Only modest efforts with limited budgets are envisioned and discussed here. The most common low budget marketing strategies are: (a) focused publicity and (b) direct contact with potential licensees. In both

cases, the intent is to make the availability of a particular technology known to potential end-users.

Focused publicity usually involves a press release in trade and other relevant publications announcing the availability of the technology. In some instances, it is further assisted with targeted mailings. Electronic bulletin boards and other electronic media specializing in technology transfer may also be used. While focused publicity requires in most cases minimal financial resources, it is rather ineffectual.

Direct contact of potential licensees may be focused to a limited number of private firms and investors. Alternatively, many potential licensees may be contacted at once with the hope that the marketed technology will match the needs of one or more firms or investors. Information for identifying and locating potential licensees may be obtained through both primary and secondary sources. Primary sources of contact information include:

- personal/business contacts of the management or technology transfer office of the PRO;
- personal/business contacts of the inventor;
- contacts suggested and facilitated by advisory groups of the PRO;
- contacts facilitated by non-profit technology brokers.

Secondary sources of information involve:

- industry directories;
- specialized on-line services;
- professional and trade association directories;
- trade publication and newsletters.

The information on the invention or technology provided to the potential licensees must be descriptive and brief.* It should typically include:

* In cases where IPR have not been yet secured or applied for, the description to potential licensees should not be enabling. It should emphasize what the invention does rather than how. If further information is requested

- an account of the benefits of the invention;
- a comparison of the invention with current alternatives;
- an account of market potential;
- a description of production methods and an estimate of associated costs;
- an estimate of investment requirements.

Some PROs may extend a licensing agreement to the first party demonstrating sufficient interest and capability. Others may enter in negotiations with multiple potential licensees. In either case, the choice of licensee(s) is important. Ultimately, the commercialization of the invention will heavily depend on the licensee's commitment, efforts and capabilities. Key attributes of successful licensees are:

- capabilities in using and marketing the technology or associated products (e.g., manufacturing capabilities, geographical scope of sales, size of customer base, gross profit margins, capital intensity, etc);
- commitment to the licensed technology (is the technology addressing the core business of the licensee? are sufficient budgets and investment for development and marketing committed?)
- adequate capitalization (a function of current financial position and access to credit and capital).

The relative importance of such attributes vary with the type of technology, its stage of development, and markets addressed.

Licensing Strategies

After one or more suitable licensees have been identified, an agreement regarding the appropriate amount and form of payment for licensing IPR owned by a PRO must be achieved. For that, the total expected profitability of the invention must

by an interested third party, it should be made available only after a confidentiality agreement has been signed.

first be evaluated. The time, effort, and money expended by the PRO in developing the technology and securing IPR is sunk costs and hence irrelevant to the evaluation process. After the total expected profitability has been calculated the shares of the PRO and the licensee(s) are decided through negotiations.

A typical initial point of negotiation is the, so called, 25 percent rule. Under this rule 25 percent of the pre-tax profits secured by the use of the licensed technology over what could be secured through an alternative technology, accrues to the PRO and the rest to the licensee. This percentage is adjusted upwards or downwards through consideration of many relevant factors including:

- the invention's stage of technical development;
- the level of investment required by the licensee;
- the amount of risk faced by the licensee;
- the availability of exclusive rights;
- the depth and breadth of IPR protection;
- the availability of technical assistance and know-how.

In general, the distribution of shares between the licensee(s) and the PRO should be reasonable. The licensee(s) should be viewed and treated as business partners rather than adversaries.

Having determined a royalty as a share of projected profits, the form of payment must also be mutually agreed upon. Several different forms of licensing remuneration exist. These include:

Royalty as Percentage of Sales: This is the most commonly used approach. Information on sales is usually readily available and hence PROs can monitor their royalties rather easily. Further, rewards to the licensor are automatically adjusted for inflation. Licensees may resist, however, this form of payment since they must pay royalties regardless of actual profit performance.

Royalties as Participation in Success: The licensor may share some of the licensee's risks under this agreement by offering to forego part of the

royalties if the licensed technology fails to achieve its projections. However, if predictions are exceeded, the licensor also shares in the increased profits.

Up Front Lump-Sum Payment: An agreed upon lump-sum payment is paid before commercialization as a one-time royalty payment for licensing the invention over a specified time period. To estimate the lump-sum payment the annual royalties over the projected economic life of the investment are calculated, discounted to present and summed. The calculated present value of invention is subsequently further discounted by 25 to 75 percent, depending on the risks faced by the licensee during commercialization and the confidence in the sales projections used to calculate annual royalties. Such forms of payment may have special appeal to PROs that could encounter difficulties enforcing contracts and convincing licensees to consistently pay periodic variable royalties.

Periodic Lump-Sum Payments: They typically involve a fixed agreed upon periodic payment by the licensee. Such payments are usually indexed to inflation.

Equity Position: This form of royalty is typical in cases where a new company is started up with emphasis the commercial exploitation of the licensed invention. A portion of the company's equity position is yielded to the licensor as a payment for the license.

A licensing agreement may also provide for various other arrangements that relate to royalty payments including:

Prepaid Royalties: A licensor may need funds for pursuing IPR yet not secured or for performing further development work. The licensee can contribute funds towards such activities which are applied against future royalties.

Minimum Royalties: They are in most cases, associated with exclusive licensing but they may be employed in non-exclusive licensing

agreements as well. The licensee is required to pay either the minimum royalty or an agreed upon annual variable royalty, whichever is greater. Minimum royalties are often viewed as instruments for obliging the licensee to more actively commercialize the technology and securing the position of the licensor.

Sub-licensing: The owner of IPR receives a pre-agreed percentage of the income secured by the licensee though sub-licensing the invention to third parties.

When licensing agreements are pursued, expert advice must be sought from a patent attorney or a licensing expert. Such services are especially important in drafting a licensing agreement. There are several reasons for seeking specialized legal advice in such cases. In many countries there are legal restrictions on the terms or the agreement breaching of which can render the agreement invalid. Furthermore, the structure of the agreement as a legal document can be complex. In case of disputes, a badly drafted agreement may leave loopholes and provide less than adequate protection for either the licensor or the licensee. Finally, tax implications are important and specialist opinion is likely to be necessary, especially in the case of international agreements.

MONITORING AND DEFENDING IPR

Manufacture, use, or sale of intellectual property without authorization by the owner constitute infringement. Monitoring, identifying and acting against infringement is an important part of pursuing and owning intellectual property. Perception of unwillingness or inability to prosecute is likely to invite infringement and hence reduces or nullifies the value of the invention.

The inventor, existing licensees, and key media may be important sources of information on potential infringement. In many countries, there also exist watching services that may monitor IPR applications by third parties in which the patents or

PBR owned by the PRO are cited. Such information often leads to discovery of willful or unintentional infringement.

When infringement is discovered and can be proven, the infringer should typically be offered a chance to license the invention. In most cases, IPR infringement disputes are settled through negotiations leading to a licensing agreement. Many patent offices offer dispute mediation services for cases where the two parties can not resolve their dispute through bilateral negotiations. However, in few cases the threat and even the actual action of litigating may be necessary. In such cases PROs should have a preliminary discussion with their IPR counsel prior to taking any action. As litigation is often expensive and, if the claims are narrow, could lead to invalidation of owned IPR it should be used only as a last resort and only when it makes good business sense.

For many inventions it is possible to insure against IPR infringement litigation costs through specialized insurance policies. Due to the terms and premium structures of such policies, coverage should be sought as early in the life of the IPR as possible.

MANAGEMENT OF IPR

Technology transfer organizations may effectively manage the process of IPR acquisition so that maximum and commercially relevant protection is secured through introduction of appropriate organizations, policies, and incentives.

Capturing Maximum IPR

Cooperative and interested scientists are key to capturing maximum IPR through maximum invention disclosures. Encouraging scientists' collaboration and participation in the process is thus important.

Increasing Understanding of IPR: Many scientists do not understand the benefits and costs associated with IPR. Even fewer appreciate the typical

requirements for applying and acquiring IPR. As a result, early publications, lack of appropriate records, or simply lack of interest often result in loss of valuable IPR. Educating scientists regarding the importance and potential value of IPR to the overall technology transfer process is a prerequisite for effective IPR management.

Creating an Inventor-Friendly Disclosure and Patenting Process: The disclosure and patenting process is complex and time consuming. If too much burden is levied on the inventor it will become a disincentive for disclosure. Simplifying invention disclosure procedures with short disclosure forms, professional assistance for preliminary invention evaluations, etc. are practices that encourage disclosure.

Creating Incentives for Inventors: Even the most inventor-friendly disclosure and patenting programs take time away from the inventors' scientific work. Instituting appropriate incentives for disclosure and acquisition of IPR encourages scientists' participation. Many public research and technology transfer organizations provide substantial monetary awards to inventors while others also employ honorary awards, contribution to research budgets and publicity to reward patent inventors.

Evaluating and Applying for IPR

Not every technical invention has commercial value. Yet, applying for and marketing IPR is

resource-intensive and expensive. Appropriate evaluation regarding the patentability and commercial value of technical inventions is thus essential so that unnecessary costs are avoided early on. Evaluation procedures may be organized in a variety of ways:

Evaluation by Inventors: A preliminary invention evaluation may be performed by the inventor who knows one or more firms working in related technical areas and can assess potential marketability.

Evaluation by a Patenting Committee: Patenting committees are typically composed by scientists with experience in IPR acquisition process and relevant technology and they may provide an initial invention evaluation.

Evaluation by Cooperating Firms: Technology transfer organizations may consult with commercial firms working in related technical areas for the commercial value of inventions. Cooperating firms may be allowed first right to such inventions for their services.

Evaluation by Technology Consultants and Other Experts: IPR consultants and market research companies may be employed to evaluate the patentability and commercial value of inventions. Research and technology transfer organizations with access to business and related educational programs may use graduate students and interns for market analysis.

5. Commercialization Schemes

As indicated earlier, a variety of schemes exist for capturing some of the rents from commercialization of technology and technical knowledge. Commercialization schemes relevant to African PROs are discussed in this part. Selected case studies from existing commercialization efforts are presented to illustrate important organizational and management issues that may arise when commercialization schemes are implemented.

SPONSORED RESEARCH: GRANTS AND CONTRACTS

In recent years, grants have been increasingly used as an alternative to formula funding of agricultural research both by government and donors because:

- they are presumed to be more efficient than formula funding for allocating scarce research resources;
- they are presumed to be effective in rewarding and encouraging excellence in research;
- they are viewed as an effective means for directing the R&D agenda towards priority areas.

PROs have become increasingly interested in grant seeking activities as formula funding from government and donors has been decreasing. Moreover, grants are looked upon by PRO administrators not only as a way for maintaining utilization levels of R&D infrastructure at acceptable levels but also as “profit-making” activities by way of overhead charges.

Overhead costs charged on grants are assumed to reflect indirect administrative costs as well as maintenance and depreciation of R&D infra-

structure. Indirect costs per grant are largely fixed and do not vary much with its size. As overhead charges are typically proportional to the direct costs, larger grants tend to overestimate actual indirect costs resulting in financial surpluses. Similarly, charges on depreciation and maintenance on any particular grant are not adjusted for capacity utilization of R&D infrastructure. Overhead charges on existing grants are not adjusted when new grants are brought in and which share in the usage of R&D infrastructure, facilities and equipment. As a result, the effect of overhead charges is compounded resulting in financial surpluses.

Despite their many positive aspects, grants should be pursued judiciously because:

- overhead for writing proposals and pursuing grant funds can be substantial, both for individual scientists and the research organization as a whole;
- long-run funding continuity is rarely secured;
- scarce resources, especially human capital, may be re-directed away from areas that are currently less popular but which could prove to be important in the future.

Like grants, research contracts have been increasing in importance in recent years. The explosion of information and scientific knowledge has forced many private firms and public organizations to seek specialized research expertise and contract out research programs. Research contracts are agreements whereby research organizations concede to provide personnel, services, facilities, equipment, or other resources toward the conduct of specific research or development efforts for an agreed upon reimburse-

ment. Research contracts are typically more complicated than grants as they may involve a variety of clauses that dictate the operations of the contractual agreement. Such clauses may involve:

- an agreed upon research team and plan;
- procedures and schedules for interim and final reports;
- financial and staffing obligations of the contracting parties;
- title of property and other equipment acquired under the contract;

- ownership of intellectual property for inventions resulting from contracted research;
- handling of proprietary or confidential information, including publication procedures;
- dispute settlement procedures;
- liability;
- termination of contact.

The following case study of contract research between the Kenya Agricultural Research Institute (KARI) and Oserian Development Company, Ltd. a private floriculture firm, illustrates some of the management issues that may arise in technology transfer through contract research.

Tissue Culture Contract Research in Kenya: A Case Study

Background

Kenya is the leading producer and exporter of cut flowers in Africa. Low labor wages and favorable climatic conditions have contributed towards the recent growth of the floriculture industry. Such growth is exemplified by a tenfold increase in the value of flowers produced in Kenya between 1980 and 1990. In recent years, flower exports have brought Kenya an average of US\$40 million per year. The industry employs an estimated 30,000 laborers, mostly seasonal workers.

The total area under cut flower production is approximately 700 ha and is concentrated around the lake Naivasha. Production is carried out by some 20 large and medium size firms and an additional 80 small-scale producers. Only the three largest producers—Sulmac, Oserian, and Shalimar—own transport and cold storage facilities while the rest of the producers depend on them for such services.

A primary impediment to the industry's further growth has traditionally been restricted supply of good quality and affordable planting material. Most large-scale farmers import planting material at small quantities and multiply them locally. Small-scale farmers use old recycled varieties which have less market value. Because of such practices, genetic

material used by the floriculture industry is often degenerated due to build up of fungi, bacteria and viruses, or due to nematode damage.

The KARI-Oserian Agreement

In the mid-1980s, KARI—the main public agricultural research organization in Kenya—developed some expertise in tissue culture through a collaborative research project with the Kenya Pyrethrum Board. This expertise was a pole of attraction for Oserian Development Company (ODC), one of the three largest floriculture producers in Kenya. ODC was interested in developing local capability for producing high quality planting material at reasonable cost through tissue culture. In 1987, ODC made direct contact with Mrs. L. Mureithi, a KARI researcher who at that time had published a short article on tissue culture technology in a local newspaper. After this initial contract found no response, ODC attempted another direct contact with the KARI researcher in 1989. With the encouragement of KARI's director who has been urging greater involvement with clientele groups, discussions between KARI and ODC were initiated to define the technical needs of ODC. As a first step, KARI agreed to devote some effort towards developing tissue culture techniques for multiplication of *statice*, a flower important to ODC and the Kenya floriculture industry. No formal

agreement was signed at that time. Discussions about potential technology transfer were to resume only after KARI had developed the technology.

Within a year, KARI had successfully developed tissue culture techniques for *stative* multiplication and approached ODC with a research contract. The reception by ODC management was less than cordial. The researcher that had developed the technology was literally handed a plantlet and was told to come back for further discussions on the contract when the plantlet was successfully multiplied by the technology allegedly developed. In the crude response of ODC's management one should recognize their attempt to reduce secondary and behavioral uncertainties before engaging in a technology transfer effort with KARI. Answering such questions as "...do they really have a worthwhile technology..." or "...could *they* really have developed such a technology..." (which typify incomplete information and suspicion) was apparently important to ODC's management before entering into a contract.

After the effectiveness of the technology was demonstrated, a research contract was signed by KARI and ODC in 1990. The research contract determined that:

- ODC would pay an annual lump sum of Ksh 100,000 to KARI for four years in exchange of exclusive rights to the *stative* tissue culture formula;
- ODC would release planting material for various flowers not covered by PBR to KARI for propagation and distribution to small holders;
- ODC would make its facilities available for training KARI employees in floriculture;
- KARI would propagate 2,000 plants/month for ODC priced at Ksh 22/plant for the first six months and Ksh 10/plant from then on;
- KARI would train ODC staff as part of the tissue culture technology transfer and the cost of the training would be paid by ODC.

ODC's target was to produce 1,000,000 plantlets per year through tissue culture. It quickly became apparent that KARI had limited capacity for producing a large number of plantlets. In response, ODC invested in a state-of-the-art tissue culture

laboratory which was completed in 1992. KARI's tissue culture resident expert who had developed the technology was temporarily transferred to ODC with primary objective to train ODC employees in the tissue culture multiplication technology.

Impact

The tissue culture transfer to ODC is expected to have substantial impacts on several accounts:

- ODC is already positioning itself to become a primary supplier of planting material for the Kenyan flower industry. High quality planting material at affordable prices could provide a boost to the industry's competitiveness and growth with obvious economic and employment effects for the sector and the economy as a whole.
- Expanding knowledge in tissue culture techniques both in KARI and in the Kenya agribusiness sector is important. Since such technical knowledge is transferable to other agricultural commodities, technology spillovers and multiplier effects in economic activity from the ODC transfer are likely to be large.
- The transfer itself has been quite visible with positive implications for KARI's public image as an effective technology transfer organization. Such image will likely promote KARI's future technology transfer efforts.

Implications

The ODC-KARI contract facilitated a fast and effective transfer of technology. Key factors that contributed to the success of the transfer include:

- demand-driven opportunity identification;
- clear understanding of technical needs and technological solutions by contracting parties;
- adequate investment and commitment to the transfer process by the end-user;
- KARI's changing culture towards greater involvement with clientele groups;
- KARI's adequate technical expertise for developing the technology of interest;
- active transfer mode through one-on-one training.

One issue that warrants attention in the ODC-KARI contract is the pricing of the technology as

defined through bilateral negotiations. KARI clearly undervalued its technology in the contracted transfer. Imported *stafice* plantlets cost approximately Ksh 35-40/plant in Kenya. By pricing its propagated plantlets at Ksh 22/plant and Ksh 10/plant after the initial six months, receiving a mere Ksh 400,000 for four years of exclusive rights on the technology and charging no overhead or trainer's fees, KARI effectively transferred most of the value generated by its technology to ODC. KARI's management, however, appears comfortable with the concept of sacrificing value in the short-run for

long term gains. Establishing a reputation of being an effective technology transfer organization and winning the trust of the farming and agribusiness sectors are primary objectives of this research organization. A positive image could significantly advance KARI's effectiveness in technology transfer and commercialization in the future. Sacrificing short run value for long term benefits may not only be efficient but necessary for PROs in many African countries where distrust between private and public sectors are deeply rooted.

BREEDING PROGRAMS

Over the last several decades, many PROs in MDCs and LDCs alike have maintained plant breeding programs. Such programs have pursued two types of crop improvements: (a) in the genetic make up for greater yields, pest resistance, or quality traits (e.g., oil and protein composition); (b) in the physical properties of the seed such as purity, germinability and others.

Plant breeding programs use one or more of the following methods:

- introduction of varieties from selected geographical locations with relevant agroclimatic conditions and often subjected to adaptive breeding;
- selection of natural mutants and promising plants from heterogeneous populations;
- introduction of hybrids and varieties originating from crossing two different genetically pure but compatible parent lines;
- genetic engineering.

PROs have accounted for most of the breeding research in food crops such as wheat, rice and maize and have emphasized development of improved varieties. Breeding research in the private sector has been dominated by multinational companies such as Pioneer, Cargill, Pfizer, Asgrow, Continental Grains, and others. Private breeding programs have emphasized hybrids and low volume-high value crops, like vegetables,

where high profits from commercialization of improved seed can be effectively captured.

An effective seed supply system begins with a successful breeding program. It also requires well-functioning seed production, conditioning and processing, and distribution systems. In most LDCs, PROs have embarked on only breeding efforts with main focus the development of improved cultivars. Such cultivars are typically passed on to a production and distribution parastatal. In general, PROs have not attempted to commercialize products created through their breeding programs. Parastatal distribution monopolies have been capturing most of the value instead. Unfortunately, this technology generation and distribution system has been quite ineffectual in many LDCs. Parastatal or public seed distribution monopolies have been characteristically inefficient in both the reproduction and distribution of seed. As a result, the quality and quantity of seed supplied in the market have been inadequate to the detriment of the farm sector. At the same time, breeding programs have often been severely under funded since they have not been able to internalize some of the economic rents generated through their breeding research activities.

One public breeding and distribution program that has been able to commercialize part of its operation while creating a dynamic seed market and securing high quality seed supplies for the farmers has been Brazil's national agricultural

research system (EMBRAPA). It supports a variety of breeding programs that produce hybrids for corn and sorghum and improved cultivars for soybeans, wheat, dry beans, cassava, oats, barley, cotton and other crops. Breeder's seed is produced by breeding programs carried out in various National Research Centers. Breeder's seed is subsequently passed on to EMBRAPA's Foundation Seed Production unit which is responsible for multiplication. Farmers with advanced managerial skills are also contracted for production of foundation seed.

Foundation seed is sold by EMBRAPA to private seed companies and cooperatives at approximately twice the price of fiscalized seed sold by these companies. Seed companies in turn use foundation seed to produce registered, certified, and fiscalized seed. Differences between these three grades involve primarily different levels of physical purity. Fiscalized seed is usually sold to farmers at a price up to twice the price of grain seed. At such prices farmers are not inclined to save seed from one year to another, effectively using high quality seed in every given year.

Returns from sales of foundation seed to EMBRAPA are probably insufficient to cover its R&D and production costs. However, by emphasizing hybrids and commercialization of a variety of improved cultivars while staying away from monopolistic structures and inefficient distribution systems, EMBRAPA has effectively created a vibrant seed market that benefits both the seed industry and the farming sector as a whole.

EMBRAPA's effort demonstrates that emphasis on commercialization does not necessarily lead to farmers' dependency on hybrid or improved cultivar seed but rather to access to high quality seed supplies at reasonable costs. Thus, considerations for commercialization of breeding programs should not be dismissed on principle.

COMMERCIALIZATION OF GENETIC RESOURCES

The commercial value of genetic resources is usually measured in terms of current and potential future contribution to the development of products and processes that benefit society (e.g., pharmaceutical and agrochemical product development, and improved lines of plants and animals through traditional breeding or genetic engineering). In this context, activities that enhance the commercial value of genetic resources usually involve:

- the preservation and enhancement of basic knowledge about such resources to facilitate future research and product development;
- research and development that identify desirable properties and introduce them into commercial products or processes.

Commercialization of genetic resources, in turn, involves appropriation of the value added from the end-user. Chances for commercialization are improved by (a) the existence of property rights, and (b) large value added in excess of market value of the genetic resource. For example, the difference in the "market price" of a randomly collected sample of genetic material and the price of a well-described and taxonomized sample for which basic properties and location are organized is equal to the value added by the basic taxonomic research activity. The higher the value of this knowledge enhancement to the end user, the better the chances for commercialization.

The main value-adding activities that holds some promise for commercialization of genetic resources are: (a) breeding programs, (b) germplasm maintenance, and (c) bioprospecting. The first option has already been discussed in some detail in the previous section. The remaining two options are examined here.

Plant Genetic Resources Conservation: Gene Banks

Genetic stock and germplasm collections have the basic responsibility of conserving, describing, and distributing valuable genetic resources. There are many national, international and personal gene banks around the globe which are quite different in their size, degree of specialization, quality, and funding resources. Gene banks have served as an “insurance policy” for the uniform cultivars and hybrids in use. They have also contributed genetic stocks to breeders, geneticists, biochemists, developmental biologists, pathologists, entomologists, and all those who work in genetic engineering and manipulate genetically controlled traits of scientific and economic importance.

Funding for national and international gene banks has traditionally come from national governments and donors. In recent years, the growing size and complexity of gene bank management have translated into increased costs. Meanwhile, public funding for both national and international gene banks, on average, has not kept pace. As a result, many gene banks have emphasized acquisition rather than value-adding characterization, documentation and evaluation of their material.

At this point, commercialization of genetic stocks and germplasm as a source of funding for research and transfer operations does not appear to be a viable option for gene banks. There are three main impediments to commercialization:

- the general lack of substantial value-adding activity with appropriate return;
- a deep-rooted public domain culture;
- a lack of property rights since Article 15(3) of the 1992 Biodiversity Treaty excluded existing collections from coverage.

Overall, public funding and grants from donors, philanthropic, and environmental organizations will likely remain the primary funding sources of gene banks in the future.

Bioprospecting

Pharmaceutical, biotechnology, agrochemical and a variety of other companies are increasingly prospecting for potentially valuable chemicals derived from plants and other natural organisms. Increasing bioprospecting activity has been fueled by improved screening technologies and the shift in consumer preferences away from chemical substances and towards plant-derived medicines and natural products. Today, more than 100 pure chemical substances extracted from plants are used by the pharmaceutical industry. It has been suggested that in the next two decades the market for pharmaceutical products derived from natural substances will grow into a several-billion-dollar market. Thus, LDCs, which harbor most of the world’s biodiversity, should capture some of the benefits from this growing market, especially after the 1992 Biodiversity Treaty established national property rights over genetic resources.

Tropical biodiversity, however, is being lost at an alarming rate due to population and development pressures. Finding ways to distribute some of the potential financial gains back to the countries and indigenous people who are able to conserve them and also assisting the development process is a growing preoccupation of national governments, environmental groups and private companies that have “turned green.” One approach that has been advocated in recent years is bioprospecting. Under this approach, private companies with screening and natural product programs will pay for access to proprietary genetic resources and indigenous knowledge on their properties and potential uses. Many of the intrinsic characteristics of such an exchange are illustrated by the INBio-Merck agreement case study that follows.

INBio: A Case Study In Bioprospecting

Mandate

Costa Rica's Instituto Nacional de Biodiversidad (INBio) was established in 1989 to carry out a large part of the national biodiversity conservation program in the country. INBio's mandate involves: (a) completing a 10-year total inventory of the 500,000 species and organisms believed to exist in Costa Rica, with the primary objective of determining what biodiversity exists and where it is located and (b) employing biodiversity for the benefit of society through non-destructive management and utilization.

A large portion of the work towards completing the National Biodiversity Inventory is performed by parataxonomists, lay people trained for the task of surveying and collecting genetic resources throughout the country, in collaboration with national and international taxonomists and curators. The collected specimens and information are then directed to INBio, where they are registered in the National Biodiversity Database. Taxonomic identity, geographical distribution and known or potential uses of the specimens are included in the database.

To achieve the objective of using biodiversity for the benefit of society, information from the National Biodiversity Database is provided to scientists, park managers, government officials and citizens, both for decision making and for educational purposes. Further, commercial non-destructive exploitation of biodiversity in the form of natural products for pharmaceutical and agrochemical applications, genetic material for biotechnology, food and ornamental plants and bio-tourism are actively pursued.

Institutional Boundaries

INBio is a private, non-profit organization created by a multi-institutional planning commission established by a presidential decree in June 1989 and legally registered as an association in October of the same year. The independent, private status has given INBio flexibility and efficiency in operation not usually available to bureaucratic governmental organizations. However, close ties with the government and several other public organizations, as well as its mandate, have secured INBio the

undisputed position as the national biodiversity research and commercialization organization in Costa Rica.

Such position was further solidified with the Law for Conservation and Wildlife, which was drafted with the help of INBio by the Costa Rican government and was adopted in the fall of 1992. Through this law, all wild plants and animals were declared "national patrimony." This change in property rights was put immediately to work by requiring that the collection of genetic material be subject to licensing. To secure a license from the Ministry of Natural Resources, collectors must submit an application detailing the collection plans. A license can be granted only when the plants and other species to be collected are exactly specified in the application. The deposit of samples to the National Collection and the submission of publications resulting from the collection to the National Library are also required.

In effect, the law established a government monopoly over commercialization of genetic resources and excluded possible competitors. As soon as the law went into effect, Polybiotica, a private company specializing in the collection and commercialization of plant material from private lands, terminated its operation. Through the re-definition of property rights over genetic resources, a license was required for collection, regardless of whether it took place on private or public land. Further, as Polybiotica depended on non-systematic (random) collection of samples, it could not submit an exact list of targeted species required in the licensing process.

Funding

Since its inception, INBio has secured significant national and international economic support. Seed funding was provided by a debt-for-nature swap whereby international and conservation organizations purchased debt notes at 15-20 percent of the original value of the debt. The Central Bank of Costa Rica exchanged the debt notes for local currency bonds, thus effectively multiplying the initial international donations by a factor of five. The debt swap allowed the creation of an initial US\$4.9 million endowment fund.

In a broadly publicized two-year contract with Merck, a large pharmaceutical company, INBio secured its first major bioprospecting agreement, worth US\$1 million. Since then, the contract with Merck was extended for two more years while additional contracts have been signed with Bristol-Meyers, British Technology Group (a technology transfer broker), Equiscience (a U.S. biotechnology company), and Disaudam-Roure (odor and fragrances). Another interesting project of INBio is the joint venture with Intergraph (a U.S. informatics company) to develop software for biodiversity inventory.

Intellectual Champions

Since its inception, INBio has had significant intellectual support and direction. Dr. Rodrigo Gamez, a plant virologist from the University of Costa Rica, and Dr. Daniel Jansen, a tropical biologist from the University of Pennsylvania, vigorously supported the idea of non-destructive management and commercialization as a means for protecting biodiversity from development pressures. Their ideas found a sympathetic ear in Costa Rica's president, Oscar Arias, who by executive decree established INBio in 1989 with Gamez as director.

INBio's active partnerships with several universities and international organizations have provided ample support from the scientific society since its inception. Dr. Thomas Eisner, a chemical ecologist at Cornell University and advocate of chemical prospecting, brokered the INBio-Merck prospecting agreement. In October 1990, Eisner organized a small conference to explore the possibilities of commercial chemical prospecting by INBio. Dr. Paul Anderson, vice president of medicinal chemistry in Merck and former post-doctoral fellow at Cornell University, attended the conference. Anderson, in turn, brought the idea to the attention of Dr. Lee Capurale, academic liaison in Merck, who supported and championed the idea inside the company. INBio and Merck signed a bioprospecting contract after almost a year of negotiations.

The Prospecting Agreement with Merck

INBio and Merck signed an agreement for genetic resource prospecting in September 1991. The two-year contract provided that INBio would furnish Merck with biological samples and chemical extracts from wild plants and insects. In return,

Merck would pay INBio US\$1 million as a front-end payment and undisclosed royalties on any resulting commercial product. The contract was extended for two more years under the same payment schedule.

Technical Background: The technical background in which the agreement between Merck and INBio materialized is of interest. For many years, pharmaceutical companies had searched for hints of drugs useful to microbes and other natural products. The advent of biotechnology, however, seemed to make the screening of natural substances obsolete as molecular understanding of disease and the ability to engineer protein promised new, more precise, and effective drugs without clues from nature. While designing drugs from "first principles" has proven difficult, biotechnology has contributed powerful tools for sorting through natural and chemical substances. Used in place of whole animal or microbial plate assays, new specific bioassays can detect even minute quantities of potentially useful compounds. Moreover, automated screening technologies allow for the screening of tens of thousands of compounds a year making screening a more productive process. This enhanced ability of screening, in turn, increases the value of genetic resources because their potential clues to the synthesis of therapeutic and agrochemical products could be uncovered sooner and at lower cost.

The Agreement: Within the framework of two consecutive contracts, Merck has been allowed the right of first refusal to develop drugs from samples of Costa Rican plants, insects (a novelty) and microbes. Soil samples are sent directly to Merck's laboratories. Further, Merck is presented with a list of plants and insects from which it can choose a limited (undisclosed) number to be supplied. INBio collects samples of the chosen species, freezes them, and prepares chemical extracts, which are subsequently sent to Merck for screening.

A primary reason for Merck's original interest in INBio was the institute's ability to provide high-quality, well-documented samples. In this fashion, samples that showed promise could be re-supplied, and related species with potentially similar properties could be readily identified and collected. Merck further enhanced the institute's capacity. In addition to the US\$1 million original payment, the company donated chemical extraction equipment valued at US\$135,000 to INBio. Merck also sent two of its natural product chemists to set up the lab

and train Costa Rican scientists in the process, while INBio personnel were sent to Merck for training.

The INBio-Merck agreement is treated as a research cooperation by both parties. There is openness on the results of both the screening and taxonomic research activity and a continuous feedback process. Both INBio and Merck scientists are encouraged by the process to interact and make suggestions for each others operation in their attempt to improve the inherently low "hit" chance of the process.

Uncertainties and the Contract: The contract signed by Merck and INBio should be viewed not only as a way of arranging payment for service but also as an instrument for reducing uncertainty in the transfer and appropriately aligning incentives for both of the transacting parties.

There are several types of uncertainty involved in the transfer of genetic material. First, there is primary uncertainty inherent in the screening process. The rule of thumb is that one out of 10,000 samples leads to a marketable product and hence screening as a process is quite random. Then there is secondary uncertainty from informational asymmetries and incompleteness. Indigenous knowledge may be available regarding the potential desirable properties or location of specific genetic material. However, in the absence of collaboration and cooperation such knowledge may be unavailable to outsiders.

On the other hand, collaboration with collectors in the absence of an up-front set of rules creates behavioral uncertainties. Screening and research on natural compounds imply a potential need for re-supply. Initial trials usually require small amounts of genetic material. If promising trials, are identified, however, then greater quantities of genetic resources are necessary. Amounts needed for clinical trials in the case of a "hit" are even greater. Hence, repeated access to the genetic resource must be available to the buyer of genetic material. In the absence of a contract, requests for additional material would signal to the collector a potential "hit" and the buyer would be vulnerable to unreasonable demands. A contract with a pre-specified payment schedule would reduce the possibility of such opportunistic behavior. A single up-front payment provides no incentive for conservation and re-supply of the genetic material for the collector. For this

reason, a step-wise payment schedule or an up-front payment and royalties combination furnish appropriate incentives for both transacting parties.

Behavioral uncertainty may also arise from mistrust regarding the competence of the collector to provide pure samples or to appropriately identify, locate, and re-supply relevant species. Reputation effects, along with other intrinsic factors (e.g. infrastructure), may be important in reducing such uncertainty. Behavioral uncertainties in the form of mistrust may also arise from unclear property rights.

The contract signed by the two transacting parties and the specific intrinsic characteristics of INBio have been essential in reducing uncertainty and facilitating cooperation. The systematic information about the location, properties and taxonomy developed by INBio is knowledge not widely available. Such information is quite valuable as it can assist throughout the screening process. Further, it assures that species showing potential could be re-supplied. The scientific expertise and reputation of INBio guarantees competence in the handling and supply of samples as well as provision of knowledge that assists the selection of species in the screening process. Further, INBio's association with the government and its mandate signal clear property rights as a national "broker" of Costa Rica's genetic resources.

The payment arrangements of the contract appear to have been effective in reducing uncertainty and appropriately aligning incentives. The up-front, agreed-upon payment explicitly recognizes and rewards the value of the genetic material, specialized information and expertise provided by INBio. It also allows for the re-supply of interesting species under a fixed payment. Similarly, royalties recognize the property rights of Costa Rica over its genetic resources and the indigenous people who preserve, organize, and improve biodiversity.

Implications

Many organizational and institutional aspects of INBio and its agreement with Merck are of interest and should be considered carefully by organizations that may be interested in bioprospecting as a source of funding for research.

First, the independent status of INBio has been important in negotiating and closing agreements

with a diverse set of research, environmental, scientific and philanthropic organizations. On the other hand, INBio's clearly mandated position as the national biodiversity organization allows INBio to negotiate bioprospecting contracts with well-defined property rights in hand.

Second, the scientific expertise and infrastructure (database, a large number of well-trained para-taxonomists, chemical extraction and other equipment) provide INBio not only scientific legitimacy but also the capacity for substantial value-adding activity. Such activity is highly valued by private companies with natural product programs, as the contracts secured by INBio indicate.

Third, the (inter)active mode of knowledge transfer that INBio has employed has secured for INBio a clear understanding of the needs of clients and research collaborators. Through a feedback process, INBio has increased its scientific and knowledge base. This will be important for future bioprospecting agreements.

In addition to these factors, Costa Rica's political stability, the high education level of its people, its biodiversity wealth, and its extensive system of national parks blanketing 25 percent of the country are all positive factors contributing to INBio's success.

CONTINUING EDUCATION AND TRAINING PROGRAMS

Continuing education and training programs (CETPs) are natural ways of relating to external constituencies and clientele groups. Their primary function is to disseminate scientific and technical knowledge to producers, entrepreneurs, technicians, and managers in production agriculture and the agribusiness sectors. CETPs can be offered for a fee covering the costs of the trainers' honorariums, instructional material, overhead and administrative expenses. Fees that can raise revenues above and beyond such expenses can be viewed as fund-raising activities. Most CETPs fall within one of the following categories:

- *Dissemination of research results and current scientific knowledge:* Keeping scientists, technicians, and managers in the workforce up-to-date implies a need for transferring to them the latest scientific knowledge and tools. Updating short courses may be used for this purpose. CETPs of that nature are becoming increasingly popular as businesses and individual scientists alike struggle to keep pace with a fast increasing rate of scientific knowledge.

- *Background information for non-technical knowledge:* Workshops, short training course, seminars, or field days may be used to provide background information to diverse audiences. They are typically designed to increase awareness, introduce improved management methods or promote key technologies. Training programs on using effective production, post-harvest, and marketing techniques, setting up and managing small businesses or cooperatives, securing credit, and financing agricultural activities are examples of training activities which regularly attract interest.
- *Training programs leading to certificates:* Workshops and seminars leading to certificates are typically designed to provide specialized technical knowledge and improve the employment opportunities of the attendees. For example, one of KARI's regional research centers offers annual workshops and associated diplomas in wheat grading that have helped employment among the workshop participants.
- *Training programs as part of technology transfer packages:* Training programs are often integral parts of technology transfer packages (e.g. KARI-Oserian tissue culture transfer). The interactive mode of this transfer process secures that experience and other tacit knowledge (not included in technology

blueprints) developed throughout the research and development process is passed on to the end-user.

CETPs can play a significant role in the overall technology transfer efforts of PROs, especially those emphasizing adaptive research. Furthermore, they can have a substantial and *immediate* impact

on economic development and growth. When such programs can also be self-financed through user-fees, they should be closely examined by technology transfer organizations. A case study of CETPs from Honduras illustrates the critical role such programs can assume. Some logistical and management issues that may arise when CETPs are implemented are also discussed.

Agricultural Training Programs in Honduras: A Case Study

The case presented here covers training programs offered by Fundacion Hondurena de Investigacion Agricola (FHIA), an agricultural research and technology transfer organization in Honduras.

Organization of FHIA

FHIA was organized in 1984 as a non-profit private agricultural research organization. United Fruit Company donated its Tropical Research Center facilities along with its prominent banana breeding program. USAID contributed a 10-year development grant of US\$20 million while the government of Honduras provided funds for operations and logistical support.

From the beginning, an organizational issue of particular importance was FHIA's long term financial self-sufficiency and sustainability. While FHIA has been quite active in its efforts to generate funds through private donations and commercialization of its operations, such funds have not been adequate for self-sufficiency. The establishment of a core fund was necessary when the original 10-year development fund was depleted in 1992. USAID supported the establishment of a trust fund by providing approximately US\$23 million. Interest payments from the endowment cover a large part of FHIA's recurrent costs and help its position towards sustainable and independent status.

Mandate and Core Research Programs

Since its establishment, FHIA's mandate has been to support agricultural diversification and help the expansion of agricultural commodity exports from Honduras through appropriate production and post-harvest technology transfer. As a result, FHIA's research involves three major thrusts: (a) bananas

and plantains, (b) cocoa and (c) a diversification program.

The banana research program is a continuation of the United Fruit Company's R&D program and emphasizes breeding of high-yielding disease- and pest- resistant varieties. It also includes evaluation of chemical and integrated controls for weeds, fungi, nematodes, and insects. Plantain research focuses on developing disease resistance as well as new varieties for greater acceptance in export markets.

FHIA has a cocoa research program with a focus on improved management practices, post-harvest technology and variety testing. The later program draws from clones and varieties developed by other national and international programs.

Crop selection, plant adaptation, management practices and post-harvest technologies are the main research emphases of the diversification program. New crops with potential for both production and market access have been selected for research including black pepper, palm hearts, mangoes, winter squash, onions, tomatoes, cucumbers and soybeans.

Improved *black sigatoka*-resistant banana and plantain varieties, dwarf plantain cultivars, improved cocoa packages and fertilization programs, off-season fruiting mangoes, improved palm hearts and black pepper production packages are all examples of technologies developed by FHIA in recent years.

Training Programs

Most of FHIA's research is adaptive in nature and emphasizes rapid transfer to end-users. Primary vehicles for dissemination of the technical knowledge generated by FHIA's core research, are

its training programs. There are two broad categories of training programs offered:

Short courses and seminars: They typically last 4-5 days and are designed to transfer technical knowledge developed through research to producers, technicians, exporters, and other entrepreneurs. They include both classroom instruction and field practice and they are held in FHIA's main facilities.

Short courses and seminars are developed and taught by the researchers and agronomists from each of FHIA's three core research units. Logistical support is provided by the communication unit. FHIA's communication unit maintains a data base containing a variety of information, including technical needs, for a large number of institutions, individuals, and businesses. Using this information, direct targeted mailings advertise upcoming seminars and short courses. Newspaper announcements are also used for the same purpose. At the conclusion of each training program, participants are asked to provide feedback through structured questionnaires. They rate the usefulness of the course and provide information regarding additional training programs they may need. Such feedback is used to update the data base maintained by the communication unit and aid the design of new training programs.

Short courses and seminars are well attended and attract participants not only from Honduras but also from other countries in Central America. A flat fee that covers all operating costs is charged. No overhead charges are included in such fees.

Field days: They are one-day training events that take place in various locations of the country. Field days are typically attended by peasants, commercial farmers, technicians and exporters and are designed to disseminate information on production and post-harvest techniques. Topics and location are decided through information on training needs and demand collected by FHIA's field staff. The core research units are once again responsible for designing and carrying out the training programs while the communication unit provides administrative support. Field staff helps with the advertisement of upcoming events. Newspaper announcements are also used. Minimal fees that cover meals, training and propagating material are charged for field days.

Impact

Revenues from user-fees are, on average, roughly equal to the operating expenses of training programs (approximately 5% of FHIA's total annual budget). On balance, such programs may represent a small net outlay for FHIA when all cost items (including salaries) are appropriately budgeted. The benefits from the training programs, however, are large both for FHIA and for the agricultural sector in Honduras. These include:

- Active delivery of technical knowledge developed in FHIA through its training programs speeds up technology transfer with important implications for the development of the agricultural sector and the local economy.
- Training programs contribute to the development of human capital in production agriculture and the agribusiness sector by improving the technical and managerial knowledge of some 500 to 1,100 individuals in any given year.
- FHIA benefits from its training programs through direct contact between the end-users and the researchers and agronomists. Such contact provides FHIA's scientists with a better understanding about the true constraints and technical needs of the end-users and assists with the relevance of the research agenda.
- Training programs provide a forum where both scientists and end-users interact in a cooperative mode, creating a relation of trust which is important for all FHIA's future technology transfer efforts.

In 1989, just five years after it began its operations, Sigma One corporation measured internal rates of return to FHIA's R&D investment to be between 17 and 76 percent for various technologies. Training programs have no doubt contributed towards achieving substantial returns on R&D investment so rapidly.

Implications

FHIA's training programs have proven financially sustainable as, by-and-large, pay for themselves. This is an important accomplishment considering that the agricultural sector in Honduras is dominated by smallholders and subsistence farmers. It is

possible that such experience could be reproduced in Africa.

The organizational structure of FHIA's training programs is also a key to their success. Training programs have been embraced as integral parts of the overall research and technology transfer programs and as such they are carried out by FHIA's core research staff. The communication unit provides logistical support to ease the burden on their time. Through this organizational structure, the

results of FHIA's research and development efforts are quickly translated into usable form and feedback from end-users is facilitated.

Feedback and evaluation procedures that follow FHIA's training programs are true value-adding components. They generate useful information about additional training needs and aid the design of effective new programs. Further, they provide information for updating a very valuable data base of potential end-users of FHIA's technologies.

AGRICULTURAL SERVICES

Many agricultural research and technology transfer organizations in LDCs maintain laboratory facilities since laboratory services are complementary to field trials and other research operations. In most cases, however, laboratory facilities are not fully utilized by in-house research and they are regularly made available to external users for a fee. Typical services offered include soil testing and surveys, pesticide residue testing, and plant and fruit analysis.

Provision of agricultural services by PROs to external users are often considered complementary to their overall technology transfer efforts since they facilitate and encourage adoption of improved production and post-harvest technologies. Their positive effects notwithstanding, agricultural services provided by PROs are plagued by inefficiency and typically constitute a net cost to these organizations. Two problems are most often encountered:

- The exact needs of the end-user are often not well understood by PROs that provide agricultural services. For example, Kenya growers who export flowers to Holland make regular use of pesticide residue analyses. Such services are typically purchased at the destination point. Although the technical capability for testing in Kenya is available, appropriate tests and reporting forms that could be used at the destination point by the regulating authority are not available.

- Delays in carrying out the agreed upon services and reporting of results are common due to irregular supplies of laboratory materials, inadequate funding, and lack of interest. Such delays are in many cases quite costly to the end-users.

Such inefficiencies are caused by a variety of factors. The most significant of these factors are:

- Smallholders and subsistence farmers are generally unable to pay for such services. In countries where such farmers dominate the agricultural sector, PROs typically reduce the prices of such services below cost so that they are made available to a larger number of farmers. In most cases, paying users do not substantially increase in number while at the same time services are subjected to inadequate returns. Insufficient funding, in turn, results in unsatisfactory services.
- Funding inadequacies from low revenues are often aggravated by improper accounting procedures. Lack of central accounting systems that can allocate revenues and expenditures across functional units is typical of many PROs in LDCs. Under such circumstances, fees from agricultural services are directed to the total fund managed by the PRO and do not return to the laboratory that provides the services. Instead, an annual budget is allocated to cover the operating costs of the laboratory. As a result, funds allocated

to laboratories are rarely proportional to the services provided.

- The organizational and management structure of PROs are often responsible for many inefficiencies. Laboratory facilities are in most cases managed by the same scientists or administrators that are responsible for the R&D activities of the organization. Hence, provision of such services to external users often compete for resources with research activities which are viewed as the priority. Services to external users are thus treated as secondary activities and in some cases as nuisances.

PROs which are not willing to subsidize or contemplate offering agricultural services as profit-making activities could consider one of the following alternatives:

- In cases where a large number of medium size farms—the typical user of such services—exists and effective demand can be secured, an independent service unit may be organized and allowed to manage its own budget.
- When effective demand for services is judged insufficient, laboratory facilities could be privatized and laboratory services for own research could be contracted out to the private organization.
- Consolidation and coordination of such services with other PROs with similar or complementary needs may be possible.

PROS AS VENTURE CAPITALISTS

In recent years, PROs have been taking ownership in private start-up companies that are created to develop or commercialize technologies produced by the PROs. In exchange of equity position, PROs may agree to provide the start-up company with exclusive rights for a particular technology, consulting services, access to lab facilities and

equipment, and other services. Primary reasons for PROs entering such joint ventures are:

- they have been unable to secure alternative licensing agreements;
- licensing may be an unsatisfactory way for capturing rents from particular technologies;
- in addition to licensing fees, in many cases it is easy to negotiate for stock with start-up companies;
- yielding equity position in lieu of payments may be the only available option for undercapitalized start-up companies;
- they are perceived as an effective means for transferring technology and contributing to local development.

For PROs that participate in joint ventures with technology start ups, forms of ownership generally involve:

- direct ownership through venture capital funds or partnership;
- indirect ownership through a “buffer” organization. Such organizations are created for reasons of legal protection and public relations but also for providing specialized expertise in joint ventures.

In general, joint ventures with technology start ups are inherently risky since the probabilities of success are typically low, but they can also result in high returns. An inherent and persistent problem for such ventures is lack of financial and management expertise by PROs that is necessary for guiding a new company through critical early stages. Further, financial risk is only one possible risk to which PROs expose themselves by entering such ventures. Threats to reputation through controversial managerial decisions, marketing of controversial products (e.g., pesticides or genetically engineered animals), or failure of the start up, are quite real. In general, many joint ventures in which PROs participate have been successful and financially rewarding. Rarely has such been the case, however, when PROs have attempted to manage such ventures themselves.

6. Technology Brokers and Intermediaries

Many PROs involved in commercialization use intermediaries to facilitate technology transfer. Technology intermediaries are private sector entities that specialize in one or more functions of commercial technology transfer. For example, many U.S. research universities and federal laboratories have turned to IPR management organizations like the Research Corporation Technologies (RCT), University Patents Inc., and others for patent administration and management services.

In a typical arrangement, PROs submit disclosures to the intermediaries and they in turn decide whether to patent and market the inventions at their own expense. For paying the up front costs of patent application as well as maintenance fees and marketing costs, technology intermediaries retain between 40 and 50 percent of the royalty income while the rest is shared by the PROs and the individual inventors. As a result, PROs do not have to get involved in administering, managing and financing IPR at substantial direct and transaction costs savings. Furthermore, intermediaries protect PROs from certain kinds of liabilities and litigation which may be awkward for many public or non-profit organizations. From all submitted inventions, however, only 10 percent is typically accepted. As a result, many PROs view the percentage of royalties retained by technology intermediaries as being too high given that they select the most promising and hence commercially less risky inventions.

A number of technology intermediaries are involved with transferring technology through start-up and venture capital companies which are created with primary objective the commercialization of promising new technologies. The Argonne Chicago

Development Corporation (ARCH), a non-profit corporation affiliated with the University of Chicago, is an example of such a technology intermediary. ARCH focuses on starting companies to commercialize technologies generated by its affiliates. It also engages in joint ventures and licensing or some combination of the three technology transfer options. ARCH's approach to transfer for technologies developed by PROs is unique in that start ups and ventures are viewed as the best means for commercializing superior inventions. ARCH typically decides whether starting up a new company is justified by the nature of the technology, chooses a management team and seeks venture capital. ARCH encourages the active involvement of inventors by offering equity position as compensation for their services.

Most intermediaries, whether for-profit or non-profit, operate in a similar business-like manner with commercial success of the technology transfer as a primary objective. Two case studies are presented here that clarify the structure of operations and organization of technology intermediaries. They are instructive in that they illustrate many important aspects of commercial technology transfer.

BRITISH TECHNOLOGY GROUP (BTG)

BTG was originally founded in 1949 by the British government to foster national innovation. In 1981 BTG was reorganized with primary objective to identify technical complementarities and out of them create and market commercial products. In 1992, BTG was privatized.

BTG owns a number of subsidiaries, start ups and venture capital firms involved in financing,

marketing, patenting and other commercial technology transfer activities world-wide. It has over 200 employees and its personnel includes executives, patent agents, legal counsels, marketing and financing specialists and other support staff. It currently manages and markets over 10,000 patents and patent applications around the world and has over 500 current licensees. Patents that are being licensed by BTG involve pharmaceutical products, medical and dental technology, chemicals and plastics, electronics and food and agribusiness products. Flagship inventions being marketed by BTG include Magnetic Resonance Imaging (MRI) technology and synthetic pyrethrins. In 1993, BTG's licensing activity yielded £24.75 million.

With its own team of executives with patent, legal, commercial, financial and technical skills and experience, BTG works with a variety of private companies and PROs with the main objective being the commercialization of technology. BTG reviews and assesses technology needs and inventions for a large number of cooperating corporate firms and PROs. It subsequently seeks partners with complementary assets and technologies. That would create new marketable products. In the process, BTG assumes the responsibility for patenting, negotiating licensing agreements, and developing marketing strategies. It typically operates on a no-fee revenue sharing basis.

The Process of Adding Value to Technology

The main business philosophy of BTG is that the value of technology is determined by its particular application(s). Within this framework, BTG's main value added activity is identification and implementation of the most promising applications of technology.

BTG is involved with both science-push and demand-pull technology transfers. In science-push situations, BTG searches for technologies are generally advanced in terms of science and show promise for commercialization. BTG may provide development and maturation funds to advance

technologies to a more commercially relevant level, and, it assumes the expenses for patenting, marketing and licensing it.

In demand-pull situations, BTG identifies technical needs of potential end-users with whom it already has a rapport (e.g., current or previous licensees and members of its inter-corporate licensing program). When no suitable technology exists to satisfy the identified technical need, BTG arranges and finances research and development of an appropriate technology with a public or private research organization with expertise in the field of interest. In demand pull situations, potential market size and profitability are more easily assessed and an interested end-user is already in place. Under such conditions, development costs tend to be lower, as an interested end-user is often ready to assume responsibility for the technology at an earlier stage, and marketing costs are almost non-existent.

When a licensing agreement is signed, the stream of royalties is first used to pay-off all R&D, marketing and patenting costs. The remaining is divided equally between BTG and the technology owner(s). BTG's key value added activity in both science-push and demand-pull transfers is matching a given technology with an appropriate entrepreneur. Working with BTG provides access not only to its specialized legal services and capital resources but more importantly to its international network of business contacts and its institutional knowledge of their technical needs.

Lessons from Key Indicators

Despite the efforts of BTG to ensure marketability, only 1 out of 10 patents is commercially successful. Commercialization of technology transfer is subject to substantial market uncertainties. Some key indicators are illuminating with regard to the costs of commercial technology transfer activities. Almost 1/3 of BTG's total 1993 licensing revenues was turned over to the owners of technology. Another 1/3 was used to pay external legal, patenting and R&D expenditures. The remaining was captured by BTG for its services. From the total expense of patenting and financing

new technology development, only ¼ (approximately £2.0 million) was expended for patent maintenance fees and amortized application fees. While significant, such costs include commercially unsuccessful technologies and hence they are more than balanced by commercially successful technology transfers. Litigation costs were a respectful £0.87 million.

Elements of Success

Commercial success even for proprietary technology is far from given. While BTG incurs significant costs in sponsoring, patenting and marketing inventions, such costs are not recovered until a technology is commercialized. Even in cases where commercialization is possible, the flow of returns is typically temporally uneven due to substantial lags between invention and commercialization. Having a large patent portfolio to market is key to BTG's success as economies of scale exist in maintaining specialized expertise necessary for patenting and marketing technologies. Furthermore, a large number of active licenses tends to smooth royalty income thus making revenues from commercialization more predictable.

The most important element of success, however, is BTG's access to a large and diverse business base that locates potential end-users. Through its previous partnership roles with a large number of companies, BTG has institutional knowledge about their core business and collateral assets as well as access to decision-makers. Its positive market image and experience in commercial technology transfer reduce uncertainty for companies, individual scientists, and public institutions further aiding its success.

INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRICULTURAL BIOTECHNOLOGY APPLICATIONS (ISAAA)

ISAAA is a non-profit technology intermediary established in 1991 and co-sponsored by public and private institutions. Its main objective is to facilitate the acquisition and transfer of proprietary biotechnologies from MDCs to LDCs. ISAAA is

structured as a small international network of technology transfer nodes. There are three centers in North America (*AmeriCenter* at Cornell University, USA), Europe (*EuroCenter* at Norwich Research Park, UK) and the Asian Pacific Rim (*AsiaCenter* at Technova, Japan) that monitor and evaluate availability of biotechnology for transfer. Similarly, there are three network offices in Africa (*AfriNet*, in Nairobi Kenya), Asia (*AsiaNet*) and Latin America (*LatiNet*).

Similar to BTG, ISAAA focuses on transfer and adaptation of proven biotechnologies that are well into the product development stage. Emphasizing mature science and technology, minimizes implementation lags and speeds up the development impact of the transfer. Because of the emphasis on mature biotechnologies, access to proprietary technology is generally necessary. Most biotechnology research is conducted by the private sector and is proprietary. Furthermore, non-proprietary public biotechnology emphasizes basic research and proof of concept rather than product development. Hence, donation of proprietary biotechnology by private collaborating parties is key to ISAAA's operations. American Cyanamid (USA), Asgrow/Upjohn (USA), ICI (UK), KWS (Germany), Kirin (Japan), Monsanto (USA), Pioneer Hi-Bred International (USA), Sandoz Seeds (Switzerland) and Schering (Germany) have all committed to donate technology and to provide training to scientists from LDCs for projects arranged by ISAAA.

Willingness of private companies to provide proprietary technology at no charge may be secured by ISAAA on the basis of one or more of the following motivations:

- they have little to lose since they are unable to commercialize proprietary biotechnologies in many LDCs due to lack of local infrastructure, enforceable IPR and understanding of local markets;
- testing and implementation in a variety of geographic locations and climatic zones advances knowledge and adds value to their proprietary technologies;

- potential future commercial benefits may be secured in the countries of transfer through establishment of unique institutional links, improvement of public image, and development of knowledge of local markets;
- potential current commercial benefits may be secured by product complementarities as multinationals are often exporters of technology and importers of raw material produced in LDCs.

A commitment that donated technologies will be used locally and will not be commercialized in the donor's target markets is an important precondition for the release of such technologies.

Operations

The strategy adopted by ISAAA in brokering transfers of biotechnology involves the following steps. First, through personal interaction with interested parties and clientele groups in selected LDCs, biotechnology needs and priority areas are identified. Second, through an extensive network of collaborating parties, mostly in MDCs, appropriate biotechnologies that can address the technical needs that are sought and evaluated. Third, the transfer of a proprietary technology matched with an identified need is effected through "honest broker" services. Fourth, funding from donor agencies and private investors is solicited for the transfer.

"Honest broker" services are an essential element of ISAAA's intermediation role in technology transfer. Such services involve identifying and bringing together the technology donor and recipient under conditions that are acceptable to both. A large part of the broker services involve addressing reservations and easing uncertainty through establishment of trust and formal contractual agreements. Personal relationships and ISAAA's standing are paramount in minimizing uncertainty and bringing agreement to fruition.

An ongoing transfer effort arranged by ISAAA-*AfriNet* demonstrates interesting aspects of the organization's intermediation role. ISAAA-*AfriNet* was established in July of 1994, and the first transfer activity brokered by its Director Dr. F. Wambugu is already underway. The project involves tissue culture for rapid multiplication of bananas in Kenya. The demand for banana trees in that country is substantial since the industry was hit by the fungal disease *sigatoka*. Resistant varieties exist and tissue culture biotechnologies have been developed and tested at the Horticulture Department of the J. Kenyatta University of Agriculture and Technology (JKUAT). ISAAA-*AfriNet* has secured the cooperation of a commercial tissue culture laboratory for banana multiplication in Costa Rica for the training of collaborating scientists from JKUAT. Private investors who will finance the commercial tissue culture laboratory in Kenya and commercialize its output have also been identified by ISAAA-*AfriNet*. Other arrangements that ISAAA-*AfriNet* has supported include purchase of equipment, identification of marketing and distribution agents, and establishment of a business plan.

Advanced technical skills, knowledge of local markets, and business savvy are all important in brokering such complex transfers. Institutional knowledge and access to collaborating owners of proprietary technology are also important. Bringing interested parties to the table, however, is only the first step. Managing uncertainties faced by negotiating parties regarding their roles and associated costs and benefits in the venture is paramount for catalyzing a final agreement.

IMPLICATIONS

Technology intermediaries are generally diverse in structure as well as in business and technology emphases. However, they all attempt to manage uncertainty so that the probabilities of success in commercializing technology transfer are maximized. In particular:

- they manage primary (technical) uncertainty by emphasizing mature science that has been taken beyond the proof of concept stage;
 - they manage secondary (informational) uncertainty by maximizing informational flows on available technology and potential end-users through extensive data bases and interpersonal networks;
 - they manage behavioral uncertainty forthcoming from suspicion and interpersonal conflicts and misunderstandings through active intermediation as well as personal and institutional reputation.
- In effect, such operations illustrate some of the key conditions for commercially successful technology transfers.

7. Concluding Comments

Technology has become the centerpiece in contemporary approaches to economic growth and development. Similarly, new competitive strategy theories are built around technology generation and acquisition. With that much attention on technology and a concurrent explosion of scientific and technical knowledge, the number of stakeholders in technology generation has rapidly increased. Technology stakeholders are seeking and achieving institutional changes that will facilitate transfer and commercialization of technology around the globe. In agriculture, recent institutional changes of importance include awards of patents to living organisms, enhanced plant breeders' rights, strengthening of property rights for genetic resources, and the inclusion of intellectual property rights in GATT.

For those involved with the generation of technology, success in transfer will be increasingly looked upon as a means for capturing a greater portion of its value. For technology users, it will continue to represent a primary source of growth and increasing standards of living. Accumulated experience with technology transfer has shown that most barriers to transfer are informational in nature. Incomplete information and lack of understanding or trust among transacting parties are common impediments to technology transfer. They increase uncertainty and make non-adoption of technology a rational choice.

Public research and technology transfer organizations that consider commercialization of research and technology as a way to sustain their R&D operations, will have to learn how to create value from activities that reduce informational asymmetries in technology markets. Several case studies presented in this handbook demonstrate that a large portion of value added in technology transfer is related to reductions in informational

deficiencies of technology markets. INBio's proprietary data base for bioprospecting, BTG's proprietary data base of potential licensees, and FHIA's data base of numerous technology users and their technical needs, all exemplify the value added to technology transfer through information availability.

For non-standardized goods, such as technology, markets are often incomplete. Even with good efforts, information is also incomplete in such markets. A relationship of trust between transacting parties can act to minimize uncertainties created by incomplete and asymmetric information. BTG's stature in the technology market and personal relationships with end-users and scientists, ISAAA's special status as a non-profit "honest broker", and INBio's reputation and intellectual champions, all act to increase the trust factor in their technology transfer efforts. Understanding the technical needs, constraints, and value systems of clientele groups and establishing a relationship of trust should be a preoccupation of research and technology transfer organizations with commercialization in mind. Sacrificing value in the short run for securing the chance of proving technological capabilities and establishing long term trust relationships, may be an effective strategy for successful commercialization by public research organizations.

Uncertainties from incomplete information should be actively managed within the research and technology transfer organizations as well. Policies on acceptable practices and conflict of interest should be clearly stated and broadcast. Uniform performance standards should be set and strong incentives should be provided to encourage individual commitment to commercialization. Organizations should be configured to facilitate interaction of the scientists with clientele groups.

Support staff with specialized expertise in commercialization activities should be employed to reduce the burden placed on individual scientists and technicians through such activities. The ultimate objective is to transform scientists and other civil servants into “entrepreneurs” and engage them in the organization’s commercialization effort.

Logistical issues are also important. Independent institutional status is needed for public research and technology transfer organizations that consider commercialization. The ability of governmental organizations to enforce contracts and intellectual property rights, an essential part of commercialization, is severely limited. An appropriate accounting system is a minimum requirement and it is most often missing from African public research and technology transfer organizations. Proper procedures for allocating costs among various research and technology transfer activities are necessary. Reporting expenditures to funding agencies and other contractees, pricing technology products and services, keeping track of individual project accounts for appropriate budget management, and providing incentive funds to research teams with external funding are activities essential to commercialization. Without an appropriate accounting system, such activities are not facilitated.

Public research and technology transfer organizations operating in an economic environment with an adequate number of commercial farmers and an active agribusiness sector will likely face an easier task in their quest for commercialization. Even under such circumstances, however, the adjustment process towards successful commercialization is likely to be prolonged. It is unlikely that substantial funds can be generated in the short run to sustain an organization’s operations through commercialization. Slow-changing cultures, both of the research organization and of the end-users,

long gestation periods in the R&D process, insufficient enforcement of intellectual property rights in African countries, and slowly changing relationships between public and private sector are all impediments to quick returns from commercialization. Under these circumstances, careful selection of activities for commercialization are important. Initial emphasis on commercialization of training programs, agricultural services and sponsored research with concurrent focus on adaptive research may be an efficient short term strategy. Marketing intellectual property, genetic resources, and breeding programs can be developed gradually as extraneous factors permit.

Creating, capturing and marketing of intellectual property is a long and costly process that assumes substantial expertise and overhead costs. It is possible that regional technology brokers could be created to coordinate the efforts of several public research and technology transfer organizations. In this fashion, overhead costs are spread around and sufficient scale of activity is created to make their operations economically relevant. Technology brokers could act as consulting bodies to provide specialized training and expertise on commercialization for interested organizations. More importantly, however, technology brokers could act to mediate initial commercialization efforts, a badly needed function in spotty and incomplete technology markets.

The benefits from commercialization extend beyond direct financial gains. Research and technology transfer organizations that are “commercially minded” are more in tune with the technology needs of end-users. Their research agendas are accordingly more sensitive to demand-pull conditions which facilitate technology transfer and a more immediate economic impact on the local economy. Efficiency in operation within such organizations is typically also improved. Thus indirect benefits from commercialization may be more substantial in size than the direct financial gains secured, at least in the short run.

Bibliography

- Agricultural Research and Technology Transfer Policies for the 1990s* OTA, Special Report, Congress of the U.S. Office of Technology Assessment, 1990.
- Anderson, J. R., (Editor) *Agricultural Technology: Policy Issues for the International Community* CAB International, Wallingford, UK, 1994.
- Brantley, P., *Patent Law Handbook* Clark Boardman and Callaghan, New York, 1995
- Burgelman, R., and M. Maidique, *Strategic Management of Technology and Innovation*, R.D. Irwin, Homewood, Illinois, 1988.
- Carr, R. "Menu of Best Practices in Technology Transfer" *Technology Transfer* 19:24-33, 1992.
- Contreras, M., "The Organization of Small-Country Agricultural Research System with Broad Research Demands: Institutional Diversity for Honduras" ISNAR Small Countries, Study Paper No. 4, The Hague, ISNAR, 1992.
- Drucker, P. "The Discipline of Innovation" *Harvard Business Review*, 67-72, 1985.
- Gallini, N. And Wratner, R. "Licencing in the Theory of Innovation" *Rand J. Of Economics* 16(2), 1985
- Gamez, R. "Costa Rica's National Biodiversity Institute: Biodiversity Working Sustainably for Society." *Diversity*, 7(1):79-81,1991.
- Goldscheider, R. *Technology Management: Law/Tactics/Forms* Clark, Boardman, and Callaghan, New York, 1995.
- Jacobs, A. (Editor) *Patents Throughout the World* Fourth Edition, Clark, Boardman and Callaghan, New York, 1995.
- Loveridge, R., and M. Pitt. *The Strategic Management of Technological Innovation* J. Willey & Sons, New York, 1990.
- Madu, C., "An Economic Decision Model for Technology Transfer" *Engineering Management International* 5:53-62, 1988.
- Mansfield, E. *The Economics of Technological Change*, W.W. Norton & Co. New York, 1968.
- Nelson, R. (Editor) *National Innovation Systems: A Comparative Analysis*, Oxford University Press, Oxford, 1993.
- Quinn, J. B., "Managing Innovation: Controlled Chaos" *Harvard Business Review*, May-June, 73-84, 1985
- Pardey, P. J. Roseboom, and J. Anderson. (Editors) *Agricultural Research Policy: International Quantitative Perspectives* Cambridge University Press, Cambridge, UK, 1991.
- Reddy, N. And Zhao, L. "International Technology Transfer: A Review" *Research Policy* 19:285-307, 1990.
- Roberts, L. "Chemical Prospecting: Hope for Vanishing Ecosystems?" *Science* 256:1142-43, 1992.
- Saaty, T.L. *The Analytic Hierarchy Process-Planning, Priority Setting, Resource Allocation*, McGraw-Hill Book Co., New York, 1985.

- Samli, C. *Technology Transfer: Geographic, Economic, Cultural and Technical Dimensions* Quorum Books, Westport Connecticut, 1985.
- Sedjo, R. "Property Rights, Genetic Resources, and Biotechnological Change." *J of Law and Economics* 35:199-213, 1992.
- Siebeck, W., R. Evenson, W. Lesser, and C. Braga "Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature." World Bank Discussion Papers, No. 112, Washington D.C., 1990.
- Simpson, D., J. Love, and J. Walker *The Challenge of New Technology* Westview Press, Boulder Colorado, 1987.
- Technology Transfer Practice Manual*, Volumes I & II Association of University Technology Managers, 1993.
- VanWijk, J., J. Cohen, and J. Komen. "Intellectual Property Rights for Agricultural Biotechnology: Options and Implications for Developing Countries." ISNAR, Research Report No. 3, The Hague, 1993.
- Wheelwright, S. "Commercialization of Biotech Products" *Biotechnology* 12:877-80, 1994.
- Winebrake, J. "A Study of Technology Transfer Mechanisms for Federally Funded R&D" *Technology Transfer* 19:54-61, 1992.