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Why Research Partnerships Really Matter: Innovation Theory, Institutional Arrangements and Implications for Developing New Technology for the Poor

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Summary. — This paper explores the conceptual basis for existing and emergent institutional patterns in the context of partnership approaches to technology development. Drawing examples from recent studies of private enterprise activity in India smallholder horticulture, it suggests that agricultural innovation as a process involves a wider range of organizational types than the conventional policy focus on public sector research organizations would tend to suggest. It uses the concept of a "national innovation system" to argue that a partnership approach is adopted as a core methodology for engaging science and technology development with the livelihood demands of the poor. © 2001 Elsevier Science Ltd. All rights reserved.

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1. INTRODUCTION

This paper explores the conceptual basis for existing and emerging institutional patterns of agricultural research in the context of partnership approaches to technology development. We do this at a time when "partnerships" as an approach are gaining increasing currency among the donor and international research community.[1] The concept implies collaborative relationships consisting of the public and private[2] sectors, and between "research" and "nonresearch" organizations. The rationale for this change in approach is often couched in terms of "the complementarity of different organizational styles," "pluralism in funding," "comparative advantage" and "institutional synergy." We agree that the move to this approach reflects the realities associated with successful technology development. We argue, however, that current conceptual and analytical approaches have difficulty in providing an adequate understanding of the complex process that this implies. In particular, we argue that the institutional dimension of the technology development process dictates that a more inclusive set of analytical principles is required to understand why partnerships matter, and to formulate policy to adequately support a change toward this approach.

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Since a central tenet of our argument is the importance of institutional factors in the relative success of the innovation process, we begin by defining the term as it is used in the context of the innovation debate. We then review current concepts concerning the agricultural innovation process, highlighting the difficulties these conventions have in dealing with the institutional dimensions of the process. Before presenting case studies from India, we provide a brief overview of the patterns of institutional development of the national agricultural research system in the country. Two case studies are then presented of partnership arrangements to support the position that institutional issues warrant much greater attention if productive partnerships and successful technology development are going to take place. [3] Finally we discuss the implications of the empirical evidence and the way it suggests a pattern of institutional behavior similar to that in other economic sectors where innovation is viewed in systemic terms. We then present this as an alternative framework and discuss the analytical principles that it suggests. We conclude by suggesting that these concepts could be developed to help focus agricultural technology development efforts on the needs of the poor.

2. INSTITUTIONAL ANALYSIS: SOME DEFINITIONAL POINTS

The concept of an "institution" is a difficult one and is subject to considerable confusion in the literature. Some writers see institutions as "social rules and norms" and therefore as cultural traits shown by social groups. Others see them more as specific organizations designed to fulfill a given set of functions. In this vein we suggest it is useful to follow Brinkerhoff and Goldsmith (1992) who make the distinction between "rule-oriented" institutions and "role-oriented" institutions. The former may be defined as "the rules of the game in a society or, . . ., the humanly devised constraints that shape human interaction," while the latter are defined rather as "organizations that have attained special status or legitimacy." [4] These are essentially legally identifiable organizational systems that bring together with different social backgrounds, knowledge and techno-scientific skills to address, collectively, specific socioeconomic problems and uncertainties. Such units have certain life spans and generate specific outputs in the process of dealing with problems and uncertainties.

During the last few decades, economists too have given increasing attention to the role of "institutions" in the functioning and change of economic systems. The "institutional economists" usually adopt the sociological meaning of the term, referring to things that pattern behavior—routines, norms, shared expectations, morals (Edquist & Johnson, 1997). The "new" institutional economists such as North (1990), suggest that the emergence of these rules and regulations, which can be informal as well as formal, are a mechanism for reducing transaction costs and other forms of market failure. Generally the institutional economists' position is that understanding the rules and regulations that govern behavior helps explain the shortcomings of conventional economic theory.

The practice in the innovation systems literature is to use the everyday meaning of the word institution: i.e., physical organizations dealing with research and development (R&D) and economic activity—research centers, universities, private companies, research foundations, farmers associations, cooperatives and so forth. However, Edquist and Johnson (1997) point out some ambiguity among authors, some tending only to analyze the behavior of physical organizations, whereas others focus more on the rules and regulations environment. [5] The confusion arises because generalizations from empirical observation indicate that both shape the outcome of innovation. The real problem is that institutions in the "rules and norm" sense are often intimately related to the nature of organizations, and in one sense organizations help define and operationalize the "rules of the game." In other words, they are mutually embedded concepts. Edquist and Johnson point out that understanding of innovation processes will be helped by a clear distinction between these two concepts. But since conceptual uncertainty exists concerning the relationship between rules and organizations, it is necessary to analyze the combined effects of the two concepts.

In this paper we follow the more inclusive innovation theorists' definition rather than the narrower institutional economists' convention. The term *institution(al)* is used to mean the combined environment of "rules of the game" and physical organizations and the interplay of the two. Where "rules and norms" or organi-

zations can be separately discussed and analyzed, we do so. Institutional change, being a key concept discussed in this paper, deserves special mention. We use it to refer to the evolution and dynamic interplay between "rules and norms" and organizations, usually associated with the need to perform a new task or to perform an existing one differently.

3. AGRICULTURAL R&D: CONCEPTS OF INNOVATION

The conceptual basis concerning the innovation process in agricultural sector and the way public sector R&D supports this process are revealed in the literature dealing with the measurement of performance of R&D activities and policy analysis concerning the arrangements for undertaking R&D. Two broad traditions appear to exist, each with its own implicit conceptual underpinning.

(a) *Quantitative analysis*

The first of these traditions is characterized by quantitative analysis of performance and is derived mainly from the neoclassical economics tradition. The position taken is that there is a linear relationship between investment in research, the development of agricultural technology, its subsequent adoption by farmers, and finally its ultimate impact on economic production. This is broadly reflected in the institutional set-up of agricultural R&D that serves developing countries, namely a loose association of international agricultural research institutes [6] supporting commodity and or disciplinary-based public sector research institutes at the national level. These are usually referred to as National Agricultural Research Systems (NARS). They provide technology for dissemination via a (usually) publicly-funded extension system.

Using this conceptual framework, investments in research are compared with adoption (outputs) of technology and increases in factor productivity. This is often used as part of the priority-setting process where financial allocations are made to subsectors (often commodities or research themes) based on rates of return to investment. [7] In turn such activities are often conditioned by collective wisdom concerning areas of strategic importance. [8] Institutional arrangements are addressed in the sense that decisions are made concerning the appropriate mixture of specialized commodity and thematic research centers. This is very useful in providing a snapshot of the performance of the research system, but has difficulty taking into account "process" and qualitative factors that condition both research and innovation performance, and the dynamics of the process over time. Furthermore, consistently high rates of return, particularly for major commodities, tend to confirm the perception that the innovation process, and the institutional arrangements to achieve it, is functioning effectively. [9]

At the macrolevel, this type of analysis has difficulty dealing with equity issues (although some priority commodities will clearly be more important to the poor than others). [10] A subset of this quantitative approach has therefore examined the impact of technical change (partly through adoption studies). This has led to explicit recognition of concerns over of the scale neutrality of technology. Mechanisms to address this have focused on the factor-consuming characteristics of technology, (often implemented through priority-setting exercises), and do not appear to question the effectiveness of current institutional arrangements of the R&D process to capture and account for these issues.

A more recent related set of issues concerns emerging public/private sector relationships in agriculture for example, in the seed and biotechnology industries. Again, broadly neoclassical approaches are used to predict which areas of R&D and subsequent goods and services will be provided by the private sector and in which areas market failure will necessitate public sector provision, regulation or subsidies. [11] The core of these arguments concerns the relative degree to which goods and services are of a public or private goods nature. The concepts of rivalry (in the supply of knowledge) and excludability (the capture of proprietary rights to knowledge) are used to predict which areas, through market failure, will need to remain in the public domain. This line of reasoning is also used to predict where market failures will cause underinvestment in research due to concerns over private appropriability and therefore areas where public sector research will remain a strategic activity in support of the private sector and society more generally. Similarly this approach is also used to identify which mixture of specialist organizations will be needed to deal with farmers directly.

(b) *Process analysis*

The second broad tradition takes a qualitative approach to R&D systems analysis and has developed to complement the approaches discussed above. It has tended to focus more explicitly on the process, rather than on the outputs and impact of R&D. In particular it has examined and questioned the validity of the institutional arrangements, methods and concepts that underpin it.[12] The underlying proposition in this tradition is that in actual fact hierarchical institutional arrangements typical of most centralized agricultural research systems are unable to deal with the complex technology needs of farmers, particularly small farmers (Biggs & Clay, 1981; Chambers & Jiggins, 1987a,b; Biggs, 1990).[13] It suggests that innovations are produced not by organized science alone, but by a number of actors including farmers, often in combination with other elements of the system. It also suggests that institutional arrangements embodied in the centralized science model of innovation separate scientists and farmers to such an extent that productive relations are not established and that this is detrimental to the R&D process (Biggs & Clay, 1981).

A subset of this approach concerns the conceptualization of agricultural production as a system and the need for this to be appreciated in the R&D process. The associated farming systems research debate[14] has been mainly methods-driven and has struggled to find explicit form in an appropriate institutional framework. For example, the integration of different disciplines has been particularly difficult to achieve institutionally as has the ability of existing structures to genuinely accommodate farmers in the research process (Biggs, 1989; Ewell, 1989; Farrington & Martin, 1991; Biggs & Farrington, 1993; Biggs, 1995).

The issues in the broader debate concerning the role of farmers in the research process have found expression in the participatory research movement.[15] But while the original conceptual basis of this debate explicitly made the link between the nature of institutional arrangements and the performance of the R&D process, much of the subsequent debate has focused on participatory methods rather than underlying institutional issues.[16] Biggs and Smith (1998) argue that this "methods bias" masks the fact that the most successful participatory methods have arisen in specific institutional and political circumstances and have often evolved to deal with a specific problem area in that context. This, it is suggested, often occurs through coalition building, associations of people brought together out of the necessity to deal with a specific problem and the shared belief in the choice of approach to solving it. They go on to suggest that the participatory approaches that evolved in this way were associated more with institutional innovations rather than new methods *per se*, and that transferring the methods element of the approach to new and often unreceptive institutional and organizational contexts stands little chance of success.[17]

The coalition concept of Biggs and Smith (1998) highlights the fact that successful technology development is a very complex process. Indeed it often results from the "nuances" of personal, professional and institutional relationships that change and evolve (often rapidly) over time. These (often institutional) changes take place in response to new technological needs (or opportunities) as well as political and economic circumstances. Furthermore it is these "nuances," often only identifiable through detailed case histories that are so difficult to capture in neoclassical analysis of the innovation process and the relationship between research investments and impacts on the poor. Clearly partnerships of various types are important in this view of the way innovation and technology development actually works. As the case studies in Section 4 illustrate, however, forging successful partnerships needs a much more holistic understanding of the process of technology development and the institutional arrangements necessary to achieve it. Before presenting these case studies it is useful to place them in the context of the institutional development of the Indian NARS over the last 40 years or so, explaining in brief the implications of this for the performance of the system as a whole.

4. INDIAN NATIONAL AGRICULTURAL RESEARCH SYSTEM (NARS)

The Indian NARS is one of the most extensive, diverse and complex agricultural research systems in the world. It has two major components: the research institutions that fall under the national apex body, the Indian Council for Agricultural Research (ICAR) and those administered by 29 state agricultural universities (SAU). These two components

interface quite closely, particularly through regional adaptive research orchestrated through a large number of *All India Co-ordinated* projects that bring together the collaborative efforts of the two systems. Less well integrated, but nevertheless important, are nonagricultural universities and other scientific organizations—notably those under the Council for Scientific and Industrial Research (CSIR), the Department of Biotechnology and the Department of Science and Technology, all of which conduct research related to agriculture.

The early development of ICAR can be traced back to the 1930s. Although the development of the system as it is today began in the postindependence period. A significant impetus came during the 1950s and early 1960s from international concerns over the need to increase food production in Asia.[18] This led to an Asia-wide phenomenon, commonly referred to as the "Green Revolution." In India this contributed to the development of a significant amount of India's agricultural research infrastructure and stimulated technological advances in cereal food crop production. A critical factor was the reorganization of ICAR in the late 1960s around an applied research strategy focusing on food security. This was specifically designed to capitalize on the advances in wheat breeding that had taken place in the Mexican/Rockefeller breeding program. The political will, reinforced by the specter of mounting food imports, provided increased funds to implement the strategy. The result was the adoption of a short-term, mission-oriented public sector plant breeding focus on dwarf wheat, backstopped by international technical assistance (Rajeswari, 1995). The combined result of these technical and institutional factors was enormous, allowing India to achieve food security within a decade.

Another tangible outcome of the international political economy of the time was the establishment of state-level agricultural universities based on the land-grant model. The land-grant universities were set up originally in 19th century United States with a research/extension/training mandate to serve the needs of farming communities in the state where they were located. Political processes and institutions that developed simultaneously in the United States ensured that local issues were articulated and, through the control of resources, this influenced the priorities of the local university. But for a number of social and cultural reasons such mechanisms to allow client orientation are absent in the Indian context (Brass, 1982). One reason concerns the social hierarchies that characterize Indian society. Naturally, where social hierarchies are strong, professional and institutional hierarchies will develop similarly. This can be advantageous at times. For example, the Green Revolution relied on these hierarchies to introduce, in a quite prescriptive manner, a major technical innovation. But, the difficulties such hierarchies create for inducing a client focus in research, and the constraints it imposes on communication between organizations, particularly extension and research, have been a pervasive characteristic of the public sector research system in India. This has become increasingly apparent with the growing complexity of agricultural constraints.

The structural changes of ICAR during the 1960s and 1970s led to centralization of funding, execution and management of agricultural research with greater autonomy and empowerment of ICAR as the apex body. The period also saw the rapid expansion of numbers of research organizations under ICAR and the accompanying hierarchical bureaucracies. These developments took place against the political and ideological backdrop of a closed economy; a drive for self-sufficiency in not only food production, but science and technology generally; a heavy presence of the public sector in all areas of the economy; and with a number of policy measures to restrict private sector activity in agriculture and allied fields. Only after the liberalization process began in 1991 was it acknowledged that large public sector organizations such as ICAR might need to change to match a less pervasive role for the public sector.

Although the Indian NARS had evolved over the years, by the early 1990s, for reasons of size alone, the system was already facing severe financial and operational problems. These included unplanned growth, duplication/overlap of institutional mandates, loss of complementarity among institutions, lack of funds for operating expenses, a need to modernize the research infrastructure, and the need for training and upgrading scientists' skills in frontier science and management areas (Mruthyanjaya & Ranjitha, 1998). A number of basic problems still affect Indian agriculture. For example, problems of food and nutritional security, poverty, employment and equity still persist. In

addition, new challenges are also emerging—specifically, sustainability of natural resources, environment, biodiversity and increasing exports through quality enhancement (Paroda & Mruthyaunjaya, 1999). Arrangements for achieving a client orientation in research, particularly for the poorest farmers, are still rare (Farrington & Martin, 1991). The highly bureaucratic and hierarchical nature of institutional arrangements and the complexities of governance of the NARS as a whole, have further entrenched such problems (Mruthyanjaya & Ranjitha, 1998). At the same time, wider issues are emerging including trade related adjustments associated with globalization and the effects of GATT and WTO agreements. The entry of the private sector into agricultural research and the wider implications of the role of the new state following the start of India's liberalization process are also coming to bear. The flattening of public sector funding seems also to have focused minds on the task of restructuring the system to some extent primarily in response to the changing economic and institutional climate.

In response ICAR has implemented several organizational and management reforms to improve its efficiency and accountability; forge linkages with other partners; and mobilize resources. The broad vision for these reforms is ambitious. It includes many familiar elements common to other efforts to improve the efficiency of very large public sector organizations such as redefining a strategic role for the organization; consolidation rather than expansion of research institutes; de-bureaucratization and improved administrative efficiency; decentralization of decision making; institutionalization of priority setting, monitoring and evaluation; commercialization of products and services; and partnerships with the private sector and other stakeholders.

India is not alone in recognizing the need for significant change in agricultural research sector. Around the world the swing toward privatization, decentralization and competitiveness in the late 1980s and 1990s has started to shift the conceptual view of the NARS, with the public sector monopoly of NARS increasingly being seen as an obsolete institutional model for building capacity (Byerlee & Alex, 1998; Echeverria, 1998). Byerlee and Alex (1998) indicate that this reflects the emergence and recognition of a diverse set of actors that have the potential to form an institutionally pluralistic system. These include:

—universities that have considerable research as well as teaching capacity.
—private companies engaged in developing and selling embodied technology products.
—agricultural foundations supported by both public and private funds.
—farmer organizations and cooperatives that might organize their own research or support research by other organizations.
NGOs, some of which have the capacity to undertake adaptive research.

Implementing this new vision of the NARS is at an early stage in many developing countries. The scale of reforms in an organization such as ICAR make this a formidable, time-consuming and costly task. It is however, within this broad context that the following case studies should be viewed.

5. CASE STUDIES [19]

(a) *Case study no. 1: a case of systemic failure in institutional arrangements for technology supply*

This case study was originally undertaken to understand the links between private sector activity and its relevance as a mechanism for linking small farmers with technology and markets. It was undertaken as part of wider series of studies dealing with the technological development of the Indian horticultural sector. It illustrates the experience of an export promotion organization in its attempts to forge partnerships between a private organization and an associated group of farmers and public sector scientists in order to overcome post-harvest constraints associated with access to new export markets.

(i) *Partnership arrangements*

The Vijaya Fruit and Vegetable Growers Association (Vijaya) was established in 1992 in Vijawada in southern Andhra Pradesh, India. The association is made up of 16 fruit and vegetable cooperatives (primary societies) spread over three districts around Vijawada. The primary society membership consists of approximately 500 small and medium-scale farmers (1–10 acres) who between them cultivate almost 3,000 acres of mangoes. Vijaya acts as an apex organization to undertake and coordinate the marketing of mangoes in export and high-value domestic markets. It is a private enterprise established with a specific goal of finding a better price for farmer members'

produce through direct marketing without the produce being handled by middlemen, wholesalers and traders. Farmers receive a premium price for fruit of export quality. In turn, a key function of Vijaya has been to act as a source of technical advice and inputs to assist farmers to increase the proportion of fruit that reaches export quality criteria. Initially only 10% of fruit attained this level of quality.

The initial efforts of Vijaya involved marketing its farmers' mangoes in the high-value domestic market and subsequently to the Far Eastern export market relying on airfreight arrangements. In 1995 Vijaya began exploring the potential of European markets. Assistance was sought from the Agricultural Processed Products Export Development Authority (APEDA) in the Ministry of Commerce, Government of India. APEDA provided considerable assistance to Vijaya in its efforts to link farmers to this new export market. Subsidies were provided for collecting market intelligence; cost of samples and trial shipments; cost of producing promotional literature; and underwriting commercial shipments. APEDA also supported the technical capacity of Vijaya and its farmers, not only by providing 50% of the costs of engaging national scientists but also in forming linkages between Vijaya and relevant sources of technical expertise both nationally and internationally.

Most critically, because of the uneconomically high costs of airfreight to European markets, APEDA used these technical partnership arrangements to assist Vijaya to develop controlled atmosphere (CA) container sea shipment protocols. While the technology for CA shipments in a general sense is well developed internationally in the horticultural export trade, the duration of sea shipment to Europe, coupled with the uncertainty of storage characteristics of local varieties, meant that significant adaptive research questions existed. It was also apparent that strong backward linkages existed between final destination quality and the pre and post-harvest practices of Vijaya and its farmers. Furthermore the introduction of CA storage and shipment added another element to the overall need for new quality management practices in the supply chain as a whole.

The arrangements for technical assistance to deal with these issues looked particularly impressive. The partnerships that had been put in place through contractual agreements brought together public sector scientists, Vijaya and its farmers, and held the promise of bringing to bear significant technical expertise to the problems at hand. The linkage mechanisms associated with Vijaya were extensive and appeared to demonstrate the dual function that organizations such as Vijaya can provide to a small farmer production base as a mechanism of both market and technology access.

The sources of technical assistance in this case were as follows:

On-farm:
- —the horticulture department of the local State Agricultural University,
- —a national horticultural research institute (pre-harvest),
- —a national food science research institute (post-harvest),
- an international natural resources development research institute.

Packhouse/shipment:
- —a national food science research institute,
- —an international Shipping Company,
- —an international natural resources development research institute.

(ii) *Partnership performance*

Scientists worked with Vijaya and its farmer members to formulate a set of pre- and post-harvest protocols to improve export quality. These included: pre-harvest disease control and tree management; advice on harvest maturity and fruit selection; improved harvesting practices; handling and packaging protocols; gas and temperature regimes for sea shipment; and training provision to Vijaya staff and farmers. In the following two seasons, trial shipments of mangoes under CA storage conditions were sent to Europe. The fruit was harvested and packaged under the supervision of the scientists from the post-harvest research institute that had developed the protocols for Vijaya.

Shortly after the initial trial shipments began APEDA requested the assistance of a UK-based natural resources development research institute. Initially this request came in the context of assisting with "out turn" assessments of fruit consignments arriving at European destinations. Later as a range of technical constraints emerged, assistance was sought to review protocols and make recommendations for remedial action. Initially this was seen as a purely technical task, but further investigation revealed that a more inclusive study of the organizational context of technical support arrangements was required. The results of the

out turn assessment indicated only partial success. Only 31% of the fruit was regarded as Class 1 fruit. Out of 2,441 cartons received by the importer, 33% were lost to disease, mainly *anthracnose*, but also *stem end rot*. The following technical constraints were identified:

—pre-harvest management constraints, particularly control of pests including anthracnose;

—size grading—fruit present of mixed and uneven size;

—maturity indices—the consignment contained fruit of mixed maturity, some overripe on arrival, some underripe;

—post-harvest control of disease, particularly anthracnose and stem end rot developed during storage, suggesting that post-harvest treatment for these diseases was also required;

—heat damaged fruit—suggesting the need for improved temperature control in the field and during transit to packhouse;

—CA technology—fruit had suffered from chilling injury suggesting that the temperature and possibly gas mixtures had not been correct for the particular variety of mango being shipped.

The results of the trial shipment of mangoes seemed to suggest that either recommendations provided to Vijaya and its farmers were inadequate for improving export quality or that they were not being implemented. Preliminary visits to Vijaya and its farmer members raised concerns over the recommendations being provided, particularly in the context of a predominately small and marginal farmer production system. Examples include:

—maturity indicators (with seven criteria) that could not be realistically used in routine harvesting operations (including destructive testing);

—recommendations for the use of harvesting poles that were locally unavailable;

—agro-chemical inputs which were costly and scarce; and

—management practices that were inordinately labor intensive.

Rather than the productive partnership that had been envisaged, indications suggested that both Vijaya and its farmers had been passive partners in the development of new practices. At the same time the scientists were clearly struggling to provide technical advice that took full account of the agendas and perceptions of either party. As work entered a subsequent phase with a further trial shipment planned for the following season, it was evident that technical constraints to achieving sustained production of export quality mangoes remained and that Vijaya and its farmers were aware of this. It was also apparent that the technical inputs that were being provided by national scientists were inadequate to solve these constraints. Furthermore, it was apparent that it was not necessarily the scientist themselves that were at fault, but the institutional environment they came from and the restriction this placed on their professional experience and mandate. Closer examination of the organizational and institutional context of the technical support was clearly needed.

A closer look at the institutional context revealed that to a large extent the weaknesses in the Vijaya partnership were the result of historical patterns of institutional development in Indian public sector research, a pattern where all too often, useful technical expertise is "locked up" in research institutes with limited opportunities for interactions with farmers or as in this case, private enterprise. Here it was apparent that much of the experience the scientists were drawing on was based on the results of laboratory research and literature reviews. They had little exposure to implementing their research findings in either a commercial context or the contingencies of servicing the needs of European export markets. Rigid institutional distinctions between research and extension organizations have tended to reinforce this situation.

In addition, different pieces of useful and mutually supportive technical expertise are often located in different institutions with the responsibility for linking these components left to a third party. This was particularly so in attempts to deal with anthracnose, a disease which needs to be tackled with an integrated pre- and post-harvest approach. In this case, the two sets of national scientists (one set predominantly pre-harvest, the other predominately post-harvest) were functioning as quite separate entities. Each set visited Vijaya and its farmers at separate times. Neither communicated with each other, while the implied institutional ownership of potentially commercially sensitive information created much mistrust between them.

Perhaps more important is that even where scientists are keen to assist organizations such as Vijaya—which they clearly are—bureaucratic arrangements often make it difficult to

work in new and more useful ways. The logistical arrangements for the inputs of contracted scientist also partly reflect this context. Fairly short inputs were provided for, with limited provision for allowances, travel and number of visits. As a result, while it was apparent that there was a need for *in-situ* adaptive research, logistical arrangements dictated that the inputs of scientists were short and took the form of technical advice of a pre-formulated nature.

Of equal concern, however, was the fact that Vijaya, which was, on the one hand, disappointed with these inputs, was not able facilitate more productive interaction between farmers and scientist, nor articulate the concerns which farmers had about the inappropriateness of some of the recommendations. Vijaya was clearly not aware of the interrelated nature of many of the problems and this meant that it was in a weak position to press the scientists for useful technology.

(iii) *Lessons from Vijaya*

Despite the numerous difficulties with technical support that Vijaya suffered, the case illustrates both the factors that have led to the emergence of a partnership and the types of systemic failures which are impinging on this approach to technology development. In this case the recognition (by both Vijaya and APEDA) of the need for new technology to access new markets was pivotal in the move to seek a partnership with the national research system. Achieving this by introducing contract research arrangements was in fact a fairly significant institutional innovation for both public sector and private enterprise organizations, against a backdrop of considerable mutual apprehension. It also took place at a time when institutional policies for such arrangements had only recently been put in place for the national research scientists involved. The fact that in practice this partnership approach highlighted a fairly significant set of "second generation" institutional constraints only goes to illustrate the deeper systemic weaknesses that plague the sector as whole, and the pressing need for some sort of more inclusive analysis of the process involved, and the policy reform required. Before going on to discuss the implications of these findings in greater detail, we present our second case study to illustrate a more mature scenario based on a similar set of technology and market needs.

(b) *Case study no. 2: institutional innovation in response to technology needs*

Like the Vijaya case study, the Maharashtra State Grape Growers Association (Maharashtra Rajya Draksh Bagaidar Sangh (MRDBS)) and the linked Mahagrapes concerns a private enterprise, which is founded on the farmers' association and cooperative model. In contrast to Vijaya, MRDBS has been established for over 20 years and some of the technology-input problems experienced by Vijaya have been overcome. The key feature of this case study is the institutional arrangements that have evolved over time in response to market factors and opportunities and new technology that farmer members required to benefit from these opportunities. The sequence of events was as follows.

(i) *Phase 1*

The growers' association, MRDBS, was established by farmers in the 1960s as a mechanism to support members to produce and market grapes in the domestic market. During the 1970s MRDBS sought technical advice from scientists from the NARS and from scientists abroad. This allowed the introduction of improved grape varieties that were further developed and selected by the farmers themselves. This combination of prescriptive technical advice from the NARS and the adaptations and innovativeness of farmers, increased production of grapes to the extent that by 1985 the domestic market was oversupplied with prices slumping.

(ii) *Phase 2*

In response, MRDBS encouraged the formation of cooperatives to assist with marketing. Simultaneously, a number of enterprising farmers began to explore export opportunities in the United Kingdom, Europe, and the Middle East. It was apparent that significant export markets did exist. As a result exports started on an *ad hoc* basis. From previous experience with the NARS, MRDBS was aware that suitable post-harvest technology was not available in India to allow the shipment of grapes to European markets. Some of these farmers imported cool chain technology from the United States.

(iii) *Phase 3*

With the potential of significant export markets becoming apparent, grape growers saw

the need to create an institutional structure to handle grape exports. The result, Mahagrapes, was created from the grape growers cooperatives already established by MRDBS. Mahagrapes was given the mandate to: locate internationally acceptable quality grapes from growers; identify lucrative foreign markets; and to access and develop pre-cooling and storage facilitates using imported technology. Mahagrapes went through a process of learning in export marketing, with initial failure in the Middle East, and subsequent success in European and Far Eastern markets.

(iv) *Phase 4*

At the same time that the functions of Mahagrapes were being developed (predominately on the export and post-harvest aspects), MRDBS was strengthening its arrangements to support farmer members. A well-equipped laboratory was established at Pune, with regional branches, to undertake routine analysis of soil, water, cuttings etc. These centers also provided advice and demonstrations to members. Subsequently an R&D wing was established to work on mainly grape production problems and matching varieties and grape quality with international market needs.

(v) *Phase 5*

Having established such facilities in response to gaps in public sector provision, the public sector then began to recognize the importance of MRDBS and its facilities. The R&Dwing was formally recognized by the S&T Division of the Government of India. The Agricultural University at Rahuri granted affiliated status to MRDBS. The state government allocated land to MRDBS to conduct research. APEDA appointed a full-time co-coordinator for grapes to work within the structure of MRDBS and promote grape production and export, with a specific focus on technical support. It is interesting to note that APEDA, a public sector body, chose to implement grape extension and promotion through a private structure rather through its own regional office or through existing state-level extension services. The final response of the public sector has been to establish a National Center for Grape Research under the ICAR in the buildings of MRDBS.

(vi) *Lessons from MRDBS*

The MRDBS case is a story of the way that partnerships form and change in tandem with the institutional structures needed to sustain them, in the context of changing technology needs associated with new markets. MRDBS' initial partnerships were with the NARS. As its technology needs (required for export markets) outpaced those available from the NARS, MRDBS formed new alliances with foreign sources of technology. At the same time it created its own new institutional structure to deal with export markets and the acquisition and application of the required technology. As MRDBS' own technical skills developed it became less reliant on these partnerships with foreign technology suppliers. The final partnership has once again been with the NARS, presumably as the latter viewed the structure put in place by MRDBS as an effective mechanism for delivering public research and extension services to the grape sector.

Key points here are that the technological developments that led to economic changes (of farmers) were the result of a dynamic process, in which institutional evolution played a fairly significant role. Partnerships were important, but it was the ability of MRDBS to form and dissolve partnerships as circumstances dictated that was key to the whole process. Institutional flexibility, that is, change and the ability to change is a central component to partnership approaches.

6. DISCUSSION

On the whole the case studies suggest that, while partnerships in research and technology development are clearly important, there are also many other complexities in the wider process of technical and economic change. In particular there has been a strong institutional dimension to this process and, in the case of MRDBS, this has clearly been associated with evolutionary dynamics. As we have argued earlier in the paper, it is this feature of technical change that both the neoclassical tradition and even the more process-oriented approaches have had difficulty dealing with conceptually and, also as a consequence, from a policy perspective. The authors believe that these case studies reveal a pattern of institutional development that is similar to that found in much of the current literature dealing with innovation and technical change in other sectors. This is a literature that stresses the need to see technical change in systemic terms, where flows of knowledge between actors and institutions in the process, and the factors that condition these

flows, are central to innovative performance. The concepts contained in this literature exhibit some striking similarities to the conceptual and policy challenges which partnership approaches are raising and as such warrant closer examination.

Historically, analysis of technology performance in the industrialized economies has used a neoclassical tradition similar to that discussed in the context of agriculture, with analysis focused on inputs (such as expenditures on R&D) and outputs (such as patents). While these indicators remain important as sources of information about content and direction of technological endeavor, [20] their ability to measure the "innovativeness" of an economy is small (OECD, 1996a). Critically, the indicators used fail to account for all the inputs and outputs in the process; the approach takes little account of the way in which the process works; and most fundamentally it has difficulty dealing with the dynamic, complex nature of the process (Clark, 1990, 1995). [21]

Over the past decade or so, fresh thinking has supplemented this input/output type analysis, with the development of a conceptual framework to account for the process nature of innovation. The literature dealing with these issues is very large indeed, but the conceptual framework that this provides contains a number of broad principles that are useful in the context of partnership arrangements. The introductory comments of a review of these concepts by Edquist (1997), provides a useful overview of the main elements of recent thinking.

> Innovations are new creations of economic significance. They may be brand new, but are more often new combinations of existing elements. Innovations may be of various kinds, e.g., technological as well as organizational. The process through which technical innovations emerge are extremely complex; they have to do with the emergence and diffusion of different knowledge elements, i.e., with scientific and technological possibilities, as well the "translation" of these into new products and production processes. This translation is by no means follows a "linear" path from basic research to applied research and further to the development and implementation of new processes and new products. Instead, it is characterized by complicated feedback mechanisms and interactive relations involving science, technology, learning, production policy and demand. [22]

Central to this view of the world has been the recognition that innovation increasingly takes place at the interface of formal research and economic activity, thus denying the primacy of either knowledge creation and validation institutions (R&D bodies universities etc.), or knowledge application institutes (usually enterprises). Rather it is partnerships between these types of actor, which are important. As economies increasingly become dependent on the production, distribution and use of knowledge—"knowledge-based economies" (OECD, 1996b), analysis has focused on flows of knowledge. This analysis stresses the importance of these institutions as nodes in a system where their interaction and interactive relationship along with other contextual factors is key to these knowledge flows. Attempts to understand the structure and dynamics of such systems are the core of modern thinking about the innovation process (Clark, forthcoming; Edquist, 1997; OECD, 1997). [23]

This conceptual framework has come to be known as "national systems of innovation" (NSI) framework" (Freeman, 1987; Lundvall, 1992). A NSI is defined in number of slightly different way (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Patel & Pavitt, 1994; Metcalfe, 1995). Broadly speaking, it can be described as the system or network of private and public sector institutions whose interactions produce, diffuse and use economically useful knowledge. The component parts of the systems and their interactions are determined by culturally defined norms, historically determined institutional developments, national priorities and are defined by geographic borders and national policies. It is not necessarily suggested that national governments have explicitly developed innovation systems in this way, although some clearly have. But, in economies where such interactive systems have evolved successfully, the innovative performance of these economies has been strong and this has been reflected in rapid rates of economic growth (Freeman, 1987, 1991). [24]

Rather than presenting a blueprint for institutional reform, NSI is concerned with mapping and evaluating channels for knowledge flows, identifying bottlenecks and suggesting appropriate remedial action. In this sense NSI presents a set of analytical principles for understanding the innovation process in a national context, and identifying leverage points for enhancing innovative performance. These principles include:

—assessing the extent of institutional interactions,

—assessing impediments to flows of knowledge between nodes,
—assessing the opportunities for and constraints to interactive learning and institutional innovation,
—assessing policy and practices that can give rise to failures of the component parts working as a system.

The authors believe that if partnerships in agricultural technology development are to emerge as a core methodology, the analytical principles of NSI have a lot to offer. Not only can they provide a useful approach to analyze the types of systems failure that the Vijaya case demonstrates. But more importantly, they can be used in the context of policy formation to identify leverage points where innovative performance can be improved and ways in which this can benefit the poor. The suggestion here is not that this approach should replace existing approaches, but rather that it should supplement them. Economic analysis of returns to investment in research is still important. Participatory methods, in an appropriate institutional context, are a key tool in increasing flows of knowledge between farmers and other parts of the innovation system.

While the NSI approach is now mainstream with organizations such as OECD and UNCTAD, [25] its application in the agriculture sector of developing countries is mainly untested. Further work is required to develop its application in contexts where the institutional nodes in the system may be nongovernmental organizations (NGOs) or civil society organizations or instances where market incentives for technological change are absent. As the circumstances in the developing country agricultural sector suggest, however, an overriding need for a more inclusive approach to understanding technology development as a process, NSI should provide a useful starting point.

7. CONCLUSIONS

Partnerships in technology development are important because of the benefits in innovative performance derived from productive relationships between those organizations engaged in formal research and those engaged in the use of new knowledge in economic production. From a policy perspective, many of the shortcomings of existing conceptual approaches to technology development in the context of partnerships could be supplemented by the analytical principles that NSI provides. A key lesson for those advocating the adoption of partnership approaches is the need to be prepared to accommodate sufficient scope for the continuous process of institutional change that is implicit in much of the current thinking about the way innovation actually works.

NOTES

1. See, for example, DFID (1997), ICRISAT (1999).

2. The term private sector is used to cover all organizational types out side of government including the enterprise sector, nongovernment organizations, farmers association and cooperatives.

3. And these partnerships need to operate across disciplines at all levels if they are to be effective. This becomes clear in the discussion of Section 5.

4. North (1990, p. 3).

5. For example, Lundvall (1992) refers predominately to "things that pattern behavior" whereas Nelson (1993) focus predominantly on formal organization.

6. These international agricultural research centers are collectively know as the Consultative Group on International Agricultural Research and are often referred to as the CG Centers. They are supported by multilateral and bilateral support as well as by contributions for member countries that they are serving.

7. The classical sources referring to the development of this approach include Schultz (1953) and Griliches (1957). More recent refinements in the approach can be found in Alston and Pardey (1996).

8. For a discussion of this, see Jha *et al.* (1995).

9. See Rajeswari (1995) for comprehensive critique of the whole returns to investment approach. See Alston and Pardey (1996) for critique of exaggerated levels of return reported.

10. Brown's *Seed of Change*, which highlighted the equity issues arising from early experiences with the

Green Revolution, was undoubtedly the seminal work in a very large body of debate, which either implicitly or explicitly questioned the ability of agricultural R&D, despite its apparent successes, to benefit the poor. Lipton and Longhurst (1989) provide a comprehensive review of this debate and draw conclusions on the impact of technical change in the Green Revolution era (Brown, 1970).

11. See, for example, Umali-Deininger (1998) and Pray and Umali-Deininger (1998).

12. See Hall and Clark (1995) for a detailed review of these concepts.

13. Others had discussed the role of farmers as innovators (notably Richards, 1885), but these authors explicitly linked it to a criticism of institutional arrangements.

14. See, for example, Tripp (1982), Collinson (1987).

15. See, for example, Chambers and Jiggins (1987b).

16. Abundant examples of this methods-driven debate can be found in PLA notes. For critic see Tripp (1989), Biggs (1995), Biggs and Smith (1998) and Hall and Nahdy (1999).

17. This builds on a series of paper by Biggs over the last decade (notably Biggs, 1990) in which he makes the point (stated in various ways) that "... agricultural research and technology diffusion are always fundamentally integrated over time with political, economic, and institutional events."

18. Anderson (1991) describes the way that this was very much a reflection of US foreign policy at the time. The concern was that growing numbers of hungry people in Asia would led to political instability and the spread of communism. The decision of the Rockefeller foundation to shift its emphasis from health to agriculture was of critical importance.

19. The case studies presented have arisen from a series of studies of the Indian horticultural sector undertaken over the past three years by scientists from the Natural Resources Institute in collaboration with Indian scientists, entrepreneurs and farmers with funding from the DFID Crop Post-Harvest Research program. This work is reported in more detail in Andrews and Hall (1997), Hall, Taylor, and Malins (1997), Hall, Sivamohan, Clark, Taylor, and Bockett (1998), Malins, Taylor, and Pitcher (1996), Malins, Hall, and Taylor (1997), Sivamohan (1997), Sivamohan and Hall (1998a,b), Taylor and Malins (1997a,b) and Taylor, Hall, and Sivamohan (1998).

20. See, for example, OECD (1996a).

21. Clark (1990) explanation of the terms complex and evolutionary (as implied by dynamic) is useful here. The processes are "complex in the sense that they are composed of many agents whose interactive behavior is only predictable by to a limited extent since it is conditioned continually by relatively unknown future events; evolutionary because the agents are continually shifting their identify (forming, dissolving and reforming) in response to the variable environments in which they are placed." (p. 15)

22. Clark (1990, p. 3).

23. Carlsson (1995) discusses a similar concept using the term technological systems. See also Clark (forthcoming) for a treatment that stresses formal information theory.

24. Edquist (1997) provides substantial discussion on the precise definition of national innovation systems, and the way different authors have interpreted the concept and its shortcomings.

25. See also UNCTAD (1996).

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