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An Analytic Cross-Country Framework

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CAPACITIES IN DEVELOPING COUNTRIES

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ASSESSING SCIENTIFIC AND TECHNOLOGICAL CAPACITIES IN DEVELOPING COUNTRIES

Introduction

The remit for this paper was to conduct a rapid review of the literature encompassing science and technology indicators and the relationship between technology and economic growth and to recommend those indicators that could assist AID both in identifying likely candidates for country programs based on science and technology (S&T) and in designing those programs. While this latter aim appears straightforward, in fact it could only be accomplished by first compiling a fairly comprehensive set of indicators that would permit assessment of the scientific and technological capacities of an economy, the S&T "system" within which these capacities are developed and deployed, and the impact of both these elements on the economy.

These tasks pose a number of difficult and unusual challenges. because the work involved, in effect, requires breaking new ground in the field. There are two reasons for this. First, although there have been attempts to assess comparatively various aspects of the relationship between S&T and economic advance in developing countries, this has not been done on a systematic and comprehensive basis. There are thus no previously developed and tested methodologies to draw on which take account of and allow the measurement of the myriad array of factors at work in this area.

The second reason stems from the accepted criteria of precisely what constitutes an indicator. Indicators are variables that represent an assumed relationship. Indicators are not simply statistics nor are statistics necessarily indicators - unless a theory makes them so by explaining how the indicator measures the underlying phenomenon that is of particular interest.1/

Moreover, specific indicators only acquire legitimacy for use in policy-making after the assumed relationships being measured are extensively emprically validated, and after standards and definitions have been agreed at the national and ideally international level. Casual

observation or experienced-based hypotheses (however plausible) as to how one variable relates to another cannot be assumed to provide sufficient grounds to justify the use of an indicator for policy making purposes. The relationships observed might be entirely spurious or due largely to other factors.

Given this strict criteria, it is not surprising that there are few, if any, reliable, internationally recognized S&T indicators that properly reflect the complicated interactions that occur between S&T-related activities and economic progress in developing countries. This is quite unlike the situation pertaining to social and economic indicators (such as the literacy rate, GNP and value-added) where there is agreement among analysts and governments over the content and implications of a broad range of measurable variables.2/ Despite all the importance attached to S&T issues, the development of empirically validated, S&T indicators relevant to developing countries has been seriously neglected.

This does not imply that this task should not be attempted, nor does it in any way undercut the critical need to have S&T as a focus of AID bilateral programs for the countries of Asia and the Near East. There is little question that the creation and effective deployment S&T capacities will be perhaps the most critical determinant of the ability of these countries to continue to advance domestically and within the international economy in which they are now deeply integrated.

Indeed we would argue that the success of AID efforts to promote privatization and liberalization as a means of creating a dynamic, self-sustaining private enterprise sector in these economies could depend largely both on the ability of domestic firms to marshall their technological resources in the competitive struggle, and on the support for these firm-level efforts provided by the S&T infrastructure and government policy measures.

However the lack of a stock of accepted, valid, "on-the-shelf" S&T indicators does pose problems that are beyond the capacity of this paper to resolve. To develop the comprehensive set of indicators called for by the terms of reference, it would be necessary to complement the few international S&T indicators that do exist, with both a variety of

established but clearly indirect and partial measures, as well as tosuggest a number of new indicators relating to aspects of S&T where measurement has not yet been attempted. This is the primary task that was attempted in this paper.

To move from this compilation of potential indicators, to identifying those most specifically suited to AID purposes requires that each candidate indicator (and relevant data set) be reviewed and assessed with regards to its theoretical rationale, empirical validity, availability, costs of collection and the numerous qualifications relating to coverage, meaning, etc. that need to be taken account of during analysis and interpretation. This would be a time and space consuming task that could only be properly done on the basis of a certain degree of interaction with AID. Given the time and resource constraints imposed on the preparation of this paper and because the initial compilation and preliminary analysis had to occur first, we have only been able to move a limited but we believe useful way in the direction of this objective.

The paper is structured as follows. The first section reviews the literature on international S&T indicators and draws lessons from efforts to use these indicators for the objectives of this paper. Section 2 presents a conceptual framework for understanding the relationship between S&T and industrial development in order to provide a conceptiual and theoretical starting point for the subsequent compilation of indicators under different categories. This is done in Sections 3 to 5. The concluding section addresses the explicit problems confronting AID as to which set of indicators, however imperfect and inadequately analyized, might used to make judgements about country suitability for S&T support and the possible focus for these efforts.

FOOTNOTES

1. See the discussion in Bhalla and Fluitman, 1985; Baster, 1972 and McGranahan, 1972

2. Indeed, the complexity of the relationship between S&T inputs, the innovation process (broadly defined), the often intangible nature of the outputs of that process and the impact of these on the economy as a whole - while well documented empirically - has defeated many attempts to generate valid S&T indicators even within the context of the advanced industrialized economies. See the discussion in Freeman, 1982.

SECTION ONE: INTERNATIONAL INDICATORS OF SCIENCE AND TECHNOLOGY: - A SELECTED REVIEW OF THE LITERATURE AND ITS LIMITATIONS

Internationally Comparable S&T Input and Output Indicators

Any effort to identify S&T indicators in relation to developing countries must start with reference to the considerable literature and work concerned with internationally accepted measures of scientific and technological activity (S&T). At the present time, these fall into three categories all of which relate to inputs into the S&T system - indicators of skilled personnel involved principally in R&D activities (formally defined) both inside firms and in specialized R&D institutions; private and public sector expenditure on scientific and technical training and education; and, private and public sector expenditure on R&D.

It has been frequently pointed out that these input indicator categories in fact measure activity relating to only one part of what is an extremely complex process linking S&T inputs to S&T outputs to competitive performance.3/ However it is necessary to start our discussion with reference to these indicators precisely because the assumed relationship between these indicators and industrial development is supported by a broad body of theoretical and empirical work - at least in relation to the developed economies.

The collection of standardized data on scientific and technological activities at a national level for purposes of international comparision has a long history. Through the 1950s, 1960s and much of the 1970s work on S&T indicators was narrowly concerned with measuring (and refining) the above mentioned input indicators of science based activities and R&D efforts in order to allow international comparisions between the OECD countries.4/

Since 1965, the UN system, particularly UNESCO, has organized the collection and analysis of data on these S&T indicators on a more global level, including developing countries. Again, the main focus of this work has been on scientific and R&D manpower and finance input indicators to facilitate international comparisions. However, over the last decade there have been efforts to expand the range of data collected beyond

these narrow boundaries. For example, in 1978, UNESCO issued a set of recommendations for the collection and standardization of measurement of a greatly expanded variety of what it called S&T services that go well beyond R&D measurement to include the flow of technical information and services from providers to users within the economy.5/

As mentioned above, it has long been recognized that measuring S&T inputs only captures one part of the relationship between S&T and economic advance. However, the measurement of output of scientific and technological activities on an internationally comparable basis has been a continuing problem for a variety of well known reasons.6/ But recently as a result of the efforts of individual rsearchers and national agencies such as the National Science Foundation, some progress is being made towards identifying acceptable output indicators.

Inter alia these include a variety of what have come to be known as "partial" indicators relating to:

a) the level of innovative activity - as measured by new product counts, costs of innovation and patent statistics;

b) the impact of science and technology on the economy - as measured by the technological balance of payments, trade in high technology products, and the relationship between technology and productivity;

c) the level and quality of the output of scientific effort - as measured by bibliometric analysis, citation indices and peer reviews.

However, though these output indicators are increasingly widely used by independent analysts in the developed countries to make comparative assessments of country performance, it appears that these indicators are not greatly influencing the policy-making process with regard to S&T in these countries.

Relevance to Developing Countries

Despite the efforts of international agencies to improve the measurement of S&T input and incorporate new output indicators, there is longstanding and widespread recognition that existing internationally accepted S&T indicators suffer major problems of validity in relation to

assessing the scientific and technological capacity of developing countries and the contribution of S&T activities to economic performance in these countries. The central problem is that the assumptions underlying the use of these indicators as proxies for innovative effort in the developed countries bear no relation to "context" of production and innovation in the developing countries, nor can they take account of the substantial quantitative and qualitative differences in the way science and technology interact with the process of industrialization in developing countries.

These reservations apply in relation to both input and output indicators. For example, the problems start with the type of data that is collected. Many developing countries do not even show a distinct budgetary item for S&T or R&D in total or sectoral expenditure allocations. Moreover while the measurement of R&D expenditure captures a significant share of innovative effort in the industrialized countries, formal (and recorded) R&D accounts for a very small share of these activities in developing countries where most technical change occurs as a result of production engineering, trouble shooting, and the adaptation of existing techniques.7/ On the output side, there is concern for instance, that the limited coverage by citation data banks of research activity and journals in the developing countries leads them to seriously misrepresent the level of S&T activity and competence in developing countries.8/

Given these reservations, there is ample justification to question the usefulness of this data for either comparisions between countries or correlations within countries between S&T indicators and other indicators of socail and economic development.9/ Nevertheless, as these are the only data available, researchers have to use them and there have been a number of studies primarily involving either comparisions between countries or exploring correlations between a given S&T indicators (i.e. expenditure on R&D or number of patents) and some indicator of economic perormanceor socio-economic development. These studies have generated some interesting but not unexpected results.10/

The knowledge generated by these analyses is of some academic value but on their own these studies are of limited usefullness either for national planning purposes or for this project - except as background information and, perhaps in a few cases, as method examples. The weaknesses of the indicators and the lack of clarity sometimes accompanying the analysis of S&T input data has lead to some harsh comments in the literature. For example, after undertaking a correlation exercise following a UNESCO methodolgy for relating S&T activities to 32 indicators of socio-economic development, Bhalla and Fluitman (1985) observe that:

> "...we will not discuss the results as they did not appear to be of much practical relevance..for example what should a planner do with the fact that for 150 countries a certain correlation exists between infant mortality and the number of patents grated, or between electricity consumption per capita and secondary school enrollments?" (p.41).

Some Lessons From The Indicator Literature

Nevertheless, despite these qualifications, the S&T indicator literature is extensive and needs to be reviewed more fully than has been possible in this paper as part of any preparation AID might undertake for its own S&T indicators projects. Particularly useful are some of the more recent methodological papers which attempt to overcome the problems mentioned above by proposing new conceptual frameworks and new types of indicators.11/

Indeed, perhaps the greatest value of the literature on S&T indicators lies not in the results of the studies but in the lessons to be learned about the identification, construction, collection, analysis and interpretation of data which purports to measure S&T activities or the relationships between S&T and some dimension of economic performance. Thus it is worthwhile highlighting some of these lessons both in relation to subsequent discussion in this paper and in relation to AID's overall program objectives and methods:

On the value of using and interpretating existing quantitative S&T indicators

1. As mentioned earlier, despite all the emphasis given to the importance of S&T in developing countries, there has been very little real progress in developing indicators specifically designed for developing country contexts and specifically designed to assist the planning function at national or project level. This is at least in part due to both political and economic constraints that lie beyond the scope of this paper to address.

However, there continue to be efforts to expand the range of internationally accepted indicators with most of the recent activity centering around initiatives arising from ECOSOC, ACAST and UNACSTD activities in relation to the Vienna Conference on S&T in developing countries and the folllow ups to the agreed Agenda for Action. The Commonwealth Secretariat has also launched an indicators project. It would be useful for AID purposes to find out how far these initiatives have gone in developing and testing new indicators and which countries have continued to participate as they might be client countries for AID S&T projects. This information was not accessible for this review.12/

2. Existing S&T data bases in most developing countries are very weak and the accuracy of the data is suspect; yet their improvement is constrained by the resource costs of doing so, the lack of skilled people, and the inherent problems of data collection in developing countries. This suggests that one possible focus for AID S&T support activities in client countries could be to help identify a set of indicators uniquely suited to national needs, support national S&T data collection and analysis efforts, and contribute to the development of both human and institutional capacities in this area.

3. Because of the weakness of the data, the lack of contextual relevance, and other biases.the three main internationally accepted S&T indicators (relating to scientific personnel, R&D expenditureand science output) should, under the very best of conditions, be considered only as partial indicators. They must be assessed together, and interpreted in

light of other indicators as well as country specific, empirical and experience-based knowledge possessed by the project designer or consultant. Indeed, this is true for any single indicator mentioned in this paper or elsewhere.

On the value of developing and measuring new quantitative S&T indicators

4. One way to overcome weakness of existing quantitative indicators is to develop new ones. There are two ways forward. The first is to use existing data series compiled for other purposes in innovative ways as proxies for various S&T related variables. The usual problems of validity, comparability and interpretation apply. However the advantage is that these data (whatever they might be) already exist thus eliminating costs of collection and speeding up the process of project design. Some a priori suggestions along these lines are given in Sections 3 to 5. It is difficult to be specific however since we do not know what data sets are avaiable for client countries - identifying these should be one of the first steps of any AID effort to measure S&T activities.

5. The second way is to develop entirely new data series that will allow national level analyses to be carried out. However to be done properly, this is a major undertaking. The ideal way forward is start from a broad concept and break it down into its component variables. If these variables are not directly measurable then indicators need to be selected on the basis of plausible assumptions about cause-effect relationships backed up by theoretical arguments or empirical proof. The data is then collected to give indicator a value and analysis is carried out to see if indicator provides a reasonable and rigourous explanation of the phenomenon being measured.13/

Thus in principle for every indicator proposed, it is necessary to make the cause-effect logic transparent and then prove it empirically or discard it. Experience suggests that a fairly lengthy process is involved between conceptualizing and specification of appropriate indicators, the running of pilot project to test availability,

collectability, costs of collection, and consistent reliability of interpretation. There is much to be learned from the recent experience of the NSF and its funding of research projects that attempted to develop new indicators relating to innovative activities - some of which though very rigourous and methodologically sound, hardly advanced the state of knowledge at all and the indicators proposed have not been taken further. 14/

6. To be useful in the particular context of developing countries, S&T indicators need to measure both input and output primarily because the ad hoc and distorted nature of the innovation process means inputs cannot be expected to be adequate measures of output. Moreover, the indicators used need to be disaggregated in variety of ways. The most obvious type of disaggregation is to move below national level to sectoral, branch, institution and firm level indicators.

7. Less obvious but more important is the need to disaggregate indicators in order to measure the contribution of S&T activities to a well-defined set of national (and AID) objectives. 15/ These objectives need themselves to be disaggregated - otherwise any data collected will be of little use in project design. For example, increasing the S&T capacity of a given country will undoubtedly be both a national and AID objective, But measuring the existence of these capacities in an undifferentiated manner will tell us little about precisely what kind of capacities are needed or the desired form of their institutional deployment.

By extension, there is little point in measuring the existence of S&T capacities or increasing resources devoted to their creation if that capacity is not being deployed to meet agreed national objectives. i.e. a national objective to maximize employment and meet basic needs is not likely to be met by the allocation of R&D/engineering resources and efforts to support large-scale capital intensive projects but by concentrating innovative efforts on small-scale projects involving "appropriate" technology. 16/

Thus the design of a bilateral aid program for S&T should start from a judgment of where the client countries' national plans and

priorities suggest efforts should be focused. Against this assessment of national objectives, the capacity of AID to support projects that contribute directly to the attainment of these objectives needs to judged. There is little point in attempting to construct new S&T indicators and collect the relevant data if AID is unable to deliver support in the areas or at the scale called for by the analysis.

8. This suggests more interaction is required between AID and consultants than possible so far in order to better define AID objectives and project capacities (both general and country specific) and therefore develop indicators which actually relate to those objectives and capacities. Part of this process could be the submission of a detailed proposal to AID on the costs and time scales involved in developing new quantitative S&T indicators. It has not been possible to provide this information in the context of this paper.

One major implication of the above for this paper is that while some new measures are proposed in the sections to follow, as noted earlier, these cannot be properly developed, tested and applied within framework of the current project. Nevertheless, we would strongly encourage AID to pursue a larger indicator project with these objectives since the benefits would be considerable.

Despite these reservations on the usefulness of existing and the feasibility of developing new indicators, a large number of possible measures do exist. Likewise, it is also possible to point to any number of "entry points" for AID S&T projects, where a priori reasoning suggests intervention would be beneficial. There is an obvious need to focus these efforts in areas where projects will have maximium impact.

The first step we must take in suggesting where these efforts should be focussed is to make clear the assumptions/logic underlying pour views about how S&T activities should and could relate to economic advance. There are, of course, many perpsectives on these issues in the literature - some of which diverge quite substantially from our own approach which is briefly outlined in the next section.

SECTION TWO: A CONCEPTUAL FRAMEWORK FOR UNDERSTANDING THE RELATIONSHIP BETWEEN S&T AND ECONOMIC PERFORMANCE IN DEVELOPING COUNTRIES

The starting point for policy (and project) design to improve S&T and S&T capacities of developing countries is inevitably determined (implicitly or explicitly) by some set of judgements and empirical observations about what is wrong with, or where improvements can be made in, current conditions. In this section, as a prelude to our indicator discussion, we present our analysis of the key features of the evolution and operation of S&T systems and the development of technological capacity within the productive sector within developing countries.

Underinvestment in Capacity Creation and Functional Incoherence in the S&T System.

The history of industrialization in the developed countries is characterized by two features relevant to our concerns in this paper. First, the well documented central role of technical change as a driving force in the continual improvement of productivity and the creation of wealth demonstrates the importance of "technological dynamism" within productive enterprises as a key determinant of economic expansion and competitiveness. We define technological dynamism as the capacity to continually improve and adapt existing techniques as well as the ability to develop new techniques internally and to choose and assimilate those brought in from outside. Dahlman and Westphal (1982) use the term technological "mastery" in essentially the same manner.17/

Second, the prior existence of technologically competent producers firms acted as a source of stimulus for the creation of organic linkages with specialized educational and R&D institutions that were first created and then evolved in response to the demands for new knowledge arising from the productive sector. In turn, scientists in R&D institutions were (and are) able to count on the existence of a "knowledge-rich" environment in the productive sector that lay outside their laboratories to provide a fertile ground for the implantation of new ideas emerging out of their basic R&D work.18/

The history of industrialization in developing countries differs significantly from this experience. Third World industrial development since World War II clearly features fairly impressive advances in terms of growth in output, structural change, and the expansion of manufactured exports. This performance has been dominated by a select group of industrially advanced developing countries who exhibit many of the features of technological dynamism characteristic of industrialization in developed countries.

Extensive research has documented that these dynamic technological capacities have not suddenly appeared automatically but have frequently been deliberately created by concious decisions on the part of individual firms to invest in various mechanisms for technological "learning." This investment in capacity creation has usually occurred in response to market conditions that actually reward innovative effort - and importantly, these efforts have often been stimulated and supported by state intervention.19/

Most of the other developing countries do not exhibit an pervasive degree of technological dynamism - though obviously some elements of dynamism and mastery are present, though spread unevenly across sectors and countries. If one looks closely at the data, it is clear that a large share of the increase in output and structural change registered by these countries is due not to technical change but to the expansion of the physical base of production via new investment and the importation of foreign technology. Yet despite investments of hundreds of millions of dollars over many years in "technology transfer" projects throughtout the Third World, there has been very little acquisition or transfer of the range of "change-related" skills and knowledge which provide the foundation for technological dynamism in an economy.20/

The skills that were acquired were primarily limited to the management and operation of fixed facilities - and frequently these were not even well developed. Similarly, over the course of year to year operation, many Third World firms make relatively little effort to develop or acquire new change-related skills. There is abundant macro and micro level evidence of the effects of this lack of learning and the

minimal accumulation of technological capacities - long term stagnation or decline in productivity growth; continual dependence on imported hardware, knowledge and technical services; low levels of capacity utilization; lack of improvement in international competitiveness and in local supply capacity; poor quality; etc.21/

To be sure, major investments in education were made with the specific objective of creating S&T capacities - universities and technical colleges were built throughout developing countries in order to train skilled manpower. Likewise, formal R&D institutions (either connected to universities or engaged in sector or product specific research) were set up to create capacities and generate new knowledge that would allegedly be used by the productive sector.

However, there were three problems with this approach to the creation of S&T capacities. First, massive state support of investment in education outside of firms was not matched by state support and encouragement for investment in knowledge creation and skill accumulation inside firms - yet firm and production specific knowledge not just knowledge based on formal learning and laboratory experiments is crucial to successful technical change efforts.

Second, the educational and R&D institutions that were established in developing countries were essentially copies of S&T institutions that already existed in mature industrialized countries such as the U.S. and U.K. - institutions that were designed to specifically suit conditions in those countries and which bore no resemblance to conditions in devloping countries. Thus institutional imitation rather than institutional innovation governed the creation of developing country S&T institutions and rendered those that were created inherently structurally inappropriate to the particular scientific and technological needs of the productive sector.22/

Third, the "knowledge-poor" environment both within and surrounding productive enterprises in developing countries (which lead initially to dependence on external sources of supply) has meant there is little effective demand by producers for output of R&D institutions and, importantly but rarely recognized, a lack of involvement of producers in

these countries with the evolution of the R&D and technical education systems.

This, coupled with the failure of scientists to (want to) learn about production and develop firm specific knowledge, meant that no organic relationships developed between the education/R&D system and the productive system. Thus firms remain dependent on foreign sources of supply and the local R&D system produces new knowledge that is frequently irrelevant or unsuited to the needs of local producers.23/ The net result of all three features mentioned above is what might be termed the "functional incoherence" of the S&T system in developing countries.

In addiion to the above, the expansion of the productive sector and the creation of a seperate S&T system went forward within macro policy context defined by two sets of measures by government.

- Macroeconomic policy. Policies in areas of trade, tariffs, exchange rate, control of imports and foreign investment, credit, industry structure, local content, etc. worked against the efficient operation of a price system and demand structure that would reward innovative effort. Macro policies also worked against creation of local technology supply and investment in capacity creation. Excessive and inefficient direct state involvement in production was also counter-productive vis a vis development of technological dynamism.24/

- Science and technology policy. The creation and operation of government organizations responsible for national S&T policy has generally also worked against the creation of dynamic capacities. Again inappropriate institutional imitation vis developed country models governed the design of these policy agencies and limited their effectiveness from their very inception.25/ In addition, their policy focus in practice was almost entirely concerned with running the R&D system and squeezing more money for R&D and science education out of government. In effect, agencies set up to oversee the development of scientific and technological capabilities throughout the economy were

basically only concerned with science policy issues and the strenghtening of science.

There was, of course, some concern with whether the output of the R&D system was of use to the productive sector but the steps taken to deal with this issue were usually quite limited as this was largely seen as problem of demand and not the responsibility of R&D system of supply. Consequently, little or no attention given to policy support for the development of "user" capacities, to ensuring that technology transfer and investment projects were organized to effect maximium learning benefits, to oversee and make clear the impact of other policies on science and technology or to build build up the structure of input and services supply. Rather than removing the causes of functional incoherency, science and technlogy policy as typically followed by many countries just made the problems worse

Of course, the above analysis is oversimplified. There were and are many differences between countries in each of the areas specified both in qualititative and quantitative terms. Even the poorest countries demonstrate a degree of technological capacity in some sectors. Through their education policies, some countries have built up impressive levels of qualified personnel even if they are not well deployed. Some effective policy measures were introduced to facilitate learning and capacity accumulation, some R&D institutions are making a contribution to the productive sector.26/ Nevertheless these positive features of developing country S&T systems and the S&T policy environment are not pervasive and many of the characteristic problems described above are found in many countries.

Policy Implications and Links to Indicators

The general implications of this analysis suggest four general sets of S&T policy objectives:

i) the development and accumulation of techno-managerial capacities for technical change and technological mastery within productive enterprises;

ii) exploration of the possibilities for institutional innovation with respect to established and new S&T institutions;

iii) the pursuit of functional coherence and integration between the productive sector and R&D system and the design of "knowledge bridges" to better link the two;

iv) the development of macro economic and S&T policies which create the appropriate context that rewards innovative effort and investment in learning, and facilitates development of systemic linkages between firms and between producers and users of knowledge.

In practice, the design of policies and programmes to achieve these objectives will depend, inter alia, on the basic characteristics of the economy, the nature of existing firm and institutional S&T capacities, the prior and present macro economic and national S&T policy environment, industrial structure, and so on. Thus the steps needed will differ significantly between countries.

The Main paper suggests that it is a priori possible to group countries according to six sets of S&T related variables that in principle define different countries at different stages of economic and S&T capacity development and in effect determine the starting point for policy, and in the case of AID, project design. These are: general economic and social measures; technological capacity in the productive sector; human resources; S&T infrastructure; S&T policy; and financial institutions to support firm creation and innovation. Though for reasons of space we so not do it here, each one of these sets of variable can be interpreted in light of the analysis and policy conclusions presented above thus providing the necessary theoretical rationale for their use as indicators.

Given this, it is possible to identify a variety of indicators under each of these six categories whose analysis should in principle allow analysts to build up realistic picture of the S&T situation in particular country and point to possible projects for bilateral support. This is the focus of the discussion in the next three sections.

Section 3: SCIENCE AND TECHNOLOGY INDICATORS: BACKGROUND PREPARATION AND ASSESSING THE GENERAL STATE OF THE ECONOMY AND INDUSTRIAL SECTOR

Over the next three sections, we shall be using the categories proposed in the Main paper to discuss S&T indicators. However, in order to simplify the presentation of the material, we shall incorporate the presentation of human resource indicators in the discussion relating to the general characteristics of the economy, technological capacity in the productive sector and the S&T infrastructure. Similarly we will cover indicators for financial institutions in the presentation on S&T infrastructure and S&T policy. In this section, we introduce the indicator reveiw by first exploring some of the preparatory work that should ideally be done before carrying out a program of original data collection and analysis. Section 4 concentrates on indicators related to technological capacity in the productive sector, while Section 5 covers the last two sets of indicators on S&T infrastructure and S&T policy.

Assembling Background Knowledge to Support Project Design and Further Data Collection

The first stage in any attempt to identify and collect new S&T data is to bring together and review available background information and studies that relate to AID objectives - the design and implementation of bilateral assistance projects that will facilitate the development of S&T capacities and the acceleration of economic development in client contries. Though it may seem obvious, the review of existing knowledge is a step often neglected, with the result that money and time is wasted generating information and knowledge already available

The field of study of S&T and development is relatively well advanced articularly in relation to countries who have reached a minimium degree of industrial development. Consequently the economics of innovation, and the technology and development literature will be major sources for insights into plausible indicators and country specific features of S&T/development relationship in client countries.

A comprehensive review of this literature (which was not possible in the context of this study), particularly the many case studies that exist, would provide an invaluable basis both for the design of new quantitative indicators and for the design of qualitative assessments based on select case studies in the client country.

There are numerous sources for this material ranging from published books and mainstream journals available in the U.S. and U.K. to country and sector studies carried out in-house and commissioned by bilateral, regional and international development organizations - of which the main sources would be the World Bank, UNIDO, UNCTAD, UNRISD, UNESCO, ILO, the Asian Development Bank, IADB, etc. The International Development Research Centre of Canada is also very active in this field and has financed a large number of studies likely to be quite useful. One final source of background knowledge would be the now quite numerous Ph.D. theses that have been written on a variety of topics in the S&T field and in related areas of industrial development - with all U.S and U.K. theses being available centrally.

In-country information sources should also be reviewed. Published government documents, studies commissioned by other bilateral or international agency missions, national and local journals, unpublished reports from university-based researchers, etc. are all sources of possibly useful information. In larger countries with a tradition of social science research such as India or Brazil there will be many relevant published sources of information, perhaps too many. This will not be the case in smaller countries.

In addition, there are numerous individuals who should be consulted who are likely to be knowledgeable about specific aspects of the S&T situation in the country. Government officials and university-based policy researchers are obvious places to start but industry "wise men" should also be contacted. If any background studies or literature reviews are to be commissioned, either during preparation or during the actual data collection phase, these should ideally be done by local researchers or at least involve local researchers extensively.

However, S&T policy analysts are in short supply in most developing countries. If this is the case in the client country, this suggests another possible focus for an AID S&T project - the development of S&T policy analysis capacities in government ministries, development banks, and specialized agencies, or among universitu staff,ies, pershaps industry associations and in the private sector via support for research training, fellowships, workshops, etc.

More generally, a competent country-specific review of knowledge (both embodied in written material and present in individuals) in relation to S&T and industrial development issues, coupled with the analysis of already avaiable statistical material,could eliminate the need for major new information collection efforts and thus lead directly or at least more quickly and efficiently to project design.

S&T Indicators by Category

We can now begin our discussion of S&T indicators, organized by the four categories discussed at the beginning of this section. It should be noted, however, that as explained in the Introduction, our primary aim in this paper has been to suggest the widest range possible of data categories and indicators that, a priori, we believe reasonably reflect some aspect of the S&T issues that concern us here.

Consequently, in most cases we have not fully developed the logic linking the indicators specified to the conceptual approach outlined in Section 2; nor have we reviewed each indicator either in terms of the constraints on data availability and reliability or in relation to the many questions of method and interpretation that always need to be taken account of in the analysis of empirical data.

GENERAL STATE OF THE ECONOMY/INDUSTRIAL SECTOR

The collection and analysis of general information on the economy and the industrial sector is necessary to orient the project designer to the overall characteristics of the economy, its recent performance and

position vis other countries. There is no real need to attempt to establish any cause-effect relationships between this macro data and S&T activities or elements in the economy. The aim behind collecting this data together is simply to build up a picture of the economy and of the changes that have occurred over time in the main areas of social and economic performance. Any analysis necessary can be carried out using standard macro-economic tools.

The data falls into five categories, with the data sets for the first four usually being readily available from annual publications by the World Bank (such as the World Development Report) and statistical compilations, yearbooks and handbooks published regularly by the UN, especially UNIDO, UNCTAD and ILO and other regional development agencies.

As can be seen from the listings below, there is a large range of social and economic data from which to choose a representative sampling. Whichever data sets are selected, in order to aid comparison and analysis, the presentation of the data should (whenever relevant) show it in terms of current/constant values, over time, by indices, by per capita, as a percentage of the relevant totals, as a share of GDP/GNP, by breakdown between agriculture, industry, and services as well as showing country performance in relationship to the performance of related countries (by income level or region), all developing countries and all countries.

General:
- Population
- Physical Area
- Life expectancy
- School enrollment
- Paved roads
- Vehicles
- Telephone density
- Energy consumption (commercial)
- Literacy rate

Economic:
- GNP/GDP per capita
- Government/private consumption
- Gross domestic investment/savings
- Central government expenditure
- Income distribution
- Capital inflows
- Size of labour force
- Wholesale/consumer price index
- Rate of inflation
- Balance of payments/debt service/external debt

Production:
- Distribution/Growth of GDP across sectors;
- Industrial production indices;
- Employment - total/by production workers/wage categories;
- Share of production/imports in consumption/share of exports in production;
- Manufacturing value added (MVA);
- Earnings per employee;

Distribution of MVA across sectors/output/employee/wages;
Capital stock estimates if available;
Manufacturing investment/share of imported capital goods;
Gross domestic fixed capital formation/share of domestic capital goods/growth of manufacturing capital stock;
Productivity measures (labor) - by gross output or value-added/worker;
Indices of industrial structural change/growth rate/degree of specialization

Trade and foreign investment:

Merchandise and manufacturing exports/imports by broad sectoral category to GDP/manufacturing production;
Foreign direct investment - by stock, by profits - inflows and outflows by origination and destination;
Foreign direct investment by sector - shares of production, employment, exports and imports

Macro-economic policies: As argued in Section 2 and in the Main paper, macroeconomic policy can influence strongly the conditions under which scientific and technological development occur. Thus a review of the available information on macro-economic policy will provide a critical element of the overall context in which S&T policy and AID S&T projects need to be planned. Both quantitative and qualitative information will need to be collected on a variety of policy measures and, wherever the analysis has already been done, on their economic effects. The IMF and the World Bank will be the best sources for this information outside of the economy.

Import policies and the effective rate of protection;
Interest rate and credit policies;
Exchange rate policy;
Price control policy vis industrial materials, goods and equipment;
Policies on competition and regulation of the market;
Policies relating to industry structure and market entry and exit;
Trade policies;
Labor policies;
Policies on direct foreign investment;
Public sector ownership policies;
Share of state enterprises in different segments of the economy;
Costs and/or measures of performance of public sector enterprises in the industrial sector.

By drawing together this macro data base, the project designer will be able to get a good picture of the main economic parameters currently defining the operation of the economy. One could also carry out a variety of analyses to reveal relationships and trends that might have specific and direct implications for action in the S&T area. For example, by relating past and esimating future trends in debt servicing and manufacturing investment, the scope for new investment (and hence introducing new technology) can be demonstrated - which in turn might suggest whether policy (and AID projects) should focus on improving the assimilation of imported technology or on improving effiency in existing plants.

Alternatively by calculating the elasticity of MVA with respect to imports of raw materials and intermediates in different industries (which shows the capacity of the economy to substitute domestic inputs for imported ones), the effect of an import squeeze (caused by import restrictions or a lack of foreign exchange) on output and employment can be shown. This could be interpreted as demonstrating both the cost of restrictive policy and as a means of identifying sectors where the creation of domestic technological capacity might be pursued - in order to eliminate costly import dependencies.

One could also explore the ratio of potential output/employment/foreign exchange foregone with actual performance by calculating gross incremental capital-output ratios for some past period and relating to these to estimates of the rate of capacity expansion in particular industries. Though numerous limiting assumptions apply, the results might allow some informed speculation about a variety of issues such as where there have been missed opportunities for expansion in output. A closer examination of the reasons why output did not grow as it might have done, might well reveal that some set of technological factors were at fault - such as the lack of technical change capacity at the plant level capacity.

Depending on the data and resources available, there are other similar possibilities to be explored using macro data which while not directly observing S&T-related activities, can certainly be assumed to be indicative and thus supportive of the project design effort.

Section 4: INDICATORS FOR ASSESSING TECHNOLOGICAL CAPACITY IN THE PRODUCTIVE SECTOR

Because of the central importance of firm-level technological capacities in our analysis and thus the need to devote considerable effort to its measurement, we shall discuss indicators issues under this heading in a little more detail than we do under other headings. The measurement of technological capacity in the productive sector could focus on a variety of areas, be carried out at different levels of disaggregation and involve a range of methods. The analysis in Section 2 and in the Main paper suggests three aspects that should receive particular attention:

i) Impacts and outputs. Evidence of firm-level innovative efforts and the impact of these on performance is needed to document the existence/ non existence of enterprise-based technological capacities to produce efficiently, improve performance, acquire and adapt technologies, develop new techniques and products and generally respond to changes in competitive environment both domestically and internationally. The analysis of impact/ouput phenomena can be carried out at a macro or micro level.

ii) Investment, flows and stocks. Evidence on firm-level investment in innovative effort, in learning and capacity accumulation and on the size, nature and costs of external (input) flows of embodied and disembodied technology that expand the stock of skills and enhance competitive abilities of the firm will provide a picture of the scale and distribution of these activities. Analysis in this area can be carried out on both a macro and micro level.

iii) The process of innovation. Information on the processes of firm-level innovation that do (or do not) occur and the factors external and internal to the firm affecting the innovation process will provide insight useful to the design of policy interventions. Primarily micro-level analysis will be necessary to generate knowledge needed in this area.

We discuss indicator possibilities for each of these areas first at the macro level primarily using data that should already exist either in international or national sources, and then at the micro level where information will need to be collected via case study or surveys.

Impact and output at the macro level

a. Total factor productivity (TFP). TFP analyses typically seek to identify the sources of output growth in the economy and constitute the most robust and direct of all the macro level indicators of firm-level technological capacity. Past studies have shown that a large share of output growth, particularly in rapidly growing economies, is due not to growth in inputs but to growth of TFP. Though commonly treated the same as the "residual," TFP is slightly different and is technically defined as the ratio of the rates of growth of output and the weighted average of inputs (labour and capital where output is measured by GDP or value-added).27/

By carrying out TFP analysis, it is possible to make a broad judgement about the degree of technological capacity in an economy and the extent to which output growth is due, for instance, to simple capacity expansion - as was argued in Section 2 to be the case in most developing countries. TFP analysis also allows limited comparisons with other economies.

TFP analyses are relatively straigthforward if reliable data is available - though there are a variety of well known measurement and interpretation problems - particularly if the analysis is only carried out for the economy as a whole.28/ Thus a complete evaluation of productivity performance at the macro level would require subsectoral data on gross outputs, material inputs and working capital as well as on labour and fixed assets.

Nizhimizu and Page (1982) have sought to overcome the limitations of aggregate TFP analysis by measuring TFP growth rates at the subsectoral level in their examination of the Yugoslava economy. Pack (1984) presents a useful approach for comparing and explaining developing country performance at the sectoral level that, unusually, uses effective protection rates as a deflator, and explores explanations in terms of skill requirements, relative capital intensity and firm size.

Unfortunately, the measurement and interpretation problems plaguing aggregate and even subsectoral TFP analyses mean that such analyses can

only be a starting point for assessing the capacity question. Since , for instance, the measures do not adequately distinquish between scale and specialization effects, the forms of technical change taking place or the location of these, or the reasons why it does or does not occur, TFP analyses do not on their own explain productivity performance or give an unequivocal indication of what needs to be done to improve it.

As Tidrick (1984) demonstrates in the case of China, other information derived from studies carried out at a more micro level is needed to give a meaningful policy interpretation to TFP analysis. Pack (1982), in a similar vein, points out that in the case of TFP comparisions between countries that while additional industry level statistical analysis and refinement of data might prove useful:

> "..a greater rate of return can be obtained from detailed studies at the firm level which will provide a better understanding of the technical and behavioral base of the more aggregative observations." (p.18)

Other macro measures of impacts and output: production and trade. Staying at the macro level there are other measures that arguably shed light shed light on the capacity issue.

b. Patents, copyright and trademark applications. Among these three, patents are increasingly accepted as a reasonable output indicator in the context of developed countries. The measurement of developing country patents taken out in a third country (usually the U.S) would almost certainly show relatively little innovative activity except for the very largest economies where it might be possible to get a statistically significant result by relating patent performance to some input indicator and some measure of economic performance.

. However, comprehensive data on patents, trademarks and copyrights registered and worked (by domestic or foreign firms) within the country itself might be a valid indicator. A number of objections can be raised about the usefulness of this type of data because all three devices are often used to restrain the growth of local competititon. Yet at the same time it could be argued that their use in the domestic economy either by local or foreign firms represents the attainment of some minimal level of technological capacity in maintaining international standards of quality; or the fact that the market has reached a sufficient size and maturity to sustain technology based competition. Moreover, the rise in importance of knowledge intensive products such as software and biotechnology innovations is being paralleled by renewed interest in the role of patents and copyright as devices to protect international property rights.

Thus patent data, as well as data on trademarks and copyrights taken together might provide useful reference points for assessing technological strengths and weaknesses both in mature consumer and producer goods and in more technologically complex products. To do this, data on numbers of patents, trademarks and copyrights registered locally could be related to indicators of usage, output, investment and ownership. Among the different ways of categorizing this data, the following four are possible:

- National patents/trademarks/copyrights registered and/or applied for/by product/sector;
- Domestic patents/trademarks/copyright applications registerd and/or applied for/by product/sector;
- Foreign patent/trademark/copyright registered and/or applied for/by product/sector;
- External patent/trademark/copyright registered and/or applied for/by product/sector;

c. Structural change. It is possible to infer some useful knowledge about a country's evolving technological capacity at the sectoral level via the examination of structural change. Some of the more simple indicators which illustrate the dimensions of structural change and are usually compiled in international sources are:

- indices which capture variations in the composition of manufacturing output;

- measurement of changing output composition according to end-use as consumer, intermediate and capital goods - or according to other sectoral groupings choosen to highlight different types of technological capacity e.g. in assembly intensive products, engineering or electronics goods;

- the changing size distribution of firm share in output which assumes that as industrialization proceeeds, consolidation takes place involving a shift from cottage and small industry to larger, more technologically competent firms.

- measures of intra-industry specialization

Ariff and Hill (1986) propose an approach that goes beyond the use of above absolute indicators which seeks to explain the process of structural change by relating variations in the composition of industrial output, via comparative advantage theory, to changing factor endowments in the ASEAN countries.

They assume a stages model of changing comparative advantage (from resource-based processing, through unskilled labour-intensive manufactures to more skill and capital-intensive activities.) To assess performance across different sectors, they classify production and trade figures (following Krause (1982) and Tyers and Phillips (1984)) according to the intensity of use of four factors of production - natural resources, unskilled labour, technology and human capital.

It should be noted that while the trade data for this type of study is available from international sources, the necessary manufacturing statistics can only be attained from national censuses of industrial production.29/ In the case of this study, explanations are sought in terms of relative resource endowment, the rate of capital accumulation and, interestingly, state policy intervention in the form of domestic protection policy - with this last variable being particularly important in explaining the changing pattern of manufacturing production.

d. Trade-related measures. Various trade-related measures also give indications of the *de facto* competitive strength of an economy in various industries and these could beinterpreted as an indirect measure of technological capacity. There are a variety of direct measures such as:

- changes in the the overall structure and rate of growth of manufactured exports distinguishing between broad categories of resource-based, labour-intensive and skill intensive products;
- exports/imports of capital goods, other engineering products, etc. to domestic production and consumption of these goods;
- share of capital goods, engineering products, and other technology intensive products such as electronics in total manufactured exports;
- export/import ratios in major export sectors and/or in selected technology-intensive sectors by value/per capita/growth rate/share in country/region/world exports and imports;

However as with similar types of aggregate data, these data on their own do not imply a cause and effect relationship between the existence of technological capacities and international competitiveness since the

observed exports could be the result of temporary lulls in domestic demand during which producers sell abroad at a loss to maintain minimum capacity; government incentives and/or an undervalued exchange rate; and the activities of foreign firms.

To judge these issues, it is necessary to test for a relationship between each of these factors and export performance, as well as trying to link an explicit indicator for technological capacities or efforts (such as numbers of engineers employed or entering the workforce; investments in R&D) to that performance. As the data and information necessary to do these tests and interpretations (e.g. domestic resource costs, the details of government incentive schemes, share of foreign firms in production and export, etc) are rarely as easily available as trade data, additional data collection efforts may have to be made. Teitel and Thoumi (1986) tackle this set of problems and provide a good example of the additional data required and the difficulties involved in interpretation.

e. Exports of disembodied technology. Data on exports of disembodied technology (as distinquised from exports of technology embodied in equipment) are valuable indicators of the presence and nature of capacities that do not suffer so much from the problems mentioned above. Such disembodied technology exports typically include licenses and other technical assistance contracts, industrial and civil construction contracts, various consulting and engineering services, sales of turnkey plants, direct foreign investment - and, arguably because of the growing importance of information technology, exports of software. Unfortunately this data is only likely to be already available if studies explicitly focussing on this issue have already been carried out as is the case for some Latin American and Asian countries.30/ Otherwise it will have to be collected via firm surveys.

f. Revealed comparative advantage. We reiterate, however, that apart from disembodied technology exports, trade related data may be of limited use on their own for the purposes of this project because they do not

establish cause-effect relationships. One, perhaps roundabout, route around these problems is to carry out (or extend available) assessments of revealed comparative advantage (RCA).

RCA analysis - particularly if carried out at a sufficiently disaggregated level and informed by a perspective that accepts the proposition that "comparative advantage is made not given "(Cline, 1982) - provides a starting point for designing policy measures which seek to create, develop or enhance competitive advantage. Further, assessing trade performance under past trade regimes suggests possibilities for areas of expansion under different conditions - most notably the shift from inward to outward looking policies.

Similarly, by identifying the sequence of industries in which relative efficiency is likely to grow, RCA analysis can give a sense of priority to the concentration of government effort to promote competitiveness in certain sectors and/or on the creation of certain types of human and institutional capacity. This is information and insight that would also be useful for AID purposes in targetting those sectors where an S&T project aimed at increasing firm-level capacities might have the greatest impact.

The field of comparative advantage studies is well defined, the technical and data considerations are substantial and the need for exercising caution in interpretation on both theoretical and empirical grounds is extensively argued in the literature. UNIDO has done a good deal of innovative work in this area and UNIDO (1984), besides providing RCA indices for three digit industries across countries, also contains a comprehensive and balanced discussion of the theoreticial, technical and policy issues.31/

g. **Export destination**. Information useful for this project could also come from examination of export performance in different sectors such as capital goods in relation to the destination of those exports. Disaggregating export destination with respect to South-South trade and production/ consumption patterns might highlight possibilities for regional export expansion in particular sectors that might otherwise be

ignored. This in turn provides a basis first for the examination of capacities in those sectors and secondly for identifying interventions that could strengthen capacities for exploiting these opportunites. Nugent (1986) applies this approach in relation to capital goods and identifies a range of opportunities for South-South trade normally excluded from consideration because of scale, technology or demand constraints or because of the assumption that South-South exports are most likely to labour intensive because of similar factor endowments.

Macro Indicators of Firm-Level Innovative Efforts and Stocks of Technological Resources

Because of the past concentration on S&T input indicators as discussed in Section 1, macro level data relating to firm level innovative effort and stocks and flows of embodied and disembodied technological resources are likely to be the best S&T data available in developing countries. Depending on the strength of past and current data collection efforts at the national level, the data categories available might range from the minimium information on the numbers of people with scientific and technical qualifications in the total population and the scale of govenment support for R&D (both of these data sets in most developing countries having little direct connection to capacities in the productive sector) to much more detailed information.

Below we list some selected indicators under each of these headings for which data might already be available (from international or national sources or from previously conducted studies as discussed earlier) or where collection via firm surveys (perhaps at the sectoral level) might be feasible. These indicators include information typically only collected at the national level in developed countries and data categories more closely related to conditions in developing countries.

a. Firm-level investment in innovative effort

Annual expenditures for industrial R&D in current and constant values;
Average annual growth rate of industrial R&D at fixed prices;
Industrial R&D as a percentage of total R&D; of other R&D;
Industrial R&D as a percentage of domestic product of industry /by sector;
Total industrial R&D - by private sector/by foreign vs local/by private non-profit/by public non-profit;
Annual expenditures for industrial R&D -- by sector/foreign vs local/by size (employment) of firm;
R&D expenditures - by source of funds (goverment, internal, external);
Expenditures for R&D by major cost category - labour, other current costs, land and building, instruments and equipment;
Wage costs for salaried and/or skilled personnel;
Value and share of enterprise R&D contracted to outside agencies/by category - university/industrial R&D institute/other private - foreign and local;

b. Stocks of technological resources (including both people employed in innovative activities and suppliers of technology-related services and knowhow - both of which fall under the category of human resources as defined in the Main paper.)

i. Personnel engaged in innovative effort.

Total industrial personnel with scientific or technical qualifications;
by numbers/wages/qualification category;
by/function within enterprise - R&D, engineering, repair and maintenance, etc.;
by sector/size of firm/foreign vs local/private - public non-profit;
average annual growth rate;
Percentage of recent graduates with technical qualifications entering the labour force.

ii. Stock of technology intensive enterprises (the objective here is to document the quantity and if possible the quality of specialized sources of technological knowhow and services within the economy)

Number/output/employment/fixed assets of capital goods, engineering and metalworking firms - by product specialization if possible;
Number of mechanical repair, metalworking repair and maintenance workshops and facilities/location by sector/public-private/foreign-local;
Number/output/employment/specialization/nationality of consultant engineering and design organizations;

Number/output/employment/fixed assets of electronics and software firms;
Number/output/employment/fixed assets of specialist suppliers of technological services including quality control, testing, market research, equipment selection, etc.;
Number/output/employment/fixed assets/specialization of foreign distributors of capital goods, engineering services, IT products, etc.

c. Flows of embodied technology

Imports of industrial equipment to capital goods production;
Imports of capital goods to fixed capital formation;
Imports of raw materials/intermediates/capital goods to total production by sector/firm size/nationality;
Export/import/production ratios for capital goods and intermediates by key sectors/firm size/nationality;

Technological balance of payments data on receipts/payments/and net balance

(covering inter alia payments and receipts for -
licenses; management contracts
royalties; marketing and disribution contracts
lump sums; information services;
turnkey plants; civil and industrial construction projects;
technical services (quality, testing, maintenance and repair;
profit remittances on joint ventures/wholly owned subsidiaries.

Some qualifications on interpretation. We have already discussed the problems associated with analysis and interpretation of some of these macro data sets. Macro data on R&D expenditure probably captures only a tiny fraction of firm level investment in innovative effort but may still be of use in relation to the large economies. The same qualification applies to the manpower data - unless the available data actually distinquishes between those involved in R&D and in other types of technical change effort.

In terms of the other categories however, provided the data is available and reasonably representative, comparisions over time and between countries, normalized for size and shown as a share of the relevant total, though the simplest form of analysis is the least open to misinterpretation and could be of considerable use in project design. Again, depending on the data, it may be worthwile exploring more

complicated cause-effect relationships through some form of regression analysis - but this cannot be judged a priori.

Micro Level Indicators of Technological Capacity in the Productive Sector

As we argued earlier, knowledge gained from the empirical examination of firm-level performance could be a valuable complement to the information gleaned from macro indicators and existing studies. Two broad levels of analysis can be pursued - via surveys based on data collected from a selected sample of firms and designed to allow a rigourous examination of a limited number of features/determinants of firm performance; and in-depth case studies of fewer fiirms but allowing a deeper quantitative and/or qualitative examination to be carried out of cause and effect relationships under specific circumstances.

Needless to say, the range of information that can be collected with either of these methods is quite large - with the choice of data set depending obviously enough on the questions for which answers are being sought. Innovation analysts in the developed countries are exploring new sectoral and firm-level indicators of the innovative process in order to better understand this process.

However our preliminary judgement of these indicators is that they are not suitable for the study of innovation in developing countries.32/ A more extensive review might, however, suggest some new data categories that are worthwhile exploring further. Nevertheless in what follows, we draw on the mainstream technology and development literature to selectively discuss data requirements and indicators useful for micro level analysis.

Although we do draw attention to specific issues, we have choosen not to segregate the discussion under the three headings explored earlier - - impact/output; investments, stocks and flows; and processes of technical change and determinants of firm behavior - because of the similarities in the information required under each. Also we shall not discuss the many issues of method that arise in relation to studies of this nature but make reference to the relevant literature.

The examination of technical change and its determinants at the micro level. Our concern with technological capacities in the firm means any analysis must start with some measures of firm productivity performance over time. Otherwise it is not possible to judge the relative importance of different factors that affect or determine firm performance (or lack of it.) In our case, this involves the collection of data on basic economic and physical measures of unit input use per unit of output but might also necessitate collecting data on product quality, net profits, market share, export share of production, product mix and changes over time, and perhaps even type of customer.

Assessing the determinants of performance requires that quantitative and qualititative data be collected on a variety of variables of which we would suggest the following groups are particularly important:

- firm characteristics - in particular structure of the managerial and technical skill base;
- the nature and impact of any government policies affecting firm operation;
- the engineering determinants of productivity;33/
- the nature, cost, duration and benefits of specific technical change efforts undertaken by the firm;
- the reasons for undertaking or not undertaking technical change efforts - i.e. market demand, competition, adapting to raw material change, quality improvements, self-motivation, lack of skills/knowldege, financial constraint, etc.;
- market structure - both demand and supply;
- the individuals and firms/institutions who were the sources of knowledge to carry out the changes - and their sources of knowledge and expertise;

How this data is treated and analyized is a question of choice of method. Pack (1988) demonstrates one approach which essentially involves carrying out a rigourous TFP analysis of plant level performance in one sector across different countries. Although the data collection requirements to carry out a study of this sort, Pack's work demonstrates that a great deal of policy relevant insight and conclusions can be drawn from this level of detailed analysis.34/

A good example of analysis using survey type data (that may already be available in some countries) is carried out by UNIDO (1987a) which uses a method based on Caves and Uekusa (1985) (and quite different data categories combining macro and micro variables) to assess the determinants of manufacturing efficiency in the East Asian economies.35/ There are many other examples of case study and survey analysis in this topic area.36/

Whatever method is choosen, the aim of the analysis must be to yield insight and information on firm level technological capacities and on the most important factors affecting the accumulation and deployment of those capacities at a level of detail and rigour that is useful for AID project planning purposes. This is best decided in consultation between the analyst and project designer.

Capacity accumulation and technology transfer. The Main paper stressed that the ability to select the appropriate technology to be imported and then to effectively assimilate it is critical for those many developing countries not in a position to generate the technology themselves. We argued in Section 2 that the evidence suggests that many countries in fact do a very poor job of assimilating imported technology. Consequently the micro-level analysis of this issue could provide valuable guidelines for project focus and design. There are many case studies of technology transfer that would be useful in providing guidance on method and use of indicators.37/

One way would be to compile information on a succession of transfer events involving say the establishment of new textile production lines or plants. The technology transferred could be broken down into its embodied and disembodied elements and the degree of local versus foreign supply of each element over different projects could be tracked. this would be one indication if any local assimilation took place. If data could also be collected on performance over time for each imported line or plant, it might be possible to judge the existence of estimate the costs or benefits arising from the degree of assimilation.

Alternatively, a single investment project involving the acquisition of foreign technology could be examined to determine the extent to which a concern to absorb underlying technological knowledge and skills during the transfer process figured in the negotiation efforts and strategy of the technology importer - and in the criteria applied by government in its policies regarding technology transfer and foreign investment. These issues are taken up further in the next section.

Section 5: ASSESSING THE SCIENTIFIC AND TECHNOLOGICAL INFRASTRUCTURE AND SCIENCE AND TECHNOLOGY POLICY

Input, Output and Organizational Indicators for the S&T Infrastructure

As discussed in Section 2, the performance of the S&T infrastructure in developing countries cannot be assessed solely on the basis of internationally accepted input and output indicators. An explicit effort must be made to assemble data sets that capture properly the particular characteristics of the S&T infrastructure, particularly in relation to output and form and functional aspects of the institution. We try to take account of this aspect by proposing both conventional and new, untested indicators under the headings of institutional input, output and organization.

The scientific and technological infrastructure consists of a wide variety of educational institutions; public and private sector suppliers of embodied technological inputs and technical solutions; public and private sector suppliers of technological services, specialist expertise and knowledge/information; sector specific industry and professional associations; public and private sector sources of financial support for for firm start-ups and investments in innovative effort. A representative listing of the different categories of institutions and agencies would include the following:

- primary and secondary educational institutions providing instruction with a technical and scientific content;
- universities and higher educational institutions;
- technical vocational and industrial training institutions;

- public sector basic and applied R&D institutions attached to universities or government ministries;
- public or private sector R&D institutions with a sector, discipline or problem focused specialization;
- public and private sector agencies supplying technological services to the productive sector such as testing and quality control, design and marketing, computer and software support, etc.;
- consultancy and engineering design organizations (CEDOs), capital goods and engineering firms, formal sector repair and maintenance workshops and informal sector metalworking shops;

- public and private sector suppliers of information and information related services and support such as libraries and data banks;
- sector and discipline specific industry and professional associations;
- development banks, ministry-administered sources of finance, private sector sources of capital.

Input indicators. Input data on S&T infrastructure institutions (at least for the public sector) should be among the most available S&T data categories in all countries due to the past emphasis on collecting this data by international agencies. And, except for the largest countries, it should not be an onerous task to compile input data on private sector enterprises. The categories listed below include conventional quantitative input measures, data which covers the main categories of stocks of human resources involved in S&T infrastructural activities, as well as some data which would shed direct light on the issue of linkages with the productive sector.

- number/size/coverage of primary and secondary educational institutions;
- number/size/coverage/focus of technical vocational and industrial training institutions;
- number/size (by costs, student and staff)/discipline/coverage of universities and higher educational institutions with special emphasis on details of students and resources involved in industry related science and engineering courses;
- any available details on course content and curriculum design process;

- number/type of R&D/service institutions/CEDOs/workshops/ professional associations by sector/focus/discipline/or by function (pure basic research, strategic research, applied research, extension, service provision, etc.);
- size by staff/budget/revenue;
- costs (by source if any costs met by outside agencies) and by function within the institution;
- personnel by qualifications/age/length of duration/specific experience with industry;
- date of establishment.

Output indicators. The discussion in Section 2 and in the Main paper suggests that the main focus of output measurement should not simply be absolute counts of citations, papers published, etc. but rather bear some

relation to the impact of institutional activities on the productive sector and also take account of the specific conditons under which these institutions operate. There are various ways of getting at these aspects through data collected via surveys and/or case-studies. Below we give a fairly detailed listing of different types of output indicator for differing institutional forms and activity.

FORM/ACTIVITY	INDICATOR
Pure basic research	Number of papers published: - in national and regional journals; - in world's most highly cited journals; - in all external journals; - total number including formal internal papers; - above grouped according to discipline; - Number of national/regional/international citations from outside the institution; - Peer review of output; - Peer recognition in international scientific and technological community (prizes, invitations to speak at international conferences or visit overseas laboratories, membership in advisory panels, editorial boards and academies.
Strategic basic research	As for basic research, plus the following: - Number of discoveries having direct potential for national benefit; - Total estimated (projected) net benefits for 10 years, if implemented; - Number of requests for information from external researchers or other users, received and satisfactorily answered.
Applied research	As for strategic basic research, with less emphasis on paper and citation counts, plus the following: - Success in meeting goals within budget/time estimate; - Number and type of innovations; - Source of idea/source of contract - Estimated net benefit if implemented/diffused over ten years - Number of innovations successfully commercialized in-house over past ten years; - Extent of diffusion of in-house commercialized

innovations by users/sales volume measured in relation to time and adopter population;
- Number and characteristics of failures;
- Number of patents;
- Sales of technical know-how:
  - to local companies;
  - to overseas companies

Provision of Service, Linkage, Extension

(Universities and Higher Education Institutes)

- Consultancy, research and theses topics of staff and students;
- Employment (by location and function) of new graduates;

(R&D institutions)

- Nature of extension activities and mandate;
- Mechanisms to commercialize innovations;
- Size of extension effort by projects/people employed (if different from researchers) /resources - as % of total;
- Qualifications background of extension agent/ degree of industry specific experience
- Share of revenue derived from industry contracts
- Type and number of interactions between extension service and users - vis promotion efforts by extension personnel associated with specific projects as well as consultancy activities, visits, telephone calls for advice;

(Service institutions)

- As for R&D institutions but categories adjusted to take account of service being provided.

Private/public sector sources of finance

- Size of initial capitalization
- Size of annual disbursements;
- Rate of return on assets;
- Number and type of project;
- Number and reasons for rejection of application for funds;
- Share of successes and failures/reasons;
- Performance measure of funds receipients;

Functional and organizational indicators for S&T institutions. It is important to attempt an assessment of the internal and external determinants of institutional performance vis a vis linkages with the productive sector. These are issues that are particularly important with repsect to public sector R&D and service institutions. Such an assessment can probaly not be carried out on the basis of any previously collected data or information since these concerns lie outside the normal focus on evaluating institutional performance. Both qualitiative and quantitative information will be required and below we suggest a number of data information that will help to illuminate the scope for institutional reform and innovation.

- Original terms of reference, model and mandate for the creation of the institution - including any details of foreign assistance in its creation;
- Brief history of involvement/relation of users in evolution and past work of institute;
- Present pattern of user involvement in institutional operation;
- Relationship and degree of autonomy between institution and source of financing/oversight in government;
- Views of responsible government officials, and current institute administration and staff on primary audience and objective of institution's work;
- How are goals established and projects selected;
- Who is consulted in goal setting and project design/selection process with particular reference to invovlement of user community;
- Mechanisms to expose researchers (and students where relevant) to industry reality vis secondment, involvement in industry surveys, etc;
- Criteria and mechanisms for promotion and hiring - relative balance between emphasis on publishing versus producing usable results;
- Pattern of career development for staff;
- Training mechanisms and pattern of training;
- Information from case studies of success and failure;
  - If case-study information not available, these should be carried out if possible along with survey of views of actual and potential users of issues such as:
    - their past experience in working with institution;
    - their awareness of institutional capabilities and what is on offer;
    - the relevance to user needs and skills of services/output provided by institution; etc.

Assessing the Status of Science and Technology Policy

The analysis in Section 2 argued that in many developing countries the agencies, officials and policy mechanisms that are in principle responsible for scientific and technological development throughout the whole economy, in practice are often primarily concerned with science policy and the development of science. Explicit and implicit technology policy issues are left largely unattended to and on occasion, vested interests in the science community may practice a strategy of benign neglect towards these when scarce financial resources are being competed for. This is likely to be true even in those countries where the stated policy gives full weight to technological development as a national objective,

The main paper argues that as a country progresses through different stages that S&T policy, in principle, should gradually incorporate a more explicit concern with technology elements within a more strategic approach that is both more comprehensive and more focussed. The aim of assessing the status of S&T policy in the client country is to essentially to determine where the country is currently located in relation to this continuum between relative neglect of technology issues and the full integration of technology policy concerns both in explicit S&T policy and in macroeconomic and strategic developmental policy.

Assessment thus needs to focus on a number of features of the S&T policy system and S&T policy, many of which are not amenable to quantitative measurement but will require subjective evaluation. Some documentation and data may be available, but most of the information will have to be collected through direct interviews. SIncemany of the detailed data categories would be adaptations of those listed above for the assessment of S&T infrastructure, we conine our comments below to only two general areas.

The Scope and Impact of Explicit S&T Policies and the Functioning of the S&T Policy System.

An assessment of this set of issues should in principle be possible by reviewing a number of documents, data categories and learning of the nature of individual perceptions.

The terms of reference of the national body charged with overseeing S&T policy as well as any specific pieces of relevant legislation authorizing action or creating S&T institutions should specify the official scope of S&T policy. Personnal interviews with relevant officials responsible for the different parts of the explicit S&T policy system will, partly, reveal how they interpret the stated policy. Available data on how resources are actually allocated to projects and spending units will show how the stated objectives are put into practice at least at the level of resource allocation.

Beyond this and where possible, the sorts of issues listed above under the output and organizational categories for S&T infrastructure institutions that try to highlight the impact of S&T policy actions on user enteprises, and the scope for institutional innovation should be explored with relevant officials in S&T policy institutions.

It is legitimate to argue that the mere fact that a law or policy exists or that an institution or agency has been created to deal explicitly with some dimension of S&T development is evidence that a certain stage in S&T policy development has been reached. For example, the creation of a special mechanism to finance innovative effort, R&D projects, start-up enterprises, etc. would suggest that S&T policy is relatively sophisticated compared to countries where such explicit mechanisms are not in place. As the Main paper suggests, projects to assist the S&T policy making process could be designed on the basis of such information.

It is however quite a different matter to assess the extent to which resources and action flowing from the stated policy actually effects the performance of the policy institution, and has impacts in practice upon

the performance of the relevant user enterprises and institutions, and the overall effects of this on the economy.

For example, development banks play a crucial role as sources of finance for investment by the productive sector. Often they have an explicit mandate to support the development of local industry. They may however, (and often do) take decisions with regard to finance or foreign exchange applications on the basis of strict financial criteria rather than taking account of whether the planned projects will contribute to the development of local capacities. 38/

Certainly within the scope of any assessment efforts undertaken by AID, the degree of empirical validation of these connections that can be accomplished will be limited. How much depends on how well the information gained from direct examination of the S&T policy system is complemented by the knowledge arising from the assessment of the S&T infrastructure and the performance of the productive sector.

In most economies, the range of explicit S&T policy agencies, items of legislation and specific S&T financing/promotional activities will be relatively small and collecting the relevant published materials should be straightforward in principle. The ease and possibility of attaining interviews with the relevant people is, of course, an entirely different matter that cannot be judged in advance.

The S&T Scope of Macro Policies and S&T "Sensitivity" of Strategic Policy Makers.

Background work on the macro economic environment should give some indication of the extent to which macro policies take explicit account of and impact upon S&T issues, particularly in relation to capacity creation in the producive sector. This information on its own will be an important set of indicators as to the strength and weaknesses of the client country in this area. Ideally however, this knowledge should be complemented with an understanding of how S&T policy concerns are dealt with in the process of policy formulation and resource allocation in major areas of economic and social policy.

This requires documenting both the formal mechanisms and structures for dealing with S&T issues (a relatively easy task) and the informal process by which decision makers deal with the policy and financial implications of S&T issues that impinge upon their own area of responsibility - a more difficult undertaking both because of the large number of areas where macro policy impinges upon S&T issues, and because generating this knowledge will require direct interviews.

Among the most relevant parts of the government policy system that could be explored are those agencies and ministries concerned with industrial plannig, trade, commerce and domestic market regulation, finance and credit, public sector management, education, direct foreign investment and government purchasing and procurement. Direct interviews, where possible, will need to explore whether and to what extent S&T issues are taken account of in policy formulation within the relevant agency, the awareness of individual policymakers of how their decisions affect different aspects of S&T, and more specifically whether S&T issues have become an integral element of strategic industrial planning.39/

The information gained from such assessments would of course be invaluable in informing the design of projects aimed at other aspects of th S&T system - unless of course, AID is in a position to influence policy making directly. If, as is likely, there is a great deal of misunderstanding and ignorance of the importance of S&T and the connections at the policy level, this might suggest a focus for AID project efforts that could impact directly upon this area of policy - the training and "conciousness raising" of senior policy makers with regard to S&T.

CONCLUSION

In the discussion so far, we have mapped out a broad range of possible indicators that would be useful in carrying out a comprehensive assessment of S&T capacities and the effect of these on economic advance in developing countries. However, as argued in the introduction, without carrying out more rigourous review and testing, it is difficult a priori to select the subsets of these variables best able to yield a valid comprehensive assessment and those best suited to meet AID objectives.

However, it is possible to move some distance in that direction on the basis of existing knowledge and informed guesswork - though without claiming that analysis of the indicators suggested will actually produce robust and rigourous conclusions. Of course much depends on the amount of time and resources AID is prepared to commit to the assessment exercise prior to embarking on project design - the greater and more competent the effort, the greater the liklihood that the subsequent projects will make a positive contribution to economic advance in the client country. Nevertheless choices will have to be made and in what follows we make a number of suggestions as to the focus of assessment efforts, sources of data and the interpretation of results.

Assessing Country Candidacy

The Main paper properly devotes considerable attention to discussing special country circumstances that are likely to affect the usefulness of S&T interventions. It suggests six different country categories distinquished by a variety of geographical, economic, size and political criteria, a number of which are in fact likely to be present simultaneously in particular countries and thus the categories cannot be considered to be mutually exclusive (i.e. a small isolated country may be open or closed, close to or far away from major markets and progressing rapidly or falling behind). Nevertheless as the Main paper argues each set of characteristics is likely to imply a different set of policy

problems with regards to S&T and the focus of AID projects depending, of course on the starting point of the economy with regard to each set of characteristics.

From the perspective of the analysis carried out for this paper, the most important criteria for judging the candidacy of a country for S&T intervention is likely to be the degree of outward vs inward orientation of government policy. Assessing a country's position in this continuum should be relatively simple. Under the category of General Economy indicators discussed in Section 3 (and further discussed in Section 5), we listed a set concerned with macroeconomic and industrial policy that are reproduced below for reference.

Import policies and the effective rate of protection for final, intermediates and capital goods;
Interest rate and credit policies;
Exchange rate policy;
Price control policy vis industrial materials, goods and equipment;
Policies on competition and regulation of the market;
Policies relating to industry structure and market entry and exit;
Rate of inflation;
Trade policies;
Labor policies;
Policies on direct foreign investment;
Public sector ownership policies;
  Location and share of public sector enterprises in different segments of the economy;
  Costs and/or measures of performance of public sector enterprises in the industrial sector.

Government policy documents and laws setting out the specifications and elements of these macroeconomic policies should be easily available either from the government itself or agencies such as the World Bank and IMF. Equally, country specific assessments of the impact of various measures and government policies are also likely to be available as are indicators such as the effective rate of protection, the shadow prices of labour, capital and foreign exchange and perhaps some composite index of price distortion or foregone output due to government intervention.40/

While it would be a difficult, complicated and inevitably subjective task to judge the "relative" degree of inward-outward orientation of an

economy.41/ it should however be evident from this evidence whether or not a country is moving towards a greater degree of outward orientation - at least in its stated policies. If this is the case, then it suggests that the thrust of AID projects should be towards facilitating the technological ability of firms to respond to the greater market freedom and greater competition which liberalization implies - perhaps via direct or institutional support for in-firm product design, quality improvement, advanced equipment testing and training of engineers.

If there is little movement towards greater openness, than the prospects of positive firm responses to AID S&T initiatives are much less. While this isn't necessarily grounds for not undertaking an S&T programme, it does suggest that the effort might focus less on firm specific action and more on the generation of information and knowledge to inform policy makers and industrialists about the economic, social and technological costs and benefits of different policy regimes.

We would make one final point here with regard to the current wave of enthusiasm for advancing greater liberalization and privatization within developing countries. There is little doubt that moves in this direction can be an important catalyst in creating conditions conducive to economic advance in most countries. However widespread experience also suggests that such moves on their own will neither automatically make previously protected firms competitive (particularly against foreign enterprises), nor will they immediately cause enterprises to take steps (and invest resources) to strengthen their technological capacities. Movement towards greater liberalization needs to be pursued in conjunction with policies (and AID projects) which encourage and support the attainment of technological dynamism and mastery.

Making a Pragmatic Assessment of Country Capacities and Possible Points of Intervention

The analysis presented in Section 2 indicates that AID S&T bilateral program activities should focus on 3 sets of phenomena - strengthening the technological capacity of the productive sector; support for S&T

infrastructural activities that either improve links with the productive sector or establish new institutions designed to fit into local conditions and specifically address local problems; and improving the contribution of explicit S&T policy to creating conditions favourable to S&T development within the productive sector. As discussed above and in Section 5, any interventions that are planned, need to take account of the conditions created by the macro economic and industrial policy environment - an area where AID presumably does not normally become directly involved.

Under each of the three main headings (technological capacity in the productive sector, the S&T infrastructure and S&T policy) we proposed a range of indicators that would both give some idea of the relative position of the economy vis others and suggest possible points of intervention. Below we make some suggestions as to a possible focus for data collection and assessment efforts in each of these areas.

Technological capacity in the productive sector

Since most of the questions that need answering under this heading cannot in practice be dealt with for the economy as a whole at sufficient detail to determine policy and project design, assessment efforts will need to focus on specific segments of the economy.

Sector selection. One way of specifying this sectoral assessment focus would be in consultation with the government which should have some sense of priorities for its preferred pattern of sectoral development. The industries selected in this way might include - natural resource-based industries, employment-intensive industries, export-oriented sectors, basic industries with a high degree of import dependence, sectors attractive to foreign investment where the supplier base needs strengthening, activities of particular importance to social development and quality of life such as the provision of potable water, housing or energy, etc.

A second approach would be to concentrate on the core sources of technical change and skill creation within the economy - for example, the engineering industries, CEDOs, workshops and informal metalworking shops; or public sector industries with a large element of existing or potential backward linkage that can be used to foster technological development in the supplier networks; or "leading edge!" sectors such as those in the electronics complex, IT services (including software) and telecommunications which can act as a locus for the accumulation of IT-related technological capacities which will be in widespread demand throughout the economy in the future.

A third approach to sector selection would be to use some combination of the readily available production and trade indicators listed in the General Economy part of Section 3, plus existing measures of RCA, labor productivity indices, sectoral TFP rates of growth, trade performance, structural change, etc. to identify sectors that are either performing above average and therefore a source of dynamic gains; or those not performing up to potential but which could be a source of economic benefit and stimulate other sectors if it was performing well.

Capacity assessment. This data alone, combined with existing studies, should be sufficient to identify the sectoral focus of project support and possibly even the specific character of these activities. If it proves necessary to garner further information than sectoral surveys or firm-level case studies might be called for. By careful sample selection and focussed objectives, it should be possible to keep these information gathering efforts to a manageable size.

Data collection efforts at this level should, to the extent possible, answer three questions - what is the current stock of technological capacities and how do these match up to existing and future demand; what contribution do existing capacities make to firm competitiveness and, what are the main constraints affecting the accumulation and effective exploitation of the relevant capacities in the future. Surveys/case studies with these objectives should concentrate on

collecting and analyising the following data sets (on a time series basis if possible):

- market structure, pattern of demand, determinants of competitiveness (i.price, quality, etc);
- basic firm characteristics - size, age, employment, output, product mix, profitability, productivity, etc.;
- stock and deployment of skilled resources by function;
- scale, nature and causes of investment in innovative effort (broadly defined);
- sources of technological inputs (embodied and disembodied, local and foreign) and market knowledge;
- impact of policy environment;
- management views of future needs and constraints in relation to technology issues.

The pattern of answers to these questions should provide sufficient information to base initial project designs on - provided the rationale for the projects does not depend solely on the precision, rigour and robustness of the relationships explored.

S&T Infrastructure

Two issues are critical in this area - the extent to which existing institutions are serving as a source of relevant knowledge, expertise and technical solutions to the productive sector; and the possibilities for institutional reform and/or creation to better meet the needs of enterprises and where relevant national objectives. Assuming that input data on public sector enterprises is readily available but not other data, survey-based assessment efforts should have both an institutional category focus and concentrate on a fairly narrow range of issues.

The choice of which institutions is an open question best decided by those with knowledge of country conditions but should include some or all of the following - universities and technical training institutions; applied research institutes with a sectoral focus; and CEDOs and other public and private sector technical service agencies.

The data collected by the survey should answer two questions - what has been the performance of the institution/agency in terms of

successfully meeting user needs (broadly defined)?; and, how can this performance be improved both in terms of quality and quantity to meet exisitng and futue demand? The data required to provide this information will vary depending on the type of institution involved (e.g educational, versus R&D versus service provision) but can be selected from the different categories proposed under output and organizational indicators in Section 5.

For example, it will be essential to assess the scale, quality and relative size of the relevant engineering and technical training courses on offer to form some idea of the basic constraints that exist on the creation of skilled manpower and determine if project support would be feasible and useful. In relation to public sector research and service/support agencies, it will be necessary to assess the output in terms of meeting user needs and to judge the degree of user involvement in goal setting and project selection. The nature of the mechanisms in place to facilitate meeting these objectives and the views of management and staff on these issues will be a good indication of what forms of user involvement/extension work best, and whether there are possibilities for internal institutional reform versus institutional creation.

The issues to be addressed in relation to private sector providers of technological inputs and services will differ slightly from the above in that it will be most important to assess the forms of operation, marketing effort and product provided in relation to market demand; and to get a good idea of the prime internal and external constraints on further expansion.

As the work of Tiffen (1987) and others demonstrates, the existence and degree of functional incoherence present in the relationships between the S&T infrastructure and user enterprises should be readily apparent. Unfortunately, the self-preservation instinct of S&T institutions means they will see the problem of performance largely in terms of underfunding and a lack of interest in "good research" on the part of users. Overcoming these perceptions is likely to be one of the greatest obstacles to institutional reform - and might itself be a focus of an educational research project. Beyond that the basic objective of project

design will be to create knowledge bridges to the users, and to get the suppliers of knowledge more aware of the specifics of production and competition at the firm level.

S&T Policy

While there is little question that macro policies are among the most important determinants of S&T development possibilities, the scope for rapid assessment of the interactions between policy and performance will be limited. The minimium assesssment exercise should involve the collection of secondary material relating both to S&T policy institutions per se and the major economic policy agencies such as policy statements, legislation, etc. (showing how S&T issues are formally handled within governemnt policy making process) and data showing the allocation of funds to different activities - ideally separating out those concerned with S&T (and particularly capacity creation in the productive sector). This information should be sufficient to allow a judgement to be made of the level of awareness of the importance of S&T issues (in the way these have been discussed in this paper) and of the degree of integration and co-ordination between policies for S&T and macro economic policy concerns.

If a small number of interviews are possible, assessment should focus on three agencies - the national body responsible for S&T policy, the ministry responsible for industry and trade (including DFI and technology transfer) and any development banks with an industry portfolio. Very broadly, the basic thrust of the assessment will be to pinpoint current policy concerns and activities with regards to the development of capacities in the productive sector and the creation of infrastructure to support these; evaluate the level of awareness and competence to deal with these issues and the degree of understanding of how the agency's policies affect critical dimensions of S&T development; identify areas of future policy intervention where S&T issues can be more explicitly addressed.

FOOTNOTES

1. See the discussion in Bhalla and Fluitman, 1985; Baster, 1972 and McGranahan, 1972.

2. Though even such indicators as GNP are admittedly imperfect and subject to differeing interpretations by those collecting and inerpreting the data.

3. Indeed the complexity of the relationship between S&T inputs, the innovation process (broadly defined), the often intangible nature of the outputs of that process and the impact of these on the economy as a whole - while well documented empirically - has defeated many attempts to generate valid S&T indicators even within the context of the advanced industrialized economies. See the discussion in Freeman, 1982.

4. See Freeman, 1982 and the discussion in Anandakrishnan and Morita-Lou, 1985.

5. See UNESCO 1978 which defines science and technology services in terms of the following activities - S&T services provided by libraries, information centres, data banks etc., and museums of science and/or technology; the translation and editing of S&T books and periodicals; various routine scientific activities concerned with carrying out surveys and measuring physical phenomena and natural resources; prospecting and related activites to locate mineral and other resources; the gathering of information on economic and cultural phenomena to compile statistical bases; materials testing and standards setting; provision of advice to users to help them make use of S&T related information; and activities related to patents and licenses.

6. See Saltykov, 1985 for a good review and also Freeman, 1982.

7. See Bell, Ross-Larson and Westphal, 1984 and Hoffman and Girvan, 1988 for a review.

8. See Anandakrishnan and Morita-Lou, 1985 and Frame, 1985.

9. Bhalla and Fluitman, 1985 are particularly dismissive.

10. See for instance Teitel, 1987 and IADB, 1988.

11. See Bhalla and Fluitman, 1985; Saltykov, 1985 and Bochet, 1985.

12. Though see the discussion in Anandakrishnan and Morita-Lou, 1985 for details.

13. See McGranahan, Pizarro and Richard, 1979.

14. See the criticism of Hill et al, 1983 in Freeman, 1983.

15. See Bhalla and Fluitman, 1985 for a innovative approach to S&RT assessment using nationalobjectives as the starting point in defing what needs to be assessed.

16. For example the state-supported development and production of combine harvesters in India.

17. For Dahlman and Westphal, 1982, different levels of techological mastery exist relevant to - production engineering for operating existing plants; project execution that relates to the establishment of new production capacity; capital goods manufacture; and R&D to generate new knowledge. See also Hoffman and Girvan, 1988 for an extensive discussion.

18. See Hill, 1987 for an illuminating approach to this issue.

19. See Dahlman, Ross-Larson and Westphal, 1987 for the most recent review of research in this area.

20. See Hoffman and Girvan, 1988.

21. See Bell, Ross-Larson and Westphal, 1984.

22. See Bell, 1986 for an extensive historical review and Bell, 1988 for a succinct statement

23. Among the many empirical studies covering this area see Tiffen et al, 1987 and Hill, 1987.

24. See World Bank, 1987 for a good summary of how macroeconomic policies affect the development of indigenous technological capacities.

25. Bell, 1986; Bell, 1988.

26, See the review of NIC experience in Dahlman, Ross-Larson and Westphal, 1987 as well as Teitel, 1984.

27. See the discussion in Tidrick, 1984.

28. See the discussion in Tidrick, 1984; Pack, 1984 and forthcoming.

29. Appendix 1 in Ariff and Hill, 1986 gives a good discussion of data sources and data problems for this type of analysis.

30. See for example the studies cited in Teitel and Thoumi, 1986.

31. UNIDO, 1987 b also contains a useful discussion and application of RCA analysis.

32. Primarily because the data required are too specialized. However, Hill, 1983 does contain an excellent discussion of method questions in relation to collecting and assessing new innovation data categories.

33. See the discussion in Pack, 1988 for the numerous technical factors that can affect productivity and performance.

34. For instance Pack, 1988 shows that decisions to invest in new capacity creation in the textile indusry in the Phillipnes and Kenya involve much higher costs than efforts to expand output by improving the efficiency of existing plants.

35. However, they use only two variables, fixed assets per employee and turnover ratio of total assets, to explore the contribution of technology and technical change to efficiency improvement.

36. See the review of evidence and methods in Bell, Ross-Larson and Westphal, 1984.

37. See those reviewed in Hoffman and Girvan, 1988.

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