GERMAN DEVELOPMENT INSTITUTE

Strengthening Technological Capability in Developing Countries

Lessons from German Technical Cooperation

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Foreword

Industrialized and developing countries, no less than countries in transition, are faced with the challenge of heightening their competitiveness and implementing an ecologically and socially sustainable concept of development. It is of key significance in this context that in doing so they make use of science and technology, and it is important for each country to find and apply the technology mix that is right for the specific problems confronting it. It is adequately developed technological capability that is essential here, i.e. knowledge of the technologies available, the ability to evaluate and select such technologies, to utilize, adapt, improve, and, finally, to further develop them.

The OECD's Development Assistance Committee (DAC) noted in its Annual Report for 1993 that technical cooperation keyed to strengthening technological capability in developing countries potentially gives rise to enormous leverage effects working in the direction of promoting the development process. The DAC, the World Bank, and the United Nations Development Program are therefore conducting studies aimed at more exactly illuminating this problem complex.

The present study forms part of this discussion context. Based on the evaluation of German technology-oriented cooperation projects in six countries (Bolivia, Argentina, Tanzania, Zimbabwe, Indonesia, Thailand), it in particular develops an outlook on the possibilities of effectively strengthening technological capability in developing countries through development cooperation. The conclusions worked out in this study might also prove important for cooperation with countries in the process of transformation.

Berlin, August 1994

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Abbreviations

AIT	–	Asian Institute of Technology (Bangkok)
AT	–	Appropriate Technology
BMFT	–	Bundesministerium für Forschung und Technologie (German Ministry of Research and Technology)
BMZ	–	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Ministry of Economic Cooperation and Development)
CEPAL	–	Comisión Económica para América Latina y el Caribe
DAC	–	Development Assistance Committee (OECD)
DC	–	Development cooperation
DEG	–	Deutsche Investitions- und Entwicklungsgesellschaft
GDI	–	German Development Institute (Deutsches Institut für Entwicklunspolitik / DIE)
FC	–	Financial cooperation
GOPP	–	Goal-oriented project planning
GSI	–	German-Singapore Institute
GTZ	–	Gesellschaft für Technische Zusammenarbeit
IBD	–	Integrierter Beratungsdienst (Integrated Advisory Service for Private Business)
IMF	–	International Monetary Fund
INTI	–	Instituto Nacional de Tecnología Industrial (Buenos Aires)
IPI	–	Institute for Production Innovation (Dar-es-Salaam)
ISI	–	Import-substituting industrialization
LDC	–	Least developed country
M&E	–	Project monitoring and evaluation
MSTQ	–	Measuring, standardization, testing, and quality assurance
NIC	–	Newly industrializing country
R&D	–	Research and development
SMI	–	Small and medium-sized industry
TC	–	Technical cooperation
UNCED	–	United Nations Commission for Environment and Development
UNIDO	–	United Nations Industrial Development Organization

Summary

1. To strengthen competitiveness, alleviate poverty, and implement an environmentally sound development strategy, every developing country should make use of a relatively broad spectrum of technological options, ranging from simple to high technologies. Sufficiently developed technological capability is the key to this. Such capability includes comprehensive knowledge of the technologies available and the ability to evaluate and select technologies, to utilize, adapt, and improve them, and, finally, to further develop them on an independent basis.

2. Development of technological capability requires a great deal of effort on the part of those seeking to achieve it. Such effort can be supported through technology transfer. One important transfer mechanism is development cooperation, in particular technical cooperation (TC). Its aim is to transfer know-how to developing countries with an eye to enhancing their problem-solving capacity. In terms of its basic orientation, TC is therefore predestined to support the process of developing technological capability.

3. Technological capability rests on four pillars: the capacity of producers and firms for imitation and innovation, framework conditions conducive to innovation, technology-oriented institutions, and an effective system of education and training. But what is actually important is not to develop or expand institutions but to integrate them to form technological networks. The core element in strengthening technological capability is therefore a close interlinkage between the four pillars. Accordingly, the success of technology-oriented TC projects depends crucially on integrating them within their specific sectoral and/or local environment. In other words, technology-oriented TC requires in particular contributions toward developing networks and/or the integration of individual TC contributions into existing structures. Technology-oriented TC must first and foremost aim to shape and reshape structures.

4. TC measures can focus on all four pillars. Projects targeted to strengthening the innovation and imitation capacities of firms do, however, tend to run the risk of distorting competition. Initial TC efforts should therefore be concentrated on the interenterprise level. Projects geared to strengthening the third and fourth pillars, for instance by promoting management institutes, advisory bodies on innovation, institutions in the field of measuring, standardization, testing, and quality assurance (MSTQ), or technology-oriented educational and training institutions, should, however, not be restricted to a strengthening of the internal structures of the counterpart organization concerned. They must also bear in mind the systemic character of technological capability, and this in particular implies creation of close links to the productive sector (first pillar).

5. Technology-oriented TC will have to be prepared to come to terms with very heterogeneous needs on the part of partner countries. Poor countries such as Bolivia and Tanzania have neither an explicit technology policy nor effective technological and educational and training institutions. Under this condition it will frequently be necessary to provide substantial manpower and financial resources in order to be able to achieve a tangible contribution toward the strengthening of technological capability. Projects designed to develop or expand technological or educational and training institutions can in some cases - as has been shown in Tanzania, Bolivia, and Indonesia, or indeed in Thailand's early phase of development - require a relatively long period of time, from 10 to 15 years. On the other hand, advanced countries like Argentina or Thailand today have a great number of technology-relevant institutions. The innovation systems are, however, hobbled by fragmentation and remoteness from the productive sector. It is often possible under these conditions to provide a contribution toward the shaping of structures. This can be accomplished by means of TC projects targeted to strengthening technological capability by focusing on the interfaces between enterprises and private- and public-sector institutions. It is in this way possible to encourage the development of networked systems or systems contributing to institutional development.

6. In terms of development policy, the crucial question is: Can successful technology-related projects with a structure-shaping dimension be forged into tangible development successes? An orientation of this sort will steer clear of any unduly narrow proj-

ect perspectives geared primarily to the question of whether a project as such functions, i.e. whether the project is "effective". Projects designed to achieve and unfold structure-shaping effects do, however, place great demands on the process of project identification, planning, and implementation; in this they are not unlike other projects with significant impacts (far-reaching sectoral/or regional effects; replicability). In the first place, sufficiently favorable framework conditions are often absent, especially in countries with a low level of technological capability; indeed, creating these framework conditions will have to be one of the aims of the projects themselves. Secondly, in projects with broad sectoral and/or local impacts, or projects with model character, the first step will often be to build up an effective counterpart institution or a viable counterpart structure. Thirdly, it is not enough simply to optimize a project's internal structure; rather, the project must be actively imbedded in its sectoral and/or regional environment. Fourthly, orientation in terms of significant projects requires more intensive cooperation both between recipient country and the donor countries involved and improved coordination among the donors. The latter is essential for development cooperation to become a sustainable and significant factor in strengthening the strategic capability of the national actors in the partner countries. Improved donor coordination is thus an essential dimension of any development cooperation (DC) geared to significance. And, finally, fifth, the demands facing project planning and project management generally grow as the complexity of a project increases.

7. A technology-oriented TC keyed to significance need not be on easy terms with the demand that TC must in the end be targeted to achieving sustainable project successes, since it is, in comparative terms, less difficult to achieve sustainability in less complex projects. But the conflict between these requirements should not be resolved by simply doing without complex projects with significant effects. Rather, the key consideration at project level must be to find a balanced relationship between significance and sustainability, and this presupposes in particular that the greater risks associated with more complex projects be effectively limited and controlled.

8. If the risk to sustainability is to be limited, it is necessary to adhere to all criteria today regarded as essential to effective and efficient project planning and implementation. These include in particular a painstaking analysis of the project environment, the capacity, and the development potential of the project counterpart or the network of counterpart organizations (counterpart systems); early inclusion of target groups; a precise analysis of the problems confronting them and their needs situation; a realistic appraisal of the manpower, financial, and time resources required for the project. Other important factors which can reduce the risks of failure for significant projects are the carefully planned use of orientation phases and the definition of priorities for bilateral technology-oriented TC - priorities being set above all in areas in which the German side has special supply strengths. These include, for example, the areas of vocational training, MSTQ, and environmental and energy technologies.

9. The problems, conflicts, and contradictions involved in TC keyed at the same time to significance and sustainability can, it would appear, largely be managed under the conditions named. To this extent, significance should come to be regarded as a project selection and program policy criterion as crucial as effectiveness and sustainability.

10. The sustainability and significance of technology-oriented TC can be further enhanced by broadening the flow of know-how from Germany during the project cycle. In all projects know-how is chiefly transferred via long-term and short-term experts. There has been too little use made of the resources of other sources of technology such as universities, Fraunhofer Institutes, industrial and commercial associations, Steinbeiss Foundation, firms.

11. As a component of TC, a broad and continuous technology transfer effort can at the same time also be seen as a phase preparatory to cooperation in the field of technology that will be developed over the long term. This requires, among other things, improved cooperation of the activities of BMZ and BMFT. In particular, care should be taken to ensure that synergies are developed from individual strengths. BMZ's special strengths are in the field of institution-building, those of BMFT in the field of

promoting concrete scientific-technological cooperation projects involving German R&D institutions and German industry.

What is required to bring this complementarity of strengths effectively to bear is above all improved coordination between the two ministries at the working level. Of particular significance is close cooperation in exchanging information on planned major cooperation projects or programs and early coordination of information on the project components to be managed or financed by each of the ministries. Projects that both stimulate and concentrate national technological potentials and contribute toward intensifying bilateral technological and/-or economic cooperation offer a particularly promising potential.

1 Technology and development cooperation - introductory considerations

Technical cooperation (TC) aims above all at strengthening the problem-solving capability of developing countries. The guiding principle of TC is help toward self-help, for development processes cannot be imposed on a society from outside but must emerge from within. One central dimension of development is the unfolding of productive forces; and the *conditio sine qua non* of any such unfolding of productive forces is **technological capability,** i.e. the ability to scrutinize and grasp what technology components are available, to assess and select a technology, to utilize it, to adapt and improve it, and, finally, to develop technologies independently. Technological capability is a key prerequisite to the capacity for self-help, and hence support in building technological capability constitutes a core component of TC.

The development of technological capability has therefore long been an important goal of TC in the narrower sense of the term. Certain types of projects are geared directly to building or strengthening technological capability. These include projects in the field of vocational training, development of technology institutes and university departments, projects in the field of appropriate technology (AT), or the ISAT project (information service for the adaptation and dissemination of technologies) and MSTQ projects (measuring, standardization, testing, quality assurance). Then there are activities aimed at promoting the private sector - for instance, the Integrated Advisory Service for Private Business - which are also supplemented by financial cooperation (FC) (e.g. the promotion of foreign direct investment in developing countries). The strengthening of technological capability is an important implicit element of the goal function of most other TC projects.

Two weak points of what has been practiced thus far are today becoming clear: the projects explicitly geared to strengthening technological capability were not adequately interlinked and integrated into their economic environment; in the other projects little attention was paid to potential contributions to the development of **national innovation systems**, and these potential contributions were therefore often allowed to fall by the wayside.

The central argument of this study is therefore that technology-oriented TC should be geared more strongly than it has been to **networking and mediation**, i.e. to providing support for self-initiative and to the shaping of structures and systems. Two factors that are important to achieving this are a **systemic outlook on the part of TC**, extending beyond the individual project, and stepped-up cooperation with other donors. In addition, the TC projects not geared directly to strengthening technological capability and the transfer of technology should also provide a contribution toward the development of technological capability.

For developing countries technology will continue to grow in significance for four reasons:

– Most developing countries - and not at all only the newly industrializing countries (NICs) - are going through a phase of economic **reorientation** marked by a strengthening of market forces and a growing pressure to raise efficiency. Technology has a key role to play in the new framework of economic policy, for technology is a key determinant of **competitiveness**. That is why the interest in technology on the part of policy-makers in many developing countries is on the increase. In some countries technology-related search processes are being launched, and a number of countries expect the donor community to pay more heed to their technological problems. This is, incidentally, a phase which will decide on future preferential cooperation between given developing countries and given industrial countries.

– The fact that **new technologies** (information technology, biotechnology and genetic engineering, new materials) lead in many areas to jumps in efficiency and structural change in markets presents a special challenge. This will entail sharp shifts in the relative significance of individual production factors and comparative advantages. Traditional comparative advantages of developing countries, such as low wages and natural supply advantages, will decline in importance. Sustained economic development can be ensured in particular by devel-

oping and continuously expanding national technological capability.

- Successful **poverty alleviation** cannot be restricted to direct support of poor population groups. If poverty is to be alleviated markedly while population continues to grow, social and production structures will have to be changed**.** Making competent use of the entire spectrum of technology is a highly significant factor in this process.
- **Economic development** must be **environmentally compatible**. Developing countries, too, will in the future have to deploy more and more nonpolluting and resource-saving technologies. The issues here include elimination of old ecological burdens (e.g. unsafe dumps), reduction of acute environmental burdens (e.g. air pollution in urban areas, high industrial emission levels, overly wasteful exploitation of agricultural resources), and a reorientation of economic and environmental policies that keys them to an environmentally compatible concept of growth.

Technology-oriented TC will therefore take on a new significance in the future. Outdated contrasts - such as high-tech vs. appropriate technology or modern vs. traditional technology - are more counterproductive in the conceptual orientation they offer. The actual challenge is to identify the **golden section between two factors:**

- the optimal utilization of locally available factors of production - above all, technological capability already available;
- the introduction to existing production systems of a dynamic component as a means of stimulating learning processes and boosting productivity through incremental, or possibly even radical, innovations.

One of the higher-ranking targets within the goal hierarchy of German development policy is to increase economic and ecological efficiency and to assist developing countries in swiftly finding an orientation in line with international competitiveness. In development cooperation the objective of strengthening economic efficiency should be complementary to goals such as the promotion of women, poverty alleviation, or environmental and resource protection. The funds required for a social policy targeted to combatting absolute poverty will be available to countries only if they succeed in developing an efficient economic sector.

2 Point of departure, goal, and main issues of the evaluation of "Technology Selection"

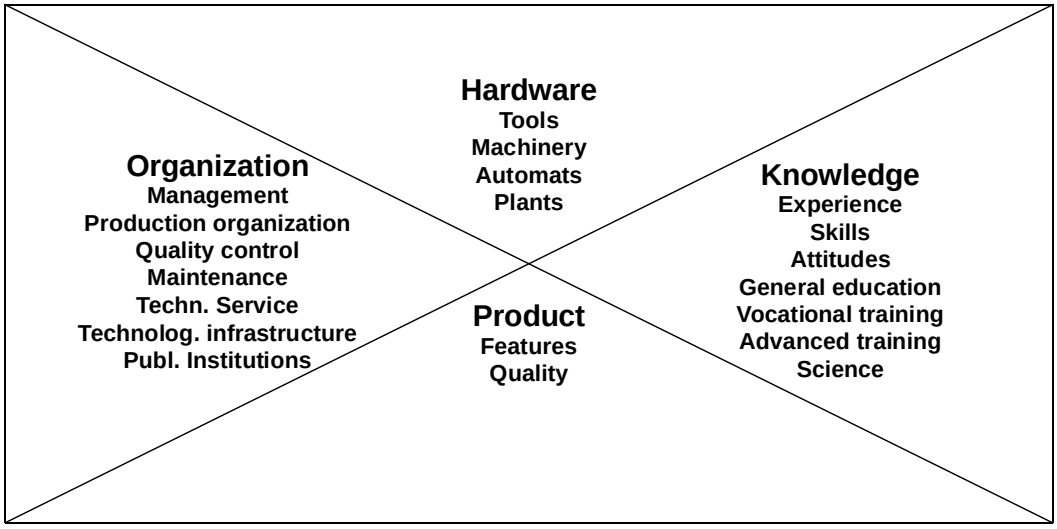
The *DAC Expert Group on Aid Evaluation* has for some time now been discussing the issue of the choice of technologies in DC projects. The point of departure of the discussion is the experience that in many development projects technical hardware has been deployed and technologies transferred that have proved nonfunctional. In BMZ's technology section this discussion gave rise to considerations on evaluating the choice of technologies used in German projects, TC projects to start with.

In the course of the preparations, however, it became clear to all involved that the original issue, the evaluation of "Technology Selection," had to be seen as too narrow. In principle there exists for every country - including LDCs - a potentially broad spectrum of technologies, ranging from low to high tech (technological pluralism). At TC project level the issue of selecting the right technology is important, since, in view of a given goal/problem, the specifically "correct" package of measures must be found if the goal is to be achieved or the problem solved. The shape given to the "right" package of measures is the central consideration of project preparation, the phase in which specifically relevant "technological" alternatives are also discussed. The view prevalent in the DAC discussion - optimization of decision-making processes on technology selection by donors - is questionable, and it misses the point of the German system of project preparation, which is marked by intensive recipient-side participation.

The main thrust of evaluation was therefore altered and placed in the context of the "development of technological capability in developing countries". In recent years this problem complex has been more

Figure 1

The Four Components of Technology



and more urgently addressed by developing countries. The main issue involved in the evaluation was: what can technology-oriented TC projects contribute toward developing or strengthening technological capability in recipient countries?

2.1 Concept of technology

There is no generally accepted definition of the concept of technology. If the widespread definitions of the concept are summed up, it is possible to narrow them down to two variants - a narrow and a broad definition.

In the **narrower sense** technology is the know-how required to develop and apply technical procedures. It exists embodied in machinery and equipment and unembodied in blueprints and technical instructions or manuals. Technology transfer is the process of conveying this know-how. The term technology transfer is often used synonymously for the international transfer between industrial countries or from industrial countries to developing countries; but the diffusion of know-how within the borders of one country is often also referred to as technology transfer.

The narrow definition of the concept has at first glance the benefit of being manageable. Its disadvantage is that its use entails the risk of losing sight of the complementary factors involved in it. The complementary factors, without which it makes little sense to deploy technology, include above all **qualification** (of the persons who operate technologies) and **organization** (i.e. the integration of a given technology into social contexts and company-level operations).

The narrow definition, and the outlook and approaches it implies, is for three reasons inappropriate:

– Technology should be viewed neither in isolation from the context in which it emerges nor from the organizational structures in which it is used. Technology does not arise in a vacuum, it invariably emerges in determinate social contexts. It is never neutral in that it is developed

in connection with specific (economic, social, political) interests.

- Technology often embodies organizational factors. A closed process in the chemical industry or a production line in the metal-working industry, for instance, not only implies technical knowledge on individual manufacturing steps, it also involves organizational knowledge on the possible arrangements of the connection between these manufacturing steps.
- A view unduly narrowed down to technical procedures will often cause projects to fail - in DC no less than in many international high-tech firms which have in recent years run aground with one-sidedly technology-oriented rationalization projects. The deployment of new technologies necessitates the development of complementary forms of organization.

A **broad definition** of technology which is adequate to these problems comprises **four components**:

- **technical hardware**, i.e. a specific configuration of machinery and equipment designed to produce a good or provide a service;
- **know-how**, i.e. scientific and technical knowledge, formal qualifications and experience-based knowledge;
- **organization**, i.e. the managerial methods used to link technical hardware and know-how;
- the **product**, i.e. the physical good or the service emerging from the production process. (Figure 1)

All of the components of technology comprise a broad spectrum:

- the hardware of traditional tools and machinery, down to and including solar engineering and microelectronics;
- the qualifications stemming from traditional knowledge that has been handed down for generations, down to and including formal qualifications, e.g. in computer skills;
- the organizational patterns of traditional solidarity-based communities, down to and including highly specific Taylorist systems and teams of workers with polyvalent qualifications;
- products ranging from simple goods of moderate quality to goods of world-class quality.

Depending on concrete situations, very **different combinations** of these factors are possible. Conversely, **no single combination** of these factors is **the one and only best one** that should be striven for under all circumstances - neither is high tech the magic word everywhere in manufacturing nor do simple technologies necessarily constitute the best solution in poor countries. Instead, a core element of technological capability (on the part of donors and recipients alike) consists in organizing **open learning and search processes** geared to finding the appropriate combination of technology components.

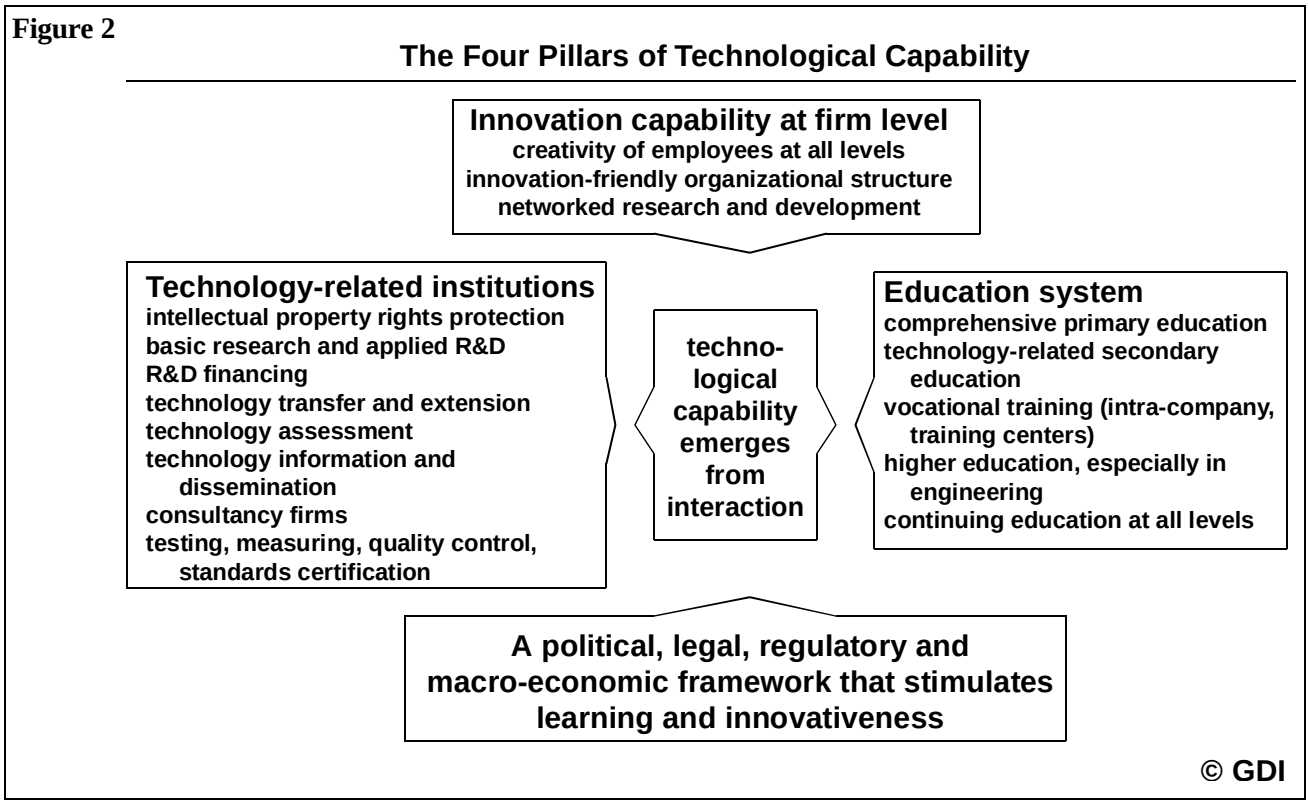
The broader definition is widespread in the international discussion on development policy. It has the advantage of providing an aid in avoiding infertile discussions in that it, for example, counteracts the tendency toward equating technical artifacts with technology. In fact, against the background of this definition it is easier to understand that technology is always involved when we speak of production - even when this involves not more than seemingly primitive technical artifacts. The broad definition was used for the present evaluation.

2.2 Creation of technological capability in developing countries

At the country level technological capability is more than the sum total of the capability of individuals, enterprises, and institutions. It emerges at the national level through the interaction between four pillars:

1. company-level innovation capability - independently of whether the unit concerned is a small farm, a microenterprise in the informal sector, or a corporation operating internationally;
2. the economic, political, administrative, and legal framework conditions essential to the ex-

Figure 2



istence of incentives to develop technological capability;

3. the direct support provided by technology-oriented governmental institutions, intermediary organizations, and certain types of service enterprises;

4. the indirect support afforded in particular by systems of training and education (Figure 2).

First pillar: enterprise-level innovation potential

The existence of technological capability in an economy stands and falls with the existence of **enterprises** capable of innovation or enterprises capable of swiftly taking over and adapting available technologies; without this pillar the other three are ineffectual. Enterprises capable of innovation and/-or imitation build ideally on three elements:

– the innovation potential in the production process, i.e. stimulation of the creative potential of employees at all levels;

– R&D efforts conducted in close connection with production and marketing departments;

– innovation-friendly managerial structures not hobbled by overly hierarchical and bureaucratic attitudes and structures.

One important element is **technological learning**, i.e. the process of mastering and then continuously improving production processes in (agricultural or industrial) enterprises. The scope and success of technological learning is not first and foremost an outcome of the nature of the technology in question. Learning is stimulated by environmental factors such as competitive pressure; it has been shown that the learning process operates more rapidly under this condition. Technological learning is more than simply "learning by doing," a process that gets along without much outside intervention. In successful companies it is the outcome of conscious decisions made by a management not satisfied with current efficiency levels and willing to supply the resources needed for continuous incremental improvement. These, for instance, include advanced

training programs for employees, material incentives for continuous improvement, or the holding of quality circles during working hours.

One important condition for learning processes is close interaction between the developers and the users of technology, e.g. in the form of close contact between a producer and at least some of his customers or in the form of close contact between a DC agency or an AT organization and its target group. This interaction is crucial if the technology chosen is to be the appropriate one and the adaptation process is to proceed not in a vacuum but selectively, in keeping with the needs of those who will be using it.

Second pillar: Framework conditions conducive to innovation

In many countries very little technological capability has been developed despite the existence of many of the conditions prerequisite to such development - because there has been a **lack of sufficient incentives** to do so. Many developing countries have in the past pursued a strategy of import-substituting industrialization (ISI). For Latin America this has been presented conceptually in studies published by the CEPAL since the 1950s; in Africa, for instance, the *Lagos Plan of Action* clearly points in this direction; as for Asia, India in particular was a prominent practitioner of this strategy. Owing to its immanent weaknesses ISI must today be seen as a failure; the terms growth crisis, productivity crisis, debt crisis, social crisis, and crisis of state refer to five clusters of causes which lead to this failure.

The productivity crisis was a major obstacle to the development of technological capability: high tariff barriers, with the lack of internal and external competition they imply, prevented the emergence of adequate pressure toward continuous improvement of efficiency and quality, i.e. entailed a lack of technological upgrading. This lack of competitive pressure permitted firms to choose their technology on the basis of arbitrary criteria, and technology institutes were able to define their research priorities arbitrarily because the potential beneficiaries of their findings were not interested in them. Imported technologies were adapted to narrow domestic markets. The consequence was constantly growing disparity vis-à-vis international productivity levels. The successive process of "growing into the world economy," which was called in theory, was for this reason largely obstructed.

What is required to develop the technological capability needed to solve pressing national problems or to create international competitiveness is, however, not merely stable economic framework conditions conducive to competition (functioning price system, competition and trade policy, financial system). These elements should by supplemented by

- institutional-political framework conditions supportive of the flow of information among social actors and leading to a continuous process of social learning;
- an explicit, often sector-specific, R&D policy and an instrumental implementation of it in programs that promote technical progress in firms (including fiscal and financial incentives);
- environmental protection regulations, a policy on natural resources, and prices which ensure the conservation and efficient utilization of resources, thus stimulating technological improvement:
- an adequate protection of intellectual property rights which does not block the dissemination of innovations and at the same time stimulates endogenous innovation;
- consumer protection regulations that boost the performance pressure faced by firms;
- industrial safety regulations and framework conditions suitable to the task of settling conflicts between employers and employees with an eye to providing support for the process of putting in place modern structures at enterprise level.

Third pillar: technology-oriented institutions

The innovation capacity of firms is supported and encouraged by **public-sector institutions, intermediary organizations, and specialized service firms**:

- technology information and dissemination institutions (including extension services or AT organizations) and industry-specific technology centers that provide information services or databases and organize industry seminars;
- consulting companies in the fields of engineering, management, and information;
- institutions in the field of measuring, standardization, testing, and quality assurance (MSTQ);
- organizations specialized in the protection of patents and trade marks, which ensure that existing mechanisms for the protection of intellectual property are in fact effectively implemented;
- scientific-technological infrastructure institutions, i.e. research centers at universities and R&D laboratories, in particular specialized industrial R&D facilities, be they operated by public or private organizations;
- institutions to fund research and technological development leading to the establishment of technology-oriented enterprises (financing via risk capital);
- institutions specialized in the exchange of information on the possibilities, costs, and modalities involved in the transfer of technologies from abroad;
- coordination centers for technology assessment.

Fourth pillar: technology-oriented educational and training institutions

An essential condition for the development of technological capability is an **educational and training system** with the following components:

- a broad-based primary education that lays the foundation for lifelong learning;
- training courses whose graduates are able to use, adapt, and, in some fields, develop new technologies (vocational training, technical/ engineering schools);
- universities specialized in scientific and technological subjects important to specific industrial sectors;
- advanced training of managers, researchers, and teachers in the field of R&D;
- interlinkage of intra- and intercompany training and advanced training.

2.3 Networking to shape systems

The actually significant factor is not the sheer existence of such institutions. What is important is to integrate them into technological networks, e.g. in the form of close interaction with possible users of technology, and ultimately to give rise to a national system of innovation. Most developing countries reveal severe deficiencies in this area. Their industrial R&D capacity is as a rule markedly underdeveloped; and the research laboratories and technology institutes established in many countries often fail to compensate for this lack. Such institutions by no means automatically contribute toward technological progress in the productive sector; on the contrary, they often reveal a tendency to ignore potential national demand and to mimic the highest echelons of international research. The knowledge obtained in this way is seldom in line with the specific problems facing the countries concerned. In the worst case the institutions are simply ineffective.

The core element in developing technological capability is therefore a **close interlinkage** between the four pillars. This has important implication for TC. Regardless of how costly they may be, activities (e.g, development of technology institutions) will come to nothing if they are not interlinked with a specific project environment and the interaction between the four pillars is obstructed.

2.4 Objective of the evaluation

The development of technological capability is a continuous process. TC should support this process, particularly by means of projects that are effective, efficient, significant, and sustainable. In specific terms this means:

effectiveness: Does the project work, and can it be seen as working when measured in terms of the goals defined? Do the means employed (i.e. including technology selection) serve the end of achieving the project's objective?

efficiency: Is there a reasonable relationship between the means employed and the output achieved?

sustainability: Are project counterpart organizations or target groups able, on their own, to continue with the project or to develop it further?

significance: Does the project have far-reaching impacts (sectoral, regional), does it have model character and is it replicable in other regions and sectors, does it contribute to the shaping of structures in one of the subsystems of the national innovation system? The opposite of significant projects are isolated projects/project islands that fail to engender any outward effects and that - even when they are efficient and effective - produce few impacts relevant in terms of development policy.

The objective of the evaluation was to develop informational bases that facilitate the identification and design of projects aimed at strengthening the technological capability in/of developing countries - particularly of projects especially in keeping with the success criteria "significance" and "sustainability".

2.5 Main issues

Projects designed to provide an effective contribution toward the strengthening of technological capability in developing countries must set their sights at providing a tangible and sustainable contribution toward the shaping of structures in one of the subsystems of the national innovation system. These considerations give rise to five main issues important to the evaluation of projects:

- How is the subsystem structured, and what direction is the subsystem moving in?
- What contribution can/should the project make in this process? What are its technological dimensions?
- For which of these technological dimensions is the project counterpart responsible, for which inputs is the German side/are German sources responsible or which is it able to mobilize? And how will counterpart efforts be linked up with external inputs?
- What are the central risk factors and/or conditions for success which might restrict or promote the effectiveness of projects?
- How, within the framework of German technology-oriented TC projects, is it possible to control the specific risk factors and strengthen the factors bearing on success?

2.6 Methods guiding the study

Two countries each from Asia, Africa, and Latin America were included in the evaluation. Two of them were NICs (Thailand and Argentina), two developing countries (Indonesia and Zimbabwe), and two LDCs (Tanzania and Bolivia). The point of this was above all to do justice to the fact that projects operate under very different framework conditions that are naturally crucial to project success.

In view of the extremely restricted possibilities available to draw generalizable conclusions on the basis of an isolated view of individual projects (even with 26 projects, three to five per country), efforts were made to form groups along the lines of the following criteria: the projects to be included were ones that

- gave rise to expectations of significance in terms of the claims they raised (i.e. were designed to shape structures);
- were located in the fields of vocational training, promotion of industry, and renewable resources (biogas, solar technology); and - as far as pos-

sible one project per country - were designed to promote the technological development of more than one country; a further aim was to cover as many different technology levels as possible;

– were, all in all, seen as successful, the assumption being that such projects provide the best basis for learning about the main issue of evaluation.

It was decided to leave out of consideration agricultural projects and the MSTQ projects that had already been subjected to multiproject evaluation.

Prior to and following the individual fieldwork, coordinative talks were conducted between the experts responsible for the country reports so as to ensure that the approach selected was uniform.

Aside from the country case studies, the investigators also made use of the studies previously prepared at the GDI on the subject matter of technology and development.

2.7 Initial hypotheses and focuses of the study

1. The central conditions for success isolated in the past few years (they have been documented, among other places, in the annual multiproject analyses of the evaluations) have also had impacts on TC projects designed to support the development of technological capability and must accordingly be taken into consideration, in particular as regards their relevance for significance and sustainability.

2. The orientation of the project evaluation, which must be keyed to the main goal of evaluation, implies that particular weight must be attached to Points 9.3.1 (especially the points regional and sectoral integration effects, technological effects, institutional effects, training effects, and effects on the mobilization of self-help) and 9.4 (sustainability) of the BMZ evaluation scheme.

3. The main fields investigated for project evaluation are the output and input sides of a project, the latter emphasizing analysis of German input and its interlinkage with the inputs of the counterpart. The scope of the study did not permit a deepened analysis of project implementation and project control in the narrower sense (see Points 7 and 8 of the BMZ evaluation grid).

3 Problems involved in the development of technological capability in the countries investigated - demands on technical cooperation

The evaluation has shown that very different specific initial and framework conditions have to be considered in supporting the development of technological capability in individual countries. The general conclusions inferred from this fact for future technology-oriented TC are summarized in the country profiles that follow. The country case studies should be referred to for project-related evaluation results.[1]

3.1 Bolivia

Structural adjustment has made considerable headway in Bolivia, and thus the concern is now to build up a number of competitive economic sectors there. The development of technological capability in the productive sector is therefore of particular importance. Bolivia is characterized by a low number of national actors capable of developing strategies. As far as structural policy is concerned, there is a lack of priorities and orientations, which has thus far frustrated efforts aimed at shaping structures from within. What contributions are being made by TC projects in Bolivia toward overcoming this problem?

It became clear in the course of the evaluation that the selection of technology in the projects in the narrower sense does not pose a crucial problem. It was also noted that the effectiveness and sustainability of the projects are frequently ensured, or at least systematically and specifically aimed at and examined. In other words, components for

1 See Section 1 of the bibliography below.

strengthening technological capability are being developed at project level.

The challenge is to translate these project successes into significant development impulses in a country as structurally weak as Bolivia. One central issue is: what degree of success is met with in bringing about an articulation between the TC projects and the environment in which they are imbedded. Is it in this way possible to provide a serious contribution toward the shaping of structures. In terms of their conception, the projects evaluated were for the most part designed in such a way as to give effective and sustainable shape to their internal structure. Frequently too little attention has been paid to actively shaping the project environment and integrating the projects into their specific sectoral context. Under the conditions posed by atomistic structures in the individual sectors, little success has been met with in translating project successes into significant development impulses. What became clear was that the meaning of the term significance and the requirements it entails have been accorded too little consideration in the project cycle in comparison with the evaluation criteria effectiveness and sustainability.

Owing to unstable and inefficient institutional framework conditions, it is difficult in Bolivia to aim directly at realizing sustainable and significant projects. It might therefore, at least to a narrow view of projects, seem advisable to carry out as few single projects as possible in order to be able to ensure more easily their effectiveness and sustainability. At the same time, however, weak countries like Bolivia have an urgent need to carry out structure-shaping reforms and to strengthen their national technological capability by means of far-reaching measures in nearly all areas of society.

The confusing number of TC projects being sponsored by the international donor community, normally limited in scope, have not led to any tangible contribution toward the shaping of structures from outside and may even entail subsequent counterproductive effects: atomistic and diffuse national structures are masked by an international cooperation characterized by a lack of priorities on the part of the donor countries and organizations and an insufficient level of donor coordination. In the donor-driven country Bolivia (donor share of the state budget: ca. 55 %) this specific combination of internal and external policy inputs is a feature typical in all sectors of society.

The outcome is that in part divergent policy concepts of different donor organizations are implemented in the various sectors. This hampers any strengthening of the strategic capability of the national actors and is detrimental to the systematic shaping of structures so urgently required in Bolivia. The national institutions are unable to integrate both the great number of projects and the (periodically changing) project conceptions into national policy strategies geared to achieving medium- and long-term effects. Instead, the policies in the individual sectors are a mirror image of the implementation of a multitude of not necessarily compatible donor activities that are as a rule keyed to a narrow project outlook and seldom take systematic consideration of the factor of project environment, thus failing to generate structure-shaping effects. While at the macroeconomic level, in the framework of structural adjustment, success has been met with in stabilizing economic policy and giving it a direction to which firms can gear their activities (opening to the outside world, strengthening of market forces, etc.), development below the macroeconomic framework has remained without direction.

The significance of TC projects could be heightened by means of two project types:

- A minimal solution is to direct the project's relationship to its environment. This includes an in-depth background analysis in the project-planning phase and regular consultations, joint seminars, informal contacts with actors from adjacent sectors, etc. in the implementation phase. Directing the relationship of projects to their environment is just as relevant as inward-oriented project management, since only in this way is it possible to ensure an adequate integration of a project into its institutional environment and to gear the output intelligently to the needs of potential clients.
- One conceivable maximal solution would be to promote far-reaching structural reforms in an

inefficient but important sector instead of implementing specific targeted measures (e.g. the strengthening of a faculty). One possibility would be a sort of systems promotion building on coordinated promotion instruments at different levels. This would mean, for example, contributing at a more broad level toward modernizing the system of higher education, i.e., beside a faculty project, complementary advisory assistance at the university level (institutional consulting, administrative reorganization) and/or ministry level (educational planning, university reform).

The latter approach presupposes on the recipient side consent, motivation, and an adequate recipient contribution toward structural reform and on the donor side a high level of competence and the willingness to assume a comprehensive and long-term commitment.

The evaluation indicates that significant and sustainable TC projects will have to overcome their overly narrow project outlook, and that this places great demands on project planning and implementation, presupposes profound practical knowledge of the environment in which a project is imbedded, and calls for the institution of orientation phases.

A systematic approach to the strengthening of technological capability in Bolivia should, specifically, bear the following points in mind:

– To strengthen technological capability in the productive sector (e.g. mining), it is necessary to deploy **modern machines and technical equipment** (in training facilities, in companies), since it is only in this way that the competitiveness of the firms will be able to be improved. Technical training designed to acquire mastery of such technical equipment is essential and must continue to constitute an important component of project conception.

– There exists a great need for adaptation, particularly at the institutional-organizational level, which is weakly developed in Bolivia. Improving the organization of labor in enterprises, developing viable institutional structures in advisory and training institutions, training in managerial and organizational know-how are no less important than technology transfer in the narrower sense. The German side must therefore attach great importance to the **strengthening of the managerial capacities** of national actors. This implies that training in projects aimed at strengthening technological capability should include not only engineers and technicians but also specialists with organizational and managerial know-how.

– Technologically relevant projects in particular must be closely aligned with the productive sector. The core problem in Bolivia is that the productive sector is decoupled from its environment. The aim must be to develop **interlinked systems**. Encouragement of cooperation between enterprises and technologically relevant institutions accelerates joint search and learning processes and contributes over time to the emergence of shared sectoral outlooks.

– Owing to the atomistic structures in almost all sectors, this process of system-building can be initiated only through a **network-oriented TC** that at the same time deploys closely coordinated instruments at several levels. The approach, realistic for more efficient developing countries, of first tackling the interfaces between firms, private and public institutions, thus stimulating the creation of networks, invariably presupposes on the part of the actors themselves a strategic capability that is yet to be developed in Bolivia.

– This not only implies that sustainable and significant projects in Bolivia will have to be conversant with **the framework conditions** pertinent to them in order to be able to adjust passively to them. The key issue is to **influence and shape them actively** in specific sectors of society, this being the only method available to shape new structures.

– A project design as demanding as this implies **sufficiently long project cycle times**.

– Implementation of sustainable and significant projects designed to strengthen technological capability in selected sectors requires both a large measure of long-term **cooperation between donor and recipient** and mutual com-

mitment to develop jointly ways of searching for and shaping relevant structures.

These considerations show how important it is to **develop more clear-cut priorities** in future technology-oriented TC with Bolivia. Technology-oriented cooperation geared to achieving far-reaching impacts and shaping structures in selected sectors is necessary, though complicated, precisely in weak countries. It is easier to ensure the success of projects, including sustainable ones, when such projects are less complex. The case of Bolivia, however, demonstrates emphatically that what is lacking in this country is not a great variety of project initiatives on the part of the donor community, what Bolivia needs is systematic contributions toward the strengthening of the strategic capabilities of national actors, toward the shaping of structures and successive development of sectoral policies keyed to coherence.

3.2 Argentina

What characterizes the economic and social system in Argentina is the rapid progress the country has made in opening its markets to foreign competition. The new economic framework conditions are depreciating part of the country's productive capacities and at the same time subjecting the institutions responsible for promoting the business sector (training institutions, technology centers, etc.) to adjustment pressure. Cooperation with Argentina in the field of technology is of considerable importance under these conditions. One condition crucial to the country's economic development is the sustainable growth of technological capability. The structural adjustment reforms carried out thus far have concentrated on macropolicy; the institutional and technological dimensions of the transformation process have largely been put on the side.

This diagnosis points in the direction of the state of affairs observed, for example, for Bolivia as well. But the initial conditions available in Argentina to boost technological capability are entirely different from the situation in structurally very weak countries like Bolivia or Tanzania. It is characteristic of Argentina's system of innovation that

- the country has long had technology institutions and vocational training facilities, and
- the know-how levels of engineers, technicians, and training personnel in technology-relevant institutions and firms are high in the Latin American context.

The gap separating Argentina from the international level of technology is accordingly smaller than that in most other Latin American economies. Argentina's system of innovation is characterized above all by its fragmentation and remoteness from the productive sector. The challenge in Argentina is to contribute toward mobilizing existing actors, increasing their effectiveness and efficiency, overcoming fragmentation by setting out to develop networked systems, and to lose no time in linking up technology-relevant institutions with the productive sector. In many cases activities capable of developing catalyzer effects will suffice here.

In Argentina cooperation in strengthening technological capability could concentrate on three core areas:

Contributions toward the restructuring of technology-relevant institutions: Many of Argentina's state-run institutions making up its national system of innovation are set for a comprehensive process of institutional reorganization and restructuring. Promotion of this difficult search and learning process would be the basic condition crucial to placing future technological cooperation on a firm footing. The deployment of organization and management experts with profound knowledge of the technological research and consulting practices in important industrial countries would be one conceivable approach. The objective would be to assist in the process of modernizing, debureaucratizing, and boosting the efficiency of existing institutions and to bring them closer to their target groups.

Promotion of networking between institutions and enterprises: The core problem facing Argentina's system of innovation is that is was impossible for a **networked system** to emerge on the basis of an obstructive import-substitution strategy. Argentina's R&D system, training institutions, and productive sector are largely decoupled. TC activities

aimed at strengthening technological capability should therefore contribute toward interlinking firms with the environment in which they operate. One means of achieving this goal might be, for instance, to deploy long-term experts with an eye to integrating systems on the basis of experience with European and other research and service networks (e.g. moderation of local, regional, sectoral, and national technology dialogues; workshops designed to encourage the exchange of information between companies; incentives to step up R&D cooperation between universities and/or technology institutes and enterprises). Any such promotion concept focusing on the interfaces between firms and institutions would, however, stimulate significant effects only if the national actors articulate a vital interest in building a networked system.

Transfer of specific know-how: In many areas Argentina has highly qualified manpower whose potential could better be mobilized if the pertinent institutions were successfully restructured. In many cases even the **provision of very specific, complementary know-how** (e.g. elements of quality-assurance systems, development of maintenance systems, other in-depth technical know-how) can amount to a significant contribution toward the strengthening of technological capability. It would be important for Argentina to carefully consider which **production- and export-oriented services** are crucial to strengthening the competitiveness of its productive sector (e.g. MSTQ, trading companies). Of some interest in this area would be promotion of transfers of know-how from developing countries experienced in exporting (e.g. cooperation with the *Fundación Chile*) or industrialized countries.

It is evident that a more advanced developing country like Argentina, whose individual actors have considerable development potential, is plagued by a lack of networks between actors and specific types of know-how (especially in building world market competence), and here even less comprehensive activities in the field of TC can trigger catalyzer effects. Effective contributions toward the shaping of structures (i.e. TC projects with a high potential for significance) can be provided here with considerably less effort and expense than in structurally weak partner countries.

3.3 Tanzania

For the projects in Tanzania the evaluation found that

- overall effectiveness is good, i.e. the goals set are being achieved;
- sustainability does not seem assured in all cases;
- important selective contributions aimed at strengthening technological capability are being made, although the significance of the projects is limited by the fact that they are not always conducive to the shaping of structures.

The problems involved in sustainability and significance stem from the particular features of the **prolonged transitional process** in which Tanzania has been engaged since the beginning of the structural adjustment process in the middle of the 1980s. The country is today in large measure donor-driven; the share of development assistance in Tanzania's GDP is approaching the 50 % level. At the same time, this picture is exacerbated by the lack of an explicitly formulated, viable development strategy. There is no intensive discussion on the direction the country's development might take in the future - apart from the general recommendations/demands of the donor community to begin with privatization and deregulation and the corresponding declarations of intent on the part of the government.

Owing to the lack of a conceptual basis and the political will ultimately required to tackle far-reaching reforms, the activities jointly undertaken by the Government of Tanzania and the donor community have, despite sizable flows of external resources, been unable to generate any major development impulses. The process of structural adjustment initiated in the middle of the 1980s along the lines of targets stipulated by the World Bank and the IMF - chiefly on the level of macropolicy and *Ordnungspolitik* - is slow in making headway. Thus far no state-owned enterprises have been privatized and the number of persons employed in the bloated public administration sector has not been cut.

Tanzania's development being largely blocked and aimless, the donor community is to a considerable

extent occupied with the rehabilitation of projects and the solution of urgent isolated problems. The Tanzanian side is tied up, not to say crippled, by the process of coming to grips with administrative problems posed by the different bureaucratic procedures made use of by every donor and by the necessity of arranging for the required counterpart contributions. Neither the government nor the donors themselves have been able to coordinate effectively the great variety of donor activities underway in Tanzania.

A technology-oriented TC geared to significance is thus objectively difficult under the framework conditions prevalent in Tanzania. For a bilateral donor like Germany, whose overall share of the foreign aid received by Tanzania runs to something like 3 to 4 %, there are very few possibilities of exerting any influence on the shape given to innovation-friendly framework conditions. In Tanzania's case progress in this area (i.e. the second pillar of technological capability) can hardly be conceived in any other way than as the outcome of a coordinated donor strategy and an intensive policy dialogue between the government and the international donor community.

Despite the on the whole unfavorable political framework conditions (government without sufficient force to push through fundamental economic reforms) and a climate more or less inimical to innovation (lack of framework conditions conducive to innovation), an attempt should be made to utilize what scope remains to achieve a technology-oriented TC keyed to shaping structures, and to do so by setting priorities in particular in two areas:

– a first priority should be set in the **educational and training sector**. The technological needs of business and industry in Tanzania manifest themselves above all in a need for technically qualified manpower (especially skilled workers and technicians; the need for engineers is met completely by the engineering faculty of the University of Dar-es-Salaam) and in demand for ad hoc advice (that could be provided e.g. by teachers from technical colleges or university professors). However, in the future the priority of support should not concentrate only on promoting individual training institutions but should focus in particular on **systems management**, i.e. on providing advisory assistance and support in reforming or rehabilitating the system of vocational training and in the development of curricula.

– A second future priority could be set in the field of **appropriate technologies**. The evaluation demonstrated that one of the key factors determining the success of dissemination measures is a subsidy component. This subsidization is - as long as it is limited in time and degressive - more than likely to produce positive economic effects, especially if it is examined in the light of the expected longer-term ecological costs of conventional economic reform. A restructuring of the Institute for Production Innovation (IPI) could be placed in this context: while it has until now been engaged in developing technologies, the IPI could in the future take on more tasks in the field of acquiring and disseminating technology information. Its job might, for instance, be to collect the information on the technologies available throughout the world and to organize the transfer of technologies to Tanzania.

3.4 Zimbabwe

With one exception, the projects evaluated in Zimbabwe are effective, and these projects appear to be sustainable. Moreover, three of the five projects are highly significant.

The importance of the general framework conditions for the significance of projects can hardly be better illustrated than by the case of vocational training in Zimbabwe. The outlook prevalent in the 1980s (i.e. a marked lack of trust in the private sector and rejection of dual structures in vocational training) entailed limitations to the effectiveness and significance of projects. In the new environment that emerged at the outset of the 1990s, the situation begins to change. The abandonment of the country's underlying socialist orientation gives rise to possibilities for a close interlinkage between the private sector and vocational training institutions, and the private sector's demand for qualified manpower is beginning to rise. The project (Harare

Institute of Technology/IHT) is instrumental in supporting vocational training and shaping it along the lines of the new framework conditions; it is therefore highly significant.

Even under the current framework conditions, however, the orientation toward significant (and sustainable) projects aimed at strengthening Zimbabwe's technological capability is encountering problems, in particular in connection with the financial bottlenecks with which the government is saddled. The effect of these bottlenecks is that the Zimbabwe government's interest in cooperation with foreign donors is seen chiefly in terms of the salutary impacts it has on the budget. In part, even TC projects are viewed in this light. Thus three of the five projects (remote sensing, family planning, consulting on energy policy) are, basically, not used to develop deficient local know-how. Indeed, this know-how is in large measure available in the "white economy," although, owing to the government's strained financial capacities, it cannot be mobilized at the usual market prices. Thus the main function of TC is to ensure that important public tasks can be looked after without imposing major strains on the budget. This state of affairs is unsatisfactory in donor eyes, particularly in that it means that the counterpart contributions pledged by the government fail in part to materialize, a factor that is obstructing the desired transfer of know-how. This distorted situation has become particularly clear in the case of the remote-sensing project. The counterpart institution is only viable because it is supported by various donors. A lack of sufficient commitment on the government's part is imposing narrow limits on the transfer of know-how.

A bilateral TC geared to helping to strengthen technological capability in Zimbabwe will have to come to terms with these specific framework conditions. One important approach would be to develop a concept that focuses on central bottlenecks, enjoys the solid support of the government, does not overstrain public resources, and is all the same in a position to provide a tangible contribution toward strengthening the national know-how base. A concept of this kind could be keyed to three of the four pillars on which technological capability rests:

Framework conditions conducive to innovation: The technological dimension is completely absent from both the structural adjustment program and thinking on development strategies. Mesolevel systems consulting could help to give this dimension - which will be central to the country's future economic development - the place it deserves in the process of policy formulation.

One conceivable measure would be to set up a technology policy unit in Zimbabwe's finance ministry; this ministry is responsible for the formulation of structural adjustment policy and is thus instrumental in setting the country's future course. Providing that it is possible to find a highly qualified expert with comprehensive experience in the formulation and implementation of technology policy, this might be supported by a policy consulting project.

The central challenge facing a department of this sort would be to initiate and stimulate the technological modernization of industry, since the viability of industry would be jeopardized by a purely market-controlled structural adjustment process focusing on the macroeconomic level. One priority task for this unit would be to evaluate the technological development level of the country's industry, which was until recently completely sheltered from competitive pressure. The department would then - in close cooperation with the private sector or the organizations representing it - have the task of formulating a technological strategy for industry. This is all the more urgent as the initiative aimed at setting up a national industrial technology institute (SIRDC) - an academic initiative - is not coordinated with the needs of the private sector.

Technology-oriented institutions and the system of education and training: Projects aimed at technological modernization of the productive sector - in particular industry - are of particular importance in Zimbabwe. In this sense, the project based at the University of Zimbabwe could in the future provide an important contribution in mining, likewise an important sector. As far as industry is concerned, however, HIT has thus far been no more than a pure training institution, as yet unable to provide firms any assistance in the field of technology. The idea, currently under discussion, of at the same time using this vocational training center as a technology

center certainly points in the right direction. It must be noted that Zimbabwe's industry manufactures not high-tech products but mature products. Its need for technological consulting is therefore not geared to the transfer of high-tech products and methods. What Zimbabwe's industry in fact needs is support in introducing modern machinery and organizational methods, above all in the fields of industrial logistics and quality assurance. HIT should not be the only institution to formulate suitable proposals; other vocational training institutions should also become active in this direction. Furthermore, the vocational training institutions should be more prepared to create courses and programs more attractive to small companies, thus contributing toward strengthening technological capability in this area.

It is on the whole apparent that, within the scope of Germany's technology-oriented TC, which includes a number of projects in different sectors, the vocational training project (HIT) has profited most from the reorientation of Zimbabwe's development strategy; in fact, the project itself is now involved in reformulating the concept of vocational training. True, public-sector financial weakness has placed limits on the possibilities of enhancing the structure-shaping contribution made by technology-oriented TC. Nevertheless, German TC can, even under the more difficult framework conditions foreseen for the future, make a significant contribution toward developing Zimbabwe's technological capability, in particular by further developing the conceptions underlying existing projects, further networking them, and, possibly, by initiating a government-level consulting project in the field of technology management.

3.5 Indonesia

In the past 25 years this country has succeeded in initiating a socioeconomic development process that has given rise to a good number of far-reaching impacts. While in 1970 some 60 % of the population lived in absolute poverty, the beginning of the 1990s saw this share reduced to around 17 %. The underlying factor was a development strategy that consistently focused on the exploitation of energy resources, the development of the country's agricultural potential and labor- and resource-intensive industries. From the beginning of the 1980s this strategy received intensive support through macroeconomic reforms, measures aimed at deregulating the economy, the opening of the economy to foreign investment and imports of capital goods, export-promotion policies, and sustained development of physical infrastructure and basic education.

This development was mainly resource-based, and as yet it has not been able to be translated into any appreciable strengthening of the country's national technological base. Today, the GNP share of spending on education and training is little more than 3 %, the share of GNP appropriated for research and development is a mere 0.2 %. The most important sources of technology are imports of capital goods and foreign direct investment.

The most important actors in the private and public sectors have, however, been aware for some time now that the country is going to have to change fundamentally its development strategy if it is to achieve the status of an NIC within 25 years or so. What is called for in particular is a transition from an extensive growth strategy to an intensive one, i.e. one based on productivity, without losing sight of the ecological dimension. What will be crucial to this strategy is

- to broaden appreciably the country's human capital base and to expand its technological infrastructure;
- to boost productivity in agriculture;
- and to increase, across a broad front, the competitiveness of the country's diversified industrial capacity.

In the future, the investment needed to implement the new strategy is to be financed more and more from domestic savings. Indonesia will nevertheless continue to rely on extensive foreign direct investment and foreign aid.

A bilateral donor like Germany, whose share of the annual foreign assistance provided to Indonesia, about 5 billion US $, constitutes something like than 2 % of the total, can provide no more than a

marginal contribution. It is thus all the more important to concentrate bilateral aid on well-defined focal points and to aim to promote projects with far-reaching impacts.

The contributions toward strengthening Indonesia's technological capability that might be expected from the projects investigated differ considerably. If the project conceptions and/or implementation planning are not adjusted, three of the five projects are apt not to give rise to any significant, i.e. structure-shaping, effects. The problem is that the projects have either not been adequately integrated into their project environment or the resources available to the projects (personnel, funding) have been too scarce to actually achieve the desired structure-shaping effects.

If these critical points are taken into account in planning future projects, and the TC priorities that have been set over the past few years are consistently retained, it would be entirely possible to achieve a tangible contribution to development in two areas crucial to strengthening Indonesia's technological capability:

1. **Strengthening the vocational training system**: Neither qualitatively nor quantitatively is Indonesia's vocational training system in line with the country's development needs. At all levels the training of skilled manpower is far behind the required levels. There are hardly any links between industry and training institutions, and the consequence is that training has little to do with actual practice.

In participating in the development of the system of polytechnic training, the German side is already providing a contribution that has a structure-shaping dimension in the field of training technicians. The project evaluation showed that it would be possible to step up the spillover effects stemming from the project if it can in the future gain more influence in the national discussion on reforming polytechnic training and if experience is exchanged with other polytechnic institutions.

In keeping with an agreement concluded with the Indonesian Government in 1992 the German side will in the future also concentrate on the training of skilled workers. This will involve developing an approach conceived along the lines of the German dual system, thus systems consulting will form an element of cooperation.

All in all, the German TC profile envisioned in the field of vocational training offers the opportunity to strengthen considerably the fourth pillar on which national technological capability rests, viz. technology-oriented educational and training institutions.

2. **Strengthening the efficiency of small and medium-sized enterprises**: To be able to hold their own in the domestic market and to take advantage of opportunities for growth in export markets, Indonesia's small and medium-sized industry will have to take steps toward boosting its productivity. In view of Indonesia's great number of small and medium-sized enterprises (roughly 25,000 companies employing between 20 and 100 persons; over 100,000 companies with 5 to 20 employees), the immediate need is to develop a promotion concept capable of generating far-reaching impacts.

The evaluation of the advisory-service project for small and medium-sized industry (SMI) in North Sumatra revealed this project to be based on an innovative approach geared to producing far-reaching impacts, even though the project still has a number of weaknesses. But the basic orientation of this approach, designed as it is to activate and strengthen industrial associations, strengthen public- and private-sector promotion institutions, and mobilize the self-help potential of firms, is very promising. It in particular reflects the insight obtained in many years of observing the effects of SMI promotion concepts that government-level SMI promotion geared to individual firms is not very promising as an approach and that what is called for is the development of a network of effective private and public promotion institutions and encouragement of networking between enterprises and supraenterprise structures.

The development of a networked system in which firms and private and public promotion institutions selectively coordinate their activities at the regional level will amount to a longer-term process in Indonesia, since the technology-oriented institutions and educational and training institutions currently in

existence there, i.e. the third and fourth pillars of technological capability, are no more than weakly developed. The SMI promotion programs conducted within the framework of German TC and keyed to the new approach will therefore have to be projected over a relatively long period of time.

3.6 Thailand

The framework conditions most important to the implementation of bilateral TC projects aimed at strengthening Thailand's technological capability are:

- Thailand is a second-generation NIC. Nevertheless, some 50 % of the country's labor force is still employed in the agricultural sector.
- Until the end of the 1980s Thailand's economic growth was based chiefly on the exploitation of the country's ample natural resources and agricultural potential and the export of resource- and labor-intensive industrial goods. The export of know-how-intensive industrial products has been gaining in significance since the end of the 1980s.
- The picture in Thailand is similar to that in Indonesia to the extent that the country's national technological base is underdeveloped. The technologies needed to develop the country have for the most part been imported. Expenditure for education and training and research and development, roughly 4 % and 0.3 % of GDP respectively, is approximately as low as it is in Indonesia.
- The foundations for the development of a scientific-technological infrastructure were first laid at he beginning of the 1980s. The country's seventh development plan (1992-1996) attaches great importance to the strengthening of national technological capability and, in particular, the development of human capital. A relatively dense network of government research and development institutions is in the process of emerging. The government is undertaking selective steps designed to intensify the relations between R&D laboratories and the private sector.

The explicit strategy now pursued by Thailand to strengthen its technological base is generating salutary effects on the planning and implementation of technology-oriented TC projects. The three projects considered in the evaluation give rise to the expectation that they will provide a far-reaching and sustainable contribution toward strengthening Thailand's technological capability.

In the coming years German TC in Thailand will chiefly focus on three areas: environmental and resource protection, vocational training, and the development of small and medium-sized industry.

The promotion of vocational training has long been one of the priority areas of bilateral TC, and in important subsectors contributions with a system-shaping character have been the result:

- The success met with in promoting the engineering faculty of the King Mongkut's Institute of Technology was not restricted to the development of a national center of excellence. The Institute's curricula, specifically geared to the practical needs of Thailand's industry, have assumed model character, being taken over by a number of other universities. The structure-shaping contribution provided by the project is thus considerable.
- Development of regional centers of excellence can also contribute toward strengthening the country's human resource base and technological potential. Over the years the Asian Institute of Technology (AIT) has acquired a good reputation as a regional technology center. It offers for students from Asian countries the opportunity to earn Masters and Ph.D. degrees in engineering, and it is currently also conducting numerous research projects relevant to the region. The AIT should continue to receive support via TC in the broadest sense.

In the future, however, the scarce funds available for bilateral TC (some 20 million DM p.a.) aimed at meeting Thailand's rapidly diversifying technological needs will continue to decrease. One solution could consist in strengthening more indirectly the third pillar of technological capability - i.e. specialized technology institutions - by, for instance, supporting the networking of Thai and German

research institutions. University partnerships, support for exchange programs for researchers and academic scholarships should therefore be stepped up in the future.

3.7 EXCURSUS: Singapore

Together with Korea and Taiwan, Singapore is one of the countries that in the past 15 years has developed a considerable measure of technological capability. One important component of Singapore's technology strategy is the training of highly specialized technical experts for middle-range leadership posts. Since the beginning of the 1980s Singapore has received support in this area above all from Germany, France, and Japan.

The German-Singapore Institute (GSI), which was established in 1981 and trains technicians in production engineering and (since 1991) plastics technology, is seen as an especially successful TC project in the field of vocational training. An institute conceived along similar lines went into operation in Malaysia in 1991. Projects of this sort are under consideration for further countries of the region. We see, in other words, that DC with advanced developing countries can give rise to important experience that can also be of significance for other countries.

The GSI's success is due in large measure to the following factors:

- The Economic Development Board in charge of the Institute is the key planning authority responsible for Singapore's economic development. It has - together with similar institutions supported by other donors (France, Japan) - made the GSI into a central element of its vocational training policy.
- Technicians are trained in close coordination with industry, including in particular foreign corporations. During their training the students work on finding solutions to concrete technological problems defined by industry.
- The Institute's pronounced user orientation ensures that training is geared to the priority needs of Singapore's industry and that curricula are constantly adapted and updated in this sense. Its current priorities include CAD/CAM technology, industrial automation, robotics, automatic assembly technology, plastics technology, mold design, product design, and construction of special machinery (production to order).
- In the course of the years close cooperation has developed between the GSI and the German enterprises located in Singapore. This finds expression, for instance, in the provision by German firms of both sizable physical resources (entire laboratories, state-of-the art machinery) and practical training slots in Singapore and in Germany. This, too, contributes toward keying training to state-of-the-art technology.
- The Institute sees itself as a "learning tank"; it is more a "production school" than a technical school of the usual type.

All in all, the GSI plays a significant role in the training of technical experts conversant with state-of-the-art technologies. Technology transfer from Germany is not restricted to the provision of long- and short-term experts in the context of bilateral TC. Sizable contributions are also made by German firms and R&D laboratories based in Germany. A cooperation agreement enables GSI graduates to pursue a course of study in mechanical engineering at the University of Bremen.

This broad-based transfer of technology from Germany is, however, not only in Singapore's interest. It at the same time boosts Germany's profile as a technologically highly capable nation and supports its position in the dynamic growth region of Southeast Asia. In other words, development-related, technological, and economic cooperation can support and supplement one another in meaningful ways.

4 Findings on the evaluation criteria effectiveness, efficiency, sustainability, and significance

4.1 Effectiveness

It became clear during the course of the evaluation that no major problem is posed by technology selection in the projects in the narrower sense. The protracted discussion on appropriate technologies has apparently had the effect that the technological adaptation and absorption capacities of the counterpart institutions are taken into account in the planning and implementation of projects; the hardware transferred is for the most part adequate to the situation involved. Moreover, hardware transfer is usually accompanied by intensive qualification measures.

But there are other types of impasses: the organizational and institutional dimension of technology transfer is often omitted from the picture, and the environmental conditions are often given too little consideration.

Organizational and institutional problems: Highly qualified technical experts are not necessarily in possession of the good managerial skills essential in an unstable and highly bureaucratized system (e.g. a university) to integrate projects adequately into their environment and to provide mooring for stable institutional structures. This problem is the reflex of an as yet myopic concept of technology that is reduced to technique and knowledge and underestimates the significance of organization. It is precisely in structurally weak countries that the institutional-organizational dimension is very important in the process of developing technological capability. This is often a matter of developing entirely new structures or giving rise to far-reaching change within institutions. What is needed here is, explicitly, **managerial and organizational know-how**.

Two examples: Support for a university faculty or an administrative department entails a good number of coordination problems. The introduction of new organizational principles in the units promoted (e.g. required attendance for university teachers during the entire week, different employment contracts, altered hierarchy levels) can heighten the effectiveness of a project and generate secondary effects on other areas within the institution concerned, but it can also provoke interinstitutional conflicts and give rise to nonsustainable parallel structures. Scientific experts are as a rule not trained to solve institutional-organizational problems of this kind.

In a university partnership project the expectation is that exemplary expert behavior will have the effect of influencing, for instance, the knowledge, skills, and attitudes held by individual project partners. This expectation will, however, prove unrealistic if the logic guiding the action of local counterparts (e.g. the customary, and tolerated, moonlighting of university professors even during the semester) and the logic of the institution responsible for the project (e.g. obstructive administrative structures, politically motivated personnel policy) point in a direction contrary to the project's logic (contribution toward faculty modernization).

Problems with the effectiveness of projects are often explained with unfavorable framework conditions or an inadequate counterpart structure. These explanations are correct to the extent that development cooperation is as a rule confronted with difficult framework conditions and weak counterpart structures. But they are inadequate, since TC is geared precisely to making a contribution toward overcoming obstructions to development. The actual problem is that these factors are not given adequate attention in project planning - counterpart effectiveness being sometimes assessed far too optimistically, which may lead to a lack of attention to the cooperative efforts required to reshape the project environment (in the narrower sense: the institution in which a project is imbedded; in the broader sense: the sector into which it is integrated).

Moreover, the specific logic pursued by a project can give rise to problems. Thus, for example, it was noted in several projects that committed project management seldom goes hand in hand with the patience needed as a rule to make allowance for **slow learning processes of the target-group**. It is precisely the latter point that is favored by project assessments with a more quantitative orientation; they often tend to underrate the institutional and organizational learning processes that are difficult

to assess objectively. Instead of improving the effectiveness of counterparts and target groups in such a way as to facilitate the implementability of the planned project or by adapting the project concept to the effectiveness of counterparts and target groups, many experts tend to invest **extra work** in projects as a means of relieving the burdens placed on cooperation partners at the expense of the aim of strengthening the competence of these partners themselves. It is possible to effectively implement a project in this way, but the question is whether the project will then prove sustainable.

If attempts fail to incorporate the action logic of target group and counterpart into the design of a project, including these institutional-organizational dimensions, project efficiency is apt to suffer. Problems often encountered in these areas indicate that the instrument of GOPP - which is keyed precisely to coordinating the goals of project, counterpart, and target group - has its limitations; it can easily introduce a spurious rationality and a sham consensus into the project cycle. One particularly problematical approach is to involve counterpart and target group only after the quantitative framework has been defined.

Dealing with project-environment problems: In projects imbedded in a weak or even obstructive environment, three approaches were observed that were employed by long-term experts as a means of safeguarding project effectiveness:

1. Confrontation with a difficult project environment that threatens to impair or significantly delay the project cycle sometimes leads to situations in which planned attempts to actively integrate a project into its environment or to influence the framework conditions affecting the project are sharply curtailed. This strategy of reducing complexity often gives rise to typical **project islands**.

2. It can be observed that, as a means of ensuring project success and adhering to time schedules in critical project situations, **parallel institutional structures** are often developed or special regulations enforced for the project that are not legitimated by conditions customary in the country concerned. This is being done instead of undertaking efforts to influence existing institutions and regulations. Seen in terms of the time factor, this strategy often proves successful. It is, in other words, entirely rational from the angle of the long-term expert who has to submit to project evaluations. If care is not taken to integrate into their environment the parallel structures which have emerged as a makeshift solution, this approach will not as a rule lead to sustainable projects.

3. A number of projects have made difficult environmental conditions into one of the project's explicit themes. We observed **active attempts to shape project environment**, e.g. via workshops with actors from the project environment aimed at altering obstructive structures or intensifying cooperation with the target group as a means of optimizing the project's effects (e.g. joint revision of training curricula by long-term experts, national training staff, and enterprises, who in the past were hardly consulted). This active approach requires considerable organizational and managerial knowledge, which is often lacking on the part of the excellent technical experts and receives too little attention in staffing decisions.

4.2 Efficiency

It was noted that in the past too little attention was paid to the issue of project efficiency, both in preparing and in implementing projects, i.e. in the process of project monitoring and project evaluation (M&E). For this reason it has in many cases been impossible to judge with adequate certainty whether the benefits expected of a project are in any reasonable way proportionate to the project's costs.

The chief problem involved in evaluating the efficiency of TC projects is that their effects can often not be expressed in monetary terms. Approaches to encountering these problems are offered above all by

- analysis of cost-effectiveness.
- preparation of project-specific efficiency indicators that make it possible to bench-mark the efficiency of a project as compared with other, similar projects in the country concerned or in other comparable countries (in training proj-

ects, for instance, the training costs per graduate),

– determination of the benefits subjectively perceived by the target group, by surveying the target group concerned.

Projects whose efficiency is judged by including the costs for German experts will as a rule show a very unfavorable cost-benefit ratio. Analysis of the efficiency of a project should therefore in principle focus on the situation that exists when the project is handed over, i.e. when the German experts have departed. Replacing as many German experts as possible with local experts or experts from countries in the region is one means of achieving a favorable cost-benefit ratio even during the project cycle. This measure would on the one hand increase efficiency and on the other hand also go some way towards strengthening the local know-how base and/or promoting local cooperation. There are models: in Bolivia, for example, Chilean experts are working in fields in which Chile has made major advances in recent years.

4.3 Sustainability

The experience gained in many years spent in observing the effects of projects indicates that TC projects have good prospects of achieving the intended goals and sustainability by the time the project is handed over above all when

– the general political, legal, economic, sociocultural, and institutional **framework conditions** affecting the project are favorable or when the project is able - as far as required - to influence these conditions;

– the project is in the hands of a **counterpart** who is either already motivated and effective or who can be sufficiently strengthened by the project; the key factor here is the emergence of partnership-like cooperation with a step-by-step transfer of responsibility to the counterpart;

– the **target group** is closely involved both in the planning phase and in the implementation phase;

– the **resources** available to the project stand in a realistic relation to the intended project goal;

– the **time horizon** provided for project implementation is realistic, i.e. not too brief;

– the **qualification** of both German and indigenous personnel is adequate to the tasks involved.

These findings were confirmed in the present evaluation. Furthermore, it was also noted that

– **sustainability** is jeopardized when the criterion of **efficiency** is not given sufficient consideration;

– **project cycle times**, especially for training sector projects that aim at shaping structures, can often amount to ten years and more;

– **target-group participation** in the planning phase sometimes gives rise to the problem that a target group (e.g. the future teachers of a school, small and medium-sized industry) is difficult to define; in this case the demands placed on the analysis of needs and bottlenecks will be accordingly greater.

Both the intensive discussion on sustainability and the results of the present study clearly indicate that sustainability can in the end only be achieved if the demands today placed on effective project planning and implementation are systematically taken into account. In other words: sustainability can as a rule not be attained by measures improvised in the final project phase or following conclusion of the project (e.g. additional funding, deployment of short-term experts). The well-known demands placed on effective **and** sustainable projects must be given systematic attention both in project planning and preparation and during the course of the project.

4.4 Significance

The study considered from the very start only projects that were seen as potentially sustainable and - in particular - significant. It is possible to speak of projects significant in terms of development policy when these projects are far-reaching (in sectoral, regional terms) and/or contribute to the shaping of

structures or have model character, i.e. can be replicated in other sectors and regions. There were, however, difficulties involved in selecting projects of this type in the six countries; in other words: the individual countries presented profiles characterized by a great number of small-scale isolated projects.

It must be emphasized that **in hardly any of the projects was "significance" addressed explicitly** as a criterion in formulating project objectives or drafting project conceptions. Target groups in the broadest sense were identified, although frequently there was a lack of any sufficiently precise analysis of the problems facing them and their needs situation. This was striking particularly in a number of technology institutes and training institutions. The project applications frequently postulated the needs of companies for manpower with a specific qualification profile or for the technological advisory services to be provided by the projects concerned. In fact, however, industry was only seldom involved in project preparation, so that its actual needs were practically impossible to determine. This weak point cannot always be attributed to the experts in charge of appraising projects. Time budgets in the project-preparation phase often fail to allow for adequate project-environment analyses. These, however, would be crucial to the selection and implementation of possible significant projects.

Many projects revealed a **significance potential** that was not always realized in the measure projected. In some cases indirect effects that projects might potentially have had on their environment long failed to be recognized (e.g. Environmental Institute in La Paz), thus sapping projects of some of their potentials, even though the relatively narrow project-planning targets were in fact met. The effectiveness and sustainability of many projects with significance potential depends on whether the project can in fact be imbedded in its environment. This is particularly true of projects supportive of service institutions designed to benefit industry (e.g. training institutions, technology consulting centers). These projects often run into trouble because too little attention is paid to embedding them in their project environment (e.g. National Industrial Technology Institute/INTI in Argentina and various training institutions).

The significance potential neglected in project planning is often recognized by experts at the local level and translated into additional pertinent activities. This can, as was noted in the course of the evaluation, heighten the project's effectiveness (e.g. university partnership with Oruro/Bolivia), though it can also lead to dissipation of efforts and resources and neglect of other project goals. All in all, it is clear that it is just as important to carefully **integrate a project into its environment** as it is to **plan and steer** the optimization of performance potential within the project.

Any lack of orientation toward significance for the most part entails an inadequate linkage with the project environment. This is often detrimental to project effectiveness in that it encourages counterpart personnel fluctuation. In many projects the main target group consists of counterpart staff (teachers, university professors, technicians, etc.). Training and further qualifying them is one, if not the only, main project activity. The logic of the members of this target group is, however, typically not the same logic that governs German project staff. For for former - if they are not outright idealists - the project is an excellent means of directly and rapidly improving their career outlook. This becomes apparent when - being sufficiently qualified - they drift off into the private sector.

The loss for the project is greater than the gain made by the firm that entices the experts away from project work. This problem might possibly be encountered by more strongly gearing projects to significance and attempting to link them more closely to the business sector. For instance, the university partnership project in Oruro includes a service center that allows university professors to engage in consulting work and thus to improve their earnings. This close link-up of the project with the target sector provides a contribution toward stemming personnel fluctuation while at the same time increasing the practical relevance of the faculties concerned. It would also be conceivable to convince firms in one sector of the effectiveness of a service institution receiving support (training center, technology institute, university faculty) and to induce them to cofund the project.

The evaluation has shown that, particularly in structurally weak countries, there can be **no talk of the existence of a system of innovation**; seen in today's terms, the Four-Pole Model (innovation system/production system, both in the industrial country and the developing country) set out in the BMZ's technology-sector concept of 1979 thus no longer appears tenable. What was behind the concepts for technology-oriented TC projects was often enough the notion of an innovation system of the type that has emerged in Germany, in part only over the past 20 years. Instead of specifically tailoring organizational-institutional solutions to the local environment in a developing country, projects were in part proposed that aimed to replicate in a developing country the individual structural elements of the German system of innovation. The technology push of technology-oriented projects of this type often entirely missed the point, for there was no productive sector that engaged in systematic R&D efforts and that thus was in possession of a receiver structure for the transfer of technology from technology institutions.

A lack of efforts toward innovation was in turn not seldom the result of framework conditions that failed to compel enterprises to engage in systematic, efficiency-oriented technological learning processes. This at the same time explains why the significance of projects is suddenly and unexpectedly on the increase in some countries that have fundamentally changed their economic course: a change to the environment suddenly gives rise to demand for services provided by the projects.

4.5 The interrelationship between sustainability and significance

The aim of TC is in principle the sustained and long-term improvement of people's economic and social situation: Sustainability of development projects thus unquestionably constitutes one essential criterion of success. This problem has been accorded broad space in the discussion on development policy conducted in recent years, within BMZ and GTZ as well.[2] Yet there is no consensus on the definition of sustainability. For instance, a cross-sectional analysis prepared by BMZ and dealing with the sustainability of TC projects discusses three **different concepts** of sustainability:

1. Sustainability is given when the project effects aimed for continue for the target group even after the project has been completed and handed over.
2. Sustainability is determined not by what survives of a project but by what has been set in motion by a project.
3. Sustainability can also have been achieved when, first, the project generates horizontal spillovers into adjacent regions/sectors or, second, the project idea or the project approach gives rise to effects at a higher decision-making level, where it forms the basis or an element of national standards or national policies, thus assuming the role of an exemplary case.

Under the conditions of a rapidly changing project environment the first definition is in many cases too narrow. Just as the project objective and the intended project output have to be adapted to an altered project environment even during the project cycle, such adjustments are also frequently required after the project has been completed. And those projects should also be rated as sustainable which have placed the counterpart in the position to independently adapt the project conception to changing framework conditions.

Basically, the third definition addresses the issue of the far-reaching impacts expected of projects and is therefore too wide. Even projects with modest objectives and less pronounced spillover effects can be seen as sustainable to the extent that they can be continued or further developed independently by the counterpart.

As far as analysis is concerned, care should be taken to keep distinct the two dimensions of sustainability and far-reaching impacts. We understand sustainability in the sense of the first two

2 See the studies listed in Section 2 of the bibliography below.

definitions. The issue of significance, on the other hand, is concerned with whether project successes are translated into tangible development impulses and successes. This is the case when a project gives rise to far-reaching impacts (sectorally, regionally) or contributes to the shaping of structures or has model character, i.e. is replicable in other sectors or regions.

The **interrelationship between sustainability and significance** is frequently a tense one: It is thus, for example, possible to achieve a maximum of sustainability (e.g. setting up a laboratory in a university faculty) without having contributed toward solving a development problem in a specific sector or region (e.g. need for educational reform). Project islands not integrated into their social environment can certainly be sustainable. Evaluations of sustainability in agricultural projects even come to the conclusion that "*highly sustainable projects were almost always small monocausal projects: the more modest, the more effective*".[3]

Especially in a turbulent and weak environment, it is easier to achieve sustainability in projects with marginal spillover effects than in projects geared to significance, i.e. to influencing and changing a project's environment.

These considerations give rise to the conclusions that

- the criteria significance and sustainability refer to very different dimensions of the development-related effectiveness of projects and must accordingly be considered specifically and explicitly during the project cycle;
- the **interrelationship** between sustainability and significance is one **marked more by tension**. On the one hand, sustainability is the *sine qua non* of significance - a project that fails or comes to nothing cannot be significant. On the other hand, however, sustainability is easier to achieve in less complex, modest projects than in projects keyed to significance. If the sustainability of TC projects is regarded as the most important success criterion, one consequence could be to avoid initiating projects that are demanding and significant - and thus risky. This would, however, mean that sustainable projects generate only marginal contributions toward the solution of social and economic development problems. In terms of development policy it thus makes little sense to resolve the tension between significance and sustainability by simply avoiding projects that are demanding, i.e. significant;
- a matter of particular concern in technology-relevant projects is to develop significant projects and to avoid project islands. In this field, concerned as it is with enhancing technological capability, **the shaping of structures and the networking** of the four pillars of technological capability constitute **central conditions of success**. The **demands placed on significant and sustainable projects** designed to strengthen technological capability are accordingly high.

4.6 Special requirements for significant projects

Above and beyond the general conditions for the success of effective and sustainable projects, projects designed to generate significant development effects place great demands on the quality of project management, planning, and implementation.

- In the first place, projects designed at the same time to shape their environment are necessary, particularly in weak countries. Since it is unlikely that sufficiently favorable **framework conditions** will be encountered in the project environment, these conditions often have to be shaped by the project itself.
- Secondly, in projects with far-reaching sectoral and/or regional impacts, or model character, it is often necessary to start out by developing an effective counterpart organization and a viable **counterpart structure**.
- Thirdly, the requirements placed on **project planning and project management** grow as complexity increases.

3 Schubert (1993), p. 43.

– Fourthly, orientation in terms of significant projects requires both more intensive **cooperation** between the recipient country and the donor countries concerned and improved **coordination** between donors. The latter is above all called for as a means of ensuring that development cooperation contributes in a sustained and significant fashion to strengthening the strategic capability of the national actors in the partner countries. Improved donor cooperation is thus a crucial dimension of any development cooperation geared to significance.

There is thus a great need to improve TC with an eye to being able to contribute to strengthening the technological capability of developing countries.

5 Conclusions and recommendations for technology-oriented technical cooperation

5.1 Chief problems and goals of technology-oriented technical cooperation

Technology and heightening competitiveness

Without sufficient technological capability, the market-oriented approaches that today shape the framework conditions for development cooperation and in many developing countries have no future perspective. In order to improve international competitiveness, TC must contribute toward strengthening and interlinking all four pillars of technological capability.

If developing countries are to be able to reach international efficiency standards, the transfer of modern technologies from abroad must be intensified. The acquisition of technology presents an attractive option above all because it is often cheaper to purchase suitable technologies abroad then to develop them at home. **Technological capability and technology transfer here stand in a complementary relationship**: without sufficient technological capability it is impossible to arrive at well-founded selection decisions and to adapt technologies. Critical factors bearing on the success of technology transfer furthermore include lasting relationships between the donors and recipients of technology and the donor's experience with the transfer and operation of technology abroad.

TC has long attempted to stimulate and promote the transfer of technology by private-sector firms. Specific programs are intended to stimulate in particular direct investment and the import of licences to developing countries (program on technology and the promotion of foreign direct investment in developing countries, guarantees, financial incentives, integrated advisory service/ IBD, DEG). Yet experience has shown: the programs designed to stimulate the technology-transfer activities of private German corporations have only partially fulfilled the expectations placed in them. The program on the promotion of foreign direct investment in developing countries, for instance, was chiefly used for investment in countries that are in any case particularly attractive. In other countries instruments of this kind can give rise to effects only when the framework conditions have been improved in such a way as to be sustainable. Dynamic economic development stimulates direct investment, not the other way around.

All TC measures aimed at boosting the efficiency of individual firms (promotion of in-company training, parts of IBD, promotion of small and medium-sized industry, and the skilled trades) must aim to avoid distortion of competition, e.g. by imbedding support of individual firms in sector-wide advisory programs. Individual firms should not be promoted at the expense of measures focused on the interenterprise level, the system-compatible intervention level (e.g. promotion of management institutes, innovation consultancy centers, and technology institutes).

Many institutions and and a lot of know-how developed in the past with TC assistance obtain a new, much more important function in an environment geared to efficiency and competition. If the technology-related TC instruments used thus far have not led to completely satisfactory results, one of the major factors has been the political and economic framework conditions in the recipient countries. The

experience gained in the countries that have pursued a strategy of import-substituting industrialization are highly instructive: there was in such cases a need for technology, but their was no pressure working in favor of technological learning and independent efforts at innovation. In sheltered domestic markets it was no problem to market goods that lagged far behind world-market standards. This is the reason why the enterprises concerned failed to avail themselves of the offers made by technology institutes or MSTQ institutions.

With the new economic framework the prospects for success of projects geared to the development of national technology-oriented institutions and educational/training institutions grow. The enterprises are now coming under intense pressure to adjust, and they are seeking technological advice, particularly in the field of quality assurance. Suitable incentives should be deployed to move the institutions to seek more intensive cooperation with firms - not only with the already competitive top performers, but also with companies with modernization and development potential.

New technologies

New technologies have thus far been perceived above all as a threat to developing countries in that an accelerated and radical process of technological change threatens to widen the technology gap, and the development of new processes and products poses a danger to the exports of many developing countries. But new technologies also offer a number of development opportunities:

- New, efficient information and communication technologies, in particular PC-based information systems, can operate in favor of decentralizing data and decision-making processes.
- Some advanced developing countries that are already experienced in computer technology have a certain potential for exporting software.
- With the aid of biotechnology and genetic engineering it is possible to develop, among other things, new varieties of plants that are better adapted to the changing ecosystem conditions prevailing in developing countries or new pharmaceuticals for tropical diseases that affect both human beings and animals.
- The threat that traditional exports (cocoa, vanilla, metals) could be displaced by biologically or genetically engineered substitutes or new materials can provide an incentive for developing countries affected to initiate a systematic program of technology assessment. Risk potentials and possibilities of responding to them can then be appraised realistically before work is begun on policy initiatives (development of bioengineering capacities, ventures into new products).

Specific points of departure for development policy include

- planned and dedicated (i.e. neither spontaneous not chaotic) deployment of data processing in projects, taking advantage of the experience of other donors;
- the development of stations to evaluate remote sensing data that can be used for harvest forecasting, preparing for prospection work, or early diagnosis of impending disasters; there are indications that the governments in developing countries have not perceived the potential of this technology and are therefore reluctant to commit resources to the funding of such projects;
- promotion of technological systems in areas like power generation (solar energy) or sewage clarification (e.g. with efficient strains of bacteria), provided that these systems can be deployed decentrally, are based on up-to-date scientific information, prove ecologically viable, and can be adapted to social structures;
- stepped up support for research in the fields of biotechnology and genetic engineering explicitly tailored to the needs of developing countries - most of the world's biotechnology and genetic engineering research is conducted by private enterprises that chiefly pursue technology lines for which the primary demand is to be found in industrialized countries. This should include assistance in the formulation of codes of ethics and/or legislative restrictions on - in particular - the use of genetic engineering.

To this end use should also be made of the know-how and the potential of regional institutions, e.g. the international agricultural research institutions or the new UNIDO centers for biotechnology and genetic engineering as well as national research and technology laboratories in developing countries.

Technology and poverty alleviation

Technology-oriented TC projects can contribute in two ways to alleviating poverty:

Indirect approach: Improved technological capability in the modern sector has the effect of boosting an economy's productivity. This creates scope for domestic reallocations of resources, and these resources can, for instance, be used for employment programs, basic health services, or basic social security.

Direct approach: The issue here is to focus on strengthening the technological capability of the target group of the poor. It would, however, be a mistake to restrict efforts made in connection with the direct approach to the use of the simple, or low, technologies. If, for example, simple tools are combined with highly developed organizational patterns of water allocation and profound knowledge of ecosystems, the result is bound to be a technologically highly developed production system. So it makes sense to make use of a relatively broad spectrum of low and high technologies to enhance the self-help capability of the poor by supporting productive activities. One important consideration is to attenuate a certain bias in favor of superficially "modern" techniques and technologies, which are often capital-intensive and were originally developed for deployment in high-wage countries, while at the same time expanding technological options. The latter has in the past been attempted by, above all, the proponents of the concept of appropriate technology (AT). The limited success thus far met with by the concept of AT is due in part to a political and economic environment inimical to AT. But another factor that should not be overlooked is the exaggerated emphasis sometimes placed on simple technologies and the technical component (development of no more than superficially adapted products and simple production techniques), at times accompanied by a lack of target group participation and a certain blindness for the aspects of economic profitability.

In the future direct poverty alleviation will have to address itself more intensively to the issue of perceiving, or systematically surveying, existing technological capacity in order then to strengthen technological capability. The paramount consideration here is that the approach should focus on early target group participation and be geared to bottlenecks. This includes all four components of technology; to name a few examples:

- the selective introduction of new tools;
- the broadening of the existing knowledge base, e.g. dissemination of information on new cultivation methods or improved techniques for processing traditional materials;
- the introduction of new products, e.g. new or improved varieties in agriculture;
- alteration of existing organizational forms, e.g. initiation of a new intraenterprise division of labor, for instance via new rules on cooperation that regulate mutual obligations within producer networks.

It should, precisely in this context, be considered that technology and technological change are closely linked with changes in the gender-specific division of labor. Social changes associated in the past with the introduction of new technologies often at the same time entailed changes in the gender-specific division of labor at the expense of women, and such changes have often subsequently proven to be dysfunctional. The issue of possible **impacts on women** is therefore of paramount importance in initiating processes of technological change.

Beyond the level of the individual producer, **technology institutions** are of some significance in the context of direct poverty alleviation; examples include AT organizations, many of which are today more user-oriented than they formerly were and now pursue an approach centered on the encouragement of entrepreneurship - the result of organizationally bound learning processes which indicate that exploitation of the individual pursuit of gain

decisively promotes the dissemination of typical AT products.

The latitudes open to the promotion of **productive activities on the part of poor population groups** depend crucially on macrolevel factors. In the past the emergence of small and microenterprises in the fields of industry and agriculture were frequently obstructed by the state. What is providing a stimulus to a growing number of countries to develop entrepreneurship are specific stable framework conditions, which include a price system that gains the trust of the economic actors; trade and credit policies that do not favor big enterprises and capital-intensive production; and transparent administrative structures. This is nevertheless only a necessary, not a sufficient, condition in that power is unequally distributed in free markets. The development of small and microenterprises that operate with appropriate technologies must be supported via dedicated funding programs, allocation of foreign exchange, and interventions on the level of technology policy.

Technology and environment

The use of technology can cause environmental damage, but it can at the same time also provide the basis of a new growth strategy that is sustainable in ecological terms. Points of departure for TC include:

- new transport systems that cover transportation needs while conserving energy and causing less damage to the environment;
- efficient energy technologies that distinctly raise the yields of conventional power generation processes, and renewable energy sources based on recent technological developments (solar cells, improved wind-energy systems, small-scale power plants);
- new water-supply, sewage-disposal, and refuse-disposal techniques based in part on findings in the fields of biotechnology and genetic engineering;
- filter technologies that reduce the environmental burden associated with conventional processes; and new process technologies.

Many developing countries are demonstrating a growing readiness to implement environmental protection measures. The success of environmental policy is bound up with all four pillars of technological capability, and these pillars can be strengthened by carefully directed TC:

Framework conditions: Crucial components of modern, innovation-oriented economic systems include the introduction, as rapidly as possible, of the internationally accepted environmental standards, and their implementation via market incentives keyed to ecological efficiency (e.g. fiscal policy), and environmental regulations.

Technology-oriented institutions and actors play a key role in disseminating environmentally sound technologies, but also in controlling the implementation of environmental regulations.

Technology-oriented educational/training institutions are crucial to encouraging ecology-minded thinking and acting. It is particularly important to integrate the environmental dimension into the curricula of vocational training and tertiary training institutions (technicians, engineers, managers, etc.).

Enterprises: The capability of farms and industrial enterprises to deploy environmentally sound processes and to produce environmentally compatible products calls for a high level of technological capability. This must also be strengthened through the transfer of environmentally sound technologies from industrialized countries.

In view of the globalization of environmental problems industrial countries are interested in seeing developing countries set out on an environmentally sound path toward development. The demand of developing countries for free or inexpensive transfers of ecologically sound technologies is one of the key issues of the Framework Covention on Climate Change. The industrialized countries are defending private property rights to technologies. Yet there is justification for providing financial support to promote the transfer of expensive but environmentally

compatible technologies to developing countries and their use there. Private-sector initiatives aimed at making environmental-protection investments in third countries (involving a pronounced reduction effect) instead of at home (which entails a marginal reduction effect) should be accepted and supported. The firms should in particular be encouraged to provide not only a financial contribution but also to become directly involved in the transfer of know-how. In doing so, support by experienced TC counterpart institutions can ensure that typical errors are avoided (overestimation of recipient technological capability, inadequate transfer of organizational know-how, insufficient recipient training, short-term relationships between the donors and recipients of technology).

5.2 Recommendations on individual pillars of technological capability

Shaping framework conditions conducive to innovation

Technology is a cross-sectional category. In most developing countries institutions engaged exclusively in the formulation of policy in this field (technology ministries, national technology commissions, and the like) have in the past shown a lack of forcefulness in their dealings with sectoral interests. This is a structural problem that cannot be solved by the deployment of advisors to government in the institutions named.

On the other hand, it has been shown that it makes sense to provide projects at the operational level with flanking at higher levels - consulting on the reformulation of university policy aimed at supporting university projects, in reformulating industrial modernization policies aimed at supporting projects that strengthen technology institutions specialized along sectoral lines, etc.

It can also make sense to provide advisory services for central institutions with genuine policy-level economic competence, and to do so with regard to the organization of

– technology assessment;
– the formulation of a technology policy for one sector/subsector;
– the development of technological networks surrounding technology-oriented institutions or between enterprises.

In view of individual national needs and requests from eastern European countries, it is, however, not realistic to assume that a great number of "technology managers" from industrial countries can be won as advisors to government in developing countries. On the other hand, there are many qualified technicians and scientists who come from developing countries but have found employment in industrial countries. Limited sojourns of such experts in their countries of origin should be supported financially. This could be a point of departure for a joint program with the private sector, where many of these experts are employed. One possibility would be to provide at least partial funding for sabbaticals for corporate managers or to sponsor time-limited professorships or guest researcher slots from TC resources.

Developing and strengthening technology-oriented institutions

Experience from industrial countries with technology institutions and technological networks consisting of firms, universities, and research laboratories cannot simply be applied to developing countries, and is not at all relevant for LDCs. Such networks have emerged where enterprises are faced with a situation of sharp competition in terms of innovation, quality, and time. Such networks presuppose that innovation activities be recognized and promoted as such at the enterprise level; this situation is given only for firms in developing countries that operate in the pertinent segments of the world market. After all, the development of a technological network is not a voluntarist activity - one that can be carried out by simply deploying a moderator. Enterprises in developing countries are usually skeptical to hostile toward the idea of close cooperation with (state-run, to make matters worse) institutions and other enterprises; what is behind this is a pronounced rivalry and the fear of losing know-how to free riders. Companies form networks

when, firstly, the benefits clearly exceed the costs and, secondly, the necessary sociocultural conditions, in particular a trust base, are either already in existence or can be created.

The development or restructuring of technology institutions is thus an extremely demanding task. Taking the following factors into account can help to reduce the likelihood of failure:

– Experience has shown that the success of R&D institutions is closely correlated with their individual **degree of specialization**: institutions with a clear-cut mandate and orientation, e.g. in terms of a specific industry or a given agricultural product, often entertain good relations with users and produce results that are implemented. It is thus important to promote institutions that are **specialized in one line of business** (e.g., the wood industry, food-processing, textiles and clothing, metallurgy), while at the same time operating on an interdisciplinary basis.

– State-run or parastatal R&D laboratories should operate with the clearly defined target of keeping in **close contact with possible users**. Funding could be made contingent on documentary evidence to this effect. Users with sufficient financial power should contribute toward financing such institutions. It is, however, important to bear in mind that the willingness of user firms to pay is limited when the R&D projects in question are joint projects, i.e. involve investments with a lengthy amortization period. Firms are more willing to pay when the institutions contribute directly to **solving acute problems** (e.g. specific weak points in production processes, quality problems, repair of defective machinery). This form of direct assistance can serve as a first step toward the establishment of a longer-term technology advisory service.

– Organizational development should involve support for institutions that are able to offer **technology assessment services** in selected areas. They should carry on an intensive dialogue with other institutions and social actors. Even in more advanced developing countries their function would be less to conduct research of their own than to organize evaluation and assessment rounds with experts from existing institutions.

Developing and strengthening educational/training institutions

Projects in the educational/training sector can contribute toward the long-term development of technological capability. Solid primary education is the *sine qua non* for effective programs in secondary education. It can make sense to develop secondary education institutions and universities even when, for reasons of development level, the demand for their graduates is low, for the demand for qualified skilled manpower tends to grow rapidly in the wake of dynamic development processes.

Vocational training institutions offering the customary training courses, as a rule lasting several years, provide a key contribution to strengthening technological capability. Vocational training should impart not only technical qualifications but also elementary managerial skills (for potential founders of new businesses) and social competence. Vocational training will continue to grow in importance, because the demand for properly qualified skilled labor and well-trained commercial personnel will grow as more and more developing countries gear their economies to the world market and new production concepts gain a foothold in industry. Furthermore, vocational training institutions can contribute to strengthening technological capability by offering additional courses:

– **short-term courses** keyed to imparting specific skills to workers and technicians. Such courses can also aim at target groups that are as a rule not reached by conventional vocational training (particularly small and microenterprises). It is important to be flexible in setting the hours and duration of such courses, because small companies are unable to do without their employees for longer periods of time.

– **Consultancy and support for private companies** on the basis of the technical know-how available to the institutions. This can often also help to bolster the low wages of training per-

sonnel and thus provide a disincentive to their departing to find employment in the private sector. The experience and knowledge gained in working together with private companies can furthermore be harnessed to develop new or more specific training courses.

In situations marked by a lack of technical culture, vocational training has an important socialization function. The development of educational/training systems will for this reason often take longer than in industrial countries. The factors that should be taken into account in assessing effectiveness, efficiency, and significance should include **contributions toward the development of a technical culture and the improvement of equal opportunities** that can be achieved by opening the way to increased upward mobility - thus at the same time helping to strengthen openness to social learning

Network-oriented technical cooperation

The study's core proposition is that technological capability emerges through the interaction between the four pillars. TC projects can as a rule be assigned to one of these pillars (most of them to the third or fourth pillar: technology-oriented institutions, educational/training system; see Appendix). It is only when such projects bear in mind the systemic character of technological capability that they provide more than a partial contribution. Significance-oriented TC implies above all contributing toward the **development of interlinked systems** and/or making allowance for the integration of a specific TC contribution into existing structures of the national system of innovation. It is essential to moor technology-relevant projects securely to the productive sector (first pillar) so as to encourage rapid learning processes in enterprises and institutions. It is also essential to bear in mind the framework conditions relevant to technology (second pillar). Framework conditions inimical to innovation (e.g. exaggerated and long-term protection of sectors of the national economy) can obstruct activities in the field of technology, regardless of how ambitious they may be.

In more efficient countries it is often possible to gear interlinkage-oriented TC to the interfaces between firms and private and public-sector institutions with an eye to networking them. The difficulty involved is to strengthen the interaction between the pillars of technological capability. In weaker countries which lack structures and effective actors at the pertinent levels of action, network-oriented TC should bring coordinated instruments (e.g. support for a faculty plus consulting on university reform) to bear at the same time. In other words, what is involved here is support for, indeed often even the development of, elementary structures in individual sectors and interlinkage, conceived at the earliest possible point of time, between the relevant institutions and actors.

5.3 Recommendations as per country type

Technology-oriented projects in least developed countries (LDCs)

In LDCs the key framework condition bearing on the activities of governments, and thus also shaping technology policy, is the structural adjustment policy which many of them are implementing. In the past this policy moved primarily on the macrolevel; only recently have sectoral areas (e.g. agriculture) been included as focal points. In the future such sector-related subprograms should, more than they have until now, reflect and explicitly address the technological and technology-policy dimension.

Until now LDCs have had neither technology policies nor national systems of innovation. The reasons are:

- a lack of the administrative capability required to formulate a technology policy;
- underdeveloped technological capability: enterprises that operate at a relatively low technological level; there is at all levels a lack of skilled and expert manpower; universities and technology institutions are seldom able to reach a critical mass;

– the tendency of administrations to avoid setting priorities so as not to alienate any potential TC donors.

The installation of a technology ministry does not offer a way out of this dilemma - an additional institution simply means creating more bureaucracies and further overextending the scarce reserves of highly qualified personnel available. Even the deployment of an advisor to a government to this end would be more apt than not to prove fruitless. More promising points of departure would include:

– establishment of a staff-level office for technology policy assigned to the agency in charge of decision-making on economic policy. An office of this type would be responsible for initiation and coordination, and would function as the contact partner of donors interested in engaging in technology-relevant DC;

– strengthening the **policy-level technological capability of ministries**, e.g. by selectively training pertinent staff members of such ministries; it is here that foreign experts could be profitably deployed, although, in the face of insufficient counterpart competence, these experts would run the risk of slipping out of their advisory role into an executive role;

– the continued development or promotion of **technology institutes and technology-oriented training institutions** - which should include a realistic time horizon for the support provided.

Two remarks remain to be made on the last point.

– LDCs have little need for technology institutions of the type represented by the Fraunhofer Institute. The manufacturing sector of LDCs tends to be more low tech and to have a **need for ad hoc consultancy**. Yet firms tend to lack a recipient capability for longer-term projects with a technology institute. Ad hoc technology consultancy can, however, be provided just as well, if not better, by training institutions which are (or at least should be) in contact with firms. It is, however, important to bear in mind that private enterprises are often quite wary of such institutions (in particular universities and autonomous institutions). **Confidence-building measures** are thus a condition central to project success.

– The situation in agriculture is somewhat different; here it can make sense to operate technology institutes specialized in specific produce types that are sold on the world market.

Donor competition and lack of coordination

The situation is especially complicated in the poor, structurally weak countries that are referred to as donor-driven. Here the national actors are hard put to formulate strategies. The field of structural policy is marked by a lack of priorities and orientations, thus frustrating any shaping of structures from within. The experience of the past has shown that an inordinate number of TC projects sponsored by the international donor community, usually projects of limited scope (i.e. not significant), will as a rule not give rise to a tangible contribution toward the shaping of structures from the outside. Atomistic and confused national structures are masked by an international cooperation characterized by a lack of priorities set by donor countries and organizations and inadequate donor coordination.

The outcome is often policy concepts of various donors that diverge even in one and the same sector, which makes it difficult to strengthen the strategic capability of national actors and thus also to tackle the urgent task of systematically shaping structures. The national institutions are unable to integrate the great number of projects and (changing) project conceptions into medium- and long-term policy strategies. Instead, the policies in the individual sectors are a mirror image of the implementation of a great variety of - not necessarily compatible - donor activities that are as a rule bound up with a narrow project outlook and seldom make systematic allowance for imbedding the projects in their project environment, thus missing a chance to contribute toward the shaping of structures.

While many of these countries have succeeded at the macroeconomic level in stabilizing economic conditions and imparting a direction to economic policy that can serve as a point of orientation for firms (opening up of markets, strengthening of

market forces, etc.), development in the areas between the macro-level conditions and the micro-level actors is largely without direction. This makes it practically impossible to shape structures in the mesodimension, the *sine qua non* of macroeconomic reforms leading to the intended reactivation of the economies concerned.

This unsatisfactory situation can be improved only by **focusing donor profiles, setting clear-cut priorities, and enhancing donor coordination.** TC projects should contribute toward developing the strategic capability of national actors in specific sectors. They should therefore be keyed to significance from the very start. Just as at the level of economic macropolicy, it is essential to create in the mesodimension **structural-policy corridors** into which national projects and donor projects can be fitted. Only in this way is it possible to overcome atomistic structures and give rise to successive reliable framework conditions for the national actors.

Technology-oriented projects in advanced developing countries

The elements essential to a system of innovation are often in existence in advanced developing countries. But fragmented structures and remoteness from the productive sector are often the features dominating the picture. While in weak countries the concern in many areas is to build new counterpart structures and to impart basic know-how, advanced societies are more in need of contributions toward mobilizing the existing actors, boosting their effectiveness and efficiency, overcoming fragmentation by devising networked systems, and rapidly linking up technology-relevant institutions with the business sector. In many cases activities can be sufficient that are capable of generating a catalyst effect.

Technology-oriented projects in advanced developing countries should be keyed to the following considerations:

- identification of core areas in which the individual countries - proceeding from static comparative advantages and existing capabilities - can develop dynamic comparative advantages;
- transition from an elitist orientation in science and technology to the development of a broad base - a good part of technological capability residing in the heads and hands of workers;
- encouragement of national decision-makers to free themselves from the high-tech obsession, i.e. the belief that the future belongs only to technology-intensive industries. Like industrial countries, the advanced developing countries must concentrate more on developing the capability to find the right combination of different technologies to build up competitive industries;
- improvement of the - hitherto inadequate - interlinkage between research and technology institutes, universities, and enterprises and/or producers (including the informal sector) - focusing less on building new institutions and formalized structures and more on promoting communication and interaction. In this connection it is also important to involve more intensively the relevant economic and industrial bodies (chambers and industrial associations), by, among other things, providing them a voice in the supervisory boards and steering committees of technology-oriented institutions.

In connection with this, consideration should be given to the following specifically enterprise-related activities in which FC activities could be provided with TC flanking:

- **Risk-capital financing**, with the involvement of financial intermediaries, along the lines of US practice; in other words: financial models requiring less collateral than is demanded in normal financial transactions;
- special funding programs for the establishment of new firms in the **field of software** (which is faced with special difficulties in providing collateral because of the nonphysical character of the product concerned);
- well-conceived support of spin-off projects (in which employees open up a business of their own) by providing additional financial benefits in cases in which the original employer is willing to invest in the new firm;
- advisory services on the introduction of new production concepts (e.g. lean production);

- support of the introduction of **environmental technology**, in particular new techniques geared to ecological efficiency;
- incentives designed to induce major enterprises to boost the efficiency of small and medium-sized enterprises (SME) (e.g. in the form of **supplier development programs**);
- support of projects designed for the **conversion of arms production**.

The following specific activities aimed at promoting technology-oriented institutions might also be considered:

- support of technology-oriented **centers for the establishment of new enterprises** (business incubators, with clear-cut support criteria, e.g. stipulation of a maximum period for which a new enterprise may remain with the center);
- funding of information and promotion programs on methods of and practical approaches to **quality control and quality assurance**;
- financial incentives to promote **R&D cooperation** between technology institutes/universities and firms;
- provision of different types of organizational know-how and infrastructure for technology networks (moderation of local/regional (i.e. below the national level) technology dialogues, exchange of information between firms, organization of workshops, etc.);
- development of institutions that can moderate (but not necessarily perform) **technology assessment**, i.e. that accumulate know-how in methods of technology assessment (workshops on future development, Delphi methods, etc.);
- dissemination of know-how on implementing measures designed to protect intellectual property.

Moreover, in Latin America and East/Southeast Asia the following border-crossing approaches to promotion are worthy of consideration:

- promotion of **border-crossing cooperation** between companies on the one hand and technology institutes and universities on the other;
- support (together with other donors) of **regional centers of excellence**, e.g.
  - in **research in biotechnology and genetic engineering** that can be used in the health sector (e.g. tropical diseases) and in food production;
  - **industry-specific research and consulting centers** (with a pronounced environmental-technology component), especially for the wood industry, food-processing, textiles and clothing, metallurgy, petrochemicals; possibly under the sponsorship of national and/or German firms or institutions; the main goals would be to promote the **regional** exchange of know-how and experience and **information** on and the **adaptation** of innovations from other regions;
- development and expansion of technical universities or institutions bearing resemblance to the German *Fachhochschulen* (polytechnics); these institutions would be regional in conception, practice-oriented (e.g. include practical training in firms), and geared to overcoming bottlenecks (e.g. courses in environmental engineering), and would pursue innovative approaches in teaching (project-related course of studies, interdisciplinary studies analogous to experience gained in Denmark and Norway).

5.4 Improvement of the process of project identification, planning, and implementation

The following conclusions can be drawn at project level:

- Orientation in terms of significance entails placing particularly high demands on project preparation study quality. A **painstaking analysis of project environment**, in particular the system of innovation and the demand for technological services, is essential. Orientation phases involving effort and expense make sense only after priorities have been set.
- In defining the objective and the results of the projects (GOPP terminology), it is also important to specify the output of the projects with

an eye to their intended **contribution toward the shaping of structures**.

- In project management, more emphasis should be placed on **participation of all persons concerned**; GOPP should in fact be used for an open discussion of weak points.
- Instead of aiming at adhering one-sidedly to quantitative and performance targets, the project progress reports should more **emphasize problems** that actually occur and reflect the **process character** of the projects. The scope of the flexibility open to long-term experts should be expanded; they should be able to respond quickly to exigencies calling for adjustment.
- The **flow of know-how from Germany** should be broadened during the project cycle. Nearly all projects transfer know-how via long-term experts and short-term experts, although they make little use of other technology sources available in Germany (Fraunhofer Institutes, Steinbeiss Foundation, and the like; universities, industrial associations, enterprises). This not least reflects a certain isolation of the "DC business" vis-à-vis other sectors in Germany; this isolation should be overcome. This is all the more the case as the know-how available in Germany - not only technology application but technology management as well - is in demand internationally.
- The possibility of a **continuous flow of know-how from** Germany after project completion should be introduced as a project identification criterion; in the past projects were not rare for which there was no counterpart institution in Germany. To ensure the flow of know-how it would be necessary to establish at an early point of time contacts between the TC projects and potential German partner institutions.
- A broad and continuous transfer of technology as the preliminary stage of an intended long-term technological cooperation also requires improved coordination of the activities of BMZ and BMFT. It should in particular be ensured that the strengths of each meaningfully complement one another. The special strengths of BMZ are in the field of institution-building, those of BMFT in the field of promoting concrete scientific-technological cooperation projects involving German R&D institutions and German industry. What is required to make effective use of this complementarity of strengths is above all improved coordination between the two ministries at the working level. Of particular importance are a close mutual exchange of information on specific planned major cooperation projects or programs and early coordination of the project components to be taken charge of or financed by each of the two ministries.
- Closer cooperation between BMZ and BMFT is also required to avoid predominantly technology-centered approaches to projects. Such approaches are not only, as was shown in some of the projects evaluated in the field of renewable energies, ineffective in terms of development policy. They likewise entail the risk that the results achieved will be of little benefit to the German side either. A particularly great potential is offered by projects that both activate and focus national technological potentials and contribute toward intensifying bilateral technological and/or economic cooperation.

5.5 Preference for significant projects

A strategic view of project policy

The objective of technology-oriented TC projects is to contribute toward developing a national system of innovation. The success of a technology-oriented project is measured above all in terms of the density of the network that has emerged in the project's environment. An isolated technology-oriented project must in any case be seen as a failure. For this reason the contribution of technology-oriented TC toward the shaping of structures - e.g. **significance** - should be regarded as a **criterion** of project selection and project planning just as **central** as are effectiveness and sustainability.

The emphasis on significance leads to a **strategic view of project policy**. The crucial issue is not whether a project functions well per se (is effective), and solves one of the variety of problems

concerned, but whether a project provides a significant contribution toward solving a problem that was identified as particularly urgent in the context of a concrete development strategy. Owing to the systemic character of technological capability, this is especially true of technology-relevant projects, though it also holds for TC in other areas.

From the angle of a developing country with a pronounced development orientation and a clear-cut development strategy, the problem does not consist of acquiring as many effective development projects as possible. Rather the issue is how to translate individual project successes into tangible systemic development successes. This consideration also holds true in particular for weaker developing countries like Bolivia in which there is no lack of rather effective projects sponsored by the international donor community. The development contribution provided by a great variety of project activities is nevertheless limited in that, above all, the projects do not adequately spill over into their project environment. It is therefore important to concentrate on the more development-relevant issue of a **project's potential contributions toward development and the shaping of structures** in a specific important area, and the aim must be to overcome the practice common until now of overemphasizing the internal perspective of projects.

Promotion of vertical and horizontal linkages

The best solution of the problem of ensuring significance in an ineffective but important sector would be to cease pursuing only selective and intermittent approaches and to promote structural reforms with far-reaching impacts. One conceivable approach would be a **promotion of vertical and horizontal linkages** that builds on coordinated promotion instruments at different levels. This would mean, for instance, contributing to the modernization of universities on a more broad level, i.e. offering, parallel to a university project, complementary advisory services at the university level (institutional consulting, administrative reorganization) and/or at the ministry level (educational/training planning, university reform). It is precisely in weak countries that technical cooperation keyed to achieving far-reaching impacts in a selected sector is necessary, though it may be complicated. It is easier to implement projects and to achieve sustainability in small, less complex projects

The goal of giving preference to structure-shaping projects as significant as possible and purposefully integrated into their environment leads to the question of how, above and beyond providing a counterpart with classical support, it is possible to influence additional project-environment institutions or indeed to strengthen entire systems that contribute to institutional development. Such attempts to strengthen social self-organization capability are exacting. In view of the initial situation, characterized as a rule by a lack of effectiveness on the part of the relevant private- and public-sector intermediary institution and weak interaction between them, it is important to schedule **sizable resources** for projects that aim at promoting the **development of systems keyed to institutional development.** If such projects succeed, they can provide an important contribution toward boosting the problem-solving capacities present in a sector. As long as no effective actors have emerged, projects aimed at exercising moderation and networking functions will be less successful. Projects geared to building networks presuppose the existence of fairly stable framework conditions in their specific sector and require actors capable of developing strategies.

Negative experiences in cooperation with relatively ineffective state-level institutions have led to a reorientation in the selection of counterparts. Preference is now given to cooperation with nongovernmental organizations (NGOs). But the hope of being able to **compensate for a weak public sector by mobilizing social actors** ignores the fact that **long-term development is conditioned on the effectiveness of both** and requires the development of stable framework conditions. Project planners aiming at significance should bear this condition in mind.

Setting priorities

These considerations suggest that German TC should set **clear-cut priorities**. It is only a longer-term commitment in a limited number of areas (two or three policy fields or sectors), as an alternative to the pork-barrel principle, that

- makes it possible to accumulate sectoral know-how that facilitates the integration of individual measures into the project environment;
- permits different instruments to be complemented and combined, thus giving rise to synergetic effects;
- contributes, through continuous cooperation with the recipient side, toward strengthening the strategic capability of national actors;
- strengthens the know-how and the donor profile of the German side and permits the development of project modules that can be replicated in other countries;
- facilitates donor coordination;
- diminishes the administrative effort and costs facing the German side;
- heightens transparency on the recipient side.

Development of a pronounced German supply profile

The findings of the study suggest that the process of setting priorities should be keyed to **German supply strengths** (in the end: the "German competitive advantage" as compared with those of other donor countries). DC in projects aimed at strengthening technological capability should concentrate on priorities in which **Germany has developed exemplary systems in the mesodimension,** thus ensuring the effectiveness, on the international scale, of policies, institutions, instruments, and human capital.

It became clear during the process of evaluation that developing countries are particularly interested in technological cooperation with Germany in areas in which Germany has supply strengths. These, for instance, include **dual vocational training, MSTQ, promotion programs for enterprise-level R&D, and experience with productive forms of cooperation** between the public sector, the private sector, and social groups (public-private partnership) within the framework of **dialogue-oriented economic policies**.

Such elements of system-building in the mesodimension cannot simply be copied; it is instead important that they be **cautiously adapted** to the process of shaping structures in the recipient country. In the areas named, the latter is capable of no more than developing a specific profile, step by step and with a growing share of counterpart effort. For these reasons, too, a high-profile German DC contribution should not consist of scattered individual projects which might even by hobbled with narrow time limits.

As soon as a pronounced German supply profile was developed, the great variety of interests on the part of numerous actors in the donor country and the recipient country would no longer find expression in a flood of highly mixed inquiries, applications, and projects; instead, it would be possible to specifically deploy, in a limited number of core areas, expert know-how in keeping with German supply strengths and in agreement with differently specialized donor institutions in other industrial countries so as to find solid solutions to complex problems.

Under such conditions the recipient countries could submit specific and clearly delimited applications for support. The institutions that apply for and coordinate DC have until now often been isolated, and overburdened, in their own country. This is one more reason why it is difficult to tailor German DC contributions to recipient country needs.

Strengthening national strategic capability in recipient countries

Such an orientation in terms of significant projects and priorities could contribute crucially toward strengthening national strategic capabilities in the recipient countries:

1. On both the donor side and the recipient side, a strategic view of projects increases the necessity to think about viable **concepts and strategies aimed at the development of policies in individual sectors**, while the usual practice has tended to overemphasize the internal perspective of projects. A number of BMZ sector policy papers (e.g. on vocational training), recent considerations on SME promotion keyed to generating far-reaching impacts, and the BMZ country policy papers constitute a good foundation for a reorientation of this kind.

2. Setting priorities and keying projects to significance have the effect of rendering more transparent the concepts, goals, and instruments of development cooperation for recipient and donor alike. This basis is the condition that makes possible in the first place any fertile **competition between various concepts and problem-solving strategies** and systematic search processes for patterns of problem solving adequate to specific countries. Furthermore, donor coordination is facilitated by the development of priorities and a greater measure of transparence.

3. Instead of the otherwise frequent "side by side" of scarcely coordinated policies of different donors in one and the same sector and the great measure of randomness and disarray involved in formulating sectoral policies and shaping the mesodimension, it would be possible to lay the groundwork for an orderly **institutional pluralism**.

4. In the case of technology-oriented TC, the underlying "four-pillar concept" of technological capability gives rise to the necessity of an approach geared to networking and the shaping of structures. There are many indications that considerations related to the field of technology-oriented TC - the overcoming of a too narrow project outlook, an orientation in terms of significance, and the setting of priorities - are also of importance to other areas of TC.

Appendix: Overview of the projects involved in the evaluation				
	Contribution to technological capability building			
	framework conditions	technology-or. institutions	training institutions	firm-level
Tanzania				
Faculty of Engineering at the University of Dar-es-Salaam		(●)	●	
Institute of Production Innovation		●		
Special Energy Program Tanzania		●		(●)
Technical College Arusha			●	
Zimbabwe				
Vocational Training (Harare Institute of Technology, Msasa Vocational Training Center)			●	
Departments of Mining and Metallurgy at the University of Zimbabwe			●	
Remote sensing data evaluation center		●		
Information, education, communication in family planning			(●)	
Energy policy advisor	●			
Bolivia				
Institut for Ecology at the University La Paz	(●)		●	
Department of Metallurgy at the University Oruro		(●)	●	
Integrated water management La Paz	●			
Rural regional development Santa Cruz	●			
Dissemination of renewable energies	●	●		
Argentina				
National Institute of Industrial Technology (INTI)		●		
Training of forestry technicians Las Marias		(●)	●	
Agricultural training in the provinces Chaco und Formosa			●	
Introduction of photovoltaic pumps				
Indonesia				
Advisory service to the shipbuilding industry				●
Training of technicians, shipbuilding industry	(●)		●	
Commercial vocational training (ECONID)			●	(●)
SMI-consultancy in Northern Sumatra	(●)	●	●	●
Planning of land-use in Kalimantan		●		
Thailand				
Development of the Faculty of Engineering, KMIT			●	(●)
Biogas program	●	(●)	●	●
Support of Asian Institute of Technology		●	(●)	

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