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Evaluation of Donor-Funded Information Technology Transfer Projects in China: *A Lifecycle Approach*

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1998

Abstract

Information technology forms an increasingly important component of donor-funded development projects, yet evaluation of such projects has been comparatively-rarely reported. This paper presents an evaluation of the information technology component within four Chinese technology projects, each of which is both described and evaluated. The evaluation is structured around a framework: the information technology transfer life-cycle. Using this life-cycle approach, a number of shortcomings are identified within the various technology projects. More general issues are also identified, for example, around training and the role of donor agencies. Two recommendations follow. First, some ideas about the way in which IT transfer projects are managed. Second, that the life-cycle approach be used more widely in both the evaluation and planning of technology transfer projects.

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1. Introduction

Information technology (IT) is becoming an increasingly important component of projects undertaken by international development organisations (Moussa & Schware 1992, Newsum 1994, Roche & Blaine 1996). Such projects cover a very wide array of activities, and cover all sectors, but they inevitably seem to involve the transfer of information technology from Western to developing nations.

Here we will differentiate two particular types of project:

- Type 1: general development projects, such as those initiated to strengthen the infrastructure of activities which are vital to the welfare of developing countries. This paper includes details of projects covering the prediction of earthquakes, meteorological services, and the monitoring of various natural calamities like floods and forest fires.
- Type 2: IT-specific projects aimed directly at raising the technological capabilities of the producers of information technology in developing countries. This paper includes details of projects that support research and development (R&D) related to the production and diffusion of computer software.

The IT-related effects of both types of aid projects - and others with an IT component - should be to prepare the country for an appropriate and efficient utilisation of information technology to achieve its development objectives.

The specific focus of the paper is on the experience of four Chinese organisations which have been engaged, with financial assistance from an international donor agency, in the receipt of information technology from advanced industrialised countries during the 1980s and 1990s. The paper draws on fieldwork evidence collected by the authors whilst engaged as consultants in the evaluation of these experiences. Evidence was gathered by a mixture of group and individual interview, observation and document analysis.

The main concern of the fieldwork was to analyse:

- the sequence of events and activities that have been carried out in connection with the projects during their life;
- the quality and relevance of training programmes; and, above all
- the outcomes of technology transfer, focusing on the adaptation of technologies to local conditions, their assimilation and diffusion, and the sustainability of capabilities created.

Technology transfer has long been identified as a key issue within the development process, with the realisation that transfer is problematic. Problems are seen to arise from a number of issues, which include:

- Technology is more than just equipment, and also incorporates a surrounding shell of infrastructural requirements, technical and managerial skills that are needed in order to operate it. Whilst the transfer process has been good at 'shifting boxes' from the West to developing countries, making those boxes operational at the other end is generally much harder because necessary elements in the surrounding shell are missing. Odedra-Straub (1992), for example, cites a case in Zambia in which computing equipment remained unused due to a lack of necessary systems development skills within the recipient organisation.

- Technology also incorporates even less tangible factors. For example, technologies developed in the West incorporate particular social and cultural assumptions that may not apply in developing countries. Lind (1991), for example, blames failure of some information systems introduced into Egypt on their Western assumptions of a business environment in which formal information was valued, goods supply was relatively certain, and there was legislative stability.

- The objectives and interests of technology source and recipient are often mismatched. In particular, the Western source of technology may seek an immediate profit from the sale, but have little interest in helping the developing country recipient make the technology work. Heeks (1996), for example, describes the furore and problems that arose when Western multinationals provided obsolescent, second-hand computing equipment to Indian clients.

Studies of technology transfer in the 1950s and 1960s focused particularly on agricultural and industrial technologies. However, with the transfer of the first computers to developing countries in those decades, the focus of study came to encompass information technology too, as each of the cases just cited exemplifies. Many cases of IT transfer to developing countries have now been reported (see, for example, the journal *Information Technology for Development*), but such cases have often been more anecdotal than analytical and this paper - whilst still rooted in case study material - attempts to create a suitable framework for analysis of major events related to IT transfer.

The conceptual framework described here - derived from praxis rather than theory - is that of the information technology transfer life-cycle. The advantage of this concept is that the life-cycle serves to identify critical benchmark events, each of which determines the subsequent course of the process. For instance, some events may become crucial bottlenecks. From the policy-making point of view, the concept may facilitate the formulation of event-targeted recommendations for assistance. Some such recommendations derived from the cases studied are provided at the end of this paper.

In addition to helping structure project planning, the life-cycle framework is of particular value in the evaluation of IT transfer projects. It provides a mechanism for structuring both data-gathering and data-reporting in the evaluation process.

A typical life-cycle - around which planning or evaluation can be structured - would include the following phases, as summarised below in figure 1:

- *Choice of technology*. During this phase the technological requirements are identified, the various alternatives for new technology surveyed, and the decision made to purchase or otherwise obtain a particular technology. Under normal conditions this phase would be undertaken during the formulation of the project, but it may also extend into the first years of implementation.

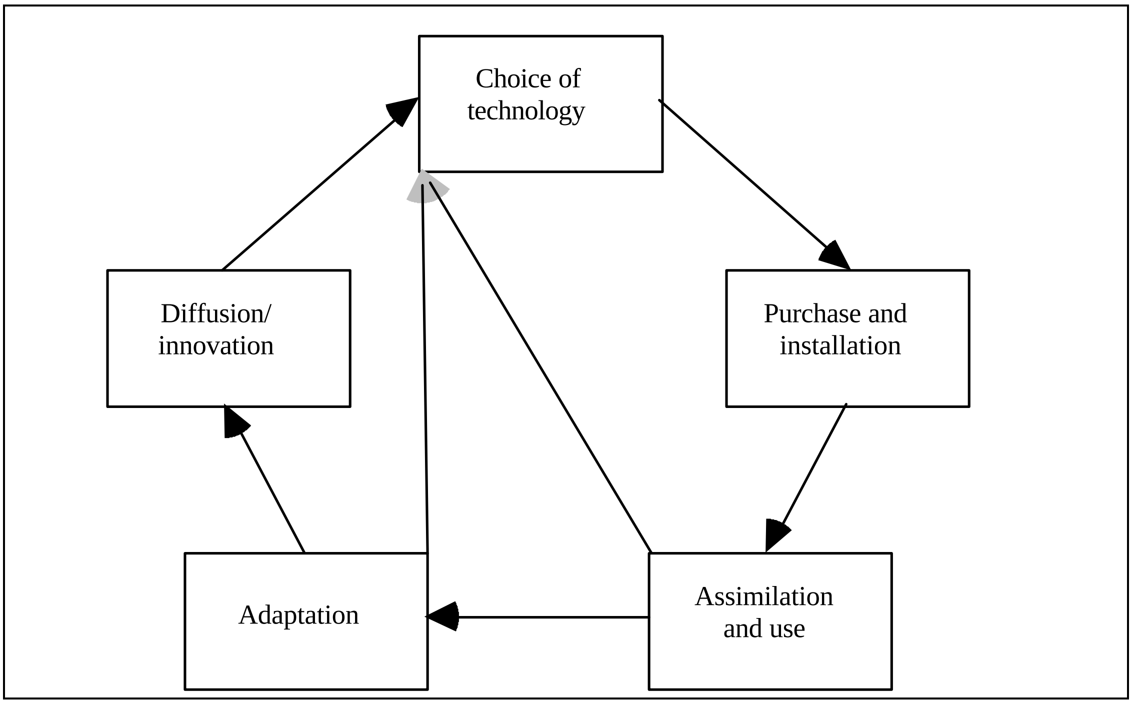
- *Purchase and installation*. This phase involves the actual procurement of the hardware and software technology. It will often include some training and consultancy to assist in the installation.

- *Assimilation and use*. The main activity of this phase is to ensure that the people who work with the new technology fully understand how it works, how they are to use it for various purposes, and how they will maintain it on a regular basis.

- *Adaptation*. In this phase the recipient alters the technology transferred. The purpose may be to improve existing performance; to add new functions; or to match local conditions, inputs or needs. Adaptation is frequently present, but not always (hence, the figure's line from assimilation and use direct to choice). Adaptation is found in both the type 1 and type 2 projects described above. However, only in the latter case is it seen as a fundamental part of the project, since it helps to build local IT capabilities.

- *Diffusion and/or innovation*. After the recipient organisation masters the technology transferred, it can undertake diffusion to other organisations. In some cases technological innovations will be generated, producing new technologies that the recipient can market locally or overseas. Even more than with adaptation, the innovation element may not always be present. Whilst it would be an intended component of most type 2 projects, it would be unusual in a type 1 project.

Figure 1: The Information Technology Transfer Life-cycle



Our analysis of the Chinese projects indicates that all the projects went through this technology transfer life-cycle. The process is depicted as cyclical rather than linear because there was a regular infusion of new technologies into the projects. The transfer process is therefore continuous rather than one-off.

2. Brief Description of Chinese IT Projects

A brief description of the four projects evaluated, which we shall call A-D, will provide a background for discussion of information technology transfer experiences.

Project A

Project A is a type 1 project. Its overall objective was to map Beijing's geology and seismic activity. This objective was to be reached by improving the observation capabilities of a central organisation in Beijing. The concrete tasks involved expansion of the scope and density of observation measurements for earthquake prediction. Therefore an information system was established designed to transmit, process and analyse the measurement data with a view to comprehensive prediction.

This objective is clearly worthwhile, particularly given the project's emphasis on trying to predict earthquakes and therefore reduce the deaths and economic damage with which earthquakes are associated. Apart from this, the project was generally well conceived and designed, with experimentation with a wide range of prediction techniques being part of the project.

Project B

Project B was also a type 1 project. Its objective was to establish a complete, operational information system for the retrieval and management of meteorological satellite data. The project could build on a preceding project funded by the same donor which had provided the basic infrastructure for receiving and processing satellite data. The next logical step was to ensure that the data could be stored safely and that the information would become available to a wider group of people. This concept fitted well with the emphasis that the Chinese government was placing on the diffusion of scientific and economic information, and the need to make meteorological services available to society.

The project was clearly motivated by the recognition that meteorological forecasts based on research utilising remote-sensing satellite data such as cloud and land images were crucial to many sectors in the Chinese economy; not least to agriculture. At the time of the evaluation, the project had succeeded in achieving many of its immediate objectives. The centre had acquired an impressive array of computer hardware and a database management system from a major Japanese vendor, and preparations were in process for managing a large amount of data which would be received from a new, geo-stationary satellite launched by the Chinese.

Project C

Project C was a type 2 project. The fundamental issue which it addressed was the effective utilisation of information technology and software in China. Several ways to input, process, and output the Chinese script had been proposed and CC-DOS, a hybrid Chinese version of the then most popular operating system for personal computers (PCs), had been launched some years before by a research institute in China. However, the approach adopted in developing operating systems such as CC-DOS was not efficient in the long-term perspective, and this project had been designed to build an organisation that would be able to develop and popularise new and more efficient systems for information processing.

When the project was formulated, the task of designing better systems for input and output of Chinese characters was seen as a major bottleneck. Therefore a research centre was created in Beijing which would work on optical character recognition (OCR) and a Chinese voice input system. A central task for the centre was also to establish a modern software development environment for Chinese information processing.

The project achieved some success in developing and commercialising a Chinese language system for information retrieval based on a foreign database management system and OCR software which is now utilised in China and abroad. At the same time, however, the project had been overtaken by unforeseen events to some degree, for instance, since more advanced operating systems such as Microsoft's Windows NT handles Chinese script under the new ISO-60646 multi-lingual standard.

Project D

Project D was a type 2 project, though its focus on information technology invokes the broader sense of 'technology', i.e. including management skills. In this project the overall development objective was to establish a central institution to help increase the quantity of high quality software being produced in China so as to match an increasing demand for IT applications. The centre set up in Beijing would be provided with the capabilities to develop an environment, quality control system and working standards 'which can be replicated by software production units of the Ministry of Electronics Industry'.

Specific targets included:

- a rise in productivity from 9 to 15-18 debugged lines of code per person-day;
- a reduction in bugs from 10 to less than 5 per 1000 source lines of code; and
- a decrease in the cost of software production by 20-30%.

In many respects, the centre succeeded in the formulation of standards and basic software engineering tools that could be useful in the emerging Chinese software industry. Nevertheless, weaknesses in terms of efforts to disseminate and commercialise such tools in cooperation with users in China reduced the actual impact of the project.

3. Characteristics of Information Technology

The key characteristics of information technology and its development on a global scale affected the outcome of the technology transfer process in these projects. It is thus useful to briefly outline these characteristics.

First, for most organisations, information technology functions as an enabling technology. Access to computers and software is critical to performance, thus enabling the organisations to carry out their most important functions. However, the main objectives of these organisations typically relate to a field of activity other than IT itself. For example, in project B, information and communications technologies are necessary for the processing of satellite data, but the main function of a centre for analysis of satellite data is not to invent new computing technologies or software programs. This enabling role is found in type 1 projects.

For a few organisations, though, information technology plays a different role and, instead of being an enabling technology, it occupies a role as a core technology. This is true in the case of any organisation involved in computer and software development, as in projects C and D. This core role is found in type 2 projects.

IT therefore performed different functions and was of differing importance for different recipient organisations. As already described above, the IT transfer life-cycle is likely to differ too in these circumstances.

Second, IT brings with it a high risk of technological obsolescence as computer systems become rapidly outdated and superseded by a new generation of computers or software. The risk of obsolescence stems from three major factors:

- A continuously and rapidly improving cost/performance ratio which means that, for instance, the performance of PCs sold in 1998 is equivalent to, or better than, minicomputers and high end servers sold at a much higher price in 1993.
- The fact that advanced computer systems and software tend to be sold when they are at an experimental stage, without rigorous testing in the market, and therefore running the risk that they or their producers 'die out' soon after purchase.
- The widespread (albeit diminishing) problems of incompatibility (different systems not working together) and lack of flexibility, making it sometimes problematic to upgrade and expand information systems with new hardware or software components.

Together these factors often lead to a situation where users who have purchased advanced computer systems feel after a few years that they need to purchase completely new computer systems and more or less scrap the old one.

Third, software is becoming an increasingly important component of the total information system. This means, on the one hand, that there is a need for systems integration bringing together the (often imported) computer hardware with suitable applications software. Simply purchasing hardware is seldom an appropriate solution. On the other hand, software engineering tools and methodologies are becoming essential to ensure that the programs and systems created are of high quality and are effective in meeting the needs of the users.

Problems Deriving from IT Characteristics

To some degree, the three basic characteristics outlined above had problematic implications for all the four projects; problems which are equally likely to afflict other IT transfer projects. For example:

- The danger of IT becoming an end in itself for type 1 projects. In other words, the problem of information systems being mistakenly shifted from an enabling to a core function. IT seems to have some deep allure for the technically-minded, at times driving them to forget that IT is intended to be just a tool for achieving some other goal. This has been a characteristic of type 1 projects for the following reasons:
    - For a number of such projects, IT represents one of the few tangible, modern outcomes of aid agency investment. In recipient organisations that have often been starved of funds and attention, the agency-funded IT comes almost to represent the delivery of foreign goods to a cargo cult.
    - Far more pragmatically, employees in (normally public sector) recipient organisations believe - often quite correctly - that IT skills attract a high premium in the local labour market. They therefore fight hard to spend time working with the new technology in the hope that this may be their ticket out of the public sector into a high-paid job.
    - Organisational pragmatism also plays a role. At least in the Chinese context, software developed by the organisation represented an asset that could be sold in the open market for hard cash at a time when the organisations were under pressure to become more commercial and more financially autonomous.

The results of such factors were clear in the Chinese projects investigated. In project A, some staff and even to a limited extent some organisational objectives had become skewed away from the initial project purpose because of information technology. There was a possibility that earthquake prediction would play second fiddle to the development of new information systems.

In project B quite a substantial human resource, technological and management effort was being directed at the development of information systems. While these systems were intended to serve the project objectives, they were placing an increasing volume of resources at one step removed from those objectives. Yet there was no intention of separating the information systems function into an autonomous sub-unit, let alone outsource it, in order to preserve clarity of purpose within the main organisation.

- The waste of resources caused by obsolescence. There were examples within all projects of the impact of obsolescence and incompatibility of computer systems and software. For example:
  - Large minicomputers which were delivered late and lay unused because they had less power than one current small desktop microcomputer.
  - Substantial inputs of resources pumped into local maintenance and even production of spares for equipment which was no longer supported by its original manufacturer.
  - Information systems which could not 'talk' to similar systems in other organisations or even within the same organisation.
  - Substantial inputs of resources pumped into solving the problem of transferring data between information systems which were not wholly compatible.

Obsolescence can be a particular problem for aid-funded technology transfer projects because there can be time delays between decision-making and installation. Such delays add to the tension that may exist between the desire to have the latest technology and the need to choose IT that is as 'future-proofed', open, flexible and compatible as possible.

In type 1 projects, such tension may be more limited, with an onus on purchasers to choose IT that is market-proven, as opposed to 'leading/bleeding edge'. In such projects, an information system that works may remain satisfactory from a user perspective for a considerable period of time, especially given the flexibility of IT to be reprogrammed for different tasks. In type 2 projects, by contrast, there is constant pressure to innovate and keep up with technological frontiers. This means the IT acquisition process is more likely to be led up 'blind alleys'.

- Software bottlenecks. Partly because of the high cost of imported software and partly because of its inability to meet local needs, there were an increasing number of software developers within all of the project organisations (not just in type 2 projects). Many of these individuals lacked sufficient or up-to-date software development skills. As a result much of the software took a very long time to produce, was error-prone, was not user-friendly, and was not that well matched to user needs.

4. Findings and Issues at the Life-cycle Stages

The above-mentioned characteristics of IT and the description of major objectives and results of each project provides a background for our discussion of the achievements and difficulties experienced during the information technology transfer life-cycle. We shall identify some of the major issues and illustrate these issues with examples from all four projects.

4a. Choice of Technology

In IT transfer projects technology choice is sometimes inadequate or inappropriate, and not enough time is spent assessing either the technologies available or their match to project needs. Partly, this reflects a lack of specification, assessment and choice skills within project organisations. Partly, it reflects problems with external assistance from consultants and agencies.

In project B, for example, the use of an outside consultant did not prevent an early choice of computer mainframe system which later had to be altered, or the choice of an optical disk system which, more than a year after its installation, was yet to be used operationally. In project A, it is likely that the technology procurement consultant compounded the problems of choice rather than expediting them. The consultant advised the Chinese institution to buy a complete, turnkey system from a small software development firm in his own country. When the firm failed to develop and deliver the system in compliance with the contract, the consultant became involved in new negotiations which led to higher prices and more delays. In the end, the system delivered in the early 1990s contained many bugs and relied on hardware dating from the early 1980s.

Executing agencies may also suffer from weaknesses in helping project authorities select the most appropriate and effective technology. In the projects under national execution it is clear that the Chinese organisation responsible was unable to play an active role in locating the vendors of appropriate technologies for the projects. The task of identifying a specific vendor therefore fell to National Project Directors, not all of whom were in a position to make informed technology decisions. Similarly, the role of the external executing agency in project D appears to have been limited to simply handling the contractual arrangements of procurement, with little advice provided on selection.

Internal skills, external assistance and more thought overall need to focused on the 'make or buy' decisions which face all project managers. Purchases of new technology are hardly ever subjected to a cost-benefit analysis or even a simple assessment of whether it would be more effective to:

- buy technology as a whole package,
- try to make it all within the organisation,
- integrate the system from a variety of bought-in components, or
- integrate a mixture of bought-in equipment and components developed in-house.

This decision-making process needs particularly to be applied to software which can be bought as a package but also - in many situations - developed by project staff, or subcontracted to a local software developer. Project managers are not encouraged to sit down and work out which of these routes will be most effective.

In many type 1 projects, for example, in-house development may be seen as the least effective route since the outcome may be software of poor quality that takes a long time to produce. For such projects, the main objective is generally rapid use of good quality information systems that will provide inputs to the (non-IT-oriented) project objectives. For type 2 projects, on the other hand, in-house development may be a more effective choice because the software program may be of less importance than the indigenised software production and maintenance capabilities that in-house development creates.

A range of more specific issues also emerged from the projects in relation to the technical specifications of the IT chosen:

- Compatibility between existing and newly-purchased information systems is something that project managers and - presumably - those sanctioning purchases should think about. Yet evidence from several of the projects indicated that such considerations about compatibility had been ignored. Data could be shared between various computers at the project site, but this was often done by having project staff create complex, time-consuming routines and interfaces to convert data. Technical specifications therefore ought to be more explicit about the need for compatibility of new systems with existing ones.

  This issue becomes even more of a concern if one broadens it out beyond the organisation. When a new information system is to be created in a donor-funded project, more explicit consideration needs to be given to:

- similar information systems existing in other service provider organisations with which the new system may need to be compatible;
- similar information systems existing in user organisations with which the new system may need to be compatible.

  Money may be spent on systems which, while meeting existing internal organisational needs, cannot break out of the organisational boundary to share data with others. Executing agencies must therefore demand an explicit recognition of compatibility issues in technical specifications.

- Related to the above point, there is a great danger - particularly given the vertically-hierarchical nature of many functions in China and the lack of cooperation between institutions - that donors fund information systems which duplicate efforts or systems made by other organisations, and which fail to derive the maximum possible benefits.

  This danger is particularly apparent in two areas: information systems and communication systems. In both cases, when equipment is purchased or systems are designed, those involved must be encouraged or required to identify similar needs or systems from which there could be gains from economies of scale or from the sharing of data. Some donors have made inter-institutional cooperation a pre-condition for release of funds in order to reduce the dangers of duplication.

- Operational considerations were often ignored. Too many of the technologies seen in use in the projects were one small event away from collapse. No funding and little thought had been given to the operational practicalities of the technologies chosen. Across various projects, computer viruses, disk crashes, electricity failures, fires, floods, theft, and telecommunications breakdowns (not to mention earthquakes) would have left donor investments inoperable. Disaster recovery issues must go into technical specifications.

- In planning and specification, equipment has often been seen as synonymous with hardware. But in the actual projects themselves, it could be seen that software was the more important part of most 'equipment'. It offers greater opportunities for adapting systems to local needs; skill entry barriers are relatively low; and technological capabilities are more readily transferable to other situations, include commercial enterprises. This has to be taken into account in the specifications, overriding software's innate intangibility which can lead it to be ignored.

- Two final elements were not sufficiently considered in the specifications - future-proofing to ensure that the technology chosen will still meet project needs in, say, three years' time; and identification of alternative technology options so that time-consuming delays do not ensue if the project's first choice proves unobtainable for some reason.

4b. Purchase and Installation

This phase tends to involve long delays. Sometimes this has had beneficial side-effects, in allowing the Chinese organisation time to develop its own technological solutions and capabilities. However, such outcomes should be the result of positive choice rather than being the consequence of delay.

In some cases the delays occur because of restrictions imposed by exporting nations. Now-defunct COCOM regulations had affected the earlier stages of some projects. In other cases, software producers had been unwilling to export packages to China owing to perceived lack of protection for intellectual property rights. China's adoption of copyright regulations for computer software has helped here, but there is still a gap between legislation and implementation that can affect Chinese technology projects.

Within project D, there were purchase problems caused by mistakes and misunderstandings in the purchase procedure. It was hard to pin down the source of these problems, but they did point to the need for better communication between project agencies and project authorities. They also suggested the need for more care to be exercised in the choice and synchronisation of technology vendors. Through lack of such care, delays occurred because software was delivered a long time after the hardware had arrived so that the computers purchased were not applied to project-related work for some time.

Once the hardware equipment has arrived, the recipient organisations had made serious efforts to ensure that it was installed properly, and staff were sent on relevant installation and maintenance training courses.

4c. Assimilation and Use

Three main techniques were identifiable within the projects to assist the process of assimilating the new technology into the organisation.

- First, staff were sent outside on training to learn about operating, using and maintaining the technology.

- Second, consultants were called in to help assimilate the technology into the organisation and improve its operational use. Because of the short time of visiting; unfamiliarity with the organisation; and the medium of interaction specified in terms of reference, this has sometimes proven ineffective.

  Foreign consultants have been involved with training, but have tended to be asked to give too many lectures. Knowledge would have been more effectively transferred through interactive workshops and small group sessions; something that could be encouraged or required within project contracts.

  Consultants have also been used for practical project inputs but have too often acted as a substitute for organisational skills rather than as a support to those skills. For example, the consultant will design a workplan or a technical specification or a training programme rather than assisting those within the organisation to do this for themselves. The result will often be that next time round, the organisation needs the consultant's assistance. Again, skill transfer and counterparting need to be contractually encouraged or required.

- Third, and normally following the other two techniques, technology is assimilated in the long term through its day-to-day use. It is this which is the crucial guarantor of 'success' with the technology. From the projects, this was seen to be a long process, with equipment only being used efficiently after many months or even years of operation.

Some equipment was never used as efficiently or effectively as it might. In part, this relates to problems of training, but it also reflects the lack of planning for technology. This, in turn, reflects an inadequate realisation of the depth of organisational change that is associated with the introduction of new technology, and a view of technology acquisition as an end in itself. Instead, as Braa et al. (1995) point out, there needs to be a much greater emphasis on the issues of learning about technology, rather than on the technology itself as some isolated artefact.

4d. Adaptation

In all the projects there was some kind of technological adaptation, sometimes a result of problems with acquiring technology from abroad. The adaptations covered three areas: performance enhancement, new functions, and match to local conditions.

Most of the adaptations could be characterised as adding functions unique to the Chinese organisational context rather than having any external orientation. This intra-organisational focus also meant that adaptations often required quite specialised 'insider' knowledge, and did not have the kind of user-friendly interface necessary for use by others with a lower level of skills or knowledge. Overall, one may say that while some of the adaptations were 'deep' in the situational knowledge required, they were also very 'narrow' and often required a relatively shallow level of adaptational skills.

In one case - project A - adaptations were primarily carried out in relation to electromechanical technology. In all other cases, the adaptations involved software development as part of an information system based on imported hardware. As noted above, the skills developed are often at one step removed from the core project objectives. Because of this, they are also skills which have been relatively ignored in the planning for project training.

The lack of inter-institutional cooperation noted above also characterised this phase, and created signs of project 'inbreeding' with little opportunity for infusion of fresh external ideas, and with duplication of effort among a number of Chinese organisations working simultaneously but separately on related projects. One glaring example was the lack of interaction between projects C and D, despite their both working on Chinese text processing output technologies and despite their being located a few hundred metres from each other within the same Institute. Political frictions were partly to blame, but so too was ignorance and a lack of mechanisms for researcher communication, which could have been addressed by donors.

4e. Diffusion and Innovation

In two of the projects - project A and project B - the emphasis of project objectives was on the diffusion of information rather than technologies. Having said this, the former designed a new telemetry system on the basis of the technology that was supplied by a foreign firm, and installed the new system in the Tianjin area. Other technological adaptations and innovations were diffused to organisations in China with seismic interests or with a need to integrate monitoring systems over long distances, for example in connection with water level monitoring at major dams.

In the other two projects - project C and project D - there were clearer technology diffusion goals, particularly for the latter. In the former project, the new Chinese information processing and retrieval system was developed in interaction with a major user organisation, one of China's leading newspapers, and diffusion to a large number of other Chinese newspapers was about to be undertaken.

In terms of diffusion generally, there was limited focus on the true beneficiaries of this diffusion; little interaction with them in order to try to improve the technologies; and little attempt to diversify the contacts or channels for diffusion (most of which rely on links that existed before the project began).

Information diffusion specifically was limited, with the paucity of inter-organisational links found in relatively poor dissemination of project information. This was lacking in two main ways - limited access for outsiders to information held within the organisation, and limited dissemination through publication or conference papers or Internet-based channels. Where a good international relationship existed, there was the irony that foreign collaborators seemed to have better access to project data than their Chinese colleagues. (Such long-term international relationships have been valuable to the projects: they have infused ideas and even spares and equipment without seeking payment; they are also likely to be a useful source of post-project support since the relationship continues even when donor funding is complete.)

Technology diffusion was also too limited from the projects. Five main channels can be identified for technology diffusion:

- direct technology transfer;
- staff turnover;
- training and advice;

- publication; and
- outsider access to internal information.

None of these was particularly well exploited, and there was a lack of focus on the barriers to diffusion and adoption of technology.

Commercialised forms of technology diffusion have attracted a great deal of interest, and there are strong pressures to increase such diffusion. All the projects had undertaken some kind of commercialisation. As an example, project A had set up a commercialisation unit and sold a dam water level monitoring system and some seismic systems in other parts to China.

However, the commercialisations had mainly been rather haphazard. The purchasers were almost all organisations with which there was some pre-existing relationship, or which were known through some informal friendship link. The main skills of commercialisation - such as raising production levels, pricing, marketing, and post-sales support - were almost entirely absent. So was any wider framework of understanding how and whether commercialisation should be undertaken.

The line between adaptation and innovation is not always easy to draw, but table 1 sets out a continuum of technological capabilities that includes both of these. In some of the projects new technologies had been developed which were not previously produced by the project organisation; thus clearly moving beyond mere adaptation. Sometimes this had arisen as an unexpected development through substitution of technology which was either not available or regarded as too expensive. In the case of the two information technology projects, there were specific objectives to produce such innovations.

Table 1: Scale of General Technological Capability

Level 1. Non-production operational capabilities
- 1a: Using the technology
- 1b: Choosing the technology
- 1c: Training others to use the technology

Level 2: Non-production technical capabilities
- 2a: Installing and troubleshooting the technology

Level 3: Adaptation without production
- 3a: Modifying the finished product to meet local consumer needs

Level 4: Basic production

- 4a: Copying technology
- 4b: Assembling technology
- 4c: Full production using existing products and processes

Level 5: Minor production modification

- 5a: Modifying the product during production to meet consumer needs
- 5b: Modifying the production process to meet consumer needs

Level 6: Production redesign

- 6a: Redesigning the product and production process to meet local consumer needs
- 6b: Redesigning a program and production process to meet regional/global consumer needs

Level 7: Innovative production

- 7a: Developing a new product to meet local consumer needs
- 7b: Developing a new product to meet regional/global consumer needs
- 7c: Developing a new production process
- 7d: Transferring a production process to other producers

Source: adapted from Narasimhan (1984), Lall (1987), and Schmitz & Hewitt (1991).

Although ranging from simple to complex, few of the developments could be regarded as substantial, original innovations. At best, they lay around level 5 in the table of technological capabilities. It was clear in some cases that the 'innovations' had been largely copied from imports, from the products of other Chinese organisations, or from textbooks. However, such a finding is not unique to these projects. Most supposed innovations from Western companies have similar roots, and the capabilities reflected in the projects' technological modifications should be a source of satisfaction.

A more critical issue is that discussed above - the limited diffusion of these modifications, and the haphazard and limited nature of commercialisation. Several of these new technologies remain at the level of prototypes and this underscores the lack of planning in much of the innovation. As part of the limited consideration about 'make or buy', projects did not think about the costs of developing technologies for themselves; how these might be sold in the market; and what competition they might face.

4f. Sustainability of Technological Capabilities

Although not explicitly one of the life-cycle stages, this is a crucial issue to be considered in relation to donor-funded projects because such funding is of limited value if organisations collapse and capabilities wither away after the withdrawal of donor support.

Unless entirely undertaken by project consultants, every action within the project life-cycle helps to create or reinforce skills. Thus, despite the fast-changing nature of information technology and rapid obsolescence, the mere act of taking part in equipment procurement provides project staff with the abilities to make a somewhat better choice of technology next time round. From the project evaluations, the following range of capabilities created could be seen, most of which follow the life-cycle:

- Analysing needs, choosing technologies and identifying technology sources
- Buying equipment and installing it
- Operating equipment
- Using equipment to achieve desired objectives
- Maintaining and repairing equipment
- Adapting technology to local conditions and needs
- Diffusing technology and related skills to other organisations
- Modifying to produce new technologies
- Producing equipment locally then marketing, selling and supporting it
- Project management: budgeting, scheduling, reporting, evaluating, making decisions, etc.

Naturally, there are deficiencies - too much continuing dependency on outsiders; lack of reflection and evaluation on what has been learned; and a lack of formal training inputs to these capabilities. However, the capabilities are worth emphasising - they can easily be overlooked because they are intangible and because they may not be included in project objectives. The projects have therefore contributed to strengthening institutional capacity in terms of technological and other capabilities.

The sustainability of these capabilities is ensured to the extent that they exist within people. So long as those people continue to work in roughly the same area, the capabilities are likely to be maintained and utilised. One potential danger lies in the push to commercialisation which, elsewhere, has resulted in staff with adaptive and innovative capabilities being transferred into sales and marketing work. Related to this, as career structures and market pressures alter in China staff with certain skills - especially those relating to software - may be lured from government institutions into more commercial organisations.

Within some of the projects, the focus on particular outputs was not certain to be sustained. The styles of individual project staff and project management were such that they encouraged staff to move on from one technological development to a newer, more fashionable one even when the earlier one was not yet completed. As a result, instead of capitalising on earlier-developed capabilities, these were ditched in favour of those relating to the new area.

Finally, institutions may not have sufficient resources to continually import new technology. Adaptive skills may therefore flourish while technology choice skills wither. The sustainability of capabilities within their existing institutional context also held some uncertainties. It is clear from the project evaluations that the institutions should be sustained, and all of them have the required supports and inputs to survive at least in the medium term. One project - project D - highlights the potential for longer-term difficulties since it lacks a clear role, a politically-powerful organisational champion, or the resources for buying new technology. While such institutions may survive, the sustenance of capabilities requires active growth rather than mere survival.

5. Cross-Cutting Issues

Some issues cut across, or lie outside, the IT transfer life-cycle. Four of these will be discussed here.

5a. Project Design: Objectives, Outputs and Roles

The objectives of all the projects studied were valid, important and worthy of donor funding. However, there was often a discontinuity between the social validity of project objectives, and the narrow focus of project outputs. The outputs were often overly technical, too heavily focused on processes within the recipient organisation, and too little focused on beneficiaries and the external social environment.

Almost all donor projects have identifiable human beneficiaries, yet too little is known about them in the planning of projects. In the process of project appraisal or - less favourably - in the early days of project implementation, such beneficiaries need to be identified and surveyed. Armed with such information, it would be easier to create outputs which were oriented to the beneficiaries, and which were more in line with project objectives than those of the projects evaluated here.

Intended outputs were also frequently too diverse. In the case of project A, for example, project outputs specifically encouraged experimentation with a diverse range of technologies, and this led to some useful ideas and discoveries. However, in other cases, excessive diversification of outputs was not useful.

Combined with problems such as overly ambitious goals or changes to project outputs over time, the problem of diversification reduced the scope for building sustainable technological capabilities in some of the projects. These have generally failed to profit from specialisation, and have missed opportunities to make a strategic choice to focus on building specialised capabilities or on exploiting economies of scale in terms of manpower resources or production.

In setting project outputs, and the related roles of the project organisation, the temptation to do 'a little bit of this, and a little bit of that' should be avoided. Where this had happened in projects C and D, the result was only limited significant and tangible output identifiable from donor investments. By contrast, project achievements were greatest where there had been a clear focus of staff and resources on a very small number of roles and outputs.

5b. Training

Training can be seen as a key activity for donor-funded technology transfer projects because, while equipment lasts only a few years, new skills, knowledge and attitudes can last a lifetime. It was clear that training had been useful and relevant in the four projects that were evaluated. Training had helped to raise the level of skills present in all the projects. Where it was absent - in other words, where project staff found themselves working on unexpected, unplanned task areas - the relatively poor levels of performance and the need for training were often painfully apparent. Nevertheless, there was potential for improvements in the nature of training as a number of problems were identified within the projects:

- Training content and location were sometimes of questionable relevance. In some cases, trainees were placed at research organisations or universities when project outputs (and, hence, required training) related to industrial beneficiaries. Similarly, training content was of an academic, research orientation when project outputs were intended to be commercially, practically applied. Information technology training was also oriented too much to operation and maintenance of hardware, and too little to software skills and to the overall setting of information systems. This is not to say that training investments had been wasted, but that they could have been more appropriately used if better planned.

- Excessive diversification of training was sometimes seen, with staff apparently trained in as many different areas as possible. While this provides a wide spread of skills and knowledge more or less vaguely related to project objectives, it meant that there was no critical mass of skills within projects that could be applied to particular outputs.

- Project directors tended to save money on training and spend it on equipment instead because of a concern with using funds to acquire material possessions rather than intangible assets.

- Some trainees went abroad and did not return. Both projects C and D had lost around half a dozen staff each to this 'brain drain'. These staff had already acquired substantial capabilities working on the project and their loss appeared to have significantly affected project progress.

- Trainees returning from abroad had occasionally undertaken further training of their colleagues involved in the project. More often, though, there was no such post-training dissemination, thus limiting the benefits from the money invested. Overcoming this may be difficult given the tendency to see training - and the skills/information thereby gained - as a personal possession.

- Study tours overseas have become an accepted part of many donor-funded technology projects. While they undoubtedly serve a valuable incentive function for senior project staff, their role in raising the level of knowledge in the projects must be questioned. Too many staff seem to go on tour, with objectives that are too broad and shallow, and with no clear plan of how any skills or knowledge are to be applied in the achievement of project outputs.

It is clear that technology project training ought to be better planned in a wide sense - to ensure that study tours are more tangibly worthwhile; to ensure that skills gained are practical and applicable to project outputs; to ensure that training is clustered enough to produce groups of staff who can work together in one area; to recognise the role of information systems - not just IT - in project development; to encourage post-training dissemination; and to ensure that some kind of training evaluation takes place, even if only rudimentary. One part of this whole process can be the creation of long-term relationships with relevant overseas institutions, which could provide clustered training and also continuing support with the training process.

5c. Monitoring and Evaluation

There were major problems with the monitoring and evaluation of all the projects. M&E had been systematically undervalued, under-resourced, done with no rigour, and even avoided at times during all the projects. Review meetings and reports occurred once or at most twice during the entire project lifetime, instead of bi-annually, and despite the fact that all the projects had some easily identifiable, ongoing problems that should have been dealt with. Monitoring and evaluation exercises were seen as a chore that no-one - not project staff, not project authorities, not executing agencies, not even donor staff - was keen on undertaking. The exercises were also seen as an end in themselves, since there were no mechanisms by which recommendations from evaluations could be discussed, decided upon and followed up.

5d. The Donor Agency

There were a number of challenges faced by the international development agency that had financed the technology transfer projects. One challenge was the constant difficulty that staff - both at programme officer level and above - had to deal with too many projects to do as fully effective a job on any individual project as they needed to, and would have wished to.

Given the pressures - often political - to spread aid money to as many different projects in as many different sectors and regions as possible, and given pressure to reduce administrative costs (which may rise proportionately if wage inflation outstrips aid budget increases, let alone cuts) by intensifying staff workloads, the donor had begun to suffer from the 'More is Less' phenomenon. That is, as the number of projects rises they are handled less and less effectively, and the overall development benefits diminish rather than rising.

In this situation, reducing the overall number of projects administered would be advisable. Projects per staff member limits could be set and adhered to and, more importantly, there could be a minimum funding level below which donors would refuse to consider project requests, or below which the donor agency sub-contracted far more of the project monitoring and administration to a competent and reliable local organisation.

Turnover of staff within all project-related agencies was perceived as a problem by the project authorities, leading to delays, misunderstandings, and a lot of duplicated effort. The donor agencies can consider the appointment of 'shadow' programme officers. The 'shadow' would cover projects whilst the main officer was off-site and, if the main officer was moved to another posting, could either cover their work until a new officer was appointed or take on their projects and have a new 'shadow' nominated. Given the heavy workloads already present within most donor agency offices, it might be that such shadowing could only be contemplated for certain prioritised projects (i.e. those in certain high profile areas, or those over a certain budget level).

A project handover document is also required, to be passed from outgoing to incoming programme officers. This would provide a simple template for the communication of basic project information that was often lost in the mass of paper within project files: key actors, events, purchases, and problems.

6. Conclusions

6a. The Information Technology Transfer Life-cycle Approach

The IT transfer life-cycle approach is not intended to be a contribution of theoretical depth to the process of technology transfer evaluation. What is does provide, however, is a clear and logical framework around which data may be gathered, and information presented, about IT transfer. Being both simple and open, the life-cycle framework can be applied to a wide variety of situations; not just those involving donor agencies and developing countries.

For example, taking the case of IT acquisition and use in a Western private sector organisation, technology is still being transferred into the organisation and the process will follow a similar pattern to that outlined above. It is therefore hoped that the life-cycle approach will prove to be a framework of practical value to all those involved in IT evaluation: external and internal consultants, organisational managers, and IT professionals.

In addition, the life-cycle stages provide a framework for the design and planning of IT transfer projects. The stages create a structure for the conceptualisation of forthcoming projects, and for the more practical work of planning the resourcing and scheduling of project interventions. By way of illustration, the following section structures its summary of project intervention recommendations according to the life-cycle stages.

6b. Donor-funded Information Technology Transfer: A Summary of Life-cycle Evaluation Recommendations

Choice of Technology

It is clear that recipient project organisations need assistance with the process of choosing technology. Judging from the problems associated with one or two project consultants, that assistance must obviously itself be well chosen, possibly within the context of some long-term cooperative linkages with foreign organisations. The role and skills of any executing agency must also come under scrutiny to ensure that they are contributing to improvements, not problems.

The 'make or buy' decision must be a subject of action, perhaps through a plan of use for the technology chosen. One could also suggest that more effort often needs to be put into the technical specifications. Donors would be well advised to get a set of guidelines on this process issued, to cover:

- analysis of requirements;
- consideration of issues like compatibility, sharing, operational risks, future-proofing, and specification of alternatives; and
- identification of appropriate technology sources.

The focus of specifications has been too much on information technology and too little on information systems; this focus needs shifting. When projects arise, software components of equipment transfers could be more clearly identified; options for local development or adaptation explicitly considered; and appropriate training provided.

Purchase and Installation

Technology purchase on these projects was characterised by delays, mistakes, misunderstandings, and scheduling problems. Poor inter-organisational communication and poor choice of vendor has lain at the heart of these difficulties, and both of these need to be improved. Installation, on the other hand, was relatively trouble free.

Assimilation and Use

To enhance the assimilation and use of technology on donor-funded projects, training, use of foreign experts, and planning all need to be reconsidered. Training has been discussed above, but the consultants need clearer terms of reference which ensure a genuine contribution to project outputs and future self-reliance. The focus must be on workshops rather than lectures; project-related material rather than a re-hash of old ideas; and support for identifiable Chinese counterparts rather than substitution and continuing dependency.

Project authorities need to lay out a clear plan of use for technology. This should identify why the technology is needed; how its assimilation and use is to be undertaken; how this use will contribute to project outputs; and what happens 'next time round' when the assimilated technology becomes redundant (overlapping with the 'make or buy' planning). Obviously, this needs to take place simultaneously with the requirements analysis and technology choice rather than after.

Adaptation

As information technology becomes an increasing part of all projects, it must be recognised that locally-adapted information systems will feature in many projects. From this recognition, it follows that training in software skills but - more importantly - training in effective information systems analysis and design are required in more and more projects.

Diffusion and Innovation

A number of the projects have developed new technologies, with the developments lying at various points along the technology capability continuum from adaptation to modification. This has been undertaken without sufficient consideration for the alternatives, for the needs of users, or for the intended outcomes. But overshadowing the development has been the issue of what happens next. Project planning and assistance needs to be more concerned with the ways in which new technologies are to be diffused from the project, and with the potential barriers to this process.

In general terms, projects need a greater focus on the processes of diffusion and dissemination. These are the elements that finally bring project results to the beneficiaries and the wider world, yet they are not seen as sufficiently important. There needs to be more training in dissemination skills: writing, locating channels for dissemination from the traditional (conferences, journals, newsletters via mailing lists) to the more recent (email lists and the World Wide Web), running training courses, and opening access to in-house information. Project documents also need to consider how diffusion will take place, to build in time and money for this, and to provide training. All this needs to be built in early, whilst donors are still focused on the projects and before attention drifts onto subsequent projects.

There is great scope for assistance with the process of commercialisation. Three activities can be suggested. First, cross-cutting training courses that bring in staff from several projects at once and train them in various aspects of commercialisation. Second, research and dissemination of results to recipient organisations about current commercialisation practice and about protection of core organisational functions and capabilities during commercialisation. Third, creation of a commercialisation organisation which would pick up technologies from project institutions and help to commercialise them.

Sustainability

For activities to be continued beyond the life of the project, skills, equipment, and an institutional setting must be maintained. A substantial breadth and depth of skills is often created by donor-funded technology projects. These are likely to be maintained in the medium term, but their development depends on the way in which institutions react to the various political and financial pressures upon them. These latter pressures mean that there are rarely clear plans for the purchase of replacement equipment, thus limiting the potential for project development.

6c. Underlying Project Agendas

Picking up an issue described earlier, one can place the blame for spending project funds on hardware rather than software on attitudes to piracy and availability of pirated programs. However, there is a deeper rationale that this suggests, which touches on many of the issues of technology transfer. This is the tacit complicity that can exist between funders and recipients about the use of project funds and, more, the objectives of aid projects.

For the recipients, funding can be spent on a wide variety of things but, in situations of capital shortage and, perhaps, import constraints, what recipient managers want more than anything is imported equipment which is flexible enough to be used for a variety of purposes other than just meeting project objectives. Computer hardware fills this niche perfectly and represents a solid contribution to organisational sustainability. It is an input to organisational efficiency or income generation that will survive well beyond the narrow confines of the project at hand and that will thus create a mechanism for organisational sustainability. As a result, all project budgets had seen a greater or lesser transfer of money from other budget heads into hardware.

Funders comply with this hardware focus, even if it may not exactly match the requirements of the project at hand because they know two things. First, that contributions to organisational sustainability may be of critical importance in the volatile polity that characterises the public sectors of many developing countries. Second, that aid funding seeks to win political influence as well as achieve immediate project outcomes. Acceding to the desire of recipient managers to buy hardware is one way to ensure that local stakeholders are satisfied by the project and, hence, by the aid agency. Political capital for the agency therefore ensues from investments in IT capital for its projects.

Of course, from this revelation of the political factors present within aid projects, we can understand two things about such projects. First, why evaluation of such projects is relatively rare - because recipient managers will strongly prefer that funds spent on evaluation are, instead, spent on 'kit': on physical equipment; and because evaluation will tend to expose shortcomings in the rational and objective purposes of such projects when, in fact, the projects serve other, more subjective purposes.

Second, it can help us to understand why recommendations from evaluatory exercises are often difficult to implement. Evaluation tends to take a rational approach, which will miss out subjective/political factors that are critical to understanding how and why projects operate. Recommendations may therefore be inappropriate to the 'real world' of the project.

Now, all of this discussion tips the balance too far in favour of a rather cynical interpretation of the political and the subjective. Self-interest abounds within technology transfer projects, but that self-interest can be aligned with broader organisational objectives. In most situations, there will therefore be both funder and recipient stakeholders who will both recognise the issues presented above as shortcomings and will wish to rectify them in order to improve the process of technology transfer and the accumulation of technological capabilities within local organisations.

For them, a relatively straightforward and rationally-conceptualised framework for evaluation will provide a useful tool: we hope that the life-cycle approach provides such a tool. Nonetheless, it represents a tool that must be used with a sensitivity to underlying agendas and to the underlying social and political context within which all donor-funded projects are situated.

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