



From Technology Transfer to Strategic Acquisition of Technological Capabilities

Lessons from African Information and Communications Technologies Firms

Introduction

This chapter will argue that developing country firms can move from ‘technology transfer’ to strategic acquisition of technological capabilities from external sources. The analysis presented here suggests the processes through which developing country firms can acquire technological capability inputs from external sources when these firms take account of the industry-specific nature of technological change, analyse the endogenous factors that influence their ability to accumulate technological capabilities through relationships with suppliers, and design specific requirements relevant to the industries in which they operate.

It argues that the requirements for service sector firms will differ from those of manufacturing firms. These insights emerge from the application of the technological capability building (TCB) system approach, which was the conceptual framework developed in a study of technological capability accumulation by twenty-six firms in the telecommunications sector of four African countries—Uganda, Ghana, Tanzania and South Africa.¹

In this approach, TCB is understood as a process of assembling or accumulating technological capabilities. It is treated as an investment activity, which is not linear, sequential or orderly and which is not necessarily overly influenced by exogenous or contextual factors. Firms are the unit of analysis, and the processes by which they built TCB systems, defined as a set of integrated processes and mechanisms that are used by firms to build technological capabilities over time, are centre-stage. The conceptual framework suggests that a firm's TCB system consists of five components, namely:

1. allocation of financial resources;
2. management practices, systems and decision-making rules;
3. practices to establish and maintain facilitating leadership and organisational culture;
4. accessing external technology capability resources from suppliers; and
5. accessing technology capability resources from the innovation system (local and global).

This approach further suggests that in an *ideal system for TCB*, there is a systematic and balanced operation of these five elements. A well-developed TCB system is necessary and sufficient to increase the existing stock of technological capabilities in a firm, defined here to include both person-embodied and non-person-embodied capabilities (such as capital equipment, software, and codified knowledge systems). Firms with underdeveloped TCB systems are expected to perform poorly in capability accumulation.

This framework was applied in the empirical study of capability development by developing country firms, and the research themes explored included the firms' relationships with external suppliers. The study offers insights into technology acquisition processes of developing country firms, more commonly referred to as *technology transfer*.

The chapter is organised into four sections: a review of the dominant theoretical explanations of what developing countries can do to improve their performance in 'technology transfer'; an exposition of the process of technology acquisition suggested by the TCB system framework; an analysis of the performance of twenty-six African telecommunication operating firms in acquiring technological inputs from external sources in light of the TCB system approach; and the insights that emerge from this analysis.

Existing Concepts and Evidence of Technology Transfer

Technology transfer: A Misnomer

Despite its widespread usage, the term *technology transfer* is problematic since it suggests passivity on the part of firms. By using the term transfer rather than acquisition, conventional researchers, perhaps inadvertently, impose a frame in which the role of developing countries is that of a recipient of imported technology (usually equipment), rather than that of an active economic agent searching for technological solutions. Farrell² and Vaitos³ criticise the implicit assumption of passivity on the part of the recipients and purchasers of technological inputs and offer an alternative—commercialisation of technology. The TCB system framework prefers the term *technology acquisition* and defines this as the range of activities that are likely to be necessary for firms in developing countries to source, purchase, install, test, and commission equipment and related services from international suppliers. In the rest of this section, the term *technology transfer* is retained to reflect the usage by contributors to this field.

Deconstructing Technology Transfer Processes

Technology transfer usually consists of commercial transactions in which a bundle of technological inputs—equipment as well as technical services, such as technical assistance, construction, engineering and related services — is exchanged.⁴ The prevailing view in academic literature is that developing country firms do not fare well in these transactions since equipment suppliers often lock developing countries into contracts of long duration and provide technical services at inflated rates. Reddy reports that technological equipment (artefacts) transferred by international firms were, on average, four times older than those used in the home country of the transnational corporations (TNCs). It is not only developing country researchers who have provided fuel for a less than positive assessment of the results of technology transfer. Research conducted from the point of view of the ‘home country’ of the TNCs has also suggested that only mature technologies should be transferred.⁵

Pavitt⁵ points out that technology transfer is best understood as a process involving the cumulative flow of codified and tacit knowledge. Bell and Pavitt⁶ take the implications of these characteristics further by suggesting that since tacit knowledge transferred is usually “firm-specific information concerning the characteristics and performance properties of production processes and product designs”, recipients would normally be obliged to devote substantial resources to assimilate, adapt, and improve upon the original technology. These authors also point out that the environmental conditions facing developing country firms, such as poor supply conditions for resource and knowledge inputs and institutional immaturity, are not conducive to sourcing external technological inputs. Studies of technological capability development in sub-Saharan Africa amply demonstrate this point for firms in this region.⁷

Technology transfer takes place in a variety of modes and at different levels within recipient firms. The main distinction is between equity-based (direct foreign investment and joint ventures) and non-equity based (licensing, franchising, management contracts, marketing and

technical service contracts, turnkey contracts and subcontracting) modes of technology transfer. In the former, technology transfer takes place via intra-firm relationships and, in the latter, it is characterised as an arms-length relationship between the recipient and transferring firms. Empirical trends for the 1980s showed that Direct Foreign Investment still accounted for the largest share of technology transfer, as measured by receipts for technology royalties, fees and technical services in the 1980s, although the context in which technology transfer takes place has changed significantly.⁸ Technology transfer also takes place through trade by importing machinery or by exporting to buyers who provide expertise.⁹

Developing country firms are likely to face specific barriers since they often engage in technology transfer across national borders. They must respond to the need to adapt technologies to local conditions as well as the differences in infrastructure between home and host locations, and distance and communication costs.¹⁰

Critical Success Factors in Technology Transfer

Hoffman and Girvan¹¹ argued that greater selectivity in policy intervention and improvements in the management of technology transfer at the national level within developing countries were possible solutions to the risks associated with the lack of genuine technology transfer. These authors also consider technology transfer to be a variegated process involving exchange of information, materials and people and explicitly recognise that the outcomes produced in technology transfer processes vary.

Studies of technology transfer suggest that firms that have been able to successfully manage technological acquisition incorporated the following elements:

- Training and learning components in technology transfer agreements and an explicit focus on acquiring various combinations of design, engineering and project management technologies.^{9,12}

- Sponsoring or otherwise encouraging overseas postgraduate training and work experience for engineers and managers, enabling them to acquire problem-solving skills and aptitudes and to gain access to informal international networks.¹³
- Establishing knowledge-acquiring operations, such as R&D centres or technological learning outposts, overseas.⁹
- Using management practices, corporate culture and leadership styles that facilitated efforts to jointly manage technology importation and local capability development activities.¹⁴ Although many studies indicated that there are likely to be long-term benefits from implementing complementary approaches, empirical studies are still relatively rare.¹⁵
- Concentrating on a wider range of activities than those associated with passive importation of technological inputs and having an awareness that passivity might lead to increased domestic production output and improvements in static efficiency but unlikely to make a contribution to learning activities.

Bell and Pavitt⁶ argue that it is possible for firms to develop effective systems for importing foreign technologies in combination with efforts to develop local technologies and to build technological capability. In their ideal-type, imported techniques and practices do not “crowd out” local technology and domestic capability building. However, these authors noted that few countries were able to implement policy regimes that supported complementarity between domestic technological capability development and acquisition of technology from abroad; instead, the majority of developing countries approached these modes of capability development as substitutes. Bell and Pavitt⁶ present a wide range of sources of imported technology, including direct foreign investment (joint ventures), sub-contracting, original equipment manufacturing (OEM) agreements, licensing, and contracts for know-how, designs, equipment and services. They observe that capability development may involve intensive efforts to improve and develop what is initially acquired, or more passive adaptation or minor modifications of imported inputs.

Linearity Assumptions

Lall¹⁶ characterises technology transfer as a process in which recipient firms, through a cumulative process, acquire capabilities of increasing levels of complexity. He suggests that firms move through four levels of technology transfer and acquire the associated capabilities, as shown in Figure 14–1. This sequential approach to technology transfer forms the basis of much of the conventional academic and policy writing on this important subject and has been influential in policy development. It is complementary to the linear view of technological capability development developed by the same author.

Figure 14–1: Levels of technology transfer in Lall’s framework

INNOVATIVE (advanced design)	Ability to develop next generation system
ADAPTIVE (technological self-reliance)	Ability to adapt product designs or reengineer production processes
DUPLICATIVE (intermediate)	Ability to expand output without further foreign assistance
OPERATIONAL (basic level)	Ability to manage/operate production facility designed and built by foreign partner

Source: Author, based on Lall,¹⁶ (Lall, 1992:167, Table 1), and Lall (1987:18, Table 1.1)

Stewart¹⁷ appears to accept this linear model and uses it to offer a pessimistic view of the impact of technology transfer on development. She argues that technology transfer between industrialised countries and developing countries is not well-suited to promoting equitable development and balanced growth in the importing country. For Stewart, since transfer involves the importation of technologies that have characteristics more suited to the home market where the technology was developed, the process can (and often does) result in the development of a dualistic society. She also argues that since only a few developing countries have been able to manage technology transfer effectively, technology transfer does not result in increased productivity, support for local technological effort and/or distribution of benefits to the majority of the population. Based on evidence from the 1980s, she also states that sub-Saharan African countries present the most

obvious example of the negative consequences of technology transfer. Stewart¹⁷ concludes by suggesting that developing countries should adopt a staged process to improve their management of technology transfer. Borrowing from Lall, she argues that a linear model of capability development and technology transfer is useful since it defines, for the developing country firm, the objective of moving phases of transfer:

“[mounting] the ladder of full assimilation . . . because higher stages permit more efficient operation of technology . . . indicates increased local technological capability, and therefore increased ability to assimilate other technologies efficiently and to acquire and bargain over new transfers, and . . . to control the direction of technological change.” (Stewart¹⁷ p. 309).

As will be discussed in greater detail in the next section, the TCB system approach, consistent with work by Bell and Pavitt,⁶ Ernst et al.,¹⁸ and Kim,¹⁰ adopts a non-linear process of technology acquisition. In this approach, the balance of interest between suppliers and buyers of technological inputs is assumed to be forever changing. This theoretical position is supported by evidence in Hoffman and Girvan,¹¹ which shows that recipient countries have exercised greater degrees of freedom in managing the terms and conditions of technology transfer.

Technology Acquisition in the TCB System Approach

The TCB system framework draws on insights from existing research and carefully considers, in particular, theoretical contributions from Bell and Pavitt,⁶ Hoffman and Girvan,¹¹ Lall,¹⁷ and Stewart;¹⁸ reviews of research on technology transfer from Boseman,¹⁹ Kumar and Siddhartan,²⁰ Radošević,²¹ and Reddy;⁴ and empirical work reported in Kumar.⁸ It is worth noting that much of this research is located within the manufacturing

sector and does not extend to intra-firm processes. The study on which this essay is based specifically focuses on aspects of these lacunae, by examining intra-firm processes of service sector firms. This conceptual framework also builds on insights from an emerging body of work that recognises that intra-firm learning processes and the experiences of non-technology-producing users may have important lessons for understanding the capability-building processes of developing country firms.²²

Technology Acquisition as a Non-linear Process

The TCB system approach accepts the notion that levels or stages of technology capability may be useful as an organising *rubric* to describe distinctions between kinds of capabilities, but regards the *stages* model of technology transfer as being less useful.

Several reasons are advanced in support of an alternative model of technology acquisition, which relaxes assumptions of linearity associated with the stages model. First, by refuting the assumption that developing country firms have an inevitability or increasing desire to move to ever “higher levels of transfer”, it allows consideration of capability development objectives, other than *generating technology*. Second, it provides for a wider range of policy guidance, augmenting the recommendations that focus only on how developing country firms can gain access to the proprietary technologies associated with “higher stages” of transfer. In the non-linear TCB system approach, there is a focus on policy interventions that can provide incentives for technology acquisition and increase mutual benefit to the actors in technology transactions. Third, the TCB approach focuses on what recipient firms must do to progress from operational to innovative levels of technology transfer and considers what specific factors limit or facilitate such movement at the intra-firm level. Fourth, the foreign partners in the TCB system approach are not considered, by definition, to be detrimental or beneficial to the accumulation of more advanced abilities by developing country firms. Instead, their role is considered to be an input to a process of capability development. The relationship between developing country firms and foreign

suppliers is considered to change over time; for example, it is assumed that the knowledge, skills and equipment provided “with foreign assistance” can be substituted by local capabilities as firms acquire more advanced capabilities. Fifth, in this framework, the nature of the technology plays a crucial role in defining the transfer relationship. In many early studies, the imbalance in capabilities between recipient and transferring firms, rather than technical change, was the major focus of attention. By not including technology specific factors, several important aspects of technology acquisition and the potential for strategy on the part of recipients were missed.

Finally, the TCB system approach regards variation as important in the ability of firms to manage technology transfer. When acquisition of technology takes place in a context where technological knowledge is mature, unchanging, and available from public sources, and the technological frontier at which innovative activity takes place (defined as the ability to generate next generation systems) is within the grasp of developing country firms, some of the assumptions of linearity hold. However, in more challenging contexts of technological change, alternative explanations are required. In light of these observations, the conceptual framework for understanding technology transfer relaxes most of these assumptions of linearity and is therefore more likely to be relevant in a wide range of contexts.

Integrating External and Internal Capability Development Processes

The TCB system approach recognises that, for the majority of developing country firms, importation of technological inputs is a major source of capability development. Internationally operating firms or local branches of such firms are the main source of supply of technological inputs, and developing country firms use a variety of mechanisms to acquire technological capabilities from external sources. The types of mechanisms include: selecting suppliers; procuring equipment and services from external suppliers under suitable terms and conditions; and

integrating this supply process with other aspects of technological capability building. Reliance on imported technological inputs is considered necessary, because the local innovation system in the majority of developing countries does not provide adequate sources of advanced technological knowledge, equipment, software and technical services.

The TCB system approach emphasises the need to balance indigenous capacity development with the importation of know-how and suggests that to effectively manage the interface with suppliers, firms must draw on many other capabilities. It is expected that firms that have developed capabilities to manage and process change, to develop leadership and culture that support learning and specific management practices to manage learning, will be more adept at acquiring technological inputs from external sources. In this framework, the ability to deploy cultural, leadership and change management strategies, is referred to as “internal processes” for building technological capabilities. In the technology transfer literature, these capabilities are referred to as “absorptive” capacities, or the ability to “manage technology transfer”. The TCB system approach extends the concept of absorptive capacity by specifying mechanisms used to manage boundary relationships, such as those with suppliers, and mechanisms that improve the ability and willingness to search for technological sources, and the ability to integrate new varieties of technology. The framework also extends the understanding of critical success factors for acquisition of technology by focusing on the individual human aspects of technology acquisition processes. These features have been treated extensively in the organisational development literature, but have received relatively little attention in the ‘technology transfer’ literature.²³

Constrained Agency Arising from Technical Change and Industry Features

The effectiveness of developing country firms acquiring technologies is considered explicitly to be under the partial control of these firms. Other important factors, such as the willingness and ability of external

suppliers to play a role in capability development and the nature of the technological inputs that the developing country firm is seeking to acquire, will also matter. Therefore, the technology acquisition process is considered to be a boundary relationship in which developing country firms exercise *constrained agency*. The firms are not completely passive actors at the mercy of TNCs, but they are also not fully in control of the extent to which they can maximise capability development objectives using externally acquired inputs. This characterisation has features in common with the treatment provided by Bell and Pavitt.⁶ The amplification provided by this approach is that it provides a detailed analysis of the conditions that influence the acquisition of different types of capabilities, and emphasises industry specific factors as one of the explanatory factors.

The limitations and opportunities for making effective use of supplier relationships for technological capability building are expected to be derived from the nature of the specific technological inputs being sought and the willingness and ability of supplier firms to provide these inputs. In the conventional technology transfer field represented here by Lall¹⁷ and Stewart,¹⁸ developing country firms are often assumed to have less access to technological inputs as a result of the concentration of innovation activity in the industrialised countries. The secular trend of the increasing concentration of innovation activity is not questioned here, but an alternative reading of its consequences for developing country firms is offered. It is argued that while the inputs for generating radical innovation may be affected by this trend, many of the capabilities that are required by developing country firms are likely to be unaffected by concentration in innovative activities. Therefore, the majority of developing country firms that do not operate at technological frontiers are unlikely to be constrained by the increasing concentration of innovative activity.

Many of the early studies of technology transfer focused on the manufacturing sector, where firms in developing countries were seeking to produce the same output (at a lower cost) as their suppliers. The trend for radical innovation and incremental innovative activity to be

increasingly concentrated in large, transnational corporations that invest heavily in professional R&D facilities and other supporting infrastructures, and that seek to appropriate returns through the enforcement of intellectual property rights, would have an impact on the manufacturing sector. This threat of the extension of proprietary rights to production technologies may have been overstated. In service sectors, the purchaser of imported inputs often does not directly compete with their suppliers, and the threat of non-disclosure of technological functionality, etc., is therefore reduced.²⁴

This approach takes account of the trends identified by Bell and Pavitt,⁶ such as the increasing specialisation in many technological markets. They note that this has led to an increase in the sources of technological inputs, particularly for processes other than radical innovation. For instance, there are many more suppliers of codified knowledge and there have been increases in the number of specialised suppliers of equipment. Other factors that may facilitate access to external inputs include increased international migration of skilled labour and information and communication technologies that assist in the technological search process. The TCB system approach also considers that technological change has implications for the relationship between suppliers of technological inputs and their customers. In the telecommunications industry, a specific technological change, which has major implications, is the increases in the embeddedness of knowledge within equipment.

By presenting a more detailed analysis of the types of technological capabilities that are likely to be desired by developing country firms, and by considering the constituent elements of technological capabilities, the TCB system approach provides a more nuanced analysis of the technological acquisition process. The approach specifically considers that international suppliers can provide only a subset of the capability inputs required from external sources. Suppliers operating in commercial markets are likely to be able to supply tacit and codified knowledge, software, equipment, etc., but cannot provide the supplier management capability that firms require to integrate these inputs. A fully operational capability to manage supplier relationships requires

active investment and components that cannot be provided by suppliers. Effectiveness in managing supplier relationships includes the ability to search for alternative sources, to negotiate supply on appropriate terms and conditions and to integrate external inputs from a variety of sources.

Another key feature of the TCB system approach to understanding the role of technological acquisition in capability building is the emphasis on understanding how the changing nature of the relationship between supplier and user and the technological characteristics of the inputs affect the process of technological acquisition. For example, sector specific studies on capability development in the telecommunications sector provide useful insights into how the acquisition of capability inputs from external sources is impacted by industry-specific factors and technological change.²⁵ Conventional studies of technology transfer often do not adequately take these factors into account.

Evidence from African Telecommunications Firms

Supplier Selection

Operating companies in the sample considered cost effectiveness, product functionality, depth of technological knowledge, technical support, track record in similar markets and speed of delivery to be among the most important criteria. The sample firms with well-developed TCB systems expressed the importance of having defined criteria and supplier selection systems that included technology assessment and evaluation mechanisms, whereas firms with underdeveloped TCB systems did not. There was a reasonably good fit between the criteria reportedly used by operating companies and the perception of their suppliers. The analysis of empirical results also confirms that operating firms did not consider the ability to generate products with a high

degree of technological novelty as an important criterion, but placed more emphasis on commercial abilities and the execution abilities of their suppliers. Wherever there were technical criteria, they were in terms of the functionality of the equipment that would be supplied. Embeddedness of knowledge and information in equipment was one of the features of technological change in the telecommunications industry that influenced the acquisition of capability inputs from suppliers of equipment. The companies reportedly used as suppliers are shown in Figure 14–2.

Figure 14–2: Identifying important suppliers of equipment and services

Company Name	Number of operating companies
Ecrisson	4
Alcatel, Cisco, Lucent, NEC, Scientific Atlanta	2
Advent, Airspan UK Ltd (formerly DSC), AT&T, BBC, BT, Digital Equipment Corporation, Divicom, ITELCO, MAS, MCL, Mitsubishi, MSI, NDS, Nortel, NTL, Plessey, Siemens, Tadiran, Varian, Fujitsu, Hughes Network Systems, Iredeto, Iridium	1

N=16 operating companies

Specific Mechanisms for Acquiring Technology from Suppliers

Eleven firms provided data on the specific mechanisms used to acquire information, know-how and skills from their suppliers of equipment and services; these data are presented in Figure 14–3. Analysis of these data suggests that the formation of joint network design teams with suppliers, as well as tendering and bid evaluation processes, were used by the highest number of sample firms for technology acquisition. Exclusive product demonstrations, long-term attachments at the suppliers’ site and interaction through social networks were among the mechanisms that were each used by one firm. There were variations among firms, according to the size and level of development of the TCB system. For example, one large national telecommunications company reported a very different pattern, insofar as the company placed its emphasis on

transfer during field trials and procurement, rather than via provision of regular training programmes.

Figure 14–3: Specific routines used for technology transfer from suppliers

Technology Transfer Mechanism	Frequency (# of firms reporting usage)
1. Formation of joint project teams for network planning	4
2. Tendering and bid evaluation processes including development of technical specifications	4
3. Intensive use of supplier technical support hotline	3
4. Regular communication at functional middle-level management with international and local divisions of supplier firms	3
5. Short-term contracts for expatriate engineers from supplier companies during testing & commissioning on site in African country	2
6. Training on specific equipment provided at supplier premises in South Africa (REGIONAL CENTRE)	2
7. Training on specific equipment provided at supplier premises in Sweden	2
8. Technical support services provided by supplier staff on operating company site	2
9. General technological training courses organised by suppliers and delivered overseas	2
10. Know-how transfer projects managed as part of procurement and equipment trial processes	2
11. Designation of executive with overall responsibility for managing supplier relationship	2
12. Long-term attachments with supplier companies on their premises	1
13. Shared social networks	1
14. Exclusive product demonstrations	1

N= 11 operating companies

Specific and Complementary Routines for Managing Supplier Relationships

Firms are not *born* with the ability to manage supplier relationships. The development of *boundary management competencies* required active investment and the implementation of routines to strengthen:

- the ability to evaluate technological capability requirements;

- the ability to scan and search, which incorporates the ability to investigate and understand technological trends, and the ability to select high-quality sources of technological inputs on appropriate terms and conditions; and
- the ability to integrate external inputs.

Only seven out of twenty-six firms used formal evaluation and/or scan and search routines. These seven firms had well-developed TCB systems, consisting of a wide range of TCB mechanisms, and they also paid attention to the integration of all capability development activity. South African operating companies were the most intensive users of formal technology search and evaluation techniques, with five out of the firms operating in South Africa reporting the use of these mechanisms. The relatively large size of the South African companies may be an explanatory factor here, since scan and search activities require a critical mass of highly skilled technical personnel. The other distinctive feature of the large South African operating companies is that their network development was funded independent of bilateral or multilateral development assistance, whereas in Uganda and Tanzania, the large public network operators did not operate independent search and scan mechanisms. It may be, as reported by the interviewees, that these firms were not able to exercise a choice in the selection of suppliers, but were obliged to use the suppliers named by the financiers. This characteristic was also the case for the Ghanaian public operator prior to privatisation.

In addition to the South African companies, two other companies in the sample reported using formal search and evaluation techniques. These two firms were *outliers* in their active approach to capability development. The Ugandan company had a technology and operational strategy that was closely influenced and directed by its major shareholder—a large South African company with operations in other parts of the continent. In the case of the other outlier, a small Tanzanian data-communication company, the implementation of formal search and evaluation techniques was linked directly to the corporate culture of the firm. This company was part of a group of companies founded

by young Africans, including MIT engineering graduates. The background of the founders, their interest in technological sophistication, their vision in promoting innovation, and their direct involvement in influencing technological strategy had enabled this small company to extend its boundaries beyond the limits imposed by its small size and the deficiencies of the local innovation system.

If informal scan and search routines, such as attending trade fairs and exhibitions and participating in different communities of interest (professional bodies, trade associations, working parties of regional and international organisations) are included, the number of firms increases to eighteen. The pattern for use of informal mechanisms differed from that for formal mechanisms in so far as there was wider representation from Ugandan, Ghanaian and Tanzanian firms. For example, a small Tanzanian private network operating company reported that its owner used trade fairs and exhibitions as a cost-effective mechanism for acquiring technological information. The owner of the firm, a technological pioneer in Tanzania, reported that he took direct and personal responsibility for this activity, drawing on his technological background in aviation and aeronautical engineering, which he used as a foundation to expand into telecommunications. Another example comes from a small Ghanaian data communications company, whose spokesperson reported an exceptionally high usage of these informal mechanisms. This firm was an active participant in technological development at the regional and international levels. The background of the founder of this business was as a professional engineer with more than 20 years of private sector overseas experience in the United States and active involvement with the United Nations development agencies as a technical assistance provider. This may account for the permeability of this firm's organisational boundaries and its high propensity to be actively engaged in technology scanning and search activities. The other intensive users of these informal mechanisms were large public network national operators in Uganda and Tanzania and the national mobile operators in South Africa.

However, the explanations for the observed patterns differ for these two groups. For the former, active participation in industry associations

and in the working parties of the African Telecommunication Union, Commonwealth Telecommunication Organisation and the International Telecommunication Union, was reported to be an important means for independent assessment of technological trends and the evaluation of suppliers. These regional and multilateral bodies were considered by interviewees to be ‘honest brokers’ since they did not fund network development, but instead were mandated to share information about appropriate technological choice and to provide information on equipment standardisation. Conversely, for the two national mobile operators in South Africa, participation in industry associations was said to focus on groupings such as the GSM Association, where employees engaged in the development of standards for particular technologies on an equal footing with the other participants. The relatively strong standing of the South African participants is demonstrated by the fact that employees of one of the operators had held international office in the GSM Association at the time the data was collected.

Another community of interest, which appears to have been an important source of external inputs, is the strategic investors and shareholders in the operating companies. Even companies with only moderate development of their TCB system and those with no discernible TCB system reported that they maintained regular communication with regional headquarters, sister companies and shareholders as a means of gaining external technological input. There were some large companies, particularly in Ghana, that used formal mechanisms for acquiring technological inputs and expertise from shareholders and strategic investors, including long-term attachments for local staff at the site of the investors and formal training courses organised by the investor companies.

In summary, the evidence drawn from interviewees shows that the sample firms engaged in activities that were designed to develop their scan and search capabilities. The foregoing analysis suggests that variations in the use and implementation of these mechanisms are related to features, such as size, organisational culture and leadership.

The TCB system approach suggests that the ability to integrate externally sourced technological inputs is likely to require *complementary*

capabilities if firms are to benefit from boundary relationships.²⁶ As noted in the earlier discussion of the conceptual framework, these features tend to be discussed in organisational development theory, but ignored by economists examining technical change and innovation. Empirical evidence supported this proposition; sample firms were found to be ineffective at supplier management when complementary aspects of technological evaluation and integration were not in place. In particular, firms that created conditions for experimentation, reinforcement of knowledge and promotion of higher-order learning were better able to integrate external inputs. Among the sample firms were those with explicit technology strategies, which considered themselves to be world-class as well as the technologically active outlier firms, as discussed earlier in this section. There was also a large Ghanaian firm that had focused its competitive strategy on the development of the technological competencies of its people. This company focused its evaluation efforts on formal needs-assessments. Similarly, firms that demonstrated a high level of competence in integrating external inputs were also those that exhibited advanced competencies in management development and practices, such as a clear definition and assignment of responsibilities.

Role of Human Factors in Accessing Tacit Knowledge

Evidence from the sample firms confirmed that supplier relationships were an important source of technological capabilities. In particular, these contractual relationships were used to acquire equipment, software, and *codified* knowledge and information in the form of equipment handbooks, training course materials, maintenance procedures and protocols. Although the equipment component typically accounted for a large percentage of the reported financial cost, contracts usually included elements of non-embodied capability. While the majority of the sample firms used traditional delivery mechanisms for accessing codified knowledge and information, a few firms augmented these with information technology tools, such as hotlines and web-based technology support. Traditional and computer-assisted mechanisms seem to

have provided operating companies with access to factual information on equipment functionality and specifications, maintenance routines and equipment and software upgrades.

Embodied capabilities were provided when suppliers organised training courses and technical support and services. A variety of mechanisms were used for the transfer of embodied capabilities, which ranged from formal classroom-based instruction at the operating company site to long-term attachments of operating company staff at the site of the supplier. Other mechanisms used by the sample firms included visiting supplier premises and reference sites, establishing joint project teams for network development, and using consultants and specialists from suppliers on short-term technical assistance assignments. The most significant characteristic of these mechanisms was that they involved the exchange of *tacit* knowledge and information between supplier and operating company. Due to the importance of the tacit component of knowledge flow, these exchanges took place using both formal and informal mechanisms, and their effectiveness of exchange appears to have been highly dependent on design and implementation. Tacit knowledge and information exchanges require trust between parties, acknowledgement of the contextual characteristic of knowledge and information, and shared meanings. As a result, the design of the exchange mechanisms that was sensitive to these characteristics would require considerable skill on the part of both the operating companies and the supplier firms.

The features of technology acquisition exchanges that appeared to improve effectiveness, particularly for transfer of tacit knowledge components, included mechanisms for:

- Selecting training instructors and “experts” who had up-to-date knowledge sets, sound fundamental technological training, good communication skills, and experience in similar operating contexts.
- Ensuring that there is regularity of contact over all phases of network development and operation and not limiting the tacit knowledge and information exchanges to commissioning and testing phases.

- Organising joint ownership of the technology acquisition objectives expressed in the design and staffing of project teams and the breadth of the activities that are assigned to buyers of technological inputs.

Other characteristics of managing supplier relationships, which reportedly contributed to the effectiveness of the sample firms' TCB efforts, included:

- The ability of personnel in the telecommunication operating companies to maintain strong social networks with the staff of supplier firms;
- Maintenance of regular contact between the staff of the operating companies and the supplier firms at all levels of hierarchy, ranging from global executives to local managers;
- Implementation of mechanisms that foregrounded joint learning, such as through equipment trials, where suppliers and operating companies were actively involved in understanding technology requirements and specifications, prior to full commercial deployment; and
- Implementation of tendering processes that resulted in maximum disclosure of codified information and provided opportunities for intensive communication between suppliers and users.

When there were weak search and scan abilities, the operating companies in the sample were less able to select suppliers that were skilled in the design of technology dissemination projects. The involuntary lack of control over choice of suppliers, on the part of the operating company, had the same effect as weak scan and search capabilities by artificially restricting suppliers. This lack of control over the design of technology acquisition projects appears to have limited the effectiveness of the exchange of codified and tacit information flows and, particularly, hampered the flow of tacit information. Another important design flaw was caused by the misconception that technology acquisition was limited to commissioning, testing and installing equipment. Smaller firms in the

sample reported that they were hampered by their lack of critical mass of qualified and experienced personnel and their inability to make appropriate selections to staff technology acquisition projects.

Impact of Technological Change

The sample firms' reliance on global market leaders as an important source of external technological inputs appeared to be related to the following features of technological change in the telecommunications industry. As more knowledge and information is encoded or embedded in equipment and software control algorithms, suppliers appeared to have been forced to become more expert in helping their customers to understand and use this sophisticated equipment. While this characteristic of embeddedness has the effect of making knowledge required for network management increasingly product (equipment/application) specific, it also increases the possibility for fine-tuning network performance characteristics through software changes. This increasing embeddedness of knowledge in equipment has meant that the supply of embodied and non-embodied elements of technological capabilities in the telecommunications industry has become increasingly coupled. This trend has had the effect of reducing the importance of intermediaries and information brokers as sources of external technological inputs. Telecommunications operating companies expect their suppliers to design and support equipment with appropriate functionalities and to understand the operational context in which that equipment will be used.

There has also been a rapid and accelerating pace of technological change in telecommunications systems, subsystems and sub-components, which has led to the need for regular, continuous interface between suppliers and operating companies. The pace of change has also had some negative consequences, in that it has created artificial crises spurring operating companies into continuous rounds of technological upgrading and "improvement".

As a result, the high levels of software controls used in the switching and access networks and the high information and knowledge content

coded in equipment (devices and components) have resulted in IT and project management becoming core competencies for telecommunications network operating companies. All professional technical employees and particularly those in specific functions, such as network management and optimisation, are required to have high levels of IT literacy.

In summary, the effect of technological change in the telecommunications industry has led developing country firms, such as those in the sample, to be more likely to use a single supplier firm as a source of external technological inputs. The single source of supply is likely to allow operating companies to take advantage of the coupling effect of having access to non-embodied capabilities and embodied capabilities. These long-term, one-stop supplier relationships were common among the sample firms, but did not necessarily lead to the deleterious effect on access to technological capabilities that was implied by conventional studies on technology transfer. There appeared to be potential shortcomings in the single-supplier mode, especially for firms without technological evaluation capabilities, insofar as the operating companies could be persuaded to make regular upgrades in technological inputs at a pace determined by their supplier, rather than at a more measured pace in line with their capacity to direct and absorb the integration of these inputs. Technological change also led to the emergence of at least two areas of core competence—IT and project management.

Impact of Specialisation and Concentration of Innovative Activity

The findings confirm that the sample firms, including those with extensive search routines, frequently used global market leaders as their suppliers (these firms were those that had led the trend to concentrate innovative activity, as measured by R&D, patents, etc.) in the equipment industry. The suppliers used by the sample firms mainly included market leaders and second-tier equipment suppliers. The evidence does not provide support for a view that developing country firms were active in diversifying their suppliers. The qualitative accounts suggested that the operating companies in the sample did not favour smaller or alternative

sources of supply. Where small companies such as Tadiran, the Israeli-based company, were used, these firms were often niche market leaders in specific segments, such as wireless in the local loop access network components and systems. This pattern is consistent with the nature of competition in the telecommunications equipment supply industry.

Put simply, the global market leaders were willing and able to provide the operating companies with access to up-to-date equipment and the technical services required to efficiently develop, deploy and maintain networks based on that equipment. Therefore, these global market leaders were the suppliers of choice of the operating companies. The evidence from the sample firms does not support the view that implementing search routines leads to greater diversification. Ironically, for the operating firms where there were multiple sources of technological inputs, this was involuntary and was imposed by multilateral agencies and heavily criticised by the purchasers. The qualitative accounts, however, do support the argument that the firms that had developed routines for technology needs assessment and integration of external inputs were better able to manage their single-supplier relationships.

The telecommunications operating companies in the four developing countries in this study selected a limited range of companies to supply their key technological inputs. While the operating companies appeared not to have an interest *per se* in the innovative performance of the supplier companies, their keen interest in functionality and standardisation of equipment led to a *de facto* limit on the range of supplier sources. This is the same outcome as if they had been explicitly interested in choosing only those companies with relatively strong innovation performance. The limited range of suppliers does not appear to have affected the ability of these developing country firms to exercise 'constrained agency' in acquiring technological inputs from these firms. This may be explained by the interest of the global market leaders in increasing their effectiveness as suppliers of non-embodied and embodied capabilities.

The suppliers to the sample firms appeared to perceive that their success in winning business from the telecommunications operating

companies in Africa was dependent on their *responsiveness* to the business needs of these companies. The perception that it was important to have joint ownership of technological development objectives between suppliers and operating companies was indicated by the inclusion of such features as the ability to jointly plan and manage network deployment and operation among the list of critical success factors reported by suppliers.

What is perhaps even more interesting is the evidence that the supplier firms were themselves investing in organisational systems that may improve their ability to be responsive to the technological development objectives of their developing country customers. For example, one of the supplier firms provided evidence that it had developed specialised career paths for technical assistance experts who were deployed to assist customers with network deployment and management. This company had also developed mechanisms whereby the employees of their customers could undertake formal certified training courses to achieve comparable levels of skill and expertise as the career network specialists of the supplier firm. There is also corroborating evidence that suggests that this company considered its ability to design these technology dissemination mechanisms as a source of core competence in all market segments, and had applied these business processes in developed markets.²⁷ The evidence from this research suggests that this company was extending implementation of these business processes to its developing country markets. The organisational innovations, which were perceived by supplier firms in the sample to be most effective, include:

- undertaking investments in their internal technological learning and facilitating knowledge dissemination;
- adapting business processes to increase knowledge and information flows between suppliers and users;
- regular and continuous interfacing with customers through a variety of formal and informal mechanisms;
- documenting the best practice mechanisms for knowledge dissemination;

- improving account management; and
- using computer-assisted tools for dissemination of information.

In summary, the changing nature of competition appears to be closely associated with the technological features of the products offered by these firms. Competitive success was considered to be increasingly dependent on the ability to assist customers in achieving their objectives and was believed to require organisational innovation to improve and maintain levels of responsiveness. On the evidence, it would appear that the global market leaders were satisfying their developing country customers in terms of their levels of responsiveness. This result suggests an interesting line of further research that would investigate whether relationships similar to the ones exhibited in the telecommunications industry are present in other sectors.

Limits on Suppliers as Source of Technological Inputs

Although equipment and service suppliers appear to have been an effective and significant source of technological inputs for the operating firms in the sample, there are indications of some types of knowledge inputs where these private sector companies were less useful. Private sector equipment and service companies provided non-embodied and embodied technological inputs that were required by operating companies, but were regarded as being less effective as sources of knowledge about fundamental scientific principles, basic technological training and understanding about the nature and direction of technological trends. The operating companies also had needs for this type of knowledge and information, which could not be satisfied through their relationships with suppliers. This “know-why” was probably more effectively sourced from innovation system institutions, such as universities, training colleges and research labs, as well as from policy and regulatory bodies. The empirical evidence also suggests that international and regional bodies might play a useful role in providing this information and knowledge.

Other communities of interest and practice also made an important contribution to supply this “know-why”.

Private-sector suppliers also did not seem to be particularly effective in providing access to knowledge and information about the best sources of codified and tacit knowledge needed by operating companies, also referred to as “know-who”. The communities of interest and practice referred to earlier appeared to be particularly good at providing independent assessments of competing sources of technological inputs, as were specialist information providers and organisers of trade fairs and exhibitions. To make use of these sources of “know-who”, operating companies had to have routines for evaluation and for searching and scanning. When operating companies used additional sources of external capability inputs, the equipment suppliers would be partners in technological choice, rather than taking direct ownership of this critical function. Private sector equipment suppliers would be unlikely to be an effective source of “know-who”, because they would be unlikely to provide objective assessments of the range of sources available. These results have policy implications for the design and functioning of national innovation systems.

Conclusion

Several key insights emerged from the study with relevance for public sector bodies as well as for strategic management of African ICT firms. First, the results suggest that African ICT firms should improve their capability to *manage* supplier relationships. Making these improvements is likely to influence whether developing country firms are able to benefit from access to external sources of technological capabilities. Effective management of supplier relationships was strongly influenced by endogenous variables, such as the level of development of the firm’s technological capability building system. In particular, the extent to which firms had acquired the specific competencies of technological

evaluation, search, acquisition, and integration appeared to strongly influence the ability of firms to benefit from commercial relationships with external suppliers. Complementary competencies that relied on human factors were found to be important for effective boundary relationship management, a component that is too often ignored in economics-based studies of “technology transfer”.

Second, the result that confirms that African ICT firms appear to exercise *constrained agency* in their management of supplier relationships is also important. This suggests that ICT firms in Africa, such as those in the sample firms, adopt technology strategies that are not concerned with being generators of radical technological innovation at the frontiers of technology, but have to do with improving the firms’ ability to use, operate and adapt state-of-the-art technological inputs in their production processes. Achieving these objectives require sophisticated user capabilities, some of which can be sourced through relationships with suppliers, and others that require internal development. In addition, it was found to be important to differentiate between the many different types of knowledge and to assess the potential value that supplier relationships can add in each case. These considerations are particularly relevant in the case of service sector developing country firms, where many components of technological capability are embedded in equipment.

An important conclusion of the study was that exogenous factors, such as technological change, increasing specialisation, concentration of innovation and the nature of competition also influence the contribution of supplier relationships to technological capability building objectives of ICT firms. On balance, the evidence suggests an optimistic interpretation of the effects of these exogenous factors. It provides illustrations of how large and small firms in the ICT sector in Africa can interact with global market leaders to the benefit of their technological objectives. The confluence of technological and market dynamics appears to be leading customers and suppliers to become keenly interested in the exchange of knowledge and this seems to be leading to more open dissemination and greater disclosure.

The empirical study outlined here confirms insights from research within the development studies field that suggest that external sources of technological capability need not crowd out domestic capability development. It extends this observation by highlighting the conditions under which the acquisition of technological capability inputs can advance the technological capability development objectives of developing country firms.

These results have important implications for public policy in such fields as Science and Technology Development, Industrial Policy and ICT policy. The evidence should also inform the intervention approaches of national science and technology institutions and international organisations that support capability development in ICT, such as the UN ICT Task Force. The analysis indicates that firms can improve technological capability accumulation by paying attention to supplier management as a *specific* aspect of capability development. It also suggests that there is considerable room for improvement in terms of how organisations in national systems of innovation assist firms to acquire knowledge that cannot be obtained from commercial sources.

Public-sector bodies in the national innovation system can play an important role in the capability building process by supplying complementary types of knowledge, “know-why” and “know-who”, for example, to support the search and scan capability of firms. To become more effective in this role, the national systems of innovation in developing countries will require considerable *strengthening* in terms of the range of institutions involved and the tools used to support capability development in firms.

Applying the TCB system approach can contribute to moving developing country firms from passive technology transfer to strategic technological capability acquisition. These strategies are particularly relevant for firms that wish to enhance strategic competitiveness and cope with rapid and fundamental technological change in the ICT sector. The empirical evidence has shown that African ICT firms can make this transition to strategic technological capability acquisition by being more effective in relationships with suppliers and the innovation system.

National and global innovation system institutions should support and enhance the efforts that are already underway by making firm-level investments in learning more effective.

NOTES

1. Marcelle, G. M. (2002). *Technological Capability Building and Learning in the Developing World: The Experience of African Telecommunications Companies*. Unpublished DPhil thesis, SPRU, University of Sussex, Brighton.
2. Farrell, T. M. A. (1979). *Do Multinational Corporations Really Transfer Technology?* Paper presented at the Integration of Science and Technology with Development: Caribbean and Latin American problems in the Context of the United Nations Conference on Science and Technology for Development, Miami April 6–8 1978.
3. Vaitos, C. (1975). The Process of Commercialisation of Technology in the Andean Pact. In H. Radice (Ed.), *International Firms and Modern Imperialism*. Harmondsworth: Penguin.
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5. See for example, Caves, R. (1996). *Multinational Enterprise and Economic Analysis* (2nd ed.). Cambridge: Cambridge University Press; Pavitt, K. (1985). Technology Transfer among the Industrially Advanced Countries: An Overview. In N. Rosenberg, and C. Frischtak (Ed.), *International Technology Transfer: Concepts, Measures and Comparisons* (pp. 3–24). New York: Praeger. and Walker, A., and Ellis, H. (2000). Technology Transfer: Strategy, Management, Process and Inhibiting Factors. A Study Relating to the Technology Transfer of Intelligent Systems. *International Journal of Innovation Management*, 4(1), 97–122.
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7. See for example, Cooper, C. (1994). Science and Technology in Africa under Conditions of Economic Crisis and Structural Adjustment, *UNU/INTECH Working Paper No.4*. Maastricht; Enos, J. (1995). *In Pursuit of Science and Technology in Sub-Saharan Africa: The Impact of Structural Adjustment Programmes*. London: Routledge and UNU-Press; Forje, J. (1991). The Three Decades of Africa's Science and Technology Policy Development. In M. Huq, P. Bhatt, C. Lewis, and A. Shibli, (Ed.), *Science, Technology and Development: North-South Co-Operation*. London: Frank Cass; Pickett, J. (1991). Indigeneous Technological Capability in Sub-Saharan Africa. In M. Huq, P. Bhatt, C. Lewis, and A. Shibli (Ed.), *Science, Technology and Development: North-South Co-Operation*. London: Frank Cass; and Wangwe, S.

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8. See Kumar, N. (1996). *Foreign Direct Investments and Technology Transfers in Development: A Perspective on Recent Literature*, UNU/INTECH Discussion Paper # 9606. Maastricht; and Kumar, N. (1997). *Foreign Direct Investments and Technology Flows to Developing Countries*. Paper presented at the Third Annual Workshop of EU-LDC Trade and Capital Relations Network on External Resources for Development, Rotterdam, Netherlands. In these studies, Kumar defines a concept of the quality of foreign direct investment (FDI) and suggests that developing countries can influence the “quality” of FDI and make conscious efforts to determine the extent to which technologies are transferred and the extent to which there is accumulation of capability through trade and investment. When the quality of FDI increases, technology is transferred and capabilities are acquired through trade and investment relationships.
 9. Hobday, M. (1995). *Innovation in East Asia: The Challenge to Japan*. Cheltenham: Edward Elgar.
 10. See Kim, L., and Nelson, R.R. (Ed.) (2000). *Technology Learning and Innovation*: Cambridge University Press; Lundvall, B.A. (1988). Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation. In G. Dosi, et al. (Ed.), *Technical Change and Economic Theory* (pp. 349–369). London: Pinter; and Teece, D. J., Pisano, G.P. and Shuen, A. (2000). Dynamic Capabilities and Strategic Management. In G. Dosi, R.R. Nelson, and S. Winter (Ed.), *The Nature and Dynamics of Organisational Capabilities*. Oxford: Oxford University Press.
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21. Radosevic, S. (1999). *International Technology Transfer and Catch-up in Economic Development*. Cheltenham: Edward Elgar.
22. See for example, Cassiolato, J. E. (1997). Learning to Use Telematics Technologies in Service Firms: Lessons from the Brazilian Experience, *Unpublished monograph prepared for UNU-INTECH*. Dutrenit, G. (1998). From Knowledge Accumulation to Strategic Capabilities: Knowledge Management in a Mexican Glass Firm. Unpublished DPhil Thesis, University of Sussex; Rimmelzwaal, B. (1996). *Technological Learning and Capacity Building in the Service Sector in Developing Countries: The Case of Medical Equipment Management*. Unpublished DPhil Thesis, University of Sussex; and Figuereido, P. (2001). *Technological Learning and Competitive Performance*. Cheltenham, Gloucestershire, UK, Edward Elgar Publishing Limited.
23. Scholars are recognising the need for a multidisciplinary approach; see for example, Francis, D. and Bessant, J. (2002) "Transferring Soft Technologies", Unpublished seminar paper presented November 4th 2002, at CENTRIM, University of Brighton, which states: "although there was little intellectual interchange between the predominately economic tradition that guided technology transfer specialists and humanistic behavioural science-orientated change agents who had constructed the methodologies of planned organisational change and developed OD. In the main, these two intellectual lifeworlds remained separate, with OD paying scant attention to technical change and technology transfer remaining naïve about the actuality of facilitating effective organisational development". (p. 3).
24. I am grateful to Dr. Louanne Barclay, University of the West Indies, Mona, for pointing out that the same would be true for developing country manufacturing firms that were operating at distinct positions in the value chain from their international suppliers.
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26. The term complementary capabilities is used in the same sense as the notion of the reinforcing effect of primary and secondary conditioning features of capabilities. See Pettigrew, A., and Whipp, R. (1991). *Managing Change for Competitive Success*. Oxford: Blackwell.
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