



Technological Learning



A Strategic Imperative
for Firms in the
Developing World



Gillian M. Marcelle



TECHNOLOGICAL LEARNING

*... for my parents, Abdul Kareem, Lerlyn Marcelle and
Anthony Applewhite*

Technological Learning

A Strategic Imperative for Firms in the
Developing World

Gillian M. Marcelle

Edward Elgar

Cheltenham, UK • Northampton, MA, USA

© Gillian M. Marcelle 2004

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical or photocopying, recording, or otherwise without the prior permission of the publisher.

Published by
Edward Elgar Publishing Limited
Glensanda House
Montpellier Parade
Cheltenham
Glos GL50 1UA
UK

Edward Elgar Publishing, Inc.
136 West Street
Suite 202
Northampton
Massachusetts 01060
USA

A catalogue record for this book
is available from the British Library

ISBN 1 84376 692 2

Printed and bound in Great Britain by MPG Books Ltd, Bodmin, Cornwall

Contents

List of Figures	vi
List of Tables	vii
Abbreviations and Acronyms	ix
Preface	xi
1. Introduction	1
2. The TCB System Approach	25
3. A Quantitative Exploration of Technological Learning	63
4. Management, Culture and Leadership for Learning	83
5. Managing Supplier Relationships	107
6. Role of the Innovation System	135
7. Strategic Balance	159
Appendices	175
References	199
Index	207

Figures

1.1	Interaction of firm-level and country-level factors	11
2.1	Three main constituent elements of technological capabilities	27
2.2	Elements and indicators of firm-level technological capability	29
2.3	Ten types of learning for developing country firms	45
2.4	Five critical components of a technological capability building system	52
3.1	Distribution of sample firms across three categories of TCB system development	65
3.2	An unbalanced TCB system	79
4.1	Key processes in learning systems	99

Tables

1.1	Summary of primary data gathering	7
1.2	Main characteristics of sample firms	8
1.3	Distribution of sample by market segment code	9
1.4	Sample firms distributed by ownership structure	9
1.5	Economic profiles Uganda, Ghana, Tanzania and South Africa	13
1.6	Key features of technological change in telecommunications	16
2.1	Key texts on organizational learning and technological capability building	26
2.2	Key routines for innovation management in developing country firms	41
2.3	Core abilities for managing innovation	42
2.4	Adapting the Hobday (1990) typology of learning mechanisms	48
3.1	Composition and characteristics of the seven groups of TCB mechanisms	64
3.2	Patterns of usage for firms across three categories of TCB system development	67
3.3	ANOVA table for frequency of TCB mechanisms	68
3.4	Sum of intensity scores for three levels of TCB system development	70
3.5	TCB gaps with the highest reported incidence	72
3.6	Correlation between TCB system development and reported gaps	73
3.7	Correlation matrix – TCB mechanisms used, years in operation and firm size	74
3.8	Correlation matrix – TCB mechanisms used, market segment, ownership type and country of operation	74
3.9a	Intensity scores for three categories of TCB system development and ideal	77
3.9b	Difference and ranks for three categories and ideal	77
4.1	Usage of internally orientated TCB mechanisms	85
4.2	Data on expenditure on TCB activities by sample firms	91
5.1	Selection criteria ranked in order of importance	108
5.2	Suppliers of equipment and services	109
5.3	Routines used for acquisition of technology capability from suppliers	111

5.4	Suppliers assessment of operating company capability	122
6.1	Desired public sector support for TCB in firm	137
6.2	Interaction between sample firms and national public policy and regulatory bodies	139

Abbreviations and Acronyms

AAT	Altech Telecommunications Ltd
ADH	Asynchronous Digital Hierarchy
ADSL	Asynchronous Digital Subscriber Line
AFRALTI	African Advanced Level Telecommunication Institute
ANOVA	Analysis of Variance
ATM	Asynchronous Transfer Mode
ATU	African Telecommunication Union
AXE	Ericsson family of telecommunication networking equipment
CCITT	Comité Consultatif International Télégraphique et Téléphonique (an ITU committee)
CLI	Caller Line Identification
CNET	Centre National d'Etudes des Télécommunications: National Center for Telecommunications Studies (France)
CSIR/STEPRI	Council for Scientific and Industrial Research/Science and Technology Policy Research Institute
CSF	Critical Success Factor
CTO	Commonwealth Telecommunication Organization
DECT	Digital European Cordless Telecommunications
DTM	Digital Terrain Model
ESRF	Economic and Social Research Foundation
ETSI	European Telecommunication Standards Institute
FCC	Federal Communications Commission (US)
FDI	Foreign Direct Investment
GIS	Geographic Information System
GMPCS	Global Mobile Personal Communication Service
GPRS	Global Packet Radio Service
GSM	Global System for Mobile Service
HIPC	Highly Indebted Poor Countries Initiative
HRD	Human Resource Development
IDD	International Direct Dialling
ICT	Information and Communication Technology
ISDN	Integrated Services Digital Network
IT/IS	Information Technology/Information Systems
ITU	International Telecommunication Union
JIT	Just in Time

JV	Joint Venture
MIS	Management Information Systems
NCA	National Communications Authority
NGO	Non Governmental Organization
NIS	National Innovation System
NTT	Nippon Telegraph and Telephone Corporation
OECD	Organisation for Economic Cooperation and Development
Oftel	Office of Telecommunication (UK)
PABX	Private Automatic Branch Exchange
PARUC	Pennsylvania Regulatory Utilities Commission
PATU	Pan-African Telecommunication Union
PTO	Public Telecommunication Operator
R&D	Research and Development
SATRA	South African Telecommunications Regulatory Authority
SC	Strategic Competence
SDH	Synchronous Digital Hierarchy
SETA	Sector Education and Training Authority
SMME	Small, Medium and Micro Enterprise
SNO	Second National Operator
TCC	Tanzania Communications Commission
TCP/IP	Transmission Control Protocol/Internet Protocol
TDMA	Time Division Multiple Access
TNC	Trans-National Corporation
TNS	Telecommunication Network-based Services
TSh	Tanzania Shilling
TT	Technology Transfer
UCC	Uganda Communications Commission
UTL	Uganda Telecommunication Ltd
UMTS	Universal Mobile Telephone Service
UNDP	United Nations Development Programme
USTTI	United States Telecommunication Training Institute
Westel	ACG Systems (Ghana) Ltd
WAN/LAN	Wide Area Network/Local Area Network
WLL	Wireless Local Loop
Z-Comms	Zakheni Communications Strategies

Preface

This book investigates how developing country firms undertake technological learning and capability building efforts. The main focus of the analysis is explaining variation in ability to effectively manage technological capability building (TCB) and learning at the individual firm level. The conceptual framework developed for this study – the TCB system approach – draws on a number of intellectual traditions, including organizational development, strategic management, innovation studies, development studies and evolutionary theory of the firm.

The main conclusion of this study is that for developing country firms, adopting a balanced systematic and coherent approach to technological learning yields significant benefits. The study will show that when developing country firms implement systems that simultaneously, proportionately and systematically direct effort at the following five key elements that is financing, management and co-ordination, culture and leadership, managing relationships with suppliers and with the innovation system, they increase the effectiveness of TCB and learning. This approach extends development studies perspectives on capability accumulation by paying greater attention to specific and general organizational learning routines and practices within firms.

An indicator is developed and applied that measures the extent to which firms are involved in an investment process that is likely to lead to greater effectiveness in capability accumulation. The results of the study demonstrate that there appears to be a structural dimension of TCB insofar as firms that are effective in capability development were found to have invested simultaneously and proportionately in all of the key elements suggested by the TCB system framework. The learning systems of firms that are effective in TCB were found to have a morphology that differed significantly from the 'systems in use' by novices and laggards.

A key insight of the analysis is that endogenous factors rather than the specific characteristics of the policy environment appear to be most important in distinguishing between the levels of performance of firms. Specifically, the breadth of learning routines, the effective integration of learning routines, and the existence of specific routines within firms appear to contribute to improved effectiveness of the firms' capability development

efforts. The results of the study are likely to be particularly relevant for firms operating in service sectors, for firms that are not aiming to generate radical innovations at the changing technological frontier, and for firms facing challenges arising from the speed, complexity and extensive effects of technological change. These factors make the findings and conclusions relevant to many industries in developing countries and, especially, to the telecommunication operating company sector.

These conclusions are drawn from an in-depth study, which develops an original conceptual framework to carry out a detailed cross-sectional analysis of technological learning and capability building in a sample of 26 telecommunication operating companies in Uganda, Ghana, Tanzania and South Africa. The unit of analysis in this study is the telecommunication operating company, that is the firm that owns or controls telecommunication networks and uses these to provide services to final customers. The empirical setting, therefore, is a fast-moving dynamic industry that is both a site of technological change and, in parallel, a site of industrial restructuring. Examining the processes that developing country firms use to build technological capabilities under these conditions has shed new light on some of the uncharted areas of science and technology policy studies.

This research would not have been possible without financial contributions from the Graduate Teaching Centre, SPRU and the Information Networks and Knowledge (INK) Research Group, University of Sussex (UK). I am also particularly grateful for the in-country support provided by my many hosts: in Uganda, Hon. Winnie Byanyima and Paul Nalikka; in Ghana, Hon. Cmdr (Rtd) PMG Griffiths; in Tanzania, Prof. Samuel Wangwe and his team at the Economic Social Research Foundation, and in South Africa, Dr Derrick Cogburn, then Director CISDA, and Ms Alison Gillwald, Director of the LINK Centre, University of Witswatersrand. In South Africa, Matsuma Marunyana provided valuable assistance for the quantitative exploration and Heather van Niekerk produced the illustrations and diagrams. I am tremendously indebted to the managers, engineers, policy makers, regulators and consultants who work in the telecommunication industry that provided access to materials and were willing to spend time having interesting discussions about capability development activities.

This book was written in Johannesburg in 2004, but my interest in the subject goes back 20 years, when Trevor Farrell taught me an undergraduate course in Science and Technology Policy at the University of the West Indies, St Augustine, Trinidad. I continue to draw inspiration from Caribbean scholars, particularly Prof. Norman Girvan, Drs T.M.A Farrell, Ralph Henry, Elizabeth Parsan, Auliana Poon, Rosina Wiltshire and Lloyd Best, who have always insisted that academic writing should be relevant to real-world development challenges.

At a personal level, several people have contributed to the completion of the research on which the book is based. The skilful guidance of my doctoral supervisor, Prof. Robin Mansell helped me to translate the intuition and observations that I gathered over several years working in industry into a more rigorous framework. She continues to be a source of motivation, invaluable insight and advice. Members of the intellectual community at the University of Sussex particularly Martin Bell, Prof. Keith Pavitt, Dr Aldo Geuna and Prof. Michael Hobday were interested in the project and often engaged me in challenging discussions. The library staff at SPRU provided invaluable assistance. Cynthia Little, who edited this volume, held my hand at many difficult stages along the way and helped to improve the final product. My friends and family have been with me in this project. I am grateful for the generosity and interest of Ainsley, Antonio, Barbara, Benu, Cathy-Mae, Cherrie-Anne, Gem, Karen, Kenneth, Kafi, Patrice, Louanne and Tuere. I also wish to specially thank Vittoria de la Grenade for her boundless enthusiasm and Chantal Collet for her unconditional support.

.... a luta continua

This page intentionally left blank

1 Introduction

This book makes a contribution to knowledge by investigating how developing country firms undertake technological learning and capability building efforts. The main focus of the analysis in the study is explaining variation in ability to effectively manage technological capability building and learning at individual firm level. Drawing on a number of intellectual traditions, including organizational development, strategic management, innovation studies, development studies and evolutionary theory of the firm, the analysis sheds light on the processes by which firms accumulate and systematically deploy a broad range of technological capabilities and acquire technological capabilities from external sources including suppliers and the innovation system.

The main conclusion of this study is that for developing country firms a systematic approach to technological learning yields significant benefits. The study will show that, when developing country firms implement systems that simultaneously, proportionately and systematically direct effort at the following five key elements, that is financing, management and co-ordination, culture and leadership, managing relationships with suppliers and with the innovation system, they increase the effectiveness of technological capability building (TCB) and learning. As will be shown, even in very poor developing countries in Africa there are firms that have been able to deploy systems that conform to this ideal and these firms have been effective in technological capability and learning. The firms that demonstrated effectiveness in learning and capability development, developed and implemented TCB systems including: mechanisms for allocating financial resources to learning and capability development; and an appropriate organizational culture and specific management practices to encourage and support technological learning, as well as to manage the relationships between firms and their equipment and service suppliers and the innovation system.

It will be shown that the ability of firms to implement effective systems for learning and capability building is characterized by path dependency insofar as the initial stock of accumulated technological capability has an influence on effectiveness. However, it will also be shown that developing country firms can compensate for weaknesses in their context and environment by a variety of management practices and boundary

relationships, including forging relationships with the global innovation system.

These conclusions are drawn from an in-depth study, which develops an original conceptual framework to carry out a detailed cross-sectional analysis of technological learning and capability building in a sample of 26 telecommunication operating companies in Uganda, Ghana, Tanzania and South Africa. The unit of analysis in this study is the telecommunication operating company, that is the firm that owns or controls telecommunication networks and uses these to provide services to final customers. The empirical setting, therefore, is a fast-moving dynamic industry that is both a site of technological change and, in parallel, a site of industrial restructuring. Examining the processes that developing country firms use to build technological capabilities under these conditions has the potential to shed new light on some of the uncharted areas of science and technology policy studies, specifically with respect to the capability accumulation processes of service sector firms and the impact of rapid technological change on the prospects for technological capability development. The conceptual framework developed in this research and the empirical strategies employed also have the potential to be extended to other industries, and may be more generally applicable in the field of technological learning.

The central research question investigated in this study is: how do firms in developing countries implement learning processes for building technological capabilities? This study differs from other work in the field of capability development because it integrates the approaches from diverse traditions and extends them by applying their insights to developing country firms. Specifically, it is argued that a systemic approach to developing technological capability is an essential requirement. The conceptual framework extends the development studies approach to understanding intra-firm processes of capability development by centrally integrating insights from organizational development and strategic management theory. The second differentiating feature is that this study of capability accumulation extends the development studies tradition by focusing on how rapid technological change affects capability development processes in service sector firms and by examining processes that enable firms to manage assets that are not under their direct control. Although the processes for acquiring technological capabilities from external sources have received attention, the processes through which firms learn how to manage these boundary relationships to more effectively acquire technological capabilities is an under-researched area.

The rest of the chapter is organized as follows. Section 2 highlights key features of the conceptual framework; this is followed by Section 3 which summarizes the methodology. Section 4 provides an overview of the

empirical context, including economic and industry features. Section 5 locates the contribution of this study within the academic literature and summarizes the implications for research, policy and firm strategy. The introduction concludes by presenting an overview of the organization of the book.

THE TCB SYSTEM APPROACH

Technological capability (TC) in this book is understood as a collection of firm-specific assets, both material and non-material, that are built up over time through non-linear processes of investment characterized by uncertainty. Building technological capabilities at firm level requires purposive co-ordinated activities over time. For this to be effective, firms must develop TCB systems consisting of internal processes and boundary relationships.

TC is defined as a firm-specific collection of equipment, skills, knowledge, aptitudes and attitudes that confer the ability to operate, understand, change and create production processes and products. The aspects of technological capability associated with human beings are referred to as the embodied elements of a technological capability, that is skills, attitudes, tacit knowledge and aptitude. These aspects of TC are coupled with non-embodied elements, such as codified knowledge, equipment and software. Firms require the tight integration of embodied and non-embodied capabilities if they are to derive benefit. If either of these broad types of capabilities is missing, or if their implementation is not well co-ordinated, it is suggested that the overall effect of having a capability may be diminished. To be operational and effective, technological capabilities should not exist in isolation, but should be integrated across an entire organization. This is defined as the organizational integration element of a TC and is similar to the concept of organizational coherence (Leonard-Barton 1995; Pettigrew and Whipp 1991) and the Tushman and Nadler (1996) concept of organizational congruence. At the detailed level, organizational integration is understood to include activities related to setting conditions for realizing the benefits from embodied and non-embodied capabilities, and management systems for decision-making, implementation and resource allocation and the establishment of a facilitating organizational culture.

The framework applied in this book builds on the resource-based approach to understanding capability development (Teece 1987; Teece and Pisano 1994; Teece et al. 2000), which suggests that a capability is only meaningful in terms of the services it delivers to the firm. This framework extends that treatment by delineating some of the human attributes that are required to

confer meaning. Unlike some other approaches, here institutional relationships are excluded from the definition of a capability (see Bell and Pavitt 1997). Instead, it is suggested that the management of institutional relationships is part of the capability building process.

The process of technological capability building (TCB) is defined as a process of assembling or accumulating technological capabilities and is regarded as an investment activity undertaken by firms. In developing the conceptual framework, the study draws upon four distinct, but related, scholarly traditions of research into organizational learning in firms. The TCB system approach draws on insights into the behavioural, structural, environmental and functional enablers of learning, and specific development studies approaches to analyzing capability development, particularly studies such as Bell (1984); Bell and Pavitt (1997); Dutrenit (2000); Ernst et al. (1998); Hobday (1990); Hoffman and Girvan (1990); Kim (1999); Leonard-Barton (1995); Pettigrew and Whipp (1991); and Tidd et al. (1997).

By treating capability development as a learning process this study permits an exploration of the aspects of TCB that are not linear, sequential or orderly. The TCB system approach argues that firm-level variation in the effectiveness and intensity of TCB effort cannot be fully explained by country-level factors and is likely to be influenced by developments that occur endogenously within the firm. The TCB system approach is designed explicitly to investigate those aspects of firm performance that cannot be explained by exogenous factors. It argues that firms may go further in capability development than is suggested by the environment in which they are located. The TCB system permits investigation and explanations of why some firms are able to compensate for external conditions that are not conducive to technological learning.

TCB activities are expected to have the potential to produce economic benefits in the medium to long term for firms and the national contexts in which they are located. Technological capability building activities are not regarded as consumption activities; rather they are regarded as having the potential to yield productivity gains, increases in output, improvements in quality, reductions in operational costs, greater operational efficiency and increased scope and range of outputs. Expectations of such outcomes provide incentives for firms to undertake the required investment. Achieving potential benefits from investments in TCB activities, however, is not expected to be automatic. It involves a learning process in which existing capabilities are transformed over time through a process of trial and error into improved or enhanced capabilities. Nevertheless, as trial and error implies, investments in TCB may not always produce enhanced outcomes. There may be failures that result in improved understanding and lead eventually to improved capabilities. The impetus for undertaking TCB

activities may also derive from internal factors, such as recognition of technological trends and existing capability gaps, or from external factors, such as changing market structure, the behaviour of competitors, actions of regulators and policy makers and information from suppliers and other knowledge creating institutions.

Firms are likely to improve the effectiveness of their learning and capability building by deploying a set of five integrated processes and mechanisms to: (1) allocate financial resources to TCB effort; (2) implement and support the TCB effort through appropriate management practices, systems and decision-making rules; (3) enable an organizational culture in which the TCB effort is exercised with committed and skilled leadership; (4) access external TC resources from suppliers; and (5) access TC resources from the innovation system (local and global).

The application of all five elements is considered to be necessary for increasing the stock of technological capabilities. There are internal processes – financing, management practices and culture and leadership – which are under the control of the firm and external (or boundary processes) – managing relationships with suppliers and with the innovation system, which are only partially under the firm's control.

Much of the policy literature on developing countries' capability accumulation experiences advocates a proactive role for public sector institutions in influencing TCB activities within firms (Lall 1987, 1992; Stewart 1984). The framework in this work positions developing country firms as active respondents to signals from public sector institutions rather than as passive agents. This contrasts with more conventional views that often see public sector bodies as 'omniscient' and better placed than the decision makers in firms to select suppliers, choose technological platforms and adjust technological capability building efforts. There is support for the need to critique this view from studies in many regions of the developing world, and particularly in Africa, where the 'state-in the lead' model of stimulating TCB performance in firms has met with dismal outcomes (Abiodun 1997; Cooper 1994; Enos 1995; Forje 1991; Pickett 1991; Stewart et al. 1992; UNCTAD 1996; Wangwe 1995).

EXAMINING LEARNING IN AFRICAN TELECOMMUNICATION FIRMS: RESEARCH STRATEGY, METHOD AND ANALYSIS

This section discusses the strategy, methodology and approach to analysing research findings. As stated earlier this study focuses on how firms in developing countries implement learning processes for building technological capabilities. Following on from this, the study also considers: