

Innovation, Learning *and*
Technological Dynamism
of Developing Countries

Edited by
Sunil Mani and
Henny Romijn

Innovation, learning, and technological dynamism of developing countries

Edited by Sunil Mani and Henny Romijn



**United Nations
University Press**

TOKYO • NEW YORK • PARIS

Contents

Acknowledgements.....	vii
Contributors	viii
List of figures	ix
List of tables	xi
Abbreviations.....	xiii
Preface	xvi
1 Introduction	1
<i>Sunil Mani and Henny Romijn</i>	
2 Exports of high technology products from developing countries: Are the figures real or are they statistical artefacts?.....	12
<i>Sunil Mani</i>	
3 Development strategies and innovation policies in globalisation: The case of Singapore	48
<i>Alexander Ebner</i>	

4 Evolution of the civil aircraft manufacturing system of innovation: A case study in Brazil	77
<i>Rosane Argou Marques</i>	
5 The political economy of technology policy: The automotive sector in Brazil (1950–2000).....	107
<i>Effie Kesidou</i>	
6 Technological learning in small-enterprise clusters: Conceptual framework and policy implications.....	135
<i>Marjolein C. J. Caniëls and Henny Romijn</i>	
7 The contribution of skilled workers in the diffusion of knowledge in the Philippines.....	158
<i>Niels Beerepoot</i>	
8 Understanding growth dynamism and its constraints in high technology clusters in developing countries: A study of Bangalore, southern India	178
<i>M. Vijayabaskar and Girija Krishnaswamy</i>	
9 Culture, innovation, and economic development: The case of the South Indian ICT clusters	202
<i>Florian Arun Taeube</i>	
Index	229

Introduction

Sunil Mani and Henny Romijn

Firms in developing countries secure their requisite technology through two sources: foreign and domestic. Assimilation of technologies created elsewhere is still the dominant mechanism for most of these countries. However, some developing countries recently have attained the coveted status of creators of new technologies. This status has been achieved through a process of learning and incremental innovation, facilitated by the introduction of complementary policies, institutions, and organisational arrangements.

Yet, in most discussions on technology development in the context of developing countries, the term “developing countries” is still being used as if referring to a homogeneous group having an average per capita income below a certain predetermined threshold (with the possible exception of the unique experience of a handful of countries from East Asia, which have been singled out as special). Such a formalistic way of grouping developing countries together tends to overlook the increasing dissimilarities between those that have, at least, the potential to catch up and even create new technologies on their own, and those that do not have this capacity.

Against the background of increasing differentiation in technological performance, the aim of this book is to highlight notable instances of successful technological catch-up and endogenous technology creation by developing countries and to point to important factors behind such success. The book starts by mapping out the broad patterns of recent tech-

nological dynamism among developing countries (chap. 2). Then it goes on to explore specific cases of technological dynamism, and concentrates on important factors that have contributed to this success. Two broad themes are explored. The first theme, which takes centre stage in chapters 3–5, relates to the role played by the policy environment and the systemic properties of the innovation process. These issues provide the setting for a detailed study of some notable technological successes in specific developing countries. The second theme, explored in chapters 6–9, deals with a particular organisational strategy that is increasingly being resorted to by policy makers from the South to enhance the innovative behaviour of firms and institutions. This organisational method draws its sustenance from agglomeration economies and is popularly referred to as “clustering”. The technological dynamism of specific clusters is analysed in these later chapters and the economic and non-economic factors that have contributed to this are identified. The main research issues addressed here are: how clustering of firms producing similar products or services can lead to improved innovative performance of the firms constituting the cluster; and under which conditions this is likely to occur. Contrasting experiences from low tech clusters from Pakistan and the Philippines and from a high tech cluster from India shed light on these questions. A refreshingly new line of analysis is the role of culture and other non-economic variables in explaining cluster dynamics.

There is thus a symbiotic link between the different chapters in this book (fig. 1.1). The first chapter (chap. 2) sets the scene for the following chapters, by empirically identifying a set of countries that have shown some spectacular results in terms of local technology development. It is found that developing countries are increasingly becoming exporters of high technology or technology-intensive products, thus reflecting the general trend observed in world trade. This chapter begins by asking the question whether this is a statistical artefact or whether there are real instances of technology dynamism. The chapters that follow furnish evidence supporting the latter view, through a further exploration of specific instances of countries, industries, and local regions in which such technological dynamism has been noticed. They contain an in-depth examination of the significance of technological performance in particular cases, and delve into the issue of where that dynamism originated and how it emerged. The chapters employ a variety of analytical approaches deriving mainly from economics, geography, and anthropology, thus reflecting the diverse disciplinary backgrounds and training of the authors. This gives each chapter its own flavour, and adds to the richness of the book as a whole. This is thus a unique collection of chapters focusing on technology and development, areas relatively unexplored in the literature.

We now turn our attention to individual chapters.

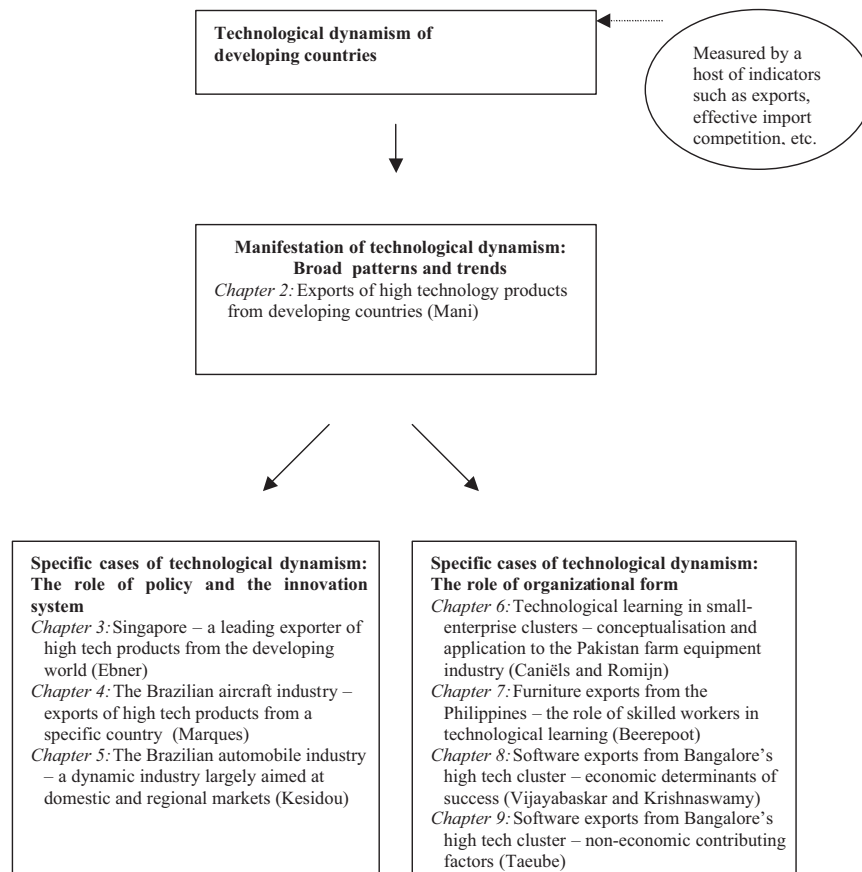


Figure 1.1 Book structure

One important way to measure the technological dynamism of developing countries is by observing the structure of their exports.¹ If the structure of exports is changing towards seemingly sophisticated items, then one may conclude that these countries are becoming technologically dynamic. Chapter 2 by Mani subjects this proposition to systematic empirical scrutiny. This chapter first develops consistent time-series data on the exports of high tech products from developing countries. Analysis of the data shows that developing countries are increasingly becoming exporters of manufactured products compared with primary products as in the past. Second, world trade is increasingly becoming a trade in high tech products. What is more striking is the significant increase in the

technology content of exports from developing countries: very nearly a quarter of the exports from developing countries are now high tech products. Third, the share of developing countries in high tech exports has dramatically increased from about 8 per cent in 1988 to about 23 per cent in 1997. However, this increase is largely concentrated in a few countries. The chapter then seeks to explain whether or not these developing countries are real exporters of high tech products. This is accomplished by a careful examination of the degree of product specialisation by both developed and developing countries, by examining their record with respect to patenting, and finally by analysing certain indicators of high tech competitiveness. The technological capability of even the high tech exporting countries varies greatly. At one end of the spectrum lie Korea and, increasingly, Singapore, which have the local capability to design, manufacture, and export high tech items. Malaysia is somewhere in the middle, while Thailand and the Philippines appear to be at the other end with (relatively speaking) a very low capability. However, the group of developing countries as a whole is fast catching up with the developed countries, so it may be unwise to write off this performance as a mere statistical artefact.

The three chapters that follow document specific cases of technological dynamism in developing countries, and shed detailed light on supporting policies and the systemic features of innovation systems. Singapore is one of the leading high tech exporters of the developing world. Ebner (chap. 3) analyses the nature and extent of technological development in Singapore and traces the role of innovation policies in explaining its technological success. He begins by mapping out the spectacular technological performance of the country. The aggregate research intensity, for instance, rose significantly from about 0.26 per cent in the early 1980s to close to 2 per cent by the late 1980s. This performance can be traced to a number of proactive state policies. To illustrate, formal state involvement in supporting domestic technology creation commenced with the establishment of the National Science and Technology Board (known since 2002 as the Agency for Science, Technology and Research). In addition, a large number public research institutes were created and several fiscal incentives were put in place. Technical education was also promoted in a significant manner so that the country had an adequate supply of trained personnel. At the same time the country also pursued a vigorous policy of promoting foreign companies, particularly as regards manufacturing. The main argument of the chapter is that the general relevance of the Singaporean case lies in the increasing importance of local agglomerations of high value-added activities which are fuelled by the process of globalisation, for they receive their structural impact from their roles as strategic hubs in multinational enterprise networks.

Brazil occupies a unique position among the developing countries. Although no more than 9 per cent of its manufactured exports are high tech products, it is the only country from the developing world to have a civil aircraft manufacturing industry. Aircraft, such as the ERJ 145 50-seater jet and the ERJ 135 37-seater jet, are manufactured by Embraer, a formerly state-owned aerospace organisation which was privatised in 1994. Marques (chap. 4) analyses the innovation system of the aircraft industry (referred to as the BASI) especially after its privatisation. Embraer, which employs almost 12,000 people and also manufactures a number of components, has particular strength in constructing undercarriages, and is a subcontractor for various overseas manufacturers of fixed/rotary wing aircraft. Brazil does not build civil aircraft jet engines, so companies such as Rolls-Royce and General Electric have established local subsidiaries to fulfil this need. Marques shows that two sets of changes have affected the BASI after privatisation in the mid-1990s. The first set of changes affected the production system resulting in: (i) increased participation of Embraer in the world civil aircraft market; (ii) increased participation of first tier foreign suppliers in product development; (iii) localisation of subsidiaries of first tier foreign suppliers in Brazil; and (iv) expanded possibilities for local second tier firms supplying first tier foreign suppliers. The second set of changes is related to the knowledge system and includes: (i) a decrease in the role of the Aerospace Technical Centre (CTA) as one of the main actors in the national knowledge system; (ii) an increase in the role of foreign suppliers and foreign science and technology (S&T) institutes in transferring technological knowledge to the Brazilian civil aircraft production system; (iii) an increase in the role of other Brazilian organisations (universities and technological centres) in supporting the application of basic technological knowledge developed abroad to the local production system needs; and (iv) evolution of the knowledge and production systems towards a wider configuration post-1994. Other sources (in addition to Embraer and the CTA) of technological knowledge for the local suppliers have become available now that there are localising foreign first tier suppliers closely related to local suppliers as well as other S&T institutes (national and foreign).

Kesidou (chap. 5) analyses the role of technology policy in making the Brazilian automotive industry very dynamic. Brazil's automotive industry is the tenth largest in the world and contributes about 12 per cent of GDP. Brazil plays host to the largest number of car assembly plants in the world and is the second largest target of foreign direct investment. In the 1990s vehicle production increased over 60 per cent, domestic car sales grew by 65 per cent, and exports expanded by around 9 per cent. In 1997, at its peak, Brazil produced more than 2 million vehicles and earned almost US\$5 billion from exports; motor vehicles accounted for

almost 10 per cent of the total value of Brazil's exports for that year. By the turn of the century production had dropped somewhat because of the economic situation, but Brazil will soon be one of the five largest automotive producers in the world, with the most modern factories. Brazil exports vehicles to other members of Mercosur. This chapter analyses historically the role of technology policy in shaping the industry since its inception in 1952. As regards the nature and extent of innovation policy, two phases are evident: the first phase concerns technology policy with respect to the automotive industry from 1952 until 1974, while the second phase relates to a structural shift in policy which is discernible during the post-1975 period. Although the state was very much involved in technology policy during the first phase, other agents, such as auto parts manufacturers and transnational corporations (TNCs), also contributed directly and indirectly to the decision-making. In contrast, the second phase is characterised by a gradual withdrawal of the state from technology policy, leaving the decision-making largely in the hands of the TNCs. However, Kesidou argues that, although the power of the federal state has been reduced, there has been considerable decentralisation of decision-making with respect to economic matters away from the federal government to governments in the states (provinces) and to cities within states. An interesting aspect of the second phase, and especially the period since the mid-1990s, is the fact that car makers' investment strategies in Brazil were basically of the "market seeking with moderate trade effort" (in the Dunning sense) variety. In other words, the industry took advantage of liberalisation to import more without altering its export orientation beyond perhaps including Mercosur in its market access strategy. So, while the industry has shown much dynamism (in the narrower sense), it has also become much more externally dependent.

Both the Singaporean and Brazilian cases thus show that developing countries can achieve technological maturity, and that they can also progress from being incremental innovators to being real innovators, provided the governments of these countries have clearly articulated policies for shaping the national and sectoral systems of innovation. However, in both countries increasing integration of their economies with the rest of the world has meant that the domestic systems of innovation have come under some strain. While Singapore has successfully managed to combine a programme of systematic globalisation with the strengthening of its domestic system of innovation, the same is not the case with Brazil, if judged by the experiences of the BASI and the auto industry.

While the importance of supportive policies for the promotion of well-functioning systems for domestic technological learning and innovation has been recognised for some time among researchers and policy makers,

awareness of the importance of spatial factors in this process is more recent. Approximately from the 1990s onwards, a voluminous body of literature has emerged which highlights the importance of regional agglomeration for economic growth and competitiveness, in both advanced and developing countries. However, despite liberal use of terms such as “learning region”, “regional innovation system”, and “innovative milieu”, so far little systematic attention has been devoted to the *technological* factors that supposedly underpin these economic benefits. This important emerging gap in the literature is taken up in the four remaining chapters of this book.

Caniëls and Romijn (chap. 6) set the scene with a framework that shows how regional clustering of companies engaged in similar and complementary economic activities could conceivably foster technological dynamism at the company level. Taking Marshall’s agglomeration benefits as their starting point, they elaborate a taxonomy of mechanisms through which these benefits may impact on firms’ investments in technological effort and on the effectiveness of their learning processes. The authors then proceed to apply the framework to the farm equipment industry in the Punjab region of Pakistan, a notable case of effective import competition among eight local agglomerations of small- and medium-sized firms. The clusters, which emerged in the 1950s, expanded to employ approximately 5,000 workers by the 1990s and supported phenomenal productivity growth in agriculture during the “green revolution”. Although by the mid-1990s it could still be described as a low tech industry, it was by then capable of manufacturing and incrementally adapting well over 50 items of farm equipment. Caniëls and Romijn illustrate how the clustered nature of the industry facilitated the process of reverse engineering that led to this achievement. Their analysis describes a range of spontaneous effects, including the establishment of specialised parts and components suppliers due to the viable size of the local market; transaction cost advantages and local knowledge spillovers arising from face-to-face interactions with suppliers and customers; and local dissemination of production knowledge and skills through inter-firm movement of workers. Several policy-relevant insights emerge, which deviate from those of earlier cluster studies with a less explicit focus on technological dynamism. The latter have linked cluster dynamism mainly to effective local inter-firm cooperation, and have accordingly tended to emphasise the importance of building trust among local parties. Instead, Caniëls and Romijn conclude that it might be better to single out a few dynamic producers for help with their innovation efforts, and let spontaneous non-collaborative clustering effects take care of wider diffusion. However, their analysis also suggests that such supply-side support policies cannot be a substitute for the need to address stagnant economic

environments in which producers have no incentives to innovate. Agglomeration can facilitate innovation, but it is by no means a sufficient condition for it to occur.

One of the agglomeration mechanisms identified by Caniëls and Romijn, namely the contribution of skilled workers to the diffusion of skills and knowledge, is chosen for detailed study by Beerepoot in his chapter about a furniture cluster in the Philippines (chap. 7). Workers are frequently mentioned as a major carrier of the region-specific knowledge by which local communities gain and retain competitive advantage. However, very little is actually known about how they transmit knowledge, and who is important for what purpose. The importance of local labour market spillovers can hardly be overemphasised in export-based clusters in developing countries, many of which consist of agglomerations of labour-intensive industries manufacturing, for example, clothes, footwear, furniture, and toys. Their competitive advantage is subject to quick erosion due to rising local labour costs and the recent entry of cheaper competitors (China!) on the world trade scene. As Beerepoot points out, under such conditions it is pertinent to identify the feasibility of pursuing an industrial strategy based on localised learning in order to cope with these challenges. The effective utilisation of an industry's best asset, a highly skilled flexible workforce, is the greatest challenge in this development trajectory. Beerepoot investigated this issue in Cebu, where a furniture cluster that had its origin in craft production grew into the prime furniture exporter in Southeast Asia during the 1970s and 1980s. The spectacular dynamism of the industry is evident from the fact that there are around 175 exporters in Cebu who provide employment to roughly 45,000 workers and jointly contribute about 1.8 per cent of Philippine GDP. However, since the 1990s the industry has ceded market share, mainly to China and Indonesia. Beerepoot found that keen competition pits parties against each other and makes them protective of their knowledge. The patterns are basically the same across the stages in the value chain and horizontally between exporters. For example, entrepreneurs increasingly resort to informal subcontracting as a means to cut costs and risk, not as a platform for sharing new ideas. Knowledge-protecting behaviour is most in evidence among entrepreneurs, managers, and designers, who stand to lose most from sharing their specialised trade contacts and internal production knowledge. Skilled production workers, in contrast, will readily teach their traditional craft skills to others on the job. On the whole, Beerepoot's findings suggest that embarking on a collective learning strategy to cope with the cluster's competitiveness problems will not be easy in the prevailing competitive environment. Indirectly, his research also concurs with the previous chapter about the

limited scope for interventions aimed at nurturing social institutions such as trust.

The final two chapters focus on the recent rise of India as a major export platform for software services since the early 1990s: exports accounted for US\$5,000 million in 2001. Bangalore, the largest cluster and earliest starter, hosts several hundreds of software firms, including around 70 leading multinationals such as Motorola, Texas Instruments, and Hewlett-Packard. Bangalore also provided growing space for Indian-owned companies, which have now become famous multinationals in their own right. Firms are beginning to climb the value chain, moving on from the provision of simple service tasks, such as data processing and operation of call centres, to offering integrated service packages and software development. Not surprisingly, this spectacular growth of technological dynamism has recently begun to attract widespread international attention. Much effort has been devoted to explaining the success in terms of particular constellations of resource endowments and Bangalore's position in the international division of labour. The last two chapters in the book add to this emerging body of literature by assessing the role played by other factors which have remained relatively under-explored to date.

Vijayabaskar and Krishnaswamy's chapter (chap. 8) draws attention to several organisational mechanisms specific to the Bangalore cluster, which may critically influence its ability to upgrade technologically, and thus its capacity to sustain its competitiveness in the world market. A particularly striking observation is that internal inter-firm specialisation in the cluster is still very limited. The authors ascribe this in part to the fact that most firms are still involved in highly similar labour-intensive operations. Few have entered into the domain of more skill-intensive operations such as design. This is in fact very difficult to do, since the prospective users are located far away, and close ongoing contact is often needed to cater effectively for their needs. This organisational feature is thus rooted in Bangalore's particular position in the international division of labour. Another notable characteristic of the cluster is the scarcity of local inter-firm networks. Networks tend to be international rather than local: there is no culture of local knowledge sharing, as in Silicon Valley. Again this can be related to Bangalore's position as a supplier of software solutions to major overseas clients, who often enforce secrecy on their software suppliers and discourage local outsourcing by them. Further features unfavourable to technological upgrading are identified in the labour market. In the absence of sufficient local opportunities for upward mobility, workers with the best skills tend to migrate abroad (although some later return with more experience). Labour mobility

problems are particularly bad for local small- and medium-scale firms, which cannot offer attractive enough career options. At this developmental stage of the cluster, the costs of high labour market spillovers appear to outweigh the benefits. While not discounting the considerable benefits from export-led development that have occurred in the cluster, the authors caution that the cluster's current excessive export dependence may well be the most important constraint on its further development. They argue that state policies should be directed towards achieving a better domestic–foreign balance.

The second chapter about Indian software by Taeube (chap. 9) investigates the role played by cultural factors in the recent achievements of the information and communication technology (ICT) sector in southern (and to some extent western) India. Taeube asks whether there is more behind this success than the constellation of economic and geographic features highlighted in the literature so far. Awareness of possible cultural influences is especially vital when possibilities for replication of India's ICT "model" are being contemplated, which is always tempting for policy makers. After surveying how different writers have conceptualised the links between culture and economic development, Taeube proceeds to make the concept operational in the specific context of South India. Hinduism serves as the relevant frame of reference here, not in the narrow sense of religion, but in the broader sense of Indian civilisation pervading all spheres of life. Two particular aspects, namely caste and ethnicity, are singled out as important attributes that could have a bearing on values and behaviour conducive to success specifically in the ICT sector. A preliminary analysis of data from surveys previously conducted in the sector supports the importance of these cultural attributes. In particular, the sector enjoys the participation of a disproportionate number of *Brahmins*, the social group in India that has been traditionally found in occupations concerned with knowledge, learning, and teaching. At the same time, the *Vaishyas*, the merchant and trader castes, are under-represented in the sector. Further, most of the key people in the Indian software industry are located in South India and come from a South Indian background in terms of ethnicity or family affiliation. Taeube then tries to unravel the ways in which this caste and ethnic profile is suited to the type of work that the ICT sector offers, and supplies some interesting matches. While his work is still in its preliminary stages, these early findings are promising and suggest that there is more behind India's recent ICT successes than "hard" economic and geographic determinants.

In sum, this book adds to the very small but growing literature on the phenomenon of the technological dynamism of developing countries (for a recent paper on this theme, see Mahmood and Singh, 2003). In the existing methodology, this dynamism has been measured through the

application of standard innovation outcome indicators such as patent statistics. The book begins by marshalling considerable quantitative evidence on inter-country variations in technological dynamism. However, the uniqueness of the book lies not only in its extension of the analysis from standard macro aggregates across countries to specific instances of dynamism, but also in the incorporation of non-economic variables, such as culture and ethnicity, in explaining this dynamism. This detailed and interdisciplinary approach renders our analysis of this growing phenomenon quite distinct.

Note

1. The ability to manufacture and sell in the international market is taken as a good indicator of a country's competitiveness.

REFERENCE

- Mahmood, P. I. and J. Singh (2003) "Technological Dynamism in Asia", *Research Policy* 32(6): 1031–1054.

© United Nations University, 2004

The views expressed in this publication are those of the authors and do not necessarily reflect the views of the United Nations University.

United Nations University Press
United Nations University, 53-70, Jingumae 5-chome,
Shibuya-ku, Tokyo, 150-8925, Japan
Tel: +81-3-3499-2811 Fax: +81-3-3406-7345
E-mail: sales@hq.unu.edu general enquiries: press@hq.unu.edu
<http://www.unu.edu>

United Nations University Office at the United Nations, New York
2 United Nations Plaza, Room DC2-2062, New York, NY 10017, USA
Tel: +1-212-963-6387 Fax: +1-212-371-9454
E-mail: unuona@ny.unu.edu

United Nations University Press is the publishing division of the United Nations University.

Cover design by Sese-Paul Design

Printed in Hong Kong

UNUP-1097
ISBN 92-808-1097-9

Library of Congress Cataloging-in-Publication Data

Innovation, learning, and technological dynamism of developing countries /
edited by Sunil Mani and Henny Romijn.

p. cm.

Includes bibliographical references and index.

ISBN 9280810979 (pbk.)

1. Technological innovations—Developing countries. I. Mani, Sunil.

II. Romijn, Henny.

T173.8.I552 2004
338'.064'091724—dc22

2004007422

Innovation, Learning and Technological Dynamism of Developing Countries

Edited by Sunil Mani and Henny Romijn

Contributors

Sunil Mani •
Marjolein C. J. Caniëls •
Henny Romijn •
Alexander Ebner •
Rosane Argou
Marques •
Effie Kesidou •
Niels Beerepoot •
M. Vijayabaskar •
Girija Krishnaswamy •
Florian Arun Tæeube

Developing countries have not normally been associated with the dynamic use and development of technologies, partly because most continue to employ and reproduce technologies that are generated elsewhere. However this situation is slowly but steadily changing.

Academic research about technological dynamism has also until now been restricted to the few countries described as Asian tigers and cubs. Much of that discussion has revolved around macro-economic studies of growth which risk failing to identify specific instances of technological dynamism in these and other countries.

This book employs a refreshingly new framework to identify cases of technological dynamism across a range of countries and industries. They vary from the recent growth of the computer software industry in India to the aircraft industry in Brazil. They touch upon technological dynamism in manufacturing and service oriented industries, and they consider how the effect of clustering, or the geographic agglomeration of firms engaged in the production of related and complementary items, can make sectors more technologically dynamic.

The papers in this book were initially presented at a conference organised by the United Nations University Institute for New Technologies (UNU-INTECH) in The Netherlands. The Dutch Research School for Resource Studies for Development (CERES) and the European Association for Development Research and Training Institutes (EADI) both sponsored the conference.

Innovation, Learning and Technological Dynamism of Developing Countries is a valuable text for scholars and students on the theory and practice of economics of technological change in developing countries. It is also a unique resource for governments, NGOs, financial institutions and multilateral agencies interested in the practicalities of promoting technological progress in manufacturing and service industries.

Sunil Mani is a researcher at the United Nations University Institute for New Technologies (UNU-INTECH), Maastricht. **Henny Romijn** is a Senior Lecturer at ECIS, Technische Universiteit Eindhoven, in Eindhoven.

Book information:

ISBN 92-808-1097-9;
300pp; US\$32.00

Order from:



**United Nations
University Press**

53-70, Jingumae 5-chome, Shibuya-ku, Tokyo 150-8925, Japan
Tel +81-3-3499-2811; Fax +81-3-3406-7345
E-mail: sales@hq.unu.edu; http://www.unu.edu