BRICS

NATIONAL SYSTEMS OF INNOVATION

Financing Innovation

EDITORS

Michael Kahn | Luiz Martins de Melo | Marcelo G. Pessoa de Matos

ROUTLEDGE

Financing Innovation

Series Editors: **José E. Cassiolato,** Federal University of Rio de Janeiro, Brazil.
Maria Clara Couto Soares, Federal University of Rio de Janeiro, Brazil.

This series of books brings together results of an intensive research programme on aspects of the National Systems of Innovation in the five BRICS countries — Brazil, Russia, India, China, and South Africa. It provides a comprehensive and comparative examination of the challenges and opportunities faced by these dynamic and emerging economies. In discussing the impact of innovation with respect to economic, geopolitical, socio-cultural, institutional and technological systems, it reveals the possibilities of new development paradigms for equitable and sustainable growth.

Books in this Series

The Role of the State
Editors: Mario Scerri and Helena M. M. Lastres
ISBN 978-0-415-84254-9

Inequality and Development Challenges
Editors: Maria Clara Couto Soares, Mario Scerri and Rasigan Maharajh
ISBN 978-0-415-71032-9

The Promise of Small and Medium Enterprises
Editors: Ana Arroio and Mario Scerri
ISBN 978-0-415-71036-7

Transnational Corporations and Local Innovation
Editors: José E. Cassiolato, Graziela Zucoloto, Dinesh Abrol and Liu Xielin
ISBN 978-0-415-71038-1

Financing Innovation
Editors: Michael Kahn, Luiz Martins de Melo and Marcelo G. Pessoa de Matos
ISBN 978-0-415-71039-8

BRICS ■ National Systems of Innovation

Financing Innovation

Editors

Michael Kahn
Luiz Martins de Melo
Marcelo G. Pessoa de Matos

IDRC | CRDI
Canada

Routledge
Taylor & Francis Group
LONDON NEW YORK NEW DELHI

First published 2014 in India
by Routledge
912 Tolstoy House, 15–17 Tolstoy Marg, Connaught Place, New Delhi 110 001

Simultaneously published in the UK
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Routledge is an imprint of the Taylor & Francis Group, an informa business

Typeset by

Glyph Graphics Private Limited
23, Khosla Complex
Vasundhara Enclave
Delhi 110 096

Printed and bound in India by

Avantika Printers Private Limited
194/2, Ramesh Market, Garhi, East of Kailash
New Delhi 110 065

British Library Cataloguing-in-Publication Data
A catalogue record of this book is available from the British Library

ISBN 978-0-415-71039-8

Contents

List of Abbreviations

ADTEN	National Technological Development Support Program
APIDC	Andhra Pradesh Industrial Development Corporation
ARMSCOR	Armaments Corporation of South Africa
ASC	Administrative Staff College
ASCI	Administrative Staff College of India
BACEN	Central Bank of Brazil
BBSDP	Black Business Supplier Development Programme
BERD	Business Expenditure on Research and Development
BNDES	National Bank of Economic and Social Development, Banco Nacional de Desenvolvimento Econômico e Social
BNDESPAR	BNDES integral subsidiary for capital markets operations
BNH	National Housing Bank
BOVESPA	São Paulo Stock Exchange
BPO	Business Process Outsourcing
BRICS	Brazil, Russia, India, China, and South Africa
BRICs	Biotechnology Regional Innovation Centres
CAPES	Commission on Qualification of Graduated Human Resources
CDB	China Development Bank
CAS	Chinese Academy of Sciences
CASS	Chinese Academy of Social Sciences
CEF	Federal Savings Bank
CIS	Co-operative Incentive Scheme
CIP	Critical Infrastructure Programme
CMIE	Centre for Monitoring Indian Economy
CNPq	National Council for Scientific and Technological Development
CONTEC	Programme for Capitalisation of Technology-based Enterprises
CPMF	Provisional Contribution on Financial Operation

CRIATEC	Programme for Creation of Technology
CSIR	Council for Scientific and Industrial Research
CVCF	Corporate Venture Capital Fund
CVM	Securities and Exchange Commission of Brazil
DACST	Department of Arts, Culture, Science and Technology
DST	Department of Science and Technology
DTI	Department of Trade and Industry
EI	Engineering Index
EIP	Enterprise Investment Programme
ELETROBRAS	Brazilian Electric Power Company
EMBRAER	Brazilian Aeronautics Enterprise
EU	European Union
FAP	Foundation to Support Research
FASIE	Russian Foundation for Assistance to Small Innova-tive Enterprises
FDI	Foreign Direct Investment
FGP	Federal Goal-oriented Programmes
FGTS	Unemployment and Retirement Guarantee Fund
FINEP	Finance Agency of Studies and Projects
FIP	Private Equity Funds
FNDCT	National Fund for Scientific and Technological Development
FUNDAP	Foundation for Administrative Development
FVCF	Foreign Venture Capital Fund
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GMM	Generalised Method of Moments
GNP	Gross National Product
GVCF	Government Venture Capital Fund
GVFL	Gujarat Venture Finance Limited
HNI	High Networth Individual
IAN	Indian Angel Network
IBGE	Brazilian Institute of Geography and Statistics
ICT	Information and Communication Technologies
IDB	Inter-American Development Bank
IDC	Industrial Development Corporation
IIT	Indian Institute of Technology
INPI	National Industrial Property Institute
IPO	Initial Public Offering
IPR	Intellectual Property Rights

IRR	Internal Rate of Return
ISCOR	Iron and Steel Corporation
ISTP	Index to Scientific & Technical Proceeding
KAS	Knowledge Application System
KDS	Knowledge Distribution System
KIS	Knowledge Innovation System
MCTI	Ministry of Science and Technology and Innovation
MEIDE	Micro Evidence on Innovation and Development
MFIEE	Mutual Funds for Investment in Emerging Enterprises
MNC	Multinational Corporation
NAL	National Aerospace Laboratories
NASDAQ	National Association of Securities Dealers Automated Quotations
NGO	Non-governmental Organisation
NIS	National Innovation System
NISC	National Innovation System of China
NMTLI	New Millennium India Technology Leadership Initiative
NRF	National Research Foundation
NSI	National System of Innovation
OECD	Organisation for Economic Cooperation and Development
PAPPE	Programme to Support Small Innovative Enterprises
PASEP	Programa de Formação do Patrimônio do Servidor Público
PATME	Programme for Technological Support to Small and Medium Enterprises
PBMR	Pebble Bed Modular Reactor
PDP	Productive Development Policy
PE	Private Equity
PETROBRAS	Brazilian Oil Company
PINTEC	Brazilian Innovation Survey
PIS	Social Integration Programme
PITCE	Technology and Foreign Trade Industrial Policy
PPP	Public–private Partnership
PRI	Public Research Institute
PROER	Programme for Restructuring and Strengthening of the Financial System

PROES	Programme of Incentive to the Reduction of State Institutions in Banking Activities
PROFARMA	Programme to Support the Development of the Health Industrial Complex
PROSOFT	Programme to Support the Software Industry Development
R&D	Research and Development
RAS	Russian Academy of Science
RBRF	Russian Basic Research Foundation
RF	Russian Federation
RFH	Russian Foundation for Humanities
RFTD	Russian Foundation for Technological Development
RHAE	Programme to Support Human Resources in Strategic Sectors
ROI	Return on Investment
SAFEX	South African Futures Exchange
SBU	Small Business Unit
SCI	Science Citation Index
SEBRAE	Brazilian Service to Support Micro and Small Enterprise
SELIC	Special System for Settlement and Custody
SEO	Socio-economic Objective
SIE	Small Innovative Enterprises
SIZ	Special Innovation Zone
SMEs	Small- and Medium-scale Enterprises
SMME	Small, Medium and Micro Enterprises
SOE	State-owned Enterprise
SPII	Support Programme for Industrial Innovation
SSAS	Sector Specific Assistance Scheme
TDB	Technology Development Board
TePP	Techno-entrepreneur Promotion Programme
THRIP	Technological Human Resources for Industry Programme
TIS	Technology Innovation System
USPTO	United States Patent and Trademark Office
UVCF	University Venture Capital Fund
VAT	Value Added Tax
VC	Venture Capital
VIF	Venture Innovation Fund

List of Figures

List of Tables

This page intentionally left blank

Foreword

The role of financing to support company strategies to introduce new products and processes in the economy has long been recognised as key. More than a hundred years ago, Joseph Schumpeter pointed out the crucial function of banks in stimulating economic growth and innovation, as well as identifying and financing new investments in production. He also emphasised the differences between countries due to the organisation of their banking and credit systems. Especially for small firms and other organisations that could not benefit from previous profits, credit was singled out as a starting point to introduce an innovation. In the third chapter of his 1911 book, *The Theory of Economic Development*, Schumpeter pointed out that credit works as a command for the economic system to accommodate the entrepreneurs' goals, and so development could flow. Later on, with the 'capitalism of trusts', innovation was fundamentally connected to large-scale firms and their initiatives. The power of these firms to accumulate reserves and to directly access capital markets changed their need for credit. Nevertheless, in his work *Business Cycles* (1939), he once again qualified the relation between credit and innovation, as he pointed out that such a relationship is essential for the capitalist machine to work properly.

In the 1970s and 1980s, among others, Chris Freeman addressed this issue when he analysed the Japanese National System of Innovation (NSI) in the post-war period. There, he stressed the systemic nature of innovation, the strong connections between banks, production systems and large conglomerates (*keiretsus*). These elements, together with the building of financing competence capable of fostering new industrial and technological capacities, were depicted as the main reason Japan was able to significantly advance in technology and innovation activities. Two related dimensions of the NSI approach are of paramount value to explain how production and innovation capabilities are acquired, used and further developed: the emphasis on historical and national trajectories, and the importance of taking into account the productive, financial, social, institutional and political contexts, as well as micro, meso and macro spheres. Another of his longest-standing arguments refers to the strategic role of government policies, especially in times of ruptures and crises, in mobilising and reorienting national production and innovation systems.

In Latin America, the so-called structuralist literature also dealt with the issue of innovation and technical progress. One of its most influential contributions relates to the argument that the main factor behind 'the passive behavior of local firms towards technological development' was related to the overall geopolitical and macroeconomic context, which in fact obstructed their potentially more active strategies and greatly contributed to limiting the scope for explicit science, technology and innovation (ST&I) policies. Comparing of firms' behaviour and their innovation trajectories in different countries has reinforced the argument that, indeed, the specific characteristics of national macroeconomic systems contain and condition the microeconomic decisions that form the standards of financing, corporate governance, international trade, competition and technical change. Actually, one of the pitfalls of most neo-classical Walrasian economic models is that macroeconomic solutions are reduced to the sum of microeconomic decisions. There is no room in this model for contextualisation or for considering the influence of malign and benign macroeconomic scenarios. For instance, it does not take into account monetary, fiscal and credit policies, nor the action (and autonomy) of central banking institutions, and, therefore, cannot account for specific relationships between the interest rate, the exchange rate, the expected inflation level and the fiscal environment.

Innovative activities are dependent upon investment strategies as a whole by firms. Innovation portfolios are positively influenced by macroeconomic stability that favour long-run investments and are negatively influenced by policies that increase uncertainty and instability, and that favour financial speculation. Therefore, it is essential to recognise that key macro variables and other macroeconomic conditions enclose and shape the space both for microeconomic decisions and for implementing policies that foster production and innovation development.

The recognition of the importance of innovation activities has led governments in different parts of the world to establish policies to guide and stimulate the productive sector. Among them, those that target funding and financing have received special attention. Main efforts have been directed at stimulating organisations to (*i*) incorporate and use new knowledge, aiming at increasing the quality and the value added to goods and services, as well as to (*ii*) endogenise and enroot these processes.

Within this context, the Brazil, Russia, India, China, and South Africa (BRICS) countries' policies are growing even more relevant as it becomes clear that they constitute a large share of the most dynamic parts of the world economy. In the beginning of this century, around two-thirds of the world gross domestic product (GDP) was concentrated in advanced economies, and in 10 years their share decreased to around 50 per cent. Indeed, the global crisis and the recession in developed economies reinforced a mismatch in the pace of growth in the least developed countries. Growth in the world economy over the last decade has relied heavily on the prominence of emerging countries. As a result, recent decades have witnessed a shrinking distance between developed and developing nations. Investment, production and consumption are gradually moving to the developing world. Within such a scenario, a dispute has also arisen for larger portions of international trade, heating up foreign competition. Preserving national autonomy and the possibility of continued growth requires a new look at the interface between macroeconomic, industrial, commercial and innovation policies. It is, therefore, important to assess the real stamina, characteristics and sustainability of this process. To examine the capacity to orient and support industrial and technological strengths is at the core of such a task.

This is precisely the central objective of this book, which provides a map of institutions and instruments and an analysis of experiences in fostering and financing innovation in BRICS. It singles out significant differences between these countries that are inherent to their historic evolution, and the specificities of their financial systems along with other parts of their NSI. In all cases, however, one will find that governments are strongly inducing innovation in the productive sector through sophisticated financial mechanisms. The chapters of the book also point out that the efficacy in using these instruments varies substantially, as BRICS countries have not only undergone major political, institutional and economic transformations, but are also inserted in specific geopolitical contexts. Moreover, they have a singular macroeconomic environment, as well as a pattern of industrial structure and specialisation, while pursuing different policy targets.

The BRICS countries' experiences in financing innovation have other points in common. First, departing from the understanding that innovation is a systemic process — involving firms along the production chain and the diverse organisations that affect it — successful policies have targeted the whole set of organisations instead of concentrating on a single individual firm or project. Given the territorial dimension of the BRICS countries, this has also meant fostering articulation and mobilisation of national, regional and local systems for production and innovation. Second, policies for financing innovation have been influenced by complementary policies, in particular those that constitute 'implicit' innovation policies, such as the macroeconomic policies, trade policies, etc. The chapters discuss the degree of integration of innovation policy and other policies. Also particularly vital in the analysis is the assessment of the level of autonomy and endogeneity of the innovation policy and its relationship with the development policy, their convergence or dissonance, and the degree of differentiation between the two.

Official government banks have played a crucial role in all five countries. It is important to note the efforts of these banks in providing compensative and decisive stimulus to the national economies during the international crisis, helping to soften its effects in most countries. Regarding the financing of innovation, in the case of China, the analysis covers the performance of the Industrial and Commercial Bank of China, the Bank of China, the China Eximbank, and especially the China Development Bank (CDB). To a lesser extent, this is also the case for India and Brazil. In the long run, governmental action and public financing have been decisive in promoting essential changes in their social and economic systems. In India, the post-independence period was marked by a perspective of planned development and the building up of a wide range of financial institutions to mobilise savings and channel investment to meet the priorities of the development plans. Ranging from the Industrial Finance Corporation of India (IFCI), the Industrial Development Bank of India (IDBI), a subsidiary of the Reserve Bank of India, to the Industrial Credit and Investment Corporation of India (ICICI), a complex set-up was erected to meet the long-term financing requirements. Transformations in the post-liberalisation period include the mobilisation of a broad array of institutions and support programmes under the leadership of the Department of Science and Technology and the National Innovation Foundation.

In Brazil, two federal government organisations are at the core of innovation promotion policies. The Studies and Projects Finance Organisation (FINEP) is specifically dedicated to fostering innovation.

The Brazilian Development Bank (BNDES), in its turn, led the way in promoting science and technology institution (STI) activities in the 1960s and 1970s and is taking up this task again. The BNDES has also been a major financier of national industry and infrastructure throughout the Brazilian industrialisation processes and plays a key role in industrial and STI policy. A new pattern of systemic and cooperative initiatives between the two institutions has characterised its activities since 2005.

Likewise, in Russia the government is the main funding source for innovative activities, establishing programmes earmarked for specific strategic goals. On a broader perspective, the challenge is to diversify the Russian economy and transform the country's high scientific capacities into technological and industrial development. The Bank for Development and Foreign Economic Affairs (Vnesheconombank, VEB) plays an important function in directing resources towards these long-term goals.

South Africa conciliates public institutions with the private banking system to finance industry, in general, and innovation, in particular. When it comes to high-risk and long-term initiatives, public institutions such as the Innovation Fund and the state-owned Industrial Development Corporation are depicted as the main players. The Development Bank of Southern Africa (DBSA) takes a stance that explicitly goes beyond the scope of a specific country, recognising the importance of integrated social and economic development in the Southern African regions.

This plurinational perspective based on the specific challenges and opportunities in developing countries is at the basis of the proposition of the BRICS Development Bank. This could provide an alternative that is capable of financing basic and future infrastructure, as well as other development needs in the BRICS economies and their neighbouring countries. Furthermore, it will soften the impact of fluctuations in the international financial system. As a matter of fact, the BRICS Summits have contributed to strengthening relations among the development banks in the five countries. During the BRICS 5th Summit, held in Durban, South Africa, in March 2013, two agreements were drawn up. Besides the BNDES, the signatory institutions included the Vnesheconombank, the Export-Import Bank of India, the CDB and the DBSA. The BRICS Multilateral Cooperation and Co-financing Agreement for Sustainable Development seeks to establish the basis for coordination and an exchange of information between the development institutions in the five countries, aimed at building partnerships, and improving mechanisms for sustainable development. According to the interests and the rules within each development institution, agreements may be signed to finance projects connected to sustainability. Examples include projects that foster the sustainable use of biodiversity, ecosystems and the regeneration of natural resources; as well as those aimed at developing, disseminating and transferring inclusive and sustainable technology; mitigating and adapting climate change; fostering renewable energy and energy efficiency; and other sustainable development infrastructure projects. The BRICS Multilateral Agreement on Co-financing for Infrastructure in Africa is mostly aimed at facilitating bilateral pacts between development banks in the bloc in order to provide support to develop infrastructure in the African continent.

A development bank anchored in developing countries can become a catalyst for change and provide opportunities for new development partnerships, giving emphasis to the innovations and other opportunities entailed in pursuing more adequate paths towards inclusive and sustainable development. It could provide essential assistance to developing countries and emerging countries as they undertake new and more sustainable infrastructure investment for growth and poverty reduction. It also represents an important opportunity to put into practice modern financial instruments and new sources of funding, such as sovereign wealth funds and public pension funds, as well as adequate forms of risk management, and innovative and cost-effective approaches. The new bank can make a major contribution to the health of the global economy by facilitating the transition to new poles of growth and demand, helping to rebalance global savings and investments, and channelling excess liquidity to productive use. It may become not only a driver for sustainable development in the developing countries, but also the engine for change from which all in the developed and developing world alike will benefit. It is worth noting that, within the scope of growing South–South cooperation, this constitutes an additional initiative, which reaffirms the importance in envisaging and financing new inclusive, sustainable and appropriate development trajectories and models. Fostering and articulating knowledge basis, efforts and capabilities can be instrumental for this purpose.

This book offers pioneering and fundamental contributions for this process and related discussion by focusing on one of its central issues: accumulated know-how on financing scientific, technological and innovation activities in the BRICS.

Enjoy reading these rich and promising experiences.

Luciano Coutinho
President
Banco Nacional de Desenvolvimento Econômico e Social

References

Schumpeter, Joseph, 1911 (1936). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*. Trans. Redvers Opie. Cambridge, Massachusetts: Harvard University Press.

———, 1939. *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*. New York, Toronto, London: McGraw-Hill Book Company.

This page intentionally left blank

Preface

This volume is the result of a collaborative effort of several people and institutions. The contributions presented here consolidate the findings of the project 'Comparative Study of the National Innovation Systems of BRICS' sponsored by the International Development Research Centre (IDRC). The project is rooted in a larger research effort on BRICS national innovation systems (NISs) being developed in the sphere of the Global Research Network for Learning, Innovation and Competence Building Systems — Globelics. The Globelics initiative on BRICS brings together universities and other research institutions from Brazil, Russia, India, China, and South Africa. It seeks to strengthen an original and less dependent thought, more appropriate to understanding development processes in less developed countries.

First and foremost, we would like to thank Professor Bengt-Åke Lundvall, the coordinator of Globelics, who supported and promoted the BRICS project from the outset in 2003 and organised the First International Workshop of the BRICS Project in Aalborg, Denmark, in 2006. Without his leadership and enthusiasm the project could not have taken off.

We owe special thanks to project researchers and coordinators for their engagement in project activities and accessibility which helped overcome difficulties that naturally emerge from the geographical and cultural diversity of BRICS. We are also very grateful to the ones who provided the necessary administrative and secretarial support allowing the good performance of the project, especially Luiza Martins, Fabiane da Costa Morais, Tatiane da Costa Morais, and Eliane Alves who helped in editing activities and whose support was crucial for formatting book manuscripts and organising tables and figures. Max dos Santos provided the technical information technology (IT) support for the research network.

The core ideas analysed in this book were discussed at international seminars organised in Brazil (2007), South Africa (2008), India (2009), and Brazil (2009) under the auspices of the BRICS Project, gathering scholars, academics, policy makers, businessmen, and civil

society representatives. Our understanding of this complex theme has evolved considerably thanks to constructive criticism from the seminar participants. We are grateful to them as well as to all other people not named here who also helped in the implementation of the project.

None of this work would have been possible without financial support. The support given by the IDRC was essential for the completion of this project and we are very obliged to them and their staff for their support. We would especially like to thank Richards Isnor, Federico Buroni, Gustavo Crespi, Veena Ravichandran, and Clara Saavedra. We are also grateful to Bill Carman, IDRC Publisher, for the technical assistance provided in the preparatory work that led to this publication.

Supplementary grants were received from various agencies of the Brazilian Ministry of Science and Technology, especially the Studies and Projects Finance Organization (FINEP) and the National Council for Scientific and Technological Development (CNPq). In particular, we would like to thank the General Secretary of the Ministry of Science and Technology, Dr Luiz Antonio Elias, and the President of FINEP, Luis Fernandes, who have given enthusiastic support to the BRICS project since its inception.

Introduction

BRICS National Systems of Innovation

José E. Cassiolato and Maria Clara Couto Soares

Preamble

The world is experiencing significant transformations in its geopolitical and economic constitution. The processes of transformation have accelerated over the last decades. A significant part of the growth potential of the world economy nowadays and for the coming decades resides in some fast-developing countries. Brazil, Russia, India, China, and South Africa (BRICS) have displayed such potential for dynamic change. In a historic rupture with past patterns of development, the BRICS countries are now playing a major role in alleviating the current global crisis whilst revealing new and alternative progressive paradigms.

Much beyond the emphasis given by international agencies to the identification of investment possibilities in the BRICS production structures or to the prospects presented by their consumer markets, our perspective in analysing the BRICS countries is inspired by their significant development opportunities, as well as their several common characteristics and challenges, and the learning potential they offer for other developing countries. Identifying and analysing these opportunities and challenges will help to uncover alternative pathways towards fulfilling their socio-political-economic development potential within the constraints of sustainability.

The central focus of this book series is the National System of Innovation (NSI) of the five BRICS countries. Each book deals with a key component of the innovation system, providing the reader with access to analyses on the role played by the state, the financing, direct investment and the small and medium enterprises (SMEs), besides approaching a particularly relevant — though still not extensively studied — aspect of the BRICS economies: the challenge of inequality and its interrelations with the NSIs of these countries.

The research endeavour that generated the publication of this book series has gathered universities and research centres from all the BRICS countries, as well as policy makers invited to discuss the outcomes. The research development and the comparative analysis of its results are intended to bring to light the challenges and opportunities of the BRICS countries' national innovation systems from the points of view of these same countries. Part of the effort undertaken was addressed to the construction of a shared methodology aimed at advancing the comprehension of the specificities of innovation systems in each country. This was done in view of the need for improvements in the analytical framework used for the analysis of the national innovation systems located in countries outside the restricted sphere of developed countries. Special attention was paid to the political implications. However, instead of searching for generalisable policy recommendations, it was sought to identify and analyse bottlenecks that are common to the BRICS economies, their complementarities and competition areas, as well as other aspects of major importance for supporting decision makers and that are able to incite reflection about the subject of innovation and development in other less developed countries.

It is worth mentioning that the research consolidated in this publication is rooted in a larger research effort on BRICS national innovation systems being developed in the spheres of Globelics[1] and the Research Network on Local Productive and Innovative Systems (RedeSist) at the Economic Institute of the Federal University of Rio de Janeiro.[2] Globelics is an international academic network which uses the concept of innovation systems (IS) as an analytical tool aimed at the comprehension of the driving forces that push economic development. It aims to advance the use of the IS perspective on a world basis. Established in 2002 and inspired by renowned scholars from the field of economics of innovation such as Christopher Freeman (1987) and Bengt-Åke Lundvall (1992), the Globelics network has, among others, the purpose of encouraging knowledge exchange between less developed countries (LDCs), thus fostering mutual learning across innovation research groups in Latin America, Africa and Asia. With this, it is sought to strengthen an original and more autonomous approach to understanding the development processes in developing countries. On the other hand, the focus put by the Globelics network on the study of innovation systems of BRICS results from the recognition that understanding the particular dynamics which connects the knowledge base with innovation and economic performance in each of the five BRICS countries is, today, a precondition for better appreciating the direction that the world economy will be following (Lundvall 2009). It is within such analytical field that the contribution offered by this book series is inserted.

In the following sections we (*a*) present the broad conceptual approach of NSI used as the guiding analytical framework for the research gathered under this book series; (*b*) characterise the increasing importance of the BRICS countries in the global scenario; and (*c*) introduce the five-book collection on NSIs in the BRICS countries.

NSI and Development — A Broad Perspective

One of the most fruitful ways of thinking developed in advanced countries in the last 30 years came from a resurrection and updating of earlier thinking that emphasised the role of innovation as an engine of economic growth and the long-run cyclical character of technical change. A seminal paper by Christopher Freeman (1982) pointed out the importance that Smith, Marx and Schumpeter attached to innovation (ibid.: 1) and accentuated its systemic and national character (ibid.: 18). Freeman also stressed the crucial role of government policies to cope with the uncertainties associated with the upsurge of a new techno-economic paradigm and the very limited circumstances under which free trade could promote economic development. Since it was formulated in the 1980s, the system of innovation (SI) approach has been increasingly used in different parts of the world to analyse processes of acquisition, use and diffusion of innovations, and to guide policy recommendations.[3]

Particularly relevant in the SI perspective is that since the beginning of the 1970s, the innovation concept has been widened to be understood as a systemic, non-linear process rather than an isolated fact. Emphasis was given to its interactive character and to the importance of (and complementarities between) incremental and radical, technical and organisational innovations and their different and simultaneous sources. A corollary of this argument is the context-specific and localised character of innovation and knowledge. This understanding of innovation as a socially determined process is in opposition to the idea of a supposed techno-globalism and implies, for instance, that acquisition of technology abroad is not a substitute for local efforts. On the contrary, one needs a lot of knowledge to be able to interpret information, select, buy (or copy), transform, and internalise technology.

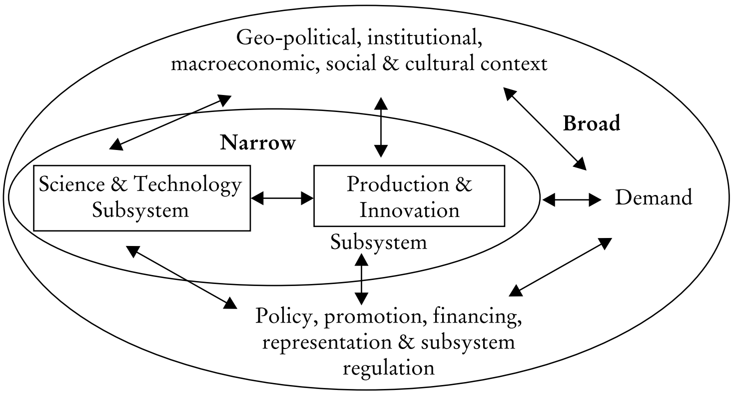
Systems of innovation, defined as a set of different institutions that contribute to the development of the innovation and learning capacity of a country, region, economic sector, or locality, comprise a series of elements and relations that relate production, assimilation, use, and diffusion of knowledge. In other words, innovative performance depends not only on firms and research and development (R&D) organisations' performance but also on how they interact, among themselves and with other agents, as well as all the other forms by which they acquire, use and diffuse knowledge. Innovation capacity derives, therefore, from the confluence of social, political, institutional, and culture-specific factors and from the environment in which economic agents operate. Different development trajectories contribute to shape systems of innovation with quite diverse characteristics requiring specific policy support.

It is this understanding of the systemic nature of innovation that allows for two crucial dimensions of the SI approach to be explicitly discussed: the emphasis on historical and national trajectories and the importance of taking into account the productive, financial, social, institutional, and political contexts, as well as micro, meso and macro spheres (Freeman 2003; Lastres et al. 2003). Although all of these contexts are relevant for a discussion about development, two in particular should be singled out that are pertinent to this study. One is the financial context, recognised by Schumpeter (1982 [1912]) in his *TheTheory of Economic Development*. For him, entrepreneurs, to become the driving force in a process of innovation, must be able to convince banks to provide the credit to finance innovation. In this sense, any discussion about innovation systems has to include the financial dimension.[4] The other is the idea that space matters, that the analysis of systems of innovation should be done at the national (Freeman 1982; Lundvall 1988) and local levels (Cassiolato et al. 2003).

The national character of SI was introduced by Christopher Freeman (1982, 1987) and Bengt-Åke Lundvall (1988) and has been widely used as an analytical tool and as a framework for policy analysis in both developed and underdeveloped countries. As a result, research and policy activities explicitly focusing on SI can be found in most countries and a rapidly growing number of studies of specific NSIs have been produced. Although some authors tend to focus on the NSI in a narrow sense, with an emphasis on R&D efforts and science and technology (S&T) organisations, a broader understanding of NSI (Freeman 1987; Lundvall 1988) is more appropriate. This approach takes into account not only the role of firms, education and research organisations and science and technology institution (STI) policies, but includes government policies as a whole, financing organisations, and other actors and elements that influence the acquisition, use and diffusion of innovations. In this case emphasis is also put on the role of historical processes — which account for differences in socio-economic capabilities and for different development trajectories and institutional evolution — creating SI with very specific local features and dynamics. As a result, a national character of SI is justified.

Figure 1 is an attempt to show both the narrow and the broad perspectives on NSI. The broad perspective includes different, connecting sub-systems that are influenced by various contexts: geopolitical, institutional, macroeconomic, social, cultural, and so on. First, there is a production and innovation sub-system which contemplates the structure of economic activities, their sectoral distribution, degree of informality and spatial and size distribution, the level and quality of employment, the type and quality of innovative effort. Second, there is a sub-system of science and technology which includes education (basic, technical, undergraduate, and postgraduate), research, training, and other elements of the scientific and technological infrastructure such as information, metrology, consulting, and intellectual property. Third, there is a policy, promotion, financing, representation, and regulation sub-system that encompasses the different forms of public and private policies both explicitly geared towards innovation or implicitly, that is, those that although not necessarily geared towards it, affect strategies for innovation. Finally, there is the role of demand, which most of the time is surprisingly absent from most analyses of SI. This dimension includes patterns of income distribution, structure of consumption, social organisation and social demand (basic infrastructure, health, education).

Figure 1: *The Narrow and Broad Perspectives on NSI*



Source: Adapted from Cassiolato and Lastres (2008).

This portrayal of the national innovation system framework is a corollary of an understanding that

- innovation capacity derives from the confluence of economic, social, political, institutional, and culture-specific factors and from the environment in which they operate, implying the need for an analytical framework broader than that offered by traditional economics (Freeman 1982, 1987; Lundvall 1988);
- the number of firms or organisations such as teaching, training and research institutes is far less important than the habits and practices of such actors with respect to learning, linkage formation and investment. These shape the nature and extensiveness of their interactions and their propensity to innovate (Mytelka 2000; Johnson and Lundvall 2003);
- main elements of knowledge are embodied in minds and bodies of agents or embedded in routines of firms and in relationships between firms and organisations. Therefore, they are localised and not easily transferred from one place/context to another,

for knowledge is something more than information and includes tacit elements (Lundvall 1988);

- the focus on interactive learning and on the localised nature of the generation, assimilation and diffusion of innovation implies that the acquisition of foreign technology abroad is not a substitute for local efforts (Cassiolato and Lastres 1999);
- national framework matters, as development trajectories contribute to shape specific systems of innovation. The diversity of NSIs is a product of different combinations of their main features that characterise their micro, meso and macroeconomic levels, as well as the articulations among these levels (Freeman 1987; Lastres 1994).

From the specific point of view of LDCs the usefulness of the SI approach resides precisely in the facts that (*a*) its central building blocks allow for their socio-economic and political specificities to be taken into account and (*b*) it does not ignore the power relations in discussing innovation and knowledge accumulation. As this book argues, these features are particularly relevant in the analysis of the BRICS countries' innovation systems. As the analysis of economic phenomena also takes into consideration their social, political and historical complexity, policy prescriptions are based on the assumption that the process of development is influenced by and reflects the particular environment of each country, rather than on recommendations derived from the reality of advanced countries. A number of development studies followed these ideas, arguing that technical change plays a central role in explaining the evolution of capitalism and in determining the historical process through which hierarchies of regions and countries are formed. Furtado (1961), for instance, established an express relation between economic development and technological change pointing out that the growth of an economy was based on the accumulation of knowledge, and understood development within a systemic, historically determined, view. Although original, these contributions have a close correspondence with Myrdal's (1968) proposition that: (*a*) contexts and institutions matter; (*b*) positive and negative feedbacks have cumulative causation; (*c*) cycles may be virtuous or vicious, and with Hirschman's (1958) point that interdependencies among different activities are important.

The need to address paradigmatic changes and the problems and options deriving from the upsurge of information technologies led to the outbreak in Latin America in the 1980s of a series of interconnected work from the innovation perspective. Building on Furtado's work on changes associated with the industrial revolution, authors like Herrera (1975) and Perez (1983) analysed the opportunities and challenges associated with the introduction of these radical changes in the region. It was only then that the innovation and development literature started to integrate the empirically validated knowledge about learning inside firms with the contributions stemming from the work of Freeman, Perez, Herrera, and others on new technologies, changes of techno-economic paradigms and systems of innovation. What gave special impetus to this direction was the empirical work focusing on technological capability building as part of a broader national innovation system. The role of government policies in orienting the speed and direction of technological changes was also highlighted (Freeman and Perez 1988).

Development processes are characterised by deep changes in the economic and social structure taking place from (technological and/or productive) discontinuities that cause and are caused by the productive, social, political, and institutional structure of each nation. Development is also seen as a systemic process, given the unequal capitalism development in the world. The recognition of national specificities of these processes is also fundamental. We found the same stress on the national character of development processes in List's work (1841), and on the NSI idea of Freeman (1982) and Lundvall (1988) in Furtado's (1961) discussion about the transformation of national economies where their structural complexity is manifested in a diversity of social and economic forms. For Furtado, it is in this transformation that the essence of development resides: structural changes 'in the internal relations of the economic and social system' (ibid.: 103) that are triggered by capital accumulation and technological innovations. The emphasis on diversity, and the recognition that: (*a*) both theory and policy recommendations are highly context dependent, (*b*) the economy is firmly embedded in society, and (*c*) knowledge and technology are context-specific, conform some general identities.

Furtado (1961) established a direct relation between economic development and technological innovation pointing out that the growth of an advanced economy was based on the accumulation of new scientific knowledge and on the application of such knowledge to solve practical problems. The Industrial Revolution set into motion a process of radical changes based on technical progress that has lasted till now and that is at the root of how the world economy is conformed. In essence, those changes: (*a*) rendered endogenous the causal factors related to growth into the economic system; (*b*) made possible a closer articulation between capital formation and experimental science. Such articulation has become one of the most fundamental characteristics of modern civilisation. As pointed out by Furtado (ibid.), the beginning of such a process took place in the countries that were able to industrialise and create technical progress first, and the quick accumulation made possible in the development of this process became the basic engine of the capitalist system. For this reason, there is a close interdependency between the evolution of the technology in the industrialised countries and the historical conditions on the basis of which such development was made possible. As the behaviour of the economic variables relies on parameters that are defined and evolve into a specific historical context, it is quite difficult to isolate the study of economic phenomena from its historical frame of reference (Furtado 2002). This assertion is more significant when analysing economic, social and technological systems that are different from each other, as in the underdeveloped economies. In this context, underdevelopment may not, and should not, be considered as an anomaly or simply a backward state. Underdevelopment may be identified as a functioning pattern and specific evolution of some economies. Social and economical peripheral structure determines a specific manner under which structural change occurs (industrialisation during the 1950s and 1960s) and technical progress is introduced. Hence different outcomes from those in developed countries are to be expected (Furtado 1961; Rodríguez 2001).

The neo-Schumpeterian perspective also argues that economic development is considered a systemic phenomenon, generated and sustained not only by inter-firm relations, but most significantly by a complex inter-institutional network of relations. Innovation is eminently a social process. Therefore, development — resulting from the introduction and diffusion of new technologies — may be considered as the outcome of cumulative trajectories historically built up according to institutional specificities and specialisation patterns inherent to a determined country, region or sector. Each country follows its own development trajectory according to its specificities and possibilities, depending fundamentally on their hierarchical and power position in the world capitalist system. The more distant underdeveloped countries are from the technological frontier, the larger will be the barriers to an innovative insertion in the new technological paradigm. More serious than technological asymmetries are knowledge and learning asymmetries, with the implication that access, understanding, absorption, domination, use and diffusion of knowledge become impossible. However, even when the access to new technologies becomes possible, most of the time they are not adequate for the reality of underdeveloped countries and/or these countries do not have a pool of sufficient knowledge to make an adequate use of them. This occurs because the learning process depends on the existence of innovative and productive capabilities that are not always available. On this aspect, Arocena and Sutz (2003) argue that there are clearly learning divides between North and South that are perhaps the main problem of underdevelopment nowadays.

The Increasing Relevance of the BRICS Countries

The BRICS denomination was originally used to connect the dynamic emerging economies of Brazil, Russia, India, China, and South Africa as continental countries bearing a strategic position in the continents of the Americas, Europe, Asia, and Africa. The BRICS are also joined by their large geographical and demographic dimensions. Collectively, they were home to 42.2 per cent of the world population as of 2010 representing nothing less than 2.9 billion people. In addition, the five countries account for approximately 30 per cent of the earth's surface, holding significant reserves of natural resources such as energy and mineral resources, water and fertile lands. As well, BRICS countries have 24.3 per cent of world biodiversity; Brazil alone embracing 9.3 per cent of the total (GEF 2008).

Moreover, it is the recent performance of these economies and their macroeconomic indicators that make them more and more the focus of surveillance and analysis. In fact, the BRICS countries display a growing economic importance. In 2000, the five countries accounted for 17.1 per cent of the world Gross Domestic Product (GDP) in public–private partnership (PPP). Their share increased to 25.7 per cent in 2010, with China and India accounting for 13.6 per cent and 5.5 per cent respectively, followed by Russia (3 per cent), Brazil (2.9 per cent) and South Africa (0.7 per cent) (IMF 2011).

The participation of the BRICS countries in world GDP is expected to rise sharply in the years to come. The impact of the financial crisis and global recession on developed world economy over the last three years has only lent support to this expectation, beyond attracting attention to the BRICS economies' capacity to remain immune or quickly recover from the crisis. Large domestic markets, proactive investment policies, monetary and tax policies with anti-cyclic capacity, presence of major public banks, and high level of reserves are elements increasingly recognised as having helped at least some BRICS economies to be less affected by the crisis.

While growth slowed in all major regions, China and India continued to grow rapidly in 2009 and 2010 (Table 1). In other BRICS countries the crisis rebounded fast. In Brazil, the GDP fell 0.2 per cent in 2009, but the economy surpassed pre-crisis growth rates in 2010 (7.5 per cent). South Africa showed a GDP decrease by 1.8 per cent in 2009 and had a 2.8 per cent increase in 2010. In Russia, heavily dependent on commodities like oil and gas, the economy has been hit more severely by the global crisis. It experienced shrinking of almost 8 per cent in 2009 but the GDP growth recovered to 3.7 per cent in 2010, beating the developed economies' growth rates. Prospects for 2015 show the five economies representing 29.5 per cent of the world economy.

The economic performance of the BRICS countries has, however, varied widely during the last decades as shown in Table 1. China has maintained its position as the fastest growing economy worldwide. India has also grown significantly and regularly. Brazil has had an irregular performance, well below its potential, but showed an enhancement in the second half of the 2000s. Russia, after the severe 1990s crisis that resulted in a decline of 40 per cent in its real GDP, has recovered and South Africa has had a small improvement in its economic performance that remains below its potential.

These different performances were accompanied by significant changes in the productive structure of the five countries, which reflect dissimilar development strategies.

The competitiveness of China's industrial sector is the main source of the country's impressive economic growth. The share of industry

Table 1: *BRICS: Average Rates of Growth of Real GDP, 1980–2015 (percentage)*

	1980–1990	*1990–2000*	*2001–2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2015**
Brazil	2.8	2.9	2.8	3.7	5.7	5.1	–0.2	7.5	4.1
Russia	–	–4.7	6.2	7.4	8.1	5.6	–7.9	3.7	5.0
India	5.8	6.0	6.9	9.8	9.3	7.3	6.5	9.7	8.1
China	10.3	10.4	9.6	11.6	13.0	9.0	8.7	10.3	9.5
South Africa	1.6	2.1	4.0	5.4	5.1	3.1	–1.8	2.8	2.8
Developed Countries	3.1	2.8	1.9	2.8	2.5	0.8	–3.2	3.0	2.3

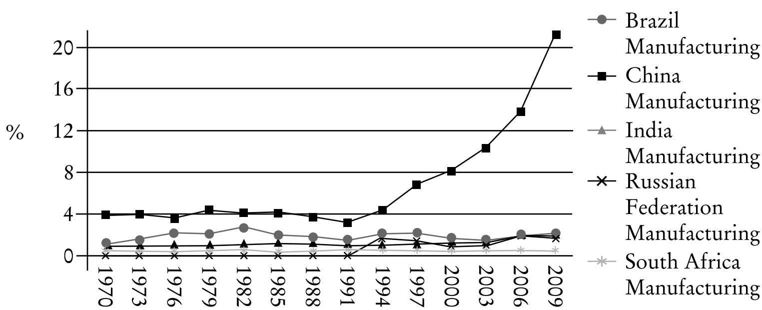
Source: UNCTAD (2010) for the period 1980–2008 and IMF (2011) for 2009–2015 data. See http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx (accessed 15 March 2011).

Note: *Estimate.

in the composition of China's GDP is unusual and growing: it was around 40 per cent in 1990 and reached 48 per cent in 2009. In contrast, in 2008, 56.1 per cent of the Chinese labour force still remained in rural areas. The relative share of the agricultural sector, which accounted for 30.2 per cent in 1980, is constantly falling, to 11 per cent of GDP in 2009. The share of services grew from 21.6 per cent in 1980 to 41 per cent in 2009.

Really impressive is the mounting share of China's manufacturing sector in world manufacturing GDP (Figure 2). In 1990, it represented 3.1 per cent of global manufacturing GDP, achieving 21.2 per cent in 2009.

Figure 2: *Manufacturing Sector: BRICS' Share in World GDP, 1970–2009*



Source: UNCTAD (2009). See http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx (accessed 15 March 2011).

China has diversified its industrial system to a significant degree during the last 25 years and the share of technologically intensive sectors in industrial output in 2009 reached 42 per cent of the total value added by the manufacturing sector. In the other four countries this share is around 15 per cent.[5] In addition, some major differences in the characteristics of the BRICS countries' manufacturing sectors should be noticed.

Brazil has gone through a structural transformation since the late 1980s, with a significant reduction of the share of industry in total GDP (declining from 41.7 per cent in 1980 to 25.4 per cent in 2009) and a high growth of services (from 50 per cent to 68.5 per cent in the same period). It is worth emphasising that agricultural goods that have had an important role in the country's trade surplus were responsible for only 6.1 per cent of GDP in 2009, showing a fall from 9.0 per cent in 1980. In Brazil, as in Russia and South Africa, the products based on natural resources and commodities have a relatively greater share of national GDP than in China and India.

Russia's economic development is heavily dependent on energy and raw material resources. As in Brazil, the contribution of manufacturing sector to GDP in Russia has declined since the 1980s, decreasing from 44.6 per cent in 1983 to 32.9 per cent in 2009. The share of defence-related industrial complex in manufacturing is significant, together with the strong production base in non-electric machines and equipment. The oil and gas industry alone accounts for more than 10 per cent of the gross value added. The share of services in total GDP has grown in the last two decades achieving 62.4 per cent in 2009 while agriculture has decreased its participation accounting for only 4.7 per cent in 2009.

The Indian economy is essentially service-led. Skills in the manufacturing sector are relatively modest and concentrated in non-durable consumer goods and in the chemical-pharmaceutical complex. However, some manufacturing segments in the automobile complex and in certain basic industries have been developing rapidly in recent years. Since the mid-1980s, the contribution of industry to India's GDP has been almost constant and around 26 per cent, but from 2004 to 2009 it increased to 28.3 per cent. India's capacity in the area of services is significant, particularly those linked to information and communication technology (ICT). The share of services in GDP has grown from 39 per cent in 1980 to 54.6 per cent in 2009. Although the agricultural sector is declining in India's GDP, it still represented 17.1 per cent in 2009 (compared to 36.8 per cent in 1980) and constitutes an important determinant of the overall economic growth.

The services sector has also been playing a more important role in the South African economy. The share of this sector in GDP was 45.4 per cent in 1980 and increased to 65.8 per cent in 2009. The development of the financial sector and the growth of tourism have contributed to this growth. Finance, real estate and business services are expanding their share with regard to government services. South Africa's industrial sector is heavily based on natural resources, mainly steel and non-ferrous metals, with some increases in capacity occurring in non-durable consumer goods and the automobile sector. The share of industry-added value in total GDP value decreased from 48.4 per cent in 1980 to 31.4 per cent in 2009. The metal and engineering sectors dominate the manufacturing sector. Although agriculture is responsible for a small share of South Africa's GDP (3 per cent in 2009), it still represents an important source of employment. The minerals and mining sector remains important also with respect to both employment and foreign trade.

The changes observed in the participation of BRICS countries in international trade were even more significant (Table 2). Their share in merchandise trade value more than doubled in the short period of 2000–10, exports rising from 7.5 to 16.4 per cent and imports from 6.2 to 14.9 per cent. However, the contribution of the five countries varied significantly. The most notable fact is the well-known growth of China in the merchandise trade value: its exports mounted from 3.9 per cent to 10.4 per cent of world exports reaching US$ 1.58 trillion in 2010, and imports increased from 3.4 per cent to 9.1 per cent in the same period.

Table 2: *BRICS: Merchandise Trade Value (in billion of current US$) and Share in World Total, 2000–10 (percentage)*

	2000		*2005*		*2010*	
Exports	*Value*	*%*	*Value*	*%*	*Value*	*%*
World	6,448.57	100.00	10,495.70	100.00	15,174.44	100.00
Brazil	55.12	0.85	118.53	1.13	201.915	1.33
China	249.20	3.86	761.95	7.26	1,578.270	10.40
India	42.38	0.66	99.62	0.95	221.406	1.46
Russia	105.57	1.64	243.80	2.32	400.424	2.64
South Africa	31.95	0.50	56.26	0.54	85.700	0.56
	2000		*2005*		*2010*	
Imports	*Value*	*%*	*Value*	*%*	*Value*	*%*
World	6,662.89	100.00	10,800.15	100.00	15,353.26	100.00
Brazil	58.64	0.88	77.63	0.72	191.46	1.25
China	225.02	3.38	660.21	6.11	1,396.20	9.09
India	51.52	0.77	142.84	1.32	328.36	2.14
Russia	49.13	0.74	137.98	1.28	273.61	1.78
South Africa	30.22	0.45	64.19	0.59	96.25	0.63

Source: UNCTAD (2010).

India also experienced a sharp increase of exports, reaching 1.46 per cent of the world total in 2010. Fostered by Chinese growth and commodities boom, the share of Brazil and Russia in world exports grew rapidly from 2000 to 2010, increasing almost four times. South Africa is the only BRICS country that still shows less than

1 per cent of world exports. On the import side, India and Russia increased their share in world imports more than fivefold. Except India and South Africa, the other BRICS countries managed to keep a surplus in their merchandise trade in 2010. In India inflows on account of invisibles have been helpful in financing the growing deficit in merchandise trade.

The BRICS economies have significantly increased their openness to international trade in the last decades. They have raised their exports and imports both in volume terms as a share of GDP, but the level of trade openness has varied quite a lot (Table 3). The greater changes occurred in China and India, particularly since the 1990s when they speeded up their international trade flows. Currently, China, South Africa and Russia are the BRICS economies with the higher levels of openness. The Brazilian economy, despite the liberalisation process in the 1990s, remains the most closed amongst the BRICS countries.

Table 3: *BRICS: Foreign Trade and Share of GDP*

	Exports + Imports (in million of current US$)				
Countries	*1970*	*1980*	*1990*	*2000*	*2010*
Brazil	8.719	25.412	61.212	113.762	393.379
China	4.833	38.919	11.471	474.227	2,972.960
India	4.792	28.839	51.144	93.941	540.489
Russia	–	–	349.249	136.973	627.323
South Africa	8.352	50.411	48.6	56.782	161.953
	Exports + Imports (GDP) (percentage)				
Countries	*1970*	*1980*	*1990*	*2000*	*2010*
Brazil	13.0	10.3	14.0	17.6	18.8
China	5.3	12.9	29.9	39.6	50.6
India	7.9	15.7	15.8	20.4	31.3
Russia	–	–	36.1	52.7	42.4
South Africa	45.7	61.2	43.4	42.7	44.5

Source: United Nations (2010b); World Bank (2011).

The bilateral trade flows between BRICS countries have been relatively restricted. However, since the first half of the 2000s there was a widespread increase of exports and imports flows between the five economies, but particularly a stronger presence of China as an important trade pole for the other four countries (Baumann 2009). In 2009, China surpassed the United States (US) as the main trade partner of

Brazil and also emerged as the second main trade partner of India and Russia. The converse does not however hold, as these four economies don't match their respective rankings insofar as they are neither the top import suppliers nor export destinations for China. China exports to Brazil, India, Russia, and South Africa at a more intense pace than it imports from them. In addition, the latter are concentrated on a few primary goods intensive in natural resources while China's exports are much more diversified and led by manufactured goods. Therefore, despite the fact that intra-BRICS trade has increased in recent years, the flows are still restricted in size and unbalanced in terms of the different rhythms and compositions of the BRICS bilateral commercial transactions.

In the last decades, the BRICS countries have been the recipients of significant amounts of foreign direct investment (FDI). Brazil received the greatest share of FDI of all BRICS economies until the first half of the 1980s. Although China has surpassed Brazil since 1985, Brazil continued to be a major destination for FDI during the 1990s, most notably during the process of privatisation that took place during that decade. Since the 2000s Russia and India have been strengthening their relevance as FDI inflow destinations (Table 4). In 2010, the BRICS countries received 17.6 per cent of global FDI inflows. Especially since 2005, there was a sharp increase of BRICS' FDI outflows. With the exception of South Africa, BRICS countries more than tripled their FDI outflows from 2005 to 2010, raising their participation in the world total from 3.6 per cent to 11.1 per cent in the period.

BRICS countries also followed different development strategies regarding FDI. Particularly remarkable has been the Chinese policy to attract multinational companies since the beginning of the 1990s. Inserted in a broader strategy aiming to expand its technological knowledge and later to strengthen the domestic industries and enterprises, China imposed conditions — such as the establishment of joint ventures and that R&D be carried out locally — that had to be met before the subsidiaries were to operate in China or sell in its markets. Brazil, Russia and South Africa — countries that liberalised their economies with few restrictions — got more portfolio investment, but most of the investment received by the manufacturing sector was used to buy up local companies. In China and India, where the capital account was not liberalised, FDI seems to have been concentrated in new investments in production and innovation.

Table 4: *BRICS: Foreign Direct Investment, Inflows and Outflows Share in the World Totals*

	Selected Years								
	1970	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*
FDI Inflows (%)									
Brazil	2.94	4.53	3.53	2.54	0.48	1.29	2.34	1.53	3.90
China	NA	NA	0.11	3.50	1.68	10.96	2.90	7.37	8.50
India	0.34	0.32	0.15	0.19	0.11	0.63	0.26	0.78	1.98
Russian Federation	NA	NA	NA	NA	NA	0.60	0.19	1.31	3.31
South Africa	2.50	0.71	–0.02	–0.80	–0.04	0.36	0.06	0.68	0.13
FDI Outflows (%)									
Brazil	0.01	0.38	0.71	0.13	0.26	0.30	0.19	0.29	0.87
China	NA	NA	NA	1.01	0.34	0.55	0.07	1.39	5.14
India	0.00	0.00	0.01	0.01	0.00	0.03	0.04	0.34	1.11
Russian Federation	NA	NA	NA	NA	NA	0.17	0.26	1.45	3.91
South Africa	0.12	0.44	1.46	0.08	0.01	0.69	0.02	0.11	0.03

Source: UNCTAD (2010).

Other relevant macroeconomic indicators could be added — such as the impressive share of BRICS in international monetary reserves (about 40 per cent of the total) — but the interest in these five emerging economies goes beyond this area. Together with their expanding economic relevance, these countries are claiming a rising geopolitical influence. They have been important players in their geographic areas of influence. However, they are pushing to have an increasing voice in the international high-level decision-making institutions, particularly through reforms in the UN system and in the Bretton Woods organisations. New dialogue spaces bringing together BRICS countries, such as the IBSA (India, Brazil and South Africa), BRICS and BASIC (Brazil, South Africa, India, and China) signal concrete steps to move forward the cooperation and coordination within and amongst these countries, which intends to go further than the mere economic sphere.[6]

Their growing leverage in international relations together with other emerging countries is associated with a repositioning of the balance of power on the world stage, which was intensified by the recent world crisis. BRICS countries want to see these changes reflected in the institutions of global governance. Since their economies will probably continue to account for a sizeable portion of the increase in global GDP in the near future, it is expected over time that BRICS will exert increasing financial and political influence, even if limited by their considerable differences and constraints to form a coherent political bloc anytime soon.[7]

The increased influence of these countries took place during a period marked by intense transformations in the global society. One of these remarkable changes is the integration in the economy of a significant portion of previously marginalised segments of the BRICS population. The highly populated China and India led this process in terms of world shares, but Brazil also had an important participation (Soares and Podcameni 2014). The present and potential dimension of BRICS domestic markets as well as the policies adopted by some BRICS countries aiming to reduce their dependence on developed countries' consumer markets has been drawing increasing attention in the last years. According to one estimate, two billion people from BRICS will join the global 'middle class' by 2030 (Wilson and Dragusanu 2008) representing a huge impact on the demand profile with expected reflexes on global investments as well as on innovation.

Simultaneously, several hurdles remain for the BRICS to overcome. One of them is the growing social gap caused by the unequal distribution of recent economic growth. While the percentage of the population below the poverty line has decreased over the past 30 years in most of the BRICS countries, inequality is still a major issue for these economies. In fact, the BRICS countries, except Brazil, show a trend of increasing income inequality that — particularly since the 1990s — has been following the rapid economic growth. Moreover, despite the improvements in recent years, Brazil is still among the countries with the worst distribution of income, together with South Africa that found itself in an even worse situation.[8] In addition, India and Russia are among those with the largest percentage of the population living below the poverty line.[9] Furthermore, beyond the income dimension, inequality has a multi-dimensional character in the BRICS countries. This challenge is exacerbated by race, gender, ethnic, and geographic dimensions and therefore demands more integrated solutions (Scerri et al. 2014).

One of the problems associated with the high poverty levels and the perverse distribution of income is the limited access to quality public services — education, health, housing and infrastructure, safety and security, etc. These problems are common to the five countries, where a significant portion of the population lacks access to essential goods and services, and demand urgent redress. This situation is reflected in poor human development indices in the BRICS countries. Other undeniable challenges faced by BRICS are unemployment, poor quality employment and increasing informality.

Another evident challenge in all five countries is the huge regional disparity in human and economic development. There is also a large gap between the rural and urban population. In general, the wealthier regions are those that are more industrialised. Practically 60 per cent of the total GDP of Brazil originates in the states of the southeast. The Chinese economic development model favours the coastal provinces, while other provinces in the interior are much less developed. In South Africa, economic activity is concentrated in Gauteng province and in the western part of Cape Town. The industrial development of Russia occurred principally around cities such as Moscow, St Petersburg, Nizhny Novgorod, and Ekaterinburg. India also shows significant inequalities between the rich regions to the south and the northern regions of the country as well as between the rural and urban populations. Therefore, regional redistribution of income and access to essential goods and services is another significant challenge that these five countries have in common (Scerri et al. 2014).

The negative environmental impact of recent growth is another huge challenge to be faced by BRICS countries. According to Carbon Dioxide Information Analysis Center–United Nations (CDIAC–UN) data for 2008, the BRICS countries are responsible for emitting 35.3 per cent of the world's total CO_2.[10] China is ranked as the world's largest emitter, accounting for 21.9 per cent followed by the United States (17.7 per cent), India (5.4 per cent) and Russia (5.3 per cent). South Africa and Brazil are responsible for 1.4 per cent and 1.2 per cent of global emissions respectively, and occupy the 13th and 17th positions internationally. If we take the example of China, we observe that fossil-fuel CO_2 emissions in the country have more than doubled in the 2000 decade alone. Energy efficiency is a big problem in China and energy consumption per product is about 40 per cent higher than in the developed world. Other environmental problems are also critical. For instance, 40 per cent of river and 75 per cent of lake water is polluted leaving 360 million rural people without clean water. As in China, the environmental impacts in other BRICS countries are also mounting.

Other than extending the existing problems in BRICS countries, one general and common issue should be emphasised. This relates to the sustainability of its current growth trajectory. This is true in terms of growing inequality, increasing environmental impacts, as well as regional and other imbalances. However, there are some recent changes that may open better future prospects.

All the BRICS countries have an important role to play in shaping the future of the world economy, but China will probably have a more prominent role in this respect. The Chinese system of innovation has been undergoing some changes in order to address two new proclaimed goals: the building of a 'harmonious growth' and the development of 'indigenous innovations' (AeA 2007). The harmonious growth aims at reducing the growing social and environmental imbalances. China's emerging 'high-growth with low-carbon' strategy has been emphasised by recent policy decisions, together with measures directed to reduce rural–urban social gaps. The indigenous innovation goal refers to the efforts to make China less reliant on foreign technology through the building of a new kind of relationship between national and foreign players in the process of developing and using new technologies.[11] China is pursuing these goals especially by linking innovation to domestic needs and by giving increased priority to domestic consumption.[12]

For Brazil, India, Russia, and South Africa, Chinese success may lead to strategies towards strengthening domestic technological capabilities and fostering clean technologies. Nevertheless, the differentiated role of the BRICS countries in the configuration of global power and the global economy will in some way constrain the evolution of BRICS national systems for innovation. In addition, their NSIs are highly dependent on their historical development and on how the different domestic actors interpret global developments as well as how they position themselves in the national and international economies. Yet, more flexibility for setting up new industrial and technological policies may be expected.

Introduction to Books 1–5

This book series attempts to cover five themes that are crucial to an understanding of the National System of Innovation of BRICS. The first book *The Role of the State*, edited by Mario Scerri (South Africa) and Helena M. M. Lastres (Brazil) aims at exploring the relationship between the state and the national systems of innovation in BRICS countries. An evolutionary approach has been adopted in order to capture the nature of the state in the respective countries and thus understand the historical and ideological basis for its role in the evolution of the NSI in the five countries. As a background, it is argued that debates on the role of the state in the development process, especially since the 1980s, have often focused on the apparent dichotomy between market-driven and state-driven development. This is a rather wasteful diversion, since it should be accepted as a starting premise that the state is essential to the structural transformation that is required for development.

The second book addresses an aspect of the NSI that is normally absent from the discussion: the relation between innovation and inequality. The objectives of the book *Inequality and Development Challenges*, edited by Maria Clara Couto Soares (Brazil), Mario Scerri and Rasigan Maharajh (South Africa) are to trace the trends in interpersonal and inter-regional inequality within BRICS in an evolutionary perspective and to analyse the co-evolution of inequality and the innovation system to highlight how the various elements of innovation and the production system and inequality mutually reinforce.

The book is driven to improving our understanding of this issue. The inequality concept is considered in its multi-dimensional character, embracing a phenomenon that goes beyond the mere income dimension and is manifested through forms increasingly complex, including, among others, assets, access to basic services, infrastructure, knowledge, as well as race, gender, ethnic, and geographic dimensions. The book adopts the broad approach of the national system of innovation to analyse the relations between BRICS innovation systems and inequality, departing from a co-evolutionary view.

As shown in the book chapters, innovation can affect inequalities in different ways and through distinct trails that are influenced by national conditions, and shaped by public policy interventions. Although innovation does not constitute the main factor of influence on inequality, it is suggested that distinct strategies for technological change may lead to different outcomes in distributive terms, thus either aggravating or mitigating inequality. Based on this understanding, the book corroborates the hypothesis that inequalities need to be explicitly taken into account in development strategies since the benefits of science, technology and innovation are not automatically distributed equally. Therefore, advancing the comprehension of inter-relations between innovation and inequality may be helpful to find ways to shape the national innovation systems so that they reduce rather than increase inequalities.

The third book aims at analysing the contribution of small and medium enterprises (SMEs) in the national system of innovation. The objective of the book *The Promise of Small and Medium Enterprises*, edited by Ana Arroio (Brazil) and Mario Scerri (South Africa) is to explore three main research goals. In the first place, to provide an overview of the main characteristics of micro, small and medium firms in the Brazilian, Russian, Indian, Chinese, and South African national systems of innovation as a basis to examine the contribution of SMEs to the economy of each country. A second goal is to bring to the forefront crucial issues in the discussion of industrial and technological policies for small firms, including the recent evolution and future trends of policies and instruments, their applicability and coordination, as well as a discussion of the macroeconomic, legal and regulatory environment. A final research objective is to draw out initiatives to promote innovation in SMEs that address common bottlenecks in BRICS countries and that can contribute to policy design and implementation by these and other countries.

The fourth book discusses the relationship between transnational corporations (TNCs) and the national system of innovation of BRICS countries. In the book *Transnational Corporations and Local Innovation*, edited by José E. Cassiolato (Brazil), Graziela Zucoloto (Brazil), Dinesh Abrol (India), and Liu Xielin (China), the thesis of technological globalisation is taken with some caution, refuting the idea that R&D activities would be inexorably internationalised. In fact, technological innovative activities in TNCs have been transformed, in relation with the financialisation of TNCs, as evidenced by the rise of their intangible assets (which includes R&D, patents, and trademarks) and a reorientation of R&D expenditures towards non-scientific activities and very downstream development.

The book chapters present a detailed presentation of the relation of the position and evolution of TNC in the country. Subsequently, there is a discussion on the local factors affecting innovation by TNCs and local firms in the country. Government policy towards TNCs has been important but as the Chinese experience shows, access to local buoyant markets has also been vital. Other issues discussed refer to how the government protects local companies from the competition of TNCs. Spillovers of TNCs to local BRICS enterprises have also been analysed and the immediate conclusion is that there is hardly any convincing evidence regarding either the existence or non-existence of spillovers. An in-depth analysis of outward FDI has also been conducted.

Finally, the fifth book deals with finance and funding in the national system of innovation. The objective was to analyse institutional character and support instruments for the innovation financing process in BRICS, focusing on institutional structure and innovation policy. This book, *Financing Innovation*, edited by Michael Kahn (South Africa), Luiz Martins de Melo and Marcelo G. Pessoa de Matos (Brazil), contributes to understanding the varied approaches to the financing of innovation. It draws on the experience of five diverse countries each of which has undergone dramatic structural adjustment in the last two to three decades. The experience of the BRICS countries presents a unique set of case studies of the transition from largely closed centrally planned and state-driven economic and science policy to a more open and market-led situation. The contributing authors examine the varying approaches to the provision of support to the full range of activities that contribute to innovation ranging from scholarship support to doctoral students, to R&D tax incentives and the provision of seed capital.

The significance of financing investments in innovation has been pointed out as an important structural bottleneck that is yet to be solved by the private financial institutions. If, on the one hand, the internationalisation, deregulation and globalisation of financial markets signals the possibility of resources at lower costs, on the other, the characteristics of investments in innovation such as the length of time needed for development, the uncertainty and the risk, point to the need of setting national institutional arrangements.

Notes

1. Available at http://www.globelics.org (accessed 3 December 2011).
2. Available at http://www.redesist.ie.ufrj.br (accessed 3 December 2011).
3. This is also true in Latin American countries, where it is being applied and understood in close connection with the basic conceptual ideas of the structuralism approach developed in the region since the 1950s

under the influence of the Economic Commission for Latin America and the Caribbean (ECLAC). In fact, since the mid-1990s, the work of RedeSist — the Research Network on Local Productive and Innovative Systems — based at the Economics Institute of Rio de Janeiro, Brazil, has been using such a dual frame of reference.

4. See, for instance, Mytelka and Farinelli (2003); Freeman (2003); Chesnais and Sauviat (2003).
5. The following data on BRICS countries' value added by sector (per cent of GDP), 1980–2009 is based on the *UNCTAD Handbook of Statistics* (2010).
6. The IBSA Dialogue Forum was established in June 2003 in Brasilia, Brazil.
   BRIC was formally constituted in June 2009 at a summit of the four countries in Yekaterinburg, Russia. In 2011, South Africa joined the group, which changed its denomination to BRICS.
   BASIC of the G4 was formed during the international climate change negotiations in December 2009 in Copenhagen, Denmark.
7. There are several economic and geopolitical factors that restrict a greater convergence of interests among BRICS countries in multilateral negotiations. The analysis of these constraints goes beyond the limited scope of this concept note, but we could cite the aforementioned relatively low degree of trade complementarities between BRICS as an important one.
8. In 2008, Gini indexes were respectively 0.54 and 0.67 according to Brazilian and South African national institutes of statistics.
9. According to World Bank statistics, the population below poverty line was 28.6 per cent in India and 30.9 per cent in Russia in the mid-2000s.
10. It is important to mention that CDIAC-UN data considers only global carbon dioxide emissions from the burning of fossil fuel, but not emissions from deforestation or other greenhouse gases, including methane.
11. The US Information Technology Office in Beijing refers to indigenous innovation as a term combining three distinct elements: *yuanshi* (original, or genuinely new); *jicheng* (integrated, or combining existing technologies in new ways); and *yinjin* (assimilated, or making improvements to imported technologies). See http://www.usito.org/ (accessed 8 January 2013).
12. In November 2008, China launched a US$ 584 billion anti-cyclical package. According to the HSBC report on climate change (Robins 2009) almost 40 per cent of the total package resources were allocated to 'green' themes. Among others, it combined the search for a lower carbon pattern with the offering of better transport conditions for lower income people placed in rural areas, fostering a niche for the development of innovations capable of attending to the specificities of this domestic market segment.

References

American Electronics Association (AeA), 2007. 'China's Fifteen Year Science and Technology Plan: What does it Mean to Spawn "Indigenous Innovation"?', *Competitiveness Series*, vol. 14, April, 2.

Arocena, R. and J. Sutz, 2003. 'Knowledge, Innovation and Learning: Systems and Policies in the North and in the South', in J. E. Cassiolato, H. M. M. Lastres and M. L. Maciel (eds), *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar, 291–310.

Baumann, R., 2009. 'El Comercio entre los Países "BRICS"', LC/BRS/R.210, Comisión Económica para América Latina y el Caribe (CEPAL), Santiago de Chile, August.

Carbon Dioxide Information Analysis Center–United Nations (CDIAC–UN), 2008. 'Global, Regional, and National Fossil-Fuel CO_2 Emissions'. http://cdiac.ornl.gov/trends/emis/overview.html (accessed 1 March 2011).

Cassiolato, J. E. and H. M. M. Lastres, 1999. *Globalização e Inovação Localizada: experiências de sistemas locais no Mercosul*. Brasília: Instituto Brasileiro de Informação em Ciência e Tecnologia.

———, 2008. 'Discussing Innovation and Development: Converging Points between the Latin American School and the Innovation Systems Perspective', Working Paper no. 08-02, Globelics Working Paper Series, The Global Network for Economics of Learning, Innovation, and Competence Building System.

Cassiolato, J. E., H. M. M. Lastres and M. L. Maciel (eds), 2003. *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar.

Chesnais, F. and C. Sauviat, 2003. 'The Financing of Innovation-related Investment in the Contemporary Global Finance-dominated Accumulation Regime', in J. E. Cassiolato, H. M. M. Lastres and M. L. Maciel (eds), *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar, 61–118.

Economist, *The*, 2010. 'A Special Report on Innovation in Emerging Markets', 15 April.

Freeman, C., 1982. 'Technological Infrastructure and International Competitiveness', Draft Paper submitted to the OECD Ad Hoc Group on Science, Technology and Competitiveness, Organisation for Economic Co-operation and Development, Paris. http://redesist.ie.ufrj.br/globelics/pdfs/GLOBELICS_0079_Freeman.pdf (accessed 24 September 2012).

Freeman, C., 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Frances Pinter.

Freeman, C., 2003. 'A Hard Landing for the "New Economy"? Information Technology and the United States National System of Innovation', in J. E. Cassiolato, H. M. M. Lastres, and M. L. Maciel (eds), *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar, 119–40.

Freeman, C. and C. Perez, 1988. 'Structural Crisis of Adjustment, Business Cycles and Investment Behaviour', in G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. L. Soete (eds), *Technical Change and Economic Theory*, London: Pinter, 38–66.

Furtado, C., 1961. *Desenvolvimento e Subdesenvolvimento*. Rio de Janeiro: Fundo de Cultura.

——, 2002. *Capitalismo Global*. São Paulo: Paz e Terra.

Global Environmental Facility (GEF), 2008. 'Index Table — Biodiversity'. http://www.thegef.org/gef/node/1805 (accessed 16 February 2011).

Herrera, A., 1975. 'Los Determinantes Sociales de la Politica Cientifica en America Latina', in J. Sábato (ed.), *El Pensamento Latinoamericano en Ciencia-Tecnologia-Desarrollo-Dependencia*. Buenos Aires: Paidos, 98–112.

Hirschman, A., 1958. *The Strategy of Economic Development*. New Haven: Yale University Press.

Instituto de Pesquisa Econômica Aplicada (IPEA), 2008. 'PNAD-2007: Primeiras Análises: Pobreza e Mudança Social', *Comunicados da Presidência*, 1(9), Instituto de Pesquisa Econômica Aplicada, Brasília.

International Monetary Fund (IMF), 2011. 'World Economic Outlook Database', September 2011. http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/index.aspx (accessed 4 October 2011).

Johnson, B. and B.-Å. Lundvall, 2003. 'Promoting Innovation Systems as a Response to the Globalising Learning Economy', in J. E. Cassiolato, H. M. M. Lastres and M. L. Maciel (eds), *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar, 141–84.

Lastres, H. M. M., 1994. *The Advanced Materials Revolution and the Japanese System of Innovation*. London: Macmillan.

Lastres, H. M. M. and J. E. Cassiolato, 2005. 'Innovation Systems and Local Productive Arrangements: New Strategies to Promote the Generation, Acquisition and Diffusion of Knowledge', *Innovation: Management, Policy & Practice*, 7(2): 172–87.

Lastres, H. M. M., J. E. Cassiolato and M. L. Maciel, 2003. 'Systems of Innovation for Development in the Knowledge Era: An Introduction', in J. E. Cassiolato, H. M. M. Lastres and M. L. Maciel (eds), *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar, 1–33.

List, F., 1841. *National System of Political Economy*. New York: Cosimo.

Lundvall, B.-Å., 1988. ‘Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation’, in G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. L. Soete (eds), *Technical Change and Economic Theory*. London: Pinter, 349–69.

———, 1992. *National System of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.

———, 2009. ‘The BRICS Countries and Europe’, in J. E Cassiolato and V. Vitorino (eds), *BRICS and Development Alternatives: Innovation Systems and Policies*. London: Anthem Press, xv–xxi.

Myrdal, G., 1968. *Asian Drama: An Inquiry into the Poverty of Nations*. London: Penguin Books.

Mytelka, L. K., 2000. ‘Local Systems of Innovation in a Globalized World Economy’, *Industry and Innovation*, 7(1): 15–32.

Mytelka, L. K. and F. Farinelli, 2003. ‘From Local Clusters to Innovation Systems’, in J. E. Cassiolato, H. M. M. Lastres and M. L. Maciel (eds), *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar, 249–72.

Perez, C., 1983. ‘Structural Change and the Assimilation of New Technologies in the Economic and Social System’, *Futures*, 15(5): 357–75.

———, 1988. ‘New Technologies and Development’, in C. Freeman and B.-Å. Lundvall (eds), *Small Countries Facing the Technological Revolution*. London: Pinter, 85–97.

Ravallion, M., 2009. *The Developing World’s Bulging (but Vulnerable) ‘Middle Class’*. Washington DC: World Bank.

Robins, N., 2009. ‘A Climate for Recovery: The Colour of Stimulus Goes Green’, HSBC Global Research. http://www.research.hsbc.com (accessed 2 December 2011).

Rodríguez, O., 2001. ‘Prebisch: actualidad de sus ideas básicas’, *Revista de la CEPAL*, 75: 41–52.

Scerri, Mario, Maria Clara Couto Soares and Rasigan Maharajh, 2014. ‘The Co-evolution of Innovation and Inequality’ in Maria Clara Couto Soares, Mario Scerri and Rasigan Maharajh (eds), *Inequality and Development Challenges*. New Delhi: Routledge, 1–18.

Schumpeter, J. A., 1982 [1912]. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle (1912/1934)*. New Jersey: Transaction Books.

Soares, Maria Clara Couto and Maria Gabriela Podcameni, 2014. ‘Inequality, Innovation System and Development: The Brazilian Experience’, in Maria Clara Couto Soares, Mario Scerri and Rasigan Maharajh (eds), *Inequality and Development Challenges*. New Delhi: Routledge, 19–79.

United Nations Conference on Trade and Development (UNCTAD), 2009. *UNCTAD Handbook of Statistics 2009*. Geneva; New York: United Nations. http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx (accessed 15 March 2011).

United Nations Conference on Trade and Development (UNCTAD), 2010. *UNCTAD Handbook of Statistics 2010*. Geneva; New York: United Nations. http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx (accessed 15 March 2011).

United Nations, 2010a. 'United Nations Statistical Databases', United Nations Statistic Division. http://unstats.un.org/unsd/databases.htm (accessed 20 March 2011).

———, 2010b. 'United Nations Commodity Trade Statistics Database', United Nations Statistic Division. http://comtrade.un.org/ (accessed 20 March 2011).

Wilson, Dominic and Raluca Dragusanu, 2008. 'The Expanding Middle: The Exploding World Middle Class and Falling Global Inequality', Global Economics Paper no. 170, Goldman Sachs, 7 July.

World Bank, 2010. 'World Economic Indicators Database 2010'. http://data.worldbank.org/data-catalog/world-development-indicators (accessed 25 March 2011).

———, 2011. 'World Development Indicators Database 2011'. http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP_PPP.pdf (accessed 1 July 2011).

This page intentionally left blank

1

The Financing of Innovation

Michael Kahn, Luiz Martins de Melo and Marcelo G. Pessoa de Matos

In general, studies based on a narrow perspective of National Systems of Innovation (NSIs) focus on the processes of interactive learning and knowledge generation within enterprises, higher education institutions, and government research institutions, as well as on the interactions amongst them that contribute to the innovation process. The issues raised are typically related to explicit science and technology (S&T) policy. In contrast, a broad approach to NSI (Freeman 1987; Lundvall 1985) incorporates a wider set of institutions. As outlined in the introduction to this publication, besides the ample context conditions, this includes also the subsystem of demand and the subsystem of policy, promotion, financing, representation and regulation.

This last subsystem is of particular relevance for this book. The role played by the state in the formulation and implementation of policies for fostering innovation, including macroeconomic policy, is highly contextual, contested and centrally important. The financial dimension plays a key role, setting incentives and constraints to innovation efforts.

In its early formulation the neo-Schumpeterian approach that informs much of the conceptual development of the NSI approach gave little emphasis to the financial perspective. Freeman (1994) in particular analysed neo-Schumpeterian research, claiming that this topic had not taken a central position. As highlighted by Levine and Zervos (1998), this is a significant gap in theory, the more so as Schumpeter, writing in the 1930s, had in fact emphasised the relevance of the banking system in economic development, underscoring the circumstances in which banks could actively encourage investments in innovation. Recent literature provides some progress in linking the financing of innovation with the financial system and in bringing in an institutional perspective of the NSI.[1] But there is still a long way ahead.

The financing of innovation has been identified as an important structural bottleneck that has yet to be solved. Coping with this challenge involves considering both the role of the state and public organisations and the role of private financial institutions. The importance of setting up national institutional arrangements is twofold. First, even if the internationalisation, deregulation and globalisation of financial markets signal the possibility of obtaining resources at lower costs, the characteristics of investments in innovation — long lead times for development, inherent uncertainty and high risk — limit the disposability of these kinds of resources (Melo 1994). The inherent characteristics of the innovation process lead banks and even markets to resist the financing of early stage innovation. This is particularly so in countries that have only recently introduced market capitalism, and where the capacity to evaluate intangible assets may not be yet well developed. And further appropriability matters may help to lower expected returns due to the difficulty of capturing profits from intangibles (Nelson 1959).

Second, considering a deliberate or implicit development strategy of a country, specific institutional set-ups may influence the areas to which resources are oriented, thus inducing or favouring specific trajectories. As stressed by Dosi (1990: 301) 'allocative criteria and rates of allocation should plausibly affect the amount of resources which the industry devotes to the innovative search, and also the directions in which the agents search'. Thus, at least as relevant as standard market failure arguments for public support to innovation, there is a strategic dimension that connects STI policy and the financial system to a development perspective.

In analysing the relationship between the financial system and investments in innovation, it is necessary to take into account the nature of the innovation process, the competition within markets and the criteria for risk and credit analysis by financial institutions for conceding the financing. Companies may use different sources for financing their investment programmes, namely: reinvestment of retained earnings; issuance of shares; issuance of securities; and bank loans. The use of each of these sources and their relative weight in the enterprise capital structure will depend on the historical and institutional development of the relationship between the financial system and the industrial system. This process is very specific to each country and its NSI. This highlights the need to go beyond benchmarks and to understand this issue within the context of each country.

This book therefore sets out to address the gap in neo-Schumpeterian analysis by offering a contribution to understanding the varied approaches to the role of finance in innovation. It draws on the experience of the five diverse BRICS countries each of which has undergone structural adjustment in the last two to three decades. The experience of the BRICS countries presents a unique set of case studies of the transition from largely closed centrally planned and state-driven economic and science policy to a more open and market-led innovation policy. Of key importance among these case studies is the role of the state.

The contributing authors examine the varying approaches to the provision of financial support to the full array of activities that contribute to innovation, ranging from idea generation and basic research to market development and 'human resources'. First, it is interesting to understand the varying importance of different types of instruments in each country, such as the financing of infrastructure, R&D tax incentives, grants, provision of seed capital and scholarship support to doctoral students. Second, the cases show how this relates to the diverse dimensions highlighted in the innovation system framework.

The individual country chapters are written within a broadly common framework starting with a synthesis of the problem of enterprise funding and the interface with the specific country financing systems. Next follows the discussion of the specificities of the innovation process and its financing. Consideration is then given to instruments and institutions for fomenting and financing innovation as well as the evidence from R&D and innovation surveys where such are available. The authors also discuss the impact of macroeconomic policies as well as implicit policies on financing for investments in innovation over the last two to three decades. The concluding sections summarise the role of the financial system in each innovation system with policy suggestions regarding the major future challenges.

In the chapter on Brazil, Melo and Rapini start by providing a detailed examination of the emergence of that country's financial system.

Over the last decades the evolution of the banking system was marked by a significant increase in the participation of foreign banks but with the prevailing dominance of national private banks and a relevant participation of public banks in specific areas. The Brazilian capital market experienced a timid development until the 1990s. It was after economic liberalisation and the stabilisation of inflation that the demand for stock shares increased. The changes in the legal framework favoured the entry of foreign capital. However, the growth of the capital market was concentrated in the secondary market. The limited rise in the market value and in the liquidity of the shares of private enterprises, discouraged both the demand of investors and new issues by the enterprises.

The banking credit is quite limited in the country and it is mostly addressed to short-term funding. It increased along the last decades, reaching the level of 40 per cent of GDP in 2008, but it is still considerably low by international standards. The extremely severe monetary policy implemented after the Real Plan, in 1994, also contributed to its scarcity and volatility. A high inflation regime was replaced by a regime of high interest rates and high compulsory deposits.

This brings us to the role of macroeconomic policy as an implicit STI policy. The cost of public debt provides the minimum base for the level of remuneration of private bonds. In the period from 1994 to 2007 Brazil presented the world's highest real interest rate, thus impeding the development of a more robust private bonds market. In addition, public debt is concentrated in short-term bonds that are daily indexed to the interest rate of monetary and interbank markets. This leads the state to offer, simultaneously, liquidity, profitability and safety. Thus, issuers of private bonds have to raise profitability to compensate for liquidity and risk.

This contributes to the financing of innovative activities to be heavily based on the enterprises' retained earnings. The participation of the financial system is almost non-existent. However, on the perspective of the firm's investment strategy, the alternative of investing resources in the financial market with high levels of return and low risk constitutes a disincentive for investments in uncertain innovative activities.

Melo and Rapini conclude that the relation between the financial system and the industrial system did not evolve in the same way it historically happened in developed countries. Thus, within a deliberate development strategy efforts were mobilised for structuring financial mechanisms for financing investment in intangible assets.

From the 1960s Brazil built a sophisticated innovation financing system. Initially, the Brazilian Development Bank (BNDES) undertook this mission. Later, the National Fund for Scientific and Technological Development (FNDCT) was created and the Studies and Projects Finance Organisation (FINEP) was assigned with its executive-secretariat. In 1997 the creation of the sectoral funds represented not only a change in funding sources for FNDCT, but also a change in the priorities for the allocation of resources. FINEP lost almost its whole autonomy in the definition of the strategy for application of FNDCT resources through sectoral funds. Currently, each sectoral fund has a managing committee and there is a general managing committee of FNDCT, in which FINEP is minor. This leads to a poor coordination and integration of activities and hinders the pursuing of strategic goals.

The authors show that the country now counts on a complex array of instruments for financing different innovative activities. These comprise fiscal incentives, long-term credit for R&D and innovation and non-reimbursable sources, such as the economic subvention. Although limited in amplitude, venture capital (VC) initiatives have existed since the 1980s, supported by the Brazilian Innovation Agency (FINEP) and BNDES (Melo 1988 and 1994). The question then turns to the impact of these initiatives on the innovation performance of Brazilian firms. Based on data from the Brazilian innovation survey, the authors show that firms invest little in R&D and present a relatively weak innovation performance, since only one-third of firms innovate and only a fraction of these introduced innovations that are new to the market. But, at the same time, the survey suggests some improvement in the access to resources. A steadily decreasing share of firms identifies the availability and cost of resources as obstacles for innovation.

In sum, Brazil built an extremely sophisticated financial system, able to do financial operations of high complexity. But, such technical capability derived from the need for agility for investing cash balances of enterprises under a regime of high inflation; and later for taking advantage of the regime of high interest rates. These capabilities helped little for improving the articulation of the financial system with the NSI. The main problem is the lack of long-term financing, which is offered only by public financial institutions. The big effort for amplifying and diversifying those resources tends to facilitate the access and lower costs. But, there is a poor coordination of activities among these public institutions, which impedes the integration of instruments and a strategic orientation of innovation policy. The more so as preferential procurement by the state is limited by law. Therefore, Melo and Rapini highlight the need for a systemic policy for industrial innovation that connects the state's purchasing power, matches demand with supply, and the necessary financial instruments. In this way it may be possible to reduce the negative impacts of implicit policies and, concomitantly, reduce uncertainty and the costs of investments in innovation.

Gorodnikova's chapter takes us to the evolving innovation system of Russia. It focuses on the transition from central planning to the market economy, tracing the period from that of Glasnost (1985–91) through to the present. The Glasnost period saw rapid increases in Gross Expenditures on R&D (GERD), but as a consequence of the economic shock therapy of the early 1990s there was a severe contraction of state-financed R&D.

Indeed the Soviet and post-Soviet economy was largely determined by the military-industrial complex's potential and by mining, metallurgy and heavy engineering industries. Accordingly, the industrial sector had always prevailed in the R&D sphere (later on to be replaced by the enterprise sector) — i.e., industrial research institutes and bureaus oriented towards the demand of specific industries. Under central planning the government allocated budget to R&D while Business Expenditures on R&D (BERD) was negligible. These deep institutional patterns persist into the present so that weak innovative orientation continues because of a mismatch between the focus of R&D, institutional structures and organisational mechanisms of the science sector on the one hand, and the needs of the economy on the other. Additional shortcomings include the separation of applied science from enterprises, since research institutes and design bureaus were oriented towards encouraging research, not innovation. The imbalance added to the low technological level of industry. Another weakness of the planned economy (and of the transitional economic mechanism) is the dissemination of innovations. Even when the country was a leader in developing major innovations, it lagged behind in terms of implementation, as for example, in the steel-making and process technologies.

Gorodnikova identifies serious hurdles for Russian innovation since the innovation system remains unbalanced and its major components operate in isolation from one other. Currently the S&T sector is not a growth factor for the national economy; rather, the whole economy of post-Soviet Russia is a factor of decline for the S&T sector. In the long run it can lead to irreversible degradation both of R&D capacity and high-technology industries; accordingly, fast modernisation of the national innovation system is a top priority. This will be no small task since, among the BRICS, Russia is unique in the collapse of GERD across the transition; in constant terms GERD has now attained half the pre-1991 level. Another unique feature of the Russian system is the small amount of research in the university sector, though this is explained by the unique character of the Academy sector that includes degree-awarding institutions.

As to innovation in the business sector, the evidence of innovation surveys going back to the early 1990s is that less than 10 per cent of Russian firms declare themselves to be engaged in technological innovation. These observations must be qualified in that there are size effects: large Russian firms innovate slightly below the European Union (EU) average. But medium-sized and small firms hardly innovate at all. This constitutes one of the main observations of the chapter: 'due to the generally weak small business support infrastructure, these companies cannot yet contribute to an overall increase of innovation activity.' There is an insufficient level of small business development in the Russian economy. Malaise persists so much so that the overall efficiency of Russian industrial companies' innovation activities is low with the return on investment dropping from 5.5 to 4.4 roubles per rouble spent on technological innovations. At 1.2 per cent of sales the innovation expenditure may be insufficient to exert the leverage required to boost productivity of capital.

The federal budget remains the main funding source for Russian R&D, with one component linked to payroll size and the second being programme specific — the Federal Goal-oriented Programmes (FGP) of which there are 52 at present. Nonetheless, severe budget constraints persist with many FGP budgets not allocated in full.

But as the author explains, more diverse sources of funds are now available ranging from private foundations, and Non-governmental Organisations (NGOs) across to public–private partnerships. In particular there are the 'mega' projects announced in May 2002. Twelve mega projects were selected; each to receive US$ 20 million for two years — the intention was to peg state involvement at no more than 50 per cent but in practice this limit was often exceeded. In 2006 responsibility for the mega projects was split between two ministries: Education and Science, and Industry and Power Generation. In spite of this potential for management confusion the project experience was found to be more positive than negative.

This much is clear: Foreign Direct Investment (FDI) remains a small component of innovation financing, and bank credit is hard to come by in the difficult financial environment of today's Russia. This is why the Russian Venture Company is so important. When it became clear that the high-technology sector was unable to attract private capital, state intervention became inevitable. Consistent with the ongoing active role of the state in the emergent market economy is Gorodnikova's suggestion for policy: 'to radically change the underlying ideology of government and public sector procurement (that) must be seen not just as means to deal with specific issues but as an important tool of industrial and innovation policy.'

Turning next to the case of India, we find Sunil Mani's econo-metric study of the impact of R&D tax incentives in that country. While noting the importance of research grants and VC, it is the operations of the tax incentive that intrigue Mani. Having traced the introduction of various market type reforms he notes that most academic studies of these have been descriptive catalogues that fall short of studying effectiveness. This to Mani is problematic given the recent estimates by the Ministry of Finance that the amount of corporate tax foregone as a result of R&D tax incentives has been increasing at a rate of 2.4 per cent per annum.

A range of input- and output-based tax incentives are available for domestic R&D, be this intramural or extramural. There are eight forms of input support, the most common being the 150 per cent deduction on intra-mural R&D expenditure that has operated since 1998. The other input deductions include capital expenditure write downs, reduced tariffs and duties. Mani notes that the existing literature (Hall and Van Reenen 2000; Mohnen 2007) on the effectiveness of R&D tax incentives is restricted to the core Organisation for Economic Cooperation and Development (OECD) countries, a situation that in part arises because of a lack of data for emerging economies, as well as the sheer difficulty of accessing such data where it exists.

In the case of India it turns out that the pharmaceutical industry, being the most R&D intensive, is the major beneficiary of the incentive, which in itself is not surprising. This incentive has the effect of lowering the industry tax rate to around 14 per cent compared with automotive (medium technology) at 26 per cent. Even so, his general finding is that the tax incentive does not have any influence on the level of R&D, except possibly in chemicals. This result follows from the fact that the incentives do not apply to the full R&D expenditure of firms but are selective. As he notes:

> [F]or tax incentive to be effective in raising R&D expenditures it must form a significant portion of R&D investments by an enterprise . . . this result corroborates the results of innovation surveys in Brazil and South Africa where innovating firms did not access fiscal incentives for innovation as an important instrument for financing their respective innovation efforts.

He argues that markets, the volume of domestic sale, and in some cases exports are the factors leading to investment in R&D.

Mani's conclusion may come as a surprise to advocates of input-style R&D tax incentives: 'Allowing firms to become larger and through that process of growth enabling them to become larger investors in R&D may be a better policy than providing them directly with subsidies.'

The next chapter takes us to the Peoples' Republic of China that from the 1950s followed the central planning model of the Soviet Union in shaping its innovation system. At that time the state-owned enterprises (SOEs) were expected to use R&D conducted in the public research institutes (PRIs). The abrupt emergence of state capitalism in 1978 saw the privatisation of many PRIs, and the opening up of the country to FDI through the establishment of plants and research centres. Jian Gao and Xielin Liu trace these developments pointing out the fundamental shifts in law pertaining to innovation policy initiated under the leadership of Deng Xiaopin (the 'South Talk' of 1992). In 1993, the 'Technology Progress Law' targeted S&T development as one of most important elements of China's economic development. The 1996 Technology Transfer Law encouraged the science sector to transfer its technology, by setting rules for technology market transactions. Further change came in 1998 with the 'State Development through Promoting Science Technology and Education' policy and in 1999 with intellectual property rights (IPR) legislation. Outputs of scientific and innovative activity have soared with China now ranked fifth for ISI publications and effecting more than 250,000 invention patent filings annually.

The central thrust is the role of innovation in promoting economic growth and the strong political support that this notion has enjoyed since the 1980s, when modern institutions such as technology parks and incubators were introduced. The authors suggest that the NSI comprises four subsystems: the knowledge innovation system (research institutes and research-oriented universities), technology innovation system (companies), knowledge distribution system (higher education and professional training) and knowledge application system (interaction between research institutes and companies). While the first three refer to the role of different organisations, the fourth 'system' highlights the pivotal challenge for shifting from a centrally planned to a more market-oriented innovation system.

In addition, the characteristics of the NSI show strong regional dimensions — the further west one moves, the stronger the role of PRIs and universities. Foreign R&D centres account for anything up to 30 per cent of China's BERD, and these tend to be located in the east. Reference is also made to China's innovation survey that shows the strong role played by machinery, equipment and software imports as drivers of innovation. This points to a strong external influence on innovation activity and can also be interpreted as part of the learning process based on the incorporation and improvement upon foreign technology.

Regarding the financing of innovation, the first resource was government support in terms of technology programmes and innovation funds. The second and main source is bank loan finance. Although representing only 10 per cent of that investment in 1988, their share increased to 70 per cent by 1991 (Gu 1999). The authors show that despite the fact that banks did not have the capability or access to critical information to assess risk at this initial stage, they relied on a project's designation as a recipient of the Torch Programme support for policy guidance. The third type of financing source was introduced in 1985 and is based on VC and capital markets. Of vital importance to the growth of new institutional forms was the establishment of Technology Zones in Shenzhen and Wuhan from the mid-1980s that was then extended with the founding of the Beijing Experimental Zone, the first national-level high and new technology industry development zone. These zones act as an institutional interface between new ventures and the broader socio-economic system (Gu 1999).

A key institutional innovation was the establishment in 1986 of the Technology Venture Investment Corporation, formed by the State Science and Technology Commission and the Ministry of Finance, to replicate the dynamism of Silicon Valley and Route 128 in the US.

It was managed and operated like an SOE; but was really a central government agency with the mandate to support national technology venture policy objectives, rather than a profit-oriented private enterprise.

At the same time central government has taken a more indirect approach and allowed the system to develop from below and has made progress towards aligning the legal and financial systems. Local governments have responded to the incentives and opportunities to foster new technology-based ventures in their regions and allowed firms greater autonomy, including setting salary levels.

Jian Gao and Xielin Liu point to the emergence of VC firms at central government level, among the universities, and especially in the private sector. This diverse set includes wholly foreign-owned VC firms. The picture that emerges is that there are diverse forms of innovation systems in China, and it might well serve to investigate these as uniquely regional, evolving forms. Data is presented to show the stellar growth of China's infrastructure and output — best illustrated in the statistic that the number of high-technology firms increased twenty fold over two decades.

In conclusion, the authors note that while encouraging free market forms the state retains a strongly 'paternalistic' stance on the economy. This may explain why VC firms do not display the same flexibility and nimbleness as their foreign counterparts. At the same time they express concern that the state has invested less in high-risk basic research than the more highly developed OECD countries, and this may be expected to change as confidence grows.

The final chapter provides the South African case. In a sense that economy has maintained its essential character for the longest period, spanning at least a century. Arguing from a sociological viewpoint Kahn shows that the South African economy, even before the 1910 political consolidation of the country, has been dominated by its minerals–energy complex (Fine and Rustomjee 1997), and that this persists to the present. Political, class, group and economic struggles continue to pivot on the fulcrum of the relationship between the state, capital, political class, labour and society.

It has been shown that modern financial capital has very deep roots in South Africa extending back to the diamond exploitation of the last quarter of the 19th century. The unique nature of the gold mineralisation required massive capital investment as well as huge sources of labour and these aspects continue to underpin the character of the economy to this day. The country has long functioned as a market economy, open to international capital flows, even during the sanctions years since global demand for strategic minerals had to be met. For its part, the state from the 1920s established the infrastructure for heavy industry: electricity, water, forestry, iron and steel, and communications. The consequence was a large public sector alongside a set of monopolistic mining houses with diversified interests. While South African transnational corporations traded globally since the early days of mining capital, the 'apartheid constructed crisis' eventually drove the economy downwards into negative growth. Then followed the political transition to democracy. But unlike Russia, its NSI survived the transition largely intact, albeit with lack of direction. Industry, faced with the challenge of globalisation underwent considerable expansion abroad to the extent that foreign sales now make up close to 50 per cent of leading company revenues.

The financing of innovation activity occurs in a local financial market that is among the most advanced in the world, standing in third rank on the Global Competitiveness Index. The evidence of innovation surveys is that companies rate themselves as highly innovative even though this is mainly incremental and oriented towards process and organisational changes. Inventors and innovators can turn to a range of sources of funds that assess the prospects for a return on investment with varying degrees of expertise.

Kahn suggests that the modernising agenda is expressed through a new 'constructed crisis' that unfolds alongside the contested distributive role of the state. Four binding constraints arise from the country's history: foreign-exchange volatility and controls, risk aversion and anti-competitive behaviour. All four of these involve financial decisions though the first, other than the underlying financial provision, refers to the specifics around human resource development. Indeed, there is a deep-seated failure to set a realistic agenda for basic education and to grapple with the hard choices around vocational and academic education. These binding constraints are evident in the paradoxes that the constructed crisis drives. According to the 2010 Global Competitiveness Report the country leads the world in auditing and reporting standards but is among the worst for the efficiency of health and primary education, being ranked 129th of 134 countries.

The main source of funds for company innovation is cash; in the absence of cash a well-established company can still leverage bank loans since the bank can value the assets of the firm as collateral. This implies that where fixed assets or a sound trading record cannot be identified loan finance will not be forthcoming. In practice, firms younger than three years will find it extremely difficult to access bank finance and will have to resort to self-financing.

Angel investors are virtually absent and there remain concerns relating to tax and exchange control regulations that may impact on the risk management strategies of local fund managers. Overall, there appears to be a very slim connection between industry and the state insofar as funding and sources of innovation information are concerned. This means that the question of effectiveness cannot be addressed by looking at the funding instruments. It is rather a question of the way that firms grow and deploy their financial, physical, human and intellectual capital, in spite of the state.

The state has shown willingness to take the greatest risk in very early stage development through the agency of the Innovation Fund, Biotechnology Regional Innovation Centres, the state-owned Industrial Development Corporation, and through support for technology development in the public utilities and defence-aerospace. The financing gap is between very early stage development and commercial start-up so that prospective entrepreneurs experience difficulty in raising capital.

A range of direct and indirect incentives are in place. Indications are that the enhanced 2007 R&D Tax Incentive has been framed too rigidly so that take-up has been very limited, favouring a few well-organised and well-established R&D performers. A second problem area is the plethora of direct incentives, most of which are not subject to independent impact assessment.

To stem the capital flight and rent-seeking behaviours in the sanctions era strict foreign exchange controls were enforced for five decades. This regime included the definition of a patent as 'capital' whose disposal was, until April 2011, subject to exchange control regulations. It is too soon to tell if this change will alter firm behaviour positively. The new law on intellectual property deriving from publicly funded research adds further complexity to the ownership of patent rights with further impact on the cost of doing business.

South Africa's structural adjustment programme was designed to lure FDI but this has not happened in depth save for the few examples given in the chapter. Indeed, if cheap energy was the draw card, that has now turned out to be a knave. Repatriation of capital is no longer a negative for FDI: the main negatives are the cost of labour, security and uncertainties with regard to property rights. Again these are not issues to do with the financing of innovation.

It is argued that the binding constraints will remain unless government shifts gear towards more pragmatic solutions. But that may be to ask the impossible of politics.

Kahn concludes by citing Aghion, Braun and Fedderke (2006), who argue that South African manufactured goods are uncompetitive by price. If this is indeed the case then why would firms report high commitment to innovation? One would expect to find low reported levels of innovation but instead we see the contrary. Firms appear to be prepared to take the risk, and fund that risk from internal sources. Firms do not read economic journals.

So what have we learnt about innovation financing? It will be evident that there is considerable heterogeneity in the approach of the country authors. This arises from the unique history of each country's economy, and the stance adopted by the writer — informed by their own viewpoint, interests and data availability. Fundamentally there are different formulations of what is understood by the concept of 'National Innovation System'. And there is the fact that the neo-Schumpeterian school has devoted little attention to financing the NIS.

That being said there is also commonalty among the five BRICS countries in that since the Second World War the state has played a strong role in their economic development path. This commonalty does not fit into a neat box labelled 'central planning' but might be characterised as an approach to managing the commanding heights of the economy both directly and through a range of regulatory actions. One could, for example, compare and contrast the former SOEs of Brazil and South Africa, the family businesses of India and South Africa (and Brazil) and the new players, China and the Russian resource giants.

Some recurrent features of these five unique experiences appear: the role of the state; the importance of institutional coordination; the influence of macroeconomic background conditions; the questioning of the efficacy of fiscal incentives, the contributions of multinational corporation (MNC) (domestic and foreign) R&D and innovation requirements; the central role of human resource availability and mobility; the risks associated with seed and VC provision, and the tensions between local and export market-led innovation strategies. Some of them deserve closer consideration.

First, we find the central role the state plays within the NSI. Although the countries portrayed in this book come from a long history of direct governmental interference in the economy, this is not a specific feature of these countries. Rather these five cases illustrate the importance of the state in any country for: (i) ensuring supportive framework conditions; (ii) providing that kind of support which is not compatible with private financial organisations' logic; and (iii) guiding efforts within a strategic perspective related to a development strategy. All chapters emphasise the importance of the framework conditions and of the state provision of financing. There is an important role for private financial organisations to play but the characteristics of innovative projects will always limit its scope. Even in the case of South Africa, where private bank loans are in the front stage, we find relevant bottlenecks for small-and medium-scale enterprises (SMEs) and new enterprises to access those resources. Further, considering that technological evolution is not neutral, but conditioned by priorities and strategies of incumbents, socio-cultural characteristics of each society, opportunities and so forth, the state has a pivotal role for directing resources to specific areas. Thus, we find a close articulation of innovation policy with the countries' development strategy in China and in India. The other countries face greater hurdles for setting this strategic guidance. The study on South Africa suggests this to be less relevant.

This brings us to another central issue. The ability to shape instruments and programmes and to guide initiatives in a coherent strategic direction is conditioned by the level of institutional coordination. This is a special hurdle in the case of the Brazilian institutional framework. The Russian case also stresses the challenges for coordination among different ministries. On the other extreme, the special characteristics of the Chinese political and economic system enable a close coordination, even 'stimulating' national banks to offer huge sums of loans for innovation projects. The absence of this strategic guidance leads to the claim by the authors of the Brazilian and Russian chapters for public procurement to play a greater role.

In India and South Africa on the other hand (both strongly coloured by British commercial practice, and home to many large family businesses) the arguments are perhaps more free market oriented. Kahn points to the long history of anti-competitive behaviour in South Africa, with the underlying tensions between race, class and capital providing the energy to drive the balance one way or another. China's vast size, varied implementation of policy, and considerable space now for individual entrepreneurs imply that generalisations (including the preceding) are risky. But the description of China's rapid march to entrepreneurial freedom suggests a single mindedness on the part of political leadership that is less evident in Brazil, India, South Africa and Russia.

Another important dimension is the macroeconomic ambience and policy. The level of basic interest rate, the exchange rate and the structure of public debt function as implicit STI policy. The capacity and the extent to which private banking and stock market may contribute to innovation financing are influenced by these factors. For example, in all countries we find the problem of marshalling support from the capital markets. But this is especially true in countries with less favourable macroeconomic conditions or instability.

The study on India sheds light on an issue which is recurrent for any country: the effectiveness of fiscal incentives for promoting novel innovation efforts. The findings converge with data from innovation surveys from South Africa and Brazil. In fact, the bulk of resources are used by large enterprises which would have invested in innovative activities anyway. It is questionable how far subsidising R&D of big pharmaceutical companies constitutes the best use for scarce public resources. Thus, it's not only about the amount of disbursements but also about what kind of strategic orientation is behind the public support to innovation. In articulation to supply side policies, demand side initiatives are imperative.

As we said before, the systems of innovation literature has not yet paid the necessary attention to the link between the innovation system and the financial system. Financing investments in innovation constitutes an important structural bottleneck that not been solved. The characteristics of investments in innovation such as long lead times for development, inherent uncertainty and high risk, point to the need for setting national institutional arrangements, the more so in the present financial turmoil, a turmoil in part owing to financial innovation itself. The creation of such alternative innovation financing instruments implies governmental actions in analysing the relation between the financial system and investments in innovation.

This has clearly not been a neo-Schumpeterian issue. At this point, it will be necessary to resort to concepts derived from Keynes' works, who formulated the concept of liquidity preference — or of money as an asset — as a central reference for the process of investment.

Regrettably, lenders, in their quest for profit, have ignored the fundamentals of intelligent lending policy. The development of increasingly complex financial derivatives, and the difficulty in quantifying their 'real' value took the finance industries of the advanced economies into new territory.

It is *schadenfreude* indeed for countries such as Brazil to find themselves in a stronger financial position than before, precisely because they have followed a more interventionist stance. In fact, the five BRICS countries have weathered the storm rather better than most, partly because of the continuing commodities super-cycle, but also because of a different macroeconomic stance.

As we have noted, the chapters are heterogeneous in theoretical and methodological terms. Some of the preceding points have been taken into account by the authors, and others not.

So, the analysis recognises the dynamics of the economic system and the pervasive uncertainty that is inherent to investment in innovation. This signifies the importance of institutions for the dynamics of the economic system, which cannot be reduced to the market.

Finally, considering all the chapters in a comparative perspective additional research questions may be posed:

- What is the nature of firms' financing and the interface between the financial system structure and industrial financing?
- How does implicit innovation policy shape entrepreneurial investments in innovative activities?
- How do the domestic financial regimes affect the ability of the BRICS transnational corporations to trade in global markets?

Note

1 Freeman and Perez (1988) argued that the five long waves of capitalism are marked by the co-evolution of financial institutions and technological institutions. As capital needs evolve together with technological changes there is a push for changes in the organisational structures of firms and for financial innovations. Zysman (1983, 1986) and Nelson (1993) discuss the

influence of different types of financial systems and broader institutional arrangements on innovation and sectoral dynamic. Christensen (1992) analyses the role financial institutions play in national innovation systems and the mutual knowledge build-up upon repeated interactions. More recently, Mayer (2002) and Chesnais and Sauviat (2003) discuss VC market and find that its evolution is closely linked with the institutional set-up of the North American system of innovation.

References

Aghion, P. and P. Howitt, 2005. 'Appropriate Growth Policy: A Unifying Framework', The 2005 Joseph Schumpeter Lecture, delivered to the 20th Annual Congress of the European Economic Association, Amsterdam, 25 August.

Aghion, P., M. Braun and J. Fedderke, 2006. 'Competition and Productivity Growth in South Africa', Working Paper #132, Harvard University Center for International Development, Cambridge.

Chesnais, F. and C. Sauviat, 2003. 'The Financing of Innovation-related Investment in the Contemporary Global Finance-dominated Accumulation Regime', in J. E. Cassiolato, H. M. M. Lastres and M. L. Maciel (eds), *Systems of Innovation and Development: Evidence from Brazil*. Cheltenham: Edward Elgar, 61–118.

Christensen, J., 1992. 'The Role of Finance in National Systems of Innovation', in L. B. Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Frances Pinter, 151–72.

Dosi, G., 1990. 'Finance, Innovation, and Industrial Change', *Journal of Economic Behavior and Organization*, 13(3): 299–319.

Fine, B. and Z. Rustomjee, 1997. *The Political Economy of South Africa. From Minerals Energy Complex to Industrialization*. Johannesburg: Witwatersrand University Press.

Freeman, C., 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Frances Pinter.

Freeman, C. and C. Perez, 1988. 'Structural Crisis of Adjustment: Business Cycles and Investment Behaviour', In G. Dosi, C. Freeman, G. Silverberg and L. Soete (eds), *Technical Change and Economic Theory*. London: Pinter, 38–66.

———, 1994. 'The Economics of Technical Change', *Cambridge Journal of Economics*, 18(5): 463–518.

Gershenkron, A., 1962. *Economic Backwardness in Historical Perspective*. Cambridge, Massachusetts: The Belknap Press of Harvard University Press.

Gu, S., 1999. *China's Industrial Technology: Market Reform and Organizational Change*. London: Routledge.

Hall, B. and J. Van Reenen, 2000. 'How Effective are Fiscal Incentives for R&D? A Review of the Evidence', *Research Policy*, 29(4–5), April: 449–69.

Klynveld Peat Marwick Goerdeler (KPMG) and South African Venture Capital and Private Equity Association (SAVCA), 2009. *Venture Capital and Private Equity Performance Survey of South Africa for the Calendar Year 2008*. Johannesburg: KPMG and SA Venture Capital Association.

Levine, R. and S. Zervos, 1998. 'Stock Markets, Banks, and Economic Growth', *The American Economic Review*, 88(3): 537–58.

Lundvall, B.-Å., 1985. *Product Innovation and User-Producer Interaction*. Aalborg: Aalborg University Press.

Mayer, C., 2002. 'The Financing and Governance of New Technologies', paper prepared for the UN University/EU DG Research Conference on Financial Systems, Corporate Investment in Innovation and Venture Capital in Brussels on 7–8 November 2002.

Melo, L. M. 'O Financiamento ao Desenvolvimento Científico e Tecnológico: a experiência da Finep — 1967 a 1988'. Unpulished M.Sc. dissertation, Universidade Federal do Rio de Janeiro, 1988.

———, 1996. 'Sistema Nacional de Inovação (SNI): Uma Proposta de Abordagem Teórica', *Texto para Discussão*, n. 357, Institute of Economics/ Universidade Federal do Rio de Janeiro, , Rio de Janeiro, April.

———, 1994. 'O Financiamento da Inovação Industrial'. Unpulished Ph.D. dissertation, Universidade Federal do Rio de Janeiro.

Minsky, H. P., 1982. 'The Financial-instability Hypothesis: Capitalist Processes and the Behaviour of the Economy', in C. P. Kindleberger and J. P. Lafargue (eds), *Financial Crises*. Cambridge: Cambridge University Press, 161–89.

Mohnen, Pierre, 2007. 'R&D Tax Incentives: Issue and Evidence', Presentation Slides, Design and Evaluation of Innovation Policy Programme (DEIP), 22 October, Maastricht: UNU-MERIT.

Mowery, D. C., 1992. 'Finance and Corporate Evolution in Five Industrial Economies, 1900–1950', *Industrial and Corporate Change*, 1(1): 1–36.

Nelson, E. R. (ed.), 1993. *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press.

Nelson, R. R., 1959. 'The Simple Economics of Basic Scientific Research', *Journal of Political Economy*, 67(3): 297–306.

Rosenberg, N., 1990. 'Why Do Firms Do Basic Research (with Their Own Money)?' *Research Policy*, 19(2): 165–74.

Schumpeter, J. A., 1982. *A Teoria do Desenvolvimento Econômico*. São Paulo: Abril Cultural.

Studart, R., 1993. 'Financial Repression and Economic Development: Towards a Post Keynesian Alternative', *Review of Political Economy*, 5(3): 277–98.

Zysman, J., 1983. *Governments, Markets, and Growth: Financial Systems and the Politics of Industrial Growth*. Oxford: Martin Robertson.

———, 1986. 'Financial Systems and Technological Innovation', paper presented at the Conference on Innovation Diffusion, Veneza, 17–21 March.

2

Innovation, Finance and Funding in the National System of Innovation

The Brazilian Case

Luiz Martins de Melo and Márcia Siqueira Rapini

Studies about National Systems of Innovation (NSIs) are focused on the processes of interactive learning and knowledge generation within enterprises and institutions of human resources training and scientific research, as well as on how these organisations interact for constituting the innovation process. It is evident that a key factor which may either help or hinder this interaction is the role played by the state in the formulation and implementation of policies for fostering innovation and, indirectly, of macroeconomic policies.

The neo-Schumpeterian approach, responsible for the creation and dissemination of the concept of NSI, gave no emphasis to the financial perspective in its researches. Freeman (1994) analysed the roll of neo-Schumpeterian research, claiming that this topic had not taken a central position in such roll. As highlighted by Levine and Zervos (1998), there is a significant gap in that theory, since Schumpeter (1982), himself, already emphasised the relevance of the bank system in economic development, underlining the circumstances in which the banks could actively encourage investments in innovation.

The significance of financing to investments in innovation has been pointed out as an important structural bottleneck that was yet to be solved by private financial institutions. If, on the one hand, the internationalisation, deregulation and globalisation of financial markets signal the possibility to access resources at lower costs, on the other, the characteristics of investments in innovation such as long-term development, the uncertainty and the risk, point to the need of setting national institutional arrangements (Melo 1994).

The creation of alternative innovation financing instruments implies governmental actions (Corder and Salles-Filho 2006).

In analysing the relation between the financial system and investments in innovation, it is necessary to take into account the nature of the innovation process, the competition within markets and the criteria for risk and credit analysis by financial institutions for conceding the financing. As emphasised by Dosi (1990: 301):

> In a very general sense, innovation concerns processes of learning and discovery about new products, new production processes and new forms of economic organization, about which, ex ante, economic actors often possess only rather unstructured beliefs on some unexploited opportunities, and which, ex post, are generally checked and selected, in product markets. However, in addition, and complementary to product market competition, innovative efforts are shaped and selected also by rates and criteria by which financial markets and financial institutions (private and public), such as stock markets and banks, allocate to business enterprises. Irrespectively of whether resources are attributed to firms or individual projects, allocative criteria and rates of allocation should plausibly affect the amount of resources which the industry devotes to the innovative search, and also the directions in which the agents search.

Such characteristics of the innovation process lead banks and even markets to resist financing innovation, particularly in countries where capitalism appeared late, which have not yet built financial systems able to properly evaluate intangible assets.

For carrying out an analysis of the problem of financing innovation, particularly in Brazil — one of the more developed countries of late capitalism — it is necessary to take into account some particular matters. The first one is the composition of investment in innovation within macroeconomic regimes of both high inflation rates and high interest rates. The second is the impact of the regime of imports liberalisation and the flexible regime of exchanges on the technology of enterprises. Third, one must examine why the discussions on relations between policies aimed at fomenting investment in innovation and the macroeconomic policies — the problem of implicit and explicit technological policies — were abandoned since the middle 1980s and only reemerged in the beginning of the 21st century (Erber 1999). These questions conduct an analysis of innovation investments as a constitutive part of the firm's investment strategy and how this strategy is affected by the macroeconomic, technological and industrial policies. It raises the problem of the valuation of the firm's assets and of its financing. This has clearly not been a neo-Schumpeterian issue. At this point, it will be necessary to resort to concepts derived from Keynes' works (1936), who formulated the concept of liquidity preference — or of money as an asset — as a central reference for the process of investment.

The analysis to be developed is based on neo-Schumpeterian theoretical assumptions such as distinct characteristics of innovation projects, technological heterogeneity of economic sectors and the role of the NSI.

Besides this introduction, the chapter is organised into seven sections. The second section provides a historical overview of the structuring of the Brazilian financial system. The third presents a synthesis of the problem of the enterprises' funding and the interface between financing systems' structure and the financing for investment in Brazil. The fourth section summarises the specificities of the innovation process and its financing in the Brazilian case, presenting existing instruments and institutions. The fifth presents recent evidences from the Brazilian Innovation Survey (PINTEC). The sixth section presents the impacts of macroeconomic policies, the implicit policies on financing for investments in innovation in Brazil in the 1980s and 1990s. The seventh aims at summarising the role of the financial system in the Brazilian Innovation System, based on what was analysed in previous sections. The concluding remarks summarise the chapter and indicate the major future challenges for the system of financing investments in innovation.

The Recent Structure of the Brazilian Financial System

In the 1950s, with the advancement of the industrialisation process, it was necessary to create the Brazilian Development Bank (BNDES) in 1952, for solving the problem of long-term funding. BNDES resources stemmed from an additional tax on the revenue tax and from technical reserves of insurance and capitalisation companies. It also counted on the resources raised in foreign currency arising from international agencies.

In the 1950s and 1960s, other governmental banks with regional scope were also created, such as, in the federal sphere, the Northeast Bank (1952) and the Amazon Bank (1996); regional development banks, such as the Farther South Development Bank (1962); and state development banks such as the Minas Gerais Developmente Bank (1962). This group of institutions formed a relatively articulated system of financial institutions able to implement public sector credit policy (Cavalcante 2002). On the other hand, the private banks were not able to follow the industrial and commercial growth, keeping their essentially regional and family-dominated character, and a limited range of services (Barker 1990).

Besides the development banks, there were the large, state-owned, commercial banks, such as Brazil Bank (Banco do Brasil) and the Federal Savings Bank (CEF). This latter is a bank which, in addition to the typical services of a commercial bank, operates as a saving bank, particularly of small savers.

Following the 1964 military coup, several institutional reforms were made in the financial system. The perception of the government was that the financial system was hampering the process of economic growth. It was considered inadequate for financing the consumption of durable goods, the needs of working capital by firms and the new stage of modernisation of Brazilian economy. The 'Law of Usury' (from 1933) established a limit of 12 per cent for the interest rates. Thus, short-term transactions became the pattern, especially in periods of high inflation rates.

The financial reforms carried out were inspired by the North American model which had a financial system segmented in conformity to the Glass-Steagall Act of June 1933. The Law of Bank Reform (Lei 4595/64) established the model of specialised institutions and was responsible for the creation of the Central Bank and the Securities and Exchange Commission of Brazil (CVM). Law 4357/64 introduced the concept of 'monetary correction'. Law 4728/65, the Law of Capital Market, regulated the activities of stock exchanges, created fiscal incentives for the issue and acquisition of stock shares and debentures and defined the functions of investment banks (Puga 1999).

The scope of operation for institutions in the financial system became defined as follows: (a) commercial banks, responsible by short-term deposits and loans; (b) investment banks, responsible for the promotion of the capital market, in order to finance private investment; (c) institutions of saving and loans, responsible for financing the housing system; (d) companies of credit, funding and investment, responsible for credit to consumers; (e) stockbrokers and dealers in charge of supporting the development of the stock exchanges. Long-term credit would be granted mainly by BNDES with resources of the Unemployment and Retirement Guarantee Fund (FGTS), the Social Integration Programme (PIS) and Programa de Formação do Patrimônio do Servidor Público (PASEP).[1]

During the reform, the Central Bank of Brazil (BACEN) was created. Another relevant change was the creation of the National Housing System in 1964, when a specific fund aimed at financing housing was created through the establishment of the National Housing Bank (BNH).

The reform of 1964, however, did not lead to a significant change in the structure of the financial system. It was unable to develop a market of long-term funding for private banks of investment, so that industrial investment was limited to public credit, through BNDES actions. On the other hand, it met one appeal by the business sector that was the expansion of credit aimed at consumption.

According to Hermann (2003), the failure of this reform points to three major factors: (1) fails in the diagnosis of the financial problem, which attributed the difficulties of long-term funding to insufficiency of domestic saving; (2) the persistence of the inflationary process; (3) failures in financial policy management, which in several occasions relaxed the valid legislation and ended up allowing financial conglomeration.

The failure in the establishment of investment banks, which were to constitute the fundamental piece for consolidation of the securities market, was attributed to the impossibility of developing long-term financial assets in economies undergoing chronic inflation. Other authors attributed the failing to the refusal of banking capital to participate in activities involving greater risks (Cruz 1994).

Moreover, as of 1967 an intensive process of bank concentration had begun. The number of private commercial banks dropped from 188 in 1968, to 72 in 1974. Between 1967 and 1976, the share of the five major banks in total volume of deposits in the financial system increased from 20.9 per cent to 34.2 per cent. Concurrently to banking concentration, a movement of financial centralisation was also observed, with the emergence of large financial conglomerates headed by commercial banks.

In the 1980s, the financial system presented a consolidated standing. However, the chronic macroeconomic instability sharpened the difficulties regarding long-term funding.[2] The restrictions of the public financing system, in their turn, created profitable short-term opportunities for the banking system. From 1985 onwards, 'holdings' started to be constituted from the conglomerates formed in the 1970s. The incorporation of non-financial enterprises was part of the strategy for equities' defense.

In 1988, another reform of the banking system was carried out. On this occasion, BACEN authorised the creation of multiple banks, which combined commercial and financial banking portfolios (Securities Commission Regulation number 1529). As stressed by Hermann (2003) the reform represented nothing but the institutionalisation of a structure already in force in the Brazilian banking system, which were banks already operating as multiple banks.

The Real Plan, implemented as of 1994, led to a reorientation of the financial system insofar as, with the end of inflation, financial institutions lost a significant part of inflationary revenue. Between 1990 and 1993, inflationary revenue as a percentage of Gross Domestic Product (GDP) reached 4 per cent. In 1994 it reduced to 2 per cent and in 1995 to 0.1 per cent. Inflationary revenue as a percentage of production imputed to the banking system, which was 87.3 per cent in 1993, reduced to 49.5 per cent in 1994 and to 1.6 per cent in 1995 (Corraza 2000).

The reduction of inflationary revenue and the growing entry of foreign banks since 1996 led to an increase in competition and to the restructuring of the Brazilian financial system. The financial system restructuration was fostered by the government, which created the Program for Restructuring and Strengthening of the Financial System (PROER) in 1995, and the Program of Incentive to the Reduction of State Institutions in Banking Activities (PROES) in 1997.

PROER aimed at providing resources, through BACEN, so that solid financial institutions acquired the financial control of banks undergoing difficulties. PROES, in its turn, aimed at promoting the recovering of state banks, restricted to three options: privatisation, liquidation or being converted to a development agency. The main outcome from PROER and PROES was the concentration of the Brazilian financial system. The reduction in the number of commercial and multiple purpose banks may be seen in Table 2.1.

Table 2.1: *Financial Institutions and Other Institutions Authorised by Central Bank of Brazil, in Operation, 1994 and 2001*

	06/30/1994		*12/31/2001*	
Types	*Headquarters*	*Agencies*	*Headquarters*	*Agencies*
Commercial banks	34	4,258	28	389
Multiple purpose banks	212	11,330	154	14,974
Development banks	6	9	4	10
Investment banks	17	51	20	47
Savings banks	2	1,929	1	1,689
Cooperative societies	853	–	1,307	–
Credit, financing and investment societies	42	103	39	72
Securities and stock brokers	244	356	177	297
Foreign exchange brokers	43	47	41	60
Security and stock dealers	371	642	156	252
Investment companies	4	0	0	0
Mercantile leasing companies	67	110	71	83
Real estate credit companies	24	40	16	27>
Micro-credit societies	–	–	14	5
Saving and loans associations	2	1	2	2
Mortgage companies	–	–	7	7
Development agencies	–	–	9	9
Total	**1,921**	**18,876**	**2,046**	**17,849**
Investment funds	1,008	0	5,182	–
Consortium management companies	507	3,516	397	10,378
Total	**3,436**	**22,392**	**7,625**	**28,227**

Source: BACEN (2002).

Another change observed in the Brazilian financial system was the growing entry of foreign institutions in the 1990s. Between June 1995 and December 1998 the number of foreign banks increased from 37 to 52. Domestic banks with foreign control jumped from 20 to 36. The participation of foreign banks in total number of commercial and multiple banks increased from 15.4 per cent to 25.6 per cent (Puga 1999). In addition to the entry of new institutions, an expansion of existing institutions by the acquisition of domestic banks was observed.

The growing presence of foreign banks may be seen in Table 2.2, which presents the market share for the banking system. The market share of banks with foreign control increased gradually, passing from 8.4 per cent in 1993 to a maximum of 29.9 per cent in 2001.

With the reduction in the participation of state-owned banks, there was an increase in credit operations carried out by private banks. In 1996, state-owned banks accounted for approximately 60 per cent of credit operations, dropping to 32 per cent in 2006.

In its turn, the participation of private banks in credit operations increased more than 60 per cent, jumping from about 42 per cent in 1996 to 68 per cent in 2006 (Table 2.3).

The participation of state-owned banks in the total credit operations decreased in the post-Real Plan period due to both privatisation and liquidation of some of these institutions, eminently federated state-owned banks, and cleaning up of balance sheets, especially by excluding the 'rotten' real estate credits from assets of CEF in the first half of 2001. According to Pinheiro (2006: 34), the state-owned banking segment operates as follows:

- They rather lend to the public sector and to the real estate segment, although both these currently account for a small part of their operations;
- They account for most part (about 60 per cent) of rural credit;
- They hold a minor share of the credit to individuals, in spite of having also significantly expanded these operations as of 1999;
- They account for approximately 40 per cent of the credit to industry and to other services, rivalling national private banks in importance, and 23 per cent of the bank financing to commerce, a segment where national and foreign private banks have greater participation.

Table 2.2: *Banking System's Market Share in Brazil (Total Assets), 1993–2004 (percentage)*

	1993	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Public banks	50.8	51.4	52.2	50.9	50.1	45.8	43	36.6	32	34.7	37.2	34.4
State-owned banks*	13.4	18.2	21.9	21.9	19.1	11.4	10.2	5.6	4.3	5.9	5.8	5.5
Bank of Brazil	22.9	18.3	13.9	12.5	14.4	17.4	15.8	15.6	16.8	17.1	18.4	17.4
Federal Savings Bank	14.5	15	16.4	16.5	16.6	17	17.1	15.4	11	11.7	13	11.5
Private banks	49.1	48.4	47.6	48.8	49.6	53.7	56.3	62.6	67.1	64.3	61.5	64.2
Domestic banks	40.7	41.2	39.2	39	36.8	35.3	33.1	35.2	37.2	36.9	40.8	41.8
Banks with foreign control	8.4	7.2	8.4	9.8	12.8	18.4	23.2	27.4	29.9	27.4	20.7	22.4
Credit cooperatives	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1	1.3	1.4
Total in the bank segment	100	100	100	100	100	100	100	100	100	100	100	100

Source: BACEN (1993–2004).
Note: *Includes state saving banks, but excludes the Federal Savings Bank and the Bank of Brazil.

Table 2.3: *Evolution of Financial Institutions' Share in Credit Operations, 1996–2006*

Institutions	*1996*	*2006*
Public	58.1	32.9
Private	41.9	68.1
National private	32.4	42.4
Foreign private	9.5	25.7

Source: IPEA (2009).

It is important to note that the privatisation of federal and regional state-owned banks, acquired principally by foreign banks, did not change the structural conditions of the banking system operation. Both long-term and short-term credits to productive activities remained scarce. In the regime of high interest rates and restrictive monetary policy (high compulsory reserves), credit remained scarce and competitive advantages of foreign banks were not very relevant.

Brazilian banking institutions, which were adapted for operating under conditions of high inflation rates, had an automated banking system precisely for avoiding inflationary losses and for daily investment in public bonds through the 'over-night' system. This situation remained the same under the Real Plan, a regime of high interest rates and exchange rate appreciation.

Therefore, the Brazilian banks, in the beginning of the 21st century, started to buy foreign banks. The foreign banks that stayed in the Brazilian market started to operate exactly as the Brazilian banks, thus frustrating hopes of those who believed that the trend to short-term operations was a characteristic of Brazilian banking institutions.

The capital market in Brazil, after the 1964 reform, did not develop as expected. According to Bastos et al. (2000) this was the result of the lack of rules, of institutions and of demands by firms. The funding needs of the enterprises were restricted and were supplied with own resources (retained earnings) and with governmental and commercial credit, such as those provided by BNDES.

Many initiatives were introduced for promoting the development of the capital market. One example was the creation of the Funds 157 (Act no. 157) which allowed tax payers to choose using from 2 per cent to 4 per cent of the due income tax for the acquisition of quotas from open capital companies. In 1976, a new 'Law of Public Corporations' (Law no. 6404) granted the right to enterprises to issue and trade up to two-thirds of preferential shares without voting rights. In this same year, a second Law of Capital Market (Law no. 6385) was established, creating the Commission of Securities and Stock (CVM) and setting general provisions on the securities and stock market. Such efforts, however, were unable to foster the development of the capital market, which presented only some sporadic surges of growth.

In the 1980s, the Brazilian stock market presented a weak performance; the market value of Brazilian enterprises practically stagnated between 1985 and 1992. A period of greater dynamism was observed following the Cruzado Plan, when the decrease of inflation rates impacted favourably on the expectations of agents, who increased the demand for stock shares (Prates 1999).

In the 1990s, with the economic liberalisation, the main change occurred in the legal framework aimed at relaxing the entry of foreign capital in the Brazilian market. The possibility of accessing the Brazilian market was conceded to foreign investors by means of either foreign institutional investors (pension funds, insurance companies, foreign financial institutions, investment funds constituted in foreign countries, etc.) or acquisition of quotas of investment funds (Prates 1999).

In 1991, Privatization Funds–Foreign Capital were created, aimed at the acquisition of securities in enterprises in the process of privatisation, and of privatisation money. In 1993, the Fixed Income Funds–Foreign Capital were created, allowing foreign investors to opt for investing in fixed income securities. In 1996, two new alternatives were opened to the participation of foreign capital in funds constituted in the country: the Fund of Investment in Emerging Enterprises and the Fund of Real Estate Investment (Studart and Hermann 2001).

With these changes, a growth in the number of pension funds in the country was observed. Between 1985 and 1997, the pension funds increased from 256 to 339. The investments of the funds grew from US$ 17 billion (2 per cent of GDP) to US$ 78 billion (11.5 per cent of GDP). Between 1992 and 1997, the number of enterprises listed in the stock exchange increased 12 per cent, whereas their market value increased 464 per cent in the same period. However, the growth of the capital market was concentrated in the secondary market (Studart 2000).

According to the summary by Prates (1999: 54):

> the degree of concentration of business at Bovespa did not reduce in the 1990 decade, once the foreign investors bought, essentially, stock

> shares from state owned enterprises, anticipating appreciation following privatization. The financial liberalization, therefore, did not result in rise of the market value nor in liquidity of the stock shares of private enterprises, what discouraged both the demand of investors and new issues by the enterprises. Thus, a vicious circle was created, once the little volume of primary issues implied reduction of the relative participation of these firms in the secondary market, which contributed to the concentration of trading on more liquid assets.

In 2000, the diagnosis was that the Brazilian capital market presented restrictions which impeded its development, namely: (1) the Brazilian tax structure did not encourage operations with variable income; (2) restrictions that the CVM, as a public body, faced for hiring and adequately remunerating qualified staff for carrying out and reinforcing the control of the market; (3) large stock of existing preferential shares (Bastos et al., 2000). In this perspective, in 2001 the new Law of Public Corporations (Law 10303/01) was sanctioned, changing the legislation of 1976. This law sought to reduce conflicts arising from distinct interests of managers and shareholders, particularly the minor ones.

In December of 2000, BOVESPA installed the New Market and Different Levels of Corporate Governance (Levels 1 and 2) aiming at providing a trading environment that boosted the interest of the investor and appreciation of the firms. The enterprises shall be committed to adopt additional practices of corporate governance, aiming at reducing the risk for the investor (BOVESPA 2009). According to *Boletim Informativo* (Newsletter) of April 2009, there were 99 companies listed in the New Market (22.9 per cent out of the total number of enterprises), which accounted for R$ 659,000 million of capitalisation (18 per cent of the total).

According to a recent report by FUNDAP (2008), the Brazilian capital market presents, since 2005, a major expansion in the increase of funds by Brazilian enterprises. In 2006 share issuing reached R$ 14.4 billion, corresponding to a growth of 225 per cent in relation to 2005. In 2007, primary (initial public offering [IPO]) and secondary issuances totaled R$ 33.1 billion. In 2007, there were 682 public companies, a growth of nearly 10 per cent in relation to 2005. Nevertheless, as highlighted by Sant'Anna (2008), the issuance of shares in the market is still restricted to a small group of sectors.

Firms Funding and Interface between the Financial System Structure and Industrial Financing

It is important to note that a firm may resort to distinct sources for financing its investment programmes. These sources may be classified as follows: (1) reinvestment of retained earnings (self-financing); (2) shares issue (raising funds either from shareholders or from public); (3) issue of securities (direct financing mechanisms); (4) banking loans (indirect financing mechanisms).

The use of each one of these sources and their relative participation in enterprises equity capital structure will depend on the historical and institutional development of the relation between financial and industrial systems.

Innovation constitutes an intangible asset characterised by high unpredictability, high costs and long-term development. The difference between the funding of an intangible asset and of a tangible one is that, in case of the latter, the asset itself serves as collateral to the lender. It reduces the uncertainty for the creditor regarding debt repayment. It is a guarantee against default. Even incurring transactions costs, the financial operation becomes linked between asset and liability.

In the case of innovation, there are no assets to guarantee the loan. Therefore, in order to finance it, the financial system must create instruments for the evaluation of intangible assets that will necessarily involve future expectations on earnings and the willingness of investors to become illiquid and with their operations detached regarding assets and liabilities.

Retained earnings is the major funding source of enterprises. This is one of the few consensus points in the literature on the issue. Being so, a decisive question will be the influence of macroeconomic policy on the funding strategy of firms: to reinvest internally or to invest in the financial market.

In the case of micro and small enterprises (MSEs), the funding presents yet other specificities. Since these enterprises will hardly have resources for their self-financing, the availability of external financing is crucial, especially for the quickly growing sectors (Arthur 1996). According to Britto, Vargas and Cassiolato (2001), regarding micro, small and medium enterprises, it is necessary to identify to what extent the aims and interests of the parts involved in the process of financing are conflicting or complementary. While these enterprises search financing at the lowest costs as possible and under friendly conditions adapted to the needs of their initiative, the financial sector tends to pass forward the specific costs of operations.

It must also be assumed that enterprises have the alternative to invest their resources in the financial market, instead of reinvesting them in the firm. Therefore, all investment decisions are decisions on constituting a portfolio of assets and of appreciating them. That is, depending on the conditionalities of economic policy (implicit innovation policy) and on the capacity of NIS, these investments may be directed either to enhancing the firms' capabilities in production and innovation or to the financial market.

The comparison between some indicators helps to understand the distance separating the Brazilian financial system from other financial systems with respect to production financing.

The banking credit, mostly addressed to short-term funding, is quite restricted. In the beginning of the 1990s it reached at most 15 per cent of GDP. In 2006, it reached 31 per cent of GDP and, in 2008, the level of 40 per cent of GDP. These are levels are too low if compared to the international ones. In Eastern Asia and the Pacific region this rate was 72 per cent and in the Middle East and Northern Africa it reached 43 per cent. Yet, the Brazilian rate is similar to the average of 28 per cent observed in Latin American economies during the 1990s (Puga 2006). Another characteristic of the Brazilian credit system was its high volatility due to macroeconomic shocks of foreign nature.

The extremely severe monetary policy implemented after the Real Plan, in July 1994, also contributed to its scarcity and volatility. A high inflation regime was replaced by a regime of high interest rates and high compulsory deposits.

In Brazil, as aforementioned, the long-term direct funding mechanisms have been little developed. In 2007, the stock of these assets (most of them comprised debentures) was equivalent to only 2.6 per cent of GDP, while the international average was 10.8 per cent of the GDP (Sant'Anna and Cruz 2008). This sample can be much biased by size and intensity of developed countries' capital markets. Although even in comparison with developing countries, we observe that the Brazilian position is very weak. South Korea which for many years had a practically state-owned credit market, already presents an indicator 10 times higher than the Brazilian (ibid.).

BNDES, between 2001 and 2007, was responsible for 20 per cent of resources used for investment by industrial and infrastructure enterprises. The participation of other sources in financing of enterprises is much more unstable. The funds raised externally got to represent 30 per cent of invested sources, although on average its participation remained at 16 per cent between 2001 and 2007. Following this, worth noting are the issuances of debentures (10 per cent) and of shares (3 per cent). Generally, the increase in importance of these sources is associated with large scope operations. Thus this does not reflect on the average behaviour of enterprises (Puga 2008).

In the Inter-American Development Bank (IDB) (2007) we find an analysis of the relation between public and private debts in Latin America. The main argument raised in this study is that the cost of public debt provides the minimum base for remuneration and terms of private bond because it establishes a reference pattern to the demand for these bonds. The market of public bonds provides a basic infrastructure for the private bonds market. The evidence points to the fact that it is not the size of public debt that hinders the development of the private bonds market. There are countries such as South Korea, Thailand and Malaysia with extensive public debts and yet well-developed corporate bonds markets, whereas others such as Brazil and Venezuela have a relatively large public debt and a small and poorly developed market of corporate bonds.

As public bonds work as references for the issuance of corporate debts, the interest rate paid by the Treasury (SELIC) represents the basic price, which added with the respective margin of risk will provide the minimum financial cost of enterprises in issuing debentures. The greater the interest rate, the lesser is the incentive to enterprises for using own issuances as a way for raising funds, because of the impacts on their costs of capital.

Among the countries with higher interest rates, China has the most developed market of corporate debt, with 3 per cent of GDP. Brazil was the country which in the period from 1994 to 2007 presented the highest real interest rate, thus impeding the development of a more robust private bonds market.

The structure and term of public debt also play a significant role in the restriction to the enhancement of the capital market. Brazilian public debt is concentrated in short-term bonds, daily indexed to the interest rate of monetary and interbank markets, SELIC. This composition makes the Brazilian public debt practically unique in the world.

These operations, agreed upon between the Central Bank and banks, assure the technical reserves of banks automatic remuneration at an interest rate that also affects public debt bonds. This indexation, an inheritance of the times of high inflation rates in the former regime, has been retained by the monetary policy of high interest rates.

The Brazilian financial system still enjoys the safety assured by the Central Bank through these operations, hindering the development of a true interbank market. There is, indeed, a negative relation between the composition of the public debt, expressed by the quotas indexed at fluctuating interest rates, and the size of the market of private fixed income bonds. To this we must add the term of public debt as an aggravating factor for the low development of the private bonds market. This combination of short-term debt indexed to a fluctuating rate makes the state offer, simultaneously, liquidity, profitability and safety. Thus, issuers of private bonds have to raise profitability for compensating liquidity and risk. Under such conditions, the chances for an issuer enterprise to attract investors to a fixed-income, long-term bond, at a suitable cost, are limited, since the buyer may always opt for a public bond with large liquidity and for a short term. For this reason, large Brazilian investors, such as pension funds and investment funds, concentrate most of their portfolios in federal public bonds.

This analysis has revealed the poor development of the capital market and of banking credit for financing long-term investments. Regarding financing of intangible assets, such as innovation, the participation of the financial system was almost non-existent. It only remained for firms to use self-financing. However, the macroeconomic context where these investment options occurred was not attractive for investment in innovation.

The need for creating specific — public — institutions, the outcome of a strategic action by the Brazilian state, showed that the relation between the financial system and the industrial system did not evolve in the same way it historically happened in developed countries (Miranda and Tavares 1999).

As a consequence of this evaluation, BNDES was created at the beginning of the 1950s, aimed fundamentally at financing of tangible assets, investment in infrastructure and both creation and expansion of production capacity in national enterprises. It is known that the financing of investment in tangible assets — machines, equipment and facilities — also includes a proportion of intangible investment, incorporated in the tangible assets (Melo 1994; OECD 1996). Therefore, there is quite a close relation between tangible and intangible investments.

In the mid-1960s, the need for structuring financial mechanisms for financing investment in intangible assets was identified. Initially, BNDES undertook this mission. Later, it became clear that the logics of financing were distinct. Then, the National Fund for Scientific and Technological Development (FNDCT) and the Brazilian Studies and Projects Finance Organization (FINEP) was assigned with its executive-secretariat.

Financing of Innovation in Brazil

The institutions for funding and supporting scientific and technological development in Brazil began to be created in the 1950s. The National Council for Scientific and Technological Development (CNPq) and the Commission on Qualification of Graduated Human Resources (CAPES) were both created in 1951 for building human resources capabilities in research and for financing projects of scientific research. Later, as aforementioned, FNDCT was created for financing initiatives for building enterprises' productive and technological capacities.

The analysis of the evolution of the sources of funds for innovation financing in Brazil is heavily based on Melo (2009). This study shows that the financing of innovation had two different periods. The first one, from 1967 to 1997, comprises the period of constitution of FNDCT and its financing through ordinary budget allocation. The second begins with the enactment of the new legislation on sectorial funds as a new source of funds for FNDCT, and continues to be in force up to now.

The creation of sectorial funds represented not only a change in funding sources for FNDCT, as also a change in the priorities defined for allocation of its resources through its Executive Secretariat, FINEP — another kind of institutional articulation between FINEP and FNDCT. These are the institutional reasons that grounded the periodisation of the analysis.

The first important difference between the two periods resides in the macroeconomic context. The major change happened in international policy during the 1980s, with the hegemony of neoliberal thought directing the economic policies towards greater trade liberalisation, and liberalisation of the account of capital of the balance of payments, flexible foreign currency exchange rates, fiscal adjustments and control of inflation. Most of these policies were opposed to the dominant policy of economic development that dominated the first period, characterised by what has been called the imports substitution model. In Brazil, these policies began to be adopted during the Collor government and were kept by the following governments, particularly the guidelines of macroeconomic policy.

Obviously, those differences led to a change in the priorities for application and in the sources of funds from FNDCT and FINEP. In the first period there was an explicit concern in the document of the National Technological Development Support Program (ADTEN) about the support to national enterprises (Brazilian capital–owned enterprises), as well as about a greater coordination between the application of FNDCT and FINEP resources, particularly because of the fact of FINEP being practically the leader of the operational strategy of them both. The source of funds of FNDCT was, in its major part, the fiscal budget. FNDCT was a fund of free application; it transferred resources to FINEP for it to finance enterprises and, in some periods, it was complemented by external financings (Melo 2009).[2]

The evolution of the source of funds is shown in Table 2.4, which presents data on the evolution of resources aimed at the financing of innovation by FNDCT and FINEP, in the period from 1967 to 1997.[3] The resources of FNDCT refer to financing of scientific development in research institutions, comprising non-reimbursable finances. The resources of FINEP refer to funding for investment in innovation within enterprises, being reimbursable. The third line (FINEP + FNDCT) represents the sum of resources, the total amount of financing for the whole process of innovation.

In the second period, the exclusivity for enterprises of national capital was withdrawn. FINEP lost almost its whole autonomy in the definition of the strategy for application of FNDCT resources through sectorial funds. Currently, each sectorial fund has a managing committee and there is a general managing committee of FNDCT, in which FINEP is minor. The strategy is much more in the hands of Ministério de Ciência e Tecnologia (MCT) than in those of FINEP. Table 2.5 shows the evolution of the source to funds to financing innovation in this period.

Sectoral funds may be decisive to finance innovation since the barrier of the restrictive monetary and fiscal policy is overcome with cessation of resources allocation to contingency reserves, and, thus,

Table 2.4: *Evolution of FINEP and FNDCT Outlays, 1967–97 (in million of constant US$, December 2006)*

Year	*FNDCT*	*FINEP*	*FINEP+FNDCT*
1967	–	25.5	25.5
1968	–	47.3	47.3
1969	–	16.0	16.0
1970	71.8	6.8	78.6
1971	119.9	18.0	137.9
1972	211.1	22.2	233.3
1973	278.9	106.5	385.4
1974	423.1	157.6	580.7
1975	499.9	279.1	779.0
1976	513.6	418.1	931.7
1977	483.6	242.9	726.5
1978	675.6	321.3	996.8
1979	1,158.4	262.7	1,421.1
1980	478.0	134.1	612.2
1981	335.5	126.0	461.4
1982	316.5	129.1	445.6
1983	230.0	105.0	334.9
1984	172.1	53.9	226.0
1985	171.3	109.1	280.4
1986	268.0	130.8	398.9
1987	252.9	381.6	634.6
1988	232.5	173.4	405.9
1989	145.4	40.0	185.5
1990	100.5	9.8	110.3
1991	48.5	32.1	80.6
1992	71.4	207.1	278.5
1993	122.7	325.3	448.0
1994	274.6	247.9	522.5
1995	245.8	267.3	513.1
1996	287.2	278.2	565.4
1997	67.7	478.1	545.8
Total	8,256.4	5,152.8	13,409.2
Average	294.9	166.2	432.6

Source: FINEP (1967–97).

allows for a greater financial availability for financing innovation. FNDCT's resources have increasingly been captured as contingency reserves, as can be seen in Table 2.6. There are currently more resources allocated to contingency reserves than those allocated to FNDCT for financing innovation and science and technology (S&T) infrastructure. This is a major contradiction between the macroeconomic policy and the industrial and STI policy, since the objectives are incompatible.

Table 2.5: *Financial Evolution of FINEP and FNDCT, 1998–2006 (in million of constant US$, December 2006)*

Ano	*FNDCT*	*FINEP*	*FINEP+FNDCT*
1998	77.5	400.8	478.3
1999	89.9	185.3	275.2
2000	123.5	104.3	227.8
2001	276.2	65.6	341.8
2002	247.3	79.9	327.2
2003	288.9	77.9	366.8
2004	335.2	77.9	413.1
2005	373.3	150.8	524.1
2006	368.4	241.4	609.8
Total	**2,180.2**	**1,384.0**	**3,564.2**
Average	**242.2**	**153.8**	**396.0**

Source: FINEP (1998–2006).

Table 2.6: *Financial Evolution of FNDCT, 1998–2006 (in million of constant US$, December 2006)*

Year	*Applied Amounts*	*Raised Funds*	*Contingency Reserves*
1998	77.5	77.5	0.0
1999	89.9	105.2	15.3
2000	123.5	212.3	88.8
2001	276.2	361.9	85.7
2002	247.3	635.5	388.2
2003	288.9	725.5	436.6
2004	335.2	726.0	390.8
2005	373.3	815.9	442.6
2006	368.4	865.8	497.4
Total	**2,180.2**	**4,525.7**	**2,345.5**

Sources: FINEP (1998–2006) and MCTI (1998–2006). Authors' own elaboration.

In Table 2.7 the average funding granted by FINEP and FNDCT in the two studied periods is presented. The first period shows an average amount of non-reimbursable funding by FNDCT and of reimbursables by FINEP that was higher than those of the second period.

Instruments for financing innovation

Fiscal incentives granted to Brazilian enterprises date back to the beginning of the 1990s and underwent a number of modifications all

Table 2.7: *Comparison between the Average Disbursements by FNDCT and FINEP in the Two Periods*

	Average 1967–97 (FINEP) and 1970–97 (FNDCT) (A)	*Average 1998–2006 (B)*	*(A)/(B) (%)*
FNDCT	294.9	242.2	21.76
FINEP	166.2	153.8	8.76

Source: FINEP (1967–97; 1998–2006). Authors' own elaboration.

along this period. Most of the times, these changes were reflexes from fiscal limitations of the Brazilian state (Pacheco 2007).

There are two modalities of non-reimbursable resources to innovative activities in Brazil. The first one is the concession of resources for scholarships and grants to research institutions and universities for developing projects in partnership, services and consultancies related to solutions of technological problems in enterprises and to development of new products and processes. The second and more recent modality is the economic subvention granted directly to enterprises.

The economic subvention for enterprises was established on the basis of Law no. 10332 of 2001. Law no. 10973, of 2004, provided for the concession of financial resources, as economic subvention, to national enterprises which aimed at the development of innovative products or processes, under the requirement of approval of the project by a granter institution. Law no. 11196/05, in its turn, institutes another form of subvention — the concession of resources for enterprises located in Brazil to hire researchers who should engage in innovative activities. The subvention could reach up to 60 per cent of the total remuneration of Masters or Ph.D. researchers.

Box 2.1 summarises the instruments for financing innovation in Brazil and Table 2.8, the value and number of firms/project approved in each programme.

Venture capital

The activities directed to venture capital (VC) in Brazil started in the 1970s, but did not continue. According to Gorgulho (1997) the expansion of VC in Brazil was restricted by the economic context (instabilities, high interest rates in the market of governmental bonds, difficulties for long-term planning) and by the lack of regulatory and fiscal mechanisms for fostering such activity. The companies were

Box 2.1: *Instruments for Financing Innovation in Brazil*

	Programme/Law	Institution	Objective	Period
Fiscal Incentives	Law of Information Technology (Law no. 8248)	MCTI	Conceded fiscal incentives to firms in TI and automation sectors. Firms should invest 5 per cent of their turnover in R&D and at least 2 per cent of the same should be applied in R&D through partnership contracts with universities or research institutes.	1991 to 2001
	Law of Information Technology	MCTI	Kept the character of the former legislation and introduced some innovations in the mode of conceding incentives.	Since 2001
	Financial Incentives to Innovation Activities (Lei do Bem)	MCTI	Consolidated the policy of incentives to R&D activities. Grants benefits any enterprise that performs R&D activities. It substitutes a tax credit for a *tax allowance*.	Since 2005
Non-reimbursable Resources	RHAE Program	CNPq	Scholarships to professionals to join research teams in enterprises.	Since 2002
	PAPPE	FINEP with FAPs	Grants to studies on technical and economic viability and to final development of new projects and processes for market introduction.	Since 2003
	PATME Program	SEBRAE	Grants to consultancies and technological services provided by scientific institutions or by research institutes to MSEs (30 per cent to 70 per cent of total budget)	Since 1994
	Economic Subvention	FINEP	Economic subvention to R&D aiming at innovative processes and products in the country by firms of any size	Since 2006
	Subvention to Researcher in Firm	FINEP	Resources to firms to hire researchers to be engaged in innovative activities	Since 2006
	Prime Program	FINEP	Subvention to start-up firms.	Since 2009

Credit for R&D & Innovation	Innovation Program	FINEP	Subsidised funding for enterprises to develop R&D&I activities (FINEP participates with up to 90 per cent of project's total costs)	2005 to 2008
	FINEP Inova Brazil	FINEP	Subsidised funding for enterprises to develop R&D&I activities with fixed rates between 4.24 per cent and 5.25 per cent for sectors defined as priority in Industrial Policy.	Since 2009
	Zero Interest	FINEP, FAPs and SEBRAE	Subsidised funding for innovative MSEs. The amortisation of the loan is fixed in 100 installs. Does not require real guarantees from MSEs.	Since 2006
	PROSOFT	BNDES	Instruments of financing and VC for firms in the software sector.	Since 1997
	PROFARMA — Program for the Support to the Development of the Health Industrial Complex	BNDES	Instruments of financing, participation in enterprises (by means of subscription of securities) and of participation in projects' results, directed to firms in the health industrial complex.	Since 2004
	Financial Support to Technological Innovation	BNDES	Subscription of securities and financing with interest rate of 4.5 per cent per year for innovation projects to the development of either new or improved products and/or processes, which involve technological risk and market opportunities. The participation of BNDES is up to 100 per cent of the items to be financed.	Since 2008
	Innovative Capital	BNDES	Support to enterprises for the development of their capacity to perform innovative activities in a systematic manner, involving investments in tangible and intangible capital. The modalities are subscription of securities and financing.	Since 2008

Source: MCTI (1991–2009), FINEP (1991–2009), BNDES (1991–2009).

Note: The sectors are: (1) 'mobilisers in strategic areas' (defense, health, ICT, nuclear energy and nanotechnology) the rate is 4.25 per cent; (2) 'for conciliating and expanding leadership' (iron and steel, petroleum, natural gas, bio-ethanol, cellulose and aeronautics complex) the rate is 4.75 per cent; (3) 'for strengthening competitiveness' (capital goods, automotive, textile, footwear and agro-industry) the rate is 5.25 per cent. Projects that do not fit to any of the Productive Development Policy (PDP) lines pay a variable long-term interest rate (TJLP) rate plus 5 per cent per year.

Table 2.8: *Value and Number of Firms Covered by Each Programme*

	Programme	*Period*	*Value (US$ million)*	*Number of Firms/Projects Approved*
Fiscal incentive	Financial incentives to innovation activities (Lei do Bem)	2006–8	1,434.0	870 firms
Non-reimbursable resources	RHAE	2003–6	22.4	2,330 scholarship and 430 projects
		2006–9	–	279 firms
	PAPPE	Until 2006	22.0	529 firms
	Subvention	2006–8	5,691.0	567 firms
	Subvention to researchers in firms	2006	10.5	37 firms and 132 researchers
Credit for R&D and innovation	Innovation programme	2005–8	10,407.0	173 projects
	Zero interest	2006–8	34.8	122 projects
	Prosoft	1997–2007	294.0	1,415 operations
	PROFARMA	2004–7	400.0	50 operations

Source: MCTI (1997–2009), FINEP (1997–2009).

only institutionalised in 1986 and the Mutual Funds for Investment in Emerging Enterprises (MFIEE) were regulated by CVM in 1994 (Instruction no. 209).

In 2003, the 391 CVM Administrative Act fostered VC funds formation with the creation of Private Equity Funds (FIP). The FIP are aimed to investments in either public or private companies which have little liquidity, with effective participation of the Fund in the enterprise's administration and in dissemination of management and control best practices (De Paula et al., 2003). The participation may happen through the acquisition of stock shares, debentures and other bonds and securities convertible to stock. In 2008, there were 171 FIPs operating in Brazil.

Venture Capital at FINEP

In 2000 FINEP created the INOVAR Program, a set of activities aimed to build innovative capabilities in SMEs which wanted to take part in risky investments programmes. INOVAR currently comprises the following activities:

- *Venture Forum FINEP*: a permanent agenda of business rounds, where participant entrepreneurs have the opportunity to present their business plans to investors such as managers of VC funds, corporate investors, 'angels', investment banks, among others.
- *Brazil Forum for IPO*: an agreement of technical cooperation between FINEP and BOVESPA to IPO from technology-based enterprises in the new market. There is an annual meeting which offers a broad exposition of the enterprises to representatives of security and stock brokers, investment banks, managers of investment funds and pension funds.
- *INOVAR Funds Incubator*: aims at fostering the creation and capitalisation of VC funds, by attracting potential investors to emerging technology-based enterprises, especially institutional investors. Between 2001 and 2007, FINEP contri-buted with resources to 11 funds which have committed equity capital amounting to US$ 240 million.
- *INOVAR Seed Progra*m: provide support to start-up enterprises. The Program *Fundo Inovar Semente* has the objective of capitalising funds, preferably local ones, for investment by

innovative MSEs with a turnover of up to US$ 1.2 thousand. In 2007, the first investment in Fundo HorizonTI was approved, a fund directed to information technology sector resources of up to R$ 8 million.

- *Brazil Forum for Innovation*: has the objective of attracting institutions of higher education and/or research for carrying out projects of technological innovation whose outcomes have potential application in the market, operating in the phases of pre-incubation, incubation and technology transfer of the innovative cycle.
- *Business Prospecting and Development Network*: has the purpose of developing a joint effort for identification and support to new opportunities of investment, to enhance technology enterprises creation with potential for increasing the VC in the future. Besides prospecting start-up enterprises, Inovar Network supports the development of business plans and provides consultancy services for technology-based enterprises and funds managers.

Between 2001 and 2008 FINEP landed resources in 22 funds which have committed capital amounting to US$ 1.23 billion. The Finep contribution amounted to US$ 134,000 (this represents a leverage of US$ 4.05). These funds are 13 of VC, three of private equity (PE) and six of seed funds, of which 12 are operating, nine are in capitation phase and one has already closed.

This timid position seems to disregard the change that occurred in the position of the capital market in Brazil (Melo 2009). Since 2005, there was a significant search for financing via the capital market. Such movement by enterprises represented a positive change in their investment expectations, which signalled a better confidence in returns of these investments. It reinforces the perception that a less restrictive monetary policy, which would make interest rates lower and exchange rates higher, would lead Brazilian enterprises to a more dynamic investment strategy and, possibly, would lead to improvements in the generation of innovations.

Venture Capital at BNDES

The Program for Capitalization of Technology-based Enterprises (CONTEC) was created in 1991, directed to technology-based SMEs. The programme supports technology-based enterprises with net turnover lower than US$ 15 million. The investments in enterprises can be made by means of subscription of convertible stock shares or debentures without the requirement of real guarantees. Since its creation, more than 700 firms were evaluated, and investments were made in 44 enterprises of several sectors totalling US$ 100 million. Twelve disinvestments were already accomplished and nine enterprises were transferred to co-management funds (Fingerl 2007).

The Fund for Start-up Enterprises (FINEE), of BNDESPAR was created in 1995, based on a perceived need to enable the capitalisation of SMEs during their process of growth. The initial equity foreseen for FINEE/BNDESPAR was of US$ 25 million and investments could happen through direct stock holding, subscription bonus and convertible debentures, without real guarantees. The maximum contribution to enterprises is US$ 4 million, and the value cannot exceed 30 per cent of the firm's equity capital.

In 2008, a new Program of Investment Funds was created, with a budget of US$ 0.75 billion. The programme has the purpose of investing in quotas of up to 10 funds, eight of them being funds of PE and two others funds of VC. BNDESPAR will have a maximum participation of 20 per cent of equity capital in FIP and of up to 25 per cent in VC funds. The programme aims at enhancing the capitalisation of enterprise of different sizes and encouraging VC culture.

In 2008, BNDES participated in 31 investment funds (seven at contracting stage), which amounted to an equity capital of about US$ 3.7 billion. Since the beginning of its activities through the funds, BNDES allowed indirect investments in more than 110 enterprises (www.bndes.gov.br, accessed 1 April 2010).

The Program for Creation of Technology (CRIATEC), an investment fund in seed capital, was approved by BNDES in 2006. It is a partnership between MCTI, FINEP and BNDES, and has the support of SEBRAE, ANPROTEC and some state institutions. The programme consists of a Restrict Mutual Investment Fund aimed at the capitalisation of innovative MSEs in their start-up stage. The programme is focused on TI, biotechnology, new materials, precision mechanical, nanotechnology and agribusiness sectors. CRIATEC will hold a budget of R$ 80 million and is expected to capitalise up to 60 innovative MSEs with an average investment between US$ 250 thousand and US$ 500 thousand.

To promote access to CRIATEC's resources to enterprises all over the country, in 2008, seven regional managers in Ceará, Minas Gerais, Pernambuco, Pará, Rio de Janeiro, Santa Catarina and São Paulo were selected. At the end of 2008, Criatec had 11 firms, an average investment per firm of US$ 717,000 accounting to the amount of US$ 7.6 billion.

Synthesis of the instruments for financing innovation

Box 2.2 presents a synthesis of the instruments aimed at fostering and financing innovation in Brazil according to distinct stages of innovation process. The different stages of the innovation process require distinct kinds of resources and support modalities. For instance, in conception and in both basic and applied research stages, resources as scholarships granted to masters or doctorate researchers and financing resources can be used.

In spite of the existence of various supporting lines and recent efforts on the part of FINEP and BNDES to create new lines of promotion and financing, some stages of the innovation process still count on few resources alternatives, as is the case of the final stages of production, commercialisation and market development.

The Innovation Activity and Its Financing

The Innovation Survey, PINTEC, applied by the Brazilian Institute of Geography and Statistics (IBGE 2010), gathers information on innovative activities carried out by the Brazilian manufacturing enterprises.[4] The survey was structured based on the conception of innovation as an interactive process, comprising interdependence between various agents, and the institutional and economic environment in which they are inserted. PINTEC is already in its fourth edition, which presents data regarding the strategies adopted by enterprises between 2006 and 2008, and incorporates the services sector (telecommunications, information technology and R&D). The other surveys were developed in the periods of 1998–2000 and 2001–3. This section is based on these PINTEC surveys (IBGE 2007). The relevance of adopting strategies aimed at the introduction of innovations for enterprises' growth and operation is illustrated through recent information available on the website of IBGE. Innovative manufacturing enterprises account for

Box 2.2: *Federal Programmes of Financial Support in Innovative Process Stages*

PROGRAMMES		INNOVATIVE PROCESS STAGES								
		Idea	Basic research	Applied research	Study on viability	Technological development	Product/ Process development	Production	Commercialization	Market development
Non reimbursable resources	RHAE (CNPq)									
	PAPPE (Finep/ Faps)									
	PATME (Sebrae/MCT)									
	Subvention (FINEP)									
	Subvention — Researcher									
Reimbursable resources	FINEP Inova Brasil									
	Juro Zero (FINEP)									
	Prosoft/ Profarma									
	Innovation Tecnológica									
	Innovative capital									

Source: Adapted from Mani (2001). Authors' own elaboration.

38.1 per cent of the total number of enterprises. Innovative enterprises from selected services sectors correspond to 46.2 per cent of all enterprises. Brazil, generally, and its manufacturing enterprises specifically, is particularised by extremely low levels of outlays in R&D. Hence, it is not surprising that outcomes from innovation efforts in Brazil are weak. IBGE (2010) data allow for ascertaining that among the nearly 107,000 enterprises covered only near 41,000 (less than two-fifths) introduced some kind of innovation during the period of three years between 2006 and 2008. Out of these firms, more than 32,000 must be deemed as simply imitative firms. They declare having introduced innovations of product or process that are new to enterprise, but not to the market where they operate. That is, only a fraction of the Brazilian enterprises were able to introduce 'actual' innovations.

The low intensity of R&D expenditures on the part of the Brazilian private sector is illustrated by data from this survey. They represented only 0.54 per cent of GDP, whereas in most developed countries this percentage reached 2 per cent. Only a small part of Brazilian enterprise can be deemed as innovators.

Data also reveal a high participation of outlays with acquisition of tangible assets (mainly machinery and equipment) in total expenditures with innovation in Brazil (nearly 45 per cent). On the other hand, the expenditures with internal R&D activities, intangible assets, are lower: 28 per cent of the total. That is, the most investment in innovation by Brazilian enterprises is directed to the acquisition of machinery and equipment.

From the technological point of view, some of the main characteristics of Brazilian industry revealed by IBGE (2007) are:

- The use of foreign technology during the process of imports substitution was not, excepting for a few cases, accompanied by an internal technological effort further than adaptation of such technologies to local conditions and few technological improvements.
- There is a small number of enterprises with formal R&D activities.
- Even among these enterprises, R&D expenditures tend to concentrate on payroll; consequently, R&D efforts, with few exceptions, are limited to incremental improvements of process and product, thus not introducing more radical innovations.

- The reduced effort of R&D results in enterprises having a limited and partial knowledge of their own production processes.
- The technical links external to firms are very faint; this is the case both for the links among enterprises and between enterprises and universities and research institutions.
- The possibility of the establishment of technical relations between enterprises is hindered by the excessive technological heterogeneity of the industry.

Such technological deficiencies do not represent a significant hindrance to economic growth during the process of imports substitution. In more recent times, however, they constitute an important bottleneck. Thus, Brazil in general and manufacturing enterprises in particular are characterised by extremely low levels of expenditures with innovation.

The enterprises of foreign equity capital innovate more than national ones, taking the domestic market as a reference. It does not necessarily imply their own efforts of technological capability building. The higher rates may reflect a strategy for internalisation of new products or processes to Brazil, although developed in a foreign country.

The scarcity of appropriate sources of financing and their high costs appear as risk factors of greater relative weight to domestic enterprises than to foreign ones; a result that is consistent with the restricted access of national enterprises to the external sources, as presented in Section 2.

Cooperation with universities has low relevance. The strongest relations of cooperation are those established with clients and suppliers.

The larger Brazilian-owned enterprises (>500 employees) showed a cooperation effort near to that of multinational companies present in the Brazilian economy and three times greater than those of smaller sizes.

Brazil has been dropping in the world ranking of the United States Patent and Trademark Office (USPTO), supplanted by other emerging countries in the last three decades. In the period 2005–7, Malaysia, China and India presented a great technological dynamism in the areas of electronics and software, with record growth rates. India, which only got to overcome Brazil in the USPTO since the past 10 years, doubled the number of patents in this area regarding the previous three years' period, reaching 44 per cent of the total, with 620 new patents, while Brazil remained on a low level of 11 per cent, with 32 registers. In electronics, China and India obtained, in this period, respectively 4.7 and 2.2 times more patents than Brazil in the same period (MCT 2008). Another interesting data is that, between 2001 and 2008, universities were responsible for most of them. They filed 1,359 requests at the National Industrial Property Institute (INPI), and the enterprises filed 933.

Table 2.9 presents the problems pointed out by innovative firms. The percentages refer to the number of innovative enterprises that ascribed high importance to problems and hindrances, in relation to the total number of innovative enterprises in each period. The main barriers to innovation in the four analysed periods did not change, although there is a reduction in the degree of importance attributed by firms to these obstacles.

The most recurrent obstacles are: excessive economic risks, high costs of innovation and shortage of appropriate sources of financing. Therefore, the main obstacles identified are rather linked to the economic field than to aspects of technical and information character and/or internal to enterprises.

These data certainly reflect the various instruments and mechanisms of financing and promotion of innovation which have been created since 2000 and described in the previous section. Such instruments, besides providing a variety of financial resources for innovation (reimbursable and non-reimbursable ones) are helping to reduce the innovation costs. Nevertheless, the macroeconomic and market conditions still remain the main hurdles pointed out by enterprises for innovating.

Table 2.10 presents total outlays in innovative activities and in R&D, as well as financing sources used by Brazilian manufacturing enterprises in the four periods covered by PINTEC. It is worth highlighting that information regarding expenditures with innovation activities and R&D refers only to the last year covered by each edition of the survey.

Between 2000 and 2008, a raise is observed in expenditures with internal R&D activities in comparison to total expenditures in innovation activities. This proportion, which was 16.7 per cent in 2000, changed to 21.7 per cent in 2003, to 25.2 per cent in 2005 and reached 28.1 per cent in 2008. The other innovation activities comprise: acquisition of external knowledge, acquisition of software, acquisition of

Table 2.9: *Innovative Enterprises that Attributed 'High' Importance to Factor as Obstacle to Innovation (percentage)*

Obstacles to Innovation	*1998–2000*	*2001– 03*	*2003–05*	*2006–08*
Excessive economic risks	26.7	24.0	17.0	17.5
High costs of innovation	32.9	24.9	19.4	21.1
Shortage of appropriate sources of financing	25.9	20.9	16.2	17.0
Organizational rigidity	3.4	2.6	3.5	6.3
Lack of qualified personnel	11.0	10.9	8.1	16.6
Lack of information about technology	6.7	6.9	4.2	5.9
Lack of information on markets	5.2	5.7	3.5	4.1
Scarce possibilities of cooperation with other enterprises/institutions	8.8	7.5	4.8	7.0
Difficulties to adapt to patterns, norms and regulations	5.2	8.1	6.4	6.1
Weak response by consumers regarding new products	4.2	4.4	3.9	4.6
Shortage of adequate external technical services	5.6	5.2	5.3	7.0
Centralisation of the innovative activity in other firm of the group	ND (1)	0.3	0.2	0.3

Source: IBGE (2000, 2003, 2005 and 2008).
Note: (1) Not available.

Table 2.10: *Financing Sources of Innovation Activities, Brazil, 2000, 2003, 2005 and 2008 (percentage)*

		Expenses with Innovation Activities (US$ thousand of 2000)		*Expenses with R&D Activities (US$ thousand of 2000)*		*Financing Sources (%)*			
						R&D Activities		*Other Innovation Activities*	
Year	*Number of Firms*	*Total*	*Per Firm*	*Total*	*Per Firm*	*Own*	*Third Parties*	*Own*	*Third Parties*
2000	19,165	11,822,094.7	616.8	1,979,667.7	267.1	88	12	65	35
2003	20,599	9,322,348.1	452.6	2,029,652.4	410.8	90	10	78	22
2005	21,966	14,427,448.7	656.8	3,629,639.7	588.5	89	11	81	19
2008	33,034	23,635,784.0	715.5	6,652,966.2	1,399.5	76	24	75	25

Source: Own elaboration. Original values in national currency based on IBGE (2000, 2003, 2005 and 2008). Average exchange rate for each year based on data from BACEN (Brazilian Central Bank).

machinery and equipment, trainings, activities aimed at the introduction of technological innovations in the market, at industrial projects and technical innovations. An increase in average expenditures with R&D by enterprises is also observed.

As can be seen in Table 2.10, a great part of R&D activities is financed with the firms' own resources. In the three first editions of the survey, the percentage of R&D activities that was financed with resources from third parties remained almost stable around the 11 per cent level. But there was a considerable increase in this share in the last edition, where the results point to a participation of external sources of 24 per cent. The last edition of the survey also revealed a considerable increase in the share of governmental sources among resources from third parties for financing R&D (representing nearly 80 per cent of them). On the other hand, the participation of resources of third parties in financing of other innovation activities was more significant in the first survey (35 per cent in 2000) than in the subsequent ones. Once more we find the same picture with a considerable increase in public resources share among third parts resources for other innovative activities (64 per cent). The big picture reveals a greater participation of private third part financing to other innovation activities than to activities of R&D. It results certainly from the fact that other innovative activities involve fewer risks than R&D activities.

Table 2.11 presents the percentage of expenditures with internal R&D activities on the total expenditure in innovative activities according to the number of a firm's employees. The data suggest that only in the case of the biggest enterprises (more than 500 employees), there was a relevant change in the relative importance of investment

Table 2.11: *Expenses with Internal R&D Activities Over Total Expenses in Innovative Activities, by Firm Size, Brazil, 2000, 2003, 2005, and 2008 (percentage)*

Range of Occupied Personnel	*2000*	*2003*	*2005*	*2008*
Total	16.7	21.8	25.2	28.1
From 10 to 29	9.1	11.1	13.6	8.9
From 30 to 49	10.8	18.0	8.2	9.7
From 50 to 99	10.8	10.5	17.8	9.8
From 100 to 249	10.2	11.7	22.4	15.2
From 250 to 499	13.4	14.3	19.3	10.4
More than 500	20.2	25.9	30.1	36.9

Source: IBGE (2000, 2003, 2005 and 2008).

in R&D as opposed to other innovative activities. The share of internal R&D expenditures on total innovation expenditures grew from 20 per cent in 2000 to almost 37 per cent in 2008. For the enterprises of other sizes these figures are oscillating. For all years, the major part of resources has been directed to the acquisition of machinery and equipments. In 2000, the outlays in this activity were higher than 50 per cent of the total; in 2003 this figure was 50 per cent, in 2005 it was 43 per cent and in 2008 nearly 45 per cent.

In terms of firm size, it is possible to observe that, in 2000 and 2003, the large enterprises (more than 500 employees) were the ones which used the most resources from third parties for accomplishing R&D activities (Table 2.12). Furthermore, whereas in 2000 there was a major participation of governmental third party resources, in 2003 the main participation was of private third party resources. In 2005 and in 2008, the small (from 30 to 49 employees) and medium enterprises (from 250 to 499 employees) were those which presented the major proportion of resources of third parties in financing R&D activities (being respectively 21 per cent and 22 per cent for 2005 and 44 per cent and 50 per cent for 2008). The other innovative activities, in their turn, count on a greater part of resources from third parties. In 2003, the major participation of public resources in other innovative activities was in small enterprises, whereas in 2005 it was in medium enterprises. In 2008 there is an increase in the share of public resources for all firm sizes.

STI Implicit Policy and Its Influence on Entrepreneurial Investments in Innovative Activities

In this section, we will start from the impact of the implementation of the Real Plan, which determines both the pattern of macroeconomic policy still prevailing and the main implicit industrial policy that Brazil has had: privatisation. The Real Plan followed the basic method used to put an end to most of the great inflations of the 20th century: recovery of confidence in the national currency through the guarantee of its external value. The anchor was the stabilisation of the nominal exchange rate, guaranteed by financing in foreign currency and, more recently, by a reserve amount able to discourage speculation against the exchange rate.

Table 2.12: *Sources of Financing Innovative Activities by Firm Size, Brazil, 2000, 2003, 2005 and 2008*

		Financing Structure (%)							
		Of R&D Activities				*Of Other Innovative Activities*			
			Of Third Parties				*Of Third Parties*		
Year	*Ranges of Occupied People*	*Own*	*Total*	*Private*	*Public*	*Own*	*Total*	*Private*	*Public*
2000	Total	88	12	4	8	65	35	19	16
	From 10 to 29	97	3	1	2	46	54	48	6
	From 30 to 49	99	1	1	1	67	33	21	12
	From 50 to 99	98	2	1	1	56	44	27	17
	From 100 to 249	95	5	4	1	47	53	40	13
	From 250 to 499	96	4	2	2	68	32	16	16
	More than 500	86	14	4	10	72	28	10	18
2003	Total	90	10	5	5	78	22	8	13
	From 10 to 29	93	7	6	1	73	27	16	10
	From 30 to 49	97	3	–	3	67	33	15	17
	From 50 to 99	98	2	1	1	71	29	12	17
	From 100 to 249	91	9	2	7	66	34	21	13
	From 250 to 499	95	5	–	4	80	20	7	13
	More than 500	89	11	6	5	82	18	5	13

(*Table 2.12 continued*)

(*Table 2.12 continued*)

		Financing Structure (%)							
		Of R&D Activities				*Of Other Innovative Activities*			
			Of Third Parties				*Of Third Parties*		
Year	*Ranges of Occupied People*	*Own*	*Total*	*Private*	*Public*	*Own*	*Total*	*Private*	*Public*
2005	Total	89	11	4	7	81	19	11	9
	From 10 to 29	93	7	6	1	84	16	9	8
	From 30 to 49	79	21	10	11	95	5	1	3
	From 50 to 99	97	3	1	2	71	29	21	8
	From 100 to 249	87	13	10	4	80	20	7	13
	From 250 to 499	78	22	7	15	80	20	7	13
	More than 500	90	10	3	7	82	18	9	9
2008	Total	76	24	4	19	75	25	9	16
	From 10 to 29	82	18	7	12	72	28	9	19
	From 30 to 49	56	44	10	34	50	50	26	24
	From 50 to 99	85	15	8	7	71	29	12	17
	From 100 to 249	73	27	4	22	75	25	7	17
	From 250 to 499	50	50	45	5	61	39	23	15
	More than 500	78	22	1	21	81	19	3	16

Source: IBGE (2000, 2003, 2005 and 2008).

> It was possible, thanks to the deflation of securities and real estate wealth observed since the end of 1989 in the global market. The American recession, which lasted until middle of 1992, and the burst of the Japanese speculative bubble were factors which required great attention from the monetary policies. The purpose was to overcome current unbalances in the financial position of companies, banks and families affected by the collapse of the exuberating burst of assets valuation that followed the redemptive intervention of 1987 (Belluzzo 2009).

The liberalisation of foreign commercial and capital flows dates back to the beginning of the 1990s. The Collor government announced an image, and the society bought it, of a modernising plan, adopting the Washington Consensus. Modernising, here, means opening markets and capital flows without any safeguard, for an economic system which operated with strict controls of both capitals and imports. Furthermore, the Brazilian economy underwent a serious recessive period which, in addition to the recession of the American economy, undermined the performance of national enterprises. It resulted in the transfer of control of several national enterprises which had been established at the time of the regime of import substitution, to foreign capital. These enterprises were, in their majority, the best qualified and those which used to make some kind of innovative effort along with the modernisation of production.

When there is a greater freedom for capital flows, a financial market is created which is much more agile and strong in both speculation and arbitrage, involving many kinds of financial innovations. In this global market, which incorporates both the commercial and the financial, the exchange rate becomes a financial asset whose price is instantly adjusted, irrespective of the conditions of the commercial market. This is the reason why a divergence may occur between the commercial exchange rate, which accelerates economic growth and employment, and the global exchange rate. This latter obeys the interests of financial speculation and arbitrage, depending upon the profits it offers to the agents (Netto 2008).

Who, then, directs this financial movement and, therefore, the global supply? It is the expectations arising on the evolution of the economy and of the exchange rate itself, besides the differences between the real internal and external interest rates. The capital flow that either valuates or devaluates the exchange rate depends, obviously, on the differences of return that one dollar may obtain in the foreign financial market and, with the same risk, in the Brazilian financial market. In 2008, our efficient Stock Exchange of Sao Paulo State (BOVESPA) provided the foreign investor a return rate in dollars of the order of 5.5 per cent per month, as against the less than 2 per cent per year in the US (ibid.).

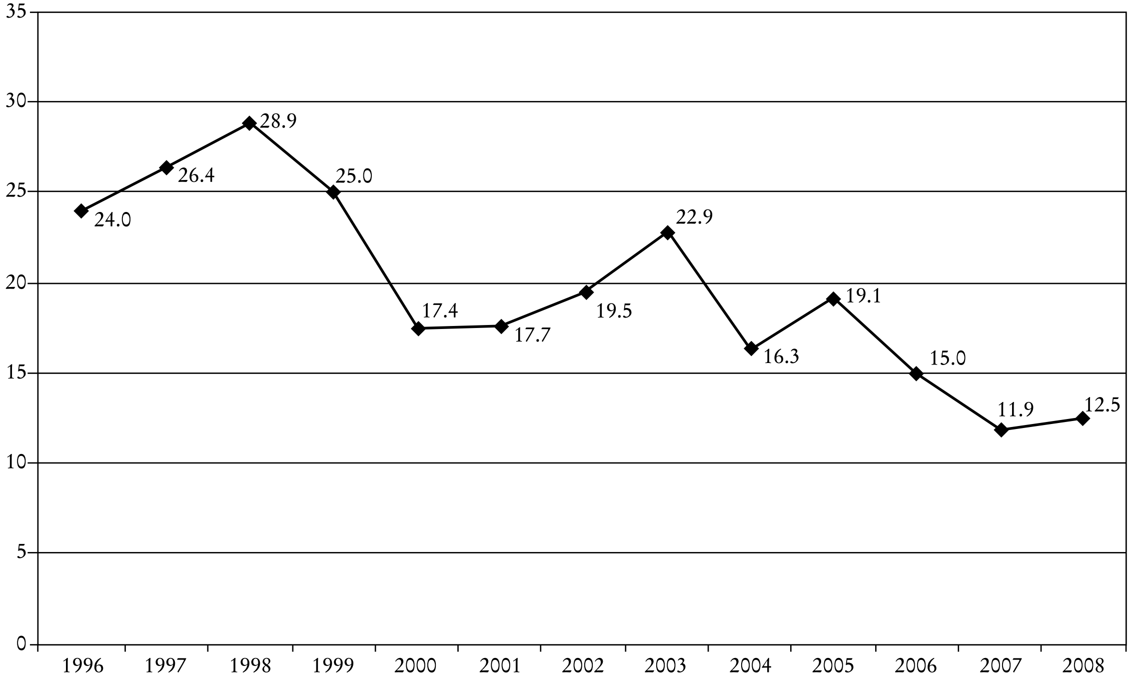
The exchange rate anchor of the Real Plan started with US $1.00 (one dollar) corresponding to R$ 0.83 (83 cents). The appreciation of the real between 1995 and 1998 caused a deficit in the current account of US$ 106 billion. Between 1999 and 2002 we accumulated more than 81 billion dollars in deficits in the current account. The exporting sector only recovered in 2003. Exports have grown at 3.2 per cent per year between 1995 and 1998, and at 8 per cent between 1999 and 2002. The surprising results of 2003 and 2004 were an outcome of the exchange rate devaluation of 2002, of the abundant supply of international credit and of the huge growth of world exports. Between 2002 and 2008, our exports grew 22 per cent per year. This was a consequence of the rise in prices and quantities of agricultural and mineral products, which generate less employment than the manufacturing industry and services (Netto 2008). For financing this deficit, the interest rate should be quite high (see Figure 2.1) and, thus, it produced the very low 2.6 per cent per year average rate of GDP growth. The gross formation of fixed capital has been very low for the same reasons above mentioned.

This implies that, in this economy, the economic incentive is directed to the production of commodities, products that in general have lower technological intensity, with low elasticity of income and of international demand. The domestic opening to foreign trade implies the existence of a strong demand for imports of products with greater technological content. Therefore, there is a structural trend towards deficits in the current account.

The process of liberalisation of productive, commercial and financial flows of the Brazilian economy with other countries culminated with the privatisations in the sectors of raw materials, energy and telecommunications. This measure has modernised consumption in the Brazilian economy, but broke apart the domestic production chains and the efforts for technological capabilities building developed in the previous decades, during the period of imports substitution.

Such movement of liberalisation and privatisation led to a reduction in the mechanisms for protection of the national enterprises and to less intervention by the state, raising the risks of their investments. The

Figure 2.1: *SELIC Rate, 1996–2008*



Source: BACEN (1996–2008).

monetary policy, which benefited rentiers to the detriment of productive sectors, strengthened the formation of defensive expectations on the part of the national enterprises. Finally, the NSI, unstructured on the grounds of lacking an explicit policy for industrial innovation, remained at very low operational level. In fact, it must be highlighted that, in this period, the integration between the implicit policies, monetary and fiscal, and the industrial innovation policy, the privatisation, was conducted in the opposite direction of the strengthening of national innovative enterprises. In this institutional context, national enterprises deepened the trend to invest in modernisation.

It is worth highlighting that privatisation in Brazil transferred assets from the state productive sector corresponding to 15 per cent of the GDP mainly to international monopolistic groups. This has been the major implicit industrial policy carried out in Brazilian history, with deep future impact on the balance of payments as shown by the data on payments of dividends, interests, royalties and profit transfers in 2008. The deficit in the current account amounted to US$ 28.3 billion in 2008, a figure that corresponds to 1.78 per cent of the GDP. In absolute terms, the negative result is the highest since 1998 and closes a period of five years of surpluses, occurred between 2003 and 2007. In the comparison with GDP, however, the deficit is not so high. In the historical average, the deficit in the current account was of 1.75 per cent of GDP between 1947 and 2008. The last negative result had been in 2002, with 1.51 per cent of GDP; in 2001, it was 4.19 per cent of GDP. The current accounts underwent a relatively quick change. In 2007, a surplus had been registered, with US$ 1.551 billion, or 0.12 per cent of GDP. From 2007 to 2008, therefore, there was a variance of US$ 29.851 billion. Little more than half of it (51.2 per cent) is due to the drop in trade surplus, which changed from US$ 40.032 billion to US$ 24.746 billion from one year to the next. The second most important factor (which responds for 38.3 per cent of the change) was the growth in transfers of profits and dividends that increased from US$ 22.435 billion in 2007 to US$ 33.875 billion in 2008. The drop in trade balance is explained by the increment of 43 per cent in imports, which were pulled by the increase of domestic demand and by the appreciation of the exchange rate. Exports increased 23 per cent from one year to the next. The growth in transfers of profits and dividends is due to three main factors. First, the appreciation of the exchange rate observed until September of 2008, which made profits become higher when converted into foreign currency. Second, the good results obtained by the enterprises, until the crisis reach the country. Third, the branches established in Brazil sent more resources in order to cover losses of the headquarters in other countries, especially in the automotive and financial segments (Ribeiro 2009). All this exposes the extreme volatility of the external sector of the Brazilian economy, with strong impacts in the formation of business sector expectations on the future of the productive investment.

In 2004, the government launched the PITCE. However, it kept the same framework of the implicit policies, the mix of appreciated exchange rate and high interest rates. The tendency since 2008 was for Brazil to start having current account surpluses and accumulate foreign currency reserves.

In 2008, a new industrial policy was launched — the PDP. The short interval between PITCE and the launch of PDP shows that the Brazilian government remains divided between liberals and developmentalists. The short interval between them exposes the absence of a long-term strategy. Without even expecting a minimum period for evaluating PITCE, PDP was launched. What can the enterprises expect about stability with such erratic behaviour of the government and a macroeconomic policy? Defensive expectations can hardly be altered. The world economic crisis which suddenly appeared in the second half of 2008 was a new hard shock on them.

The positive aspect of the last years was the cessation of the privatisation process, which allowed Brazil to enter its most important investment cycle since the end of the 'economic miracle' of the 1970s. Under the lead of Petrobras and Eletrobras, for instance, the country started again to expand public investments which, supported by state banks, incited the private sector to expand production and employment. However, the success of an industrial policy relies on the pertinence of its internal coherence, on the adequacy between strategy and the organisation of the means for reaching the determined objectives, which affords it essence. It depends on the compatibility and convergence with the macroeconomic policy, which affords the dynamism derived from positive expectations of returns of investments. And, lastly but not less important, on its institutions, which allow the prevalence of a state of trust, the basis for improvement and adaptation before the several situations of economic changes that arise intermittently.

What can be noted from the previous analysis is that Brazil is not yet fully released from the rentism subsided by significantly high real interest rates. The mistakes of the macroeconomic policies involve not only the most recent stage of appreciation of exchange rates, but principally the persistence of the logic of the fictitious valuation of wealth over the investment in production and innovation.

The Role of the Financial System in the National System of Innovation

The importance of funding for investment in innovation has been deemed as a significant structural bottleneck still not solved by private financial institutions. If, on the one hand, the internationalisation, deregulation and globalisation of the financial markets signal the possibility of resources at lower costs, on the other, the characteristics of investment in innovation, such as long term of maturation, uncertainty and risk, suggest the need of existence of domestic institutional arrangements (Melo 1994). In his work on Japan's NIS, Freeman (1987) claimed that any NIS must be prepared for operating in a way to meet requirements of innovation in four areas: the intervention of the state through public policy, the way enterprises design their strategies of R&D, the impact of education on human resources formation and training of technicians, researchers and other workers, and social innovations related to human resources formation and the conglomerated structure, the enterprises internal organisation and the relations between them, which comprise the industrial structure prevalent in a particular moment in each country.

Including or excluding institutions in a concept is a task that involves historical analysis and theoretical considerations, since at distinct historical periods, different parts of the economic system, or different interfaces between subsystems, may play the most important role in the innovation process. However, there is no investment without financing, as already emphasised in this work. In this sense, Melo (1996) sought support in post-Keynesian concepts, developed by Minsky (1982) and Studart (1993), for adding a fifth characteristic to the previous four defined earlier: the institutional organisation and the structure of the financial sector.

In order for NIS to operate with efficacy, it is fundamental that the previous establishment of an institutional environment of innovation policy take into account the three factors that comprise it. System means that subsystems of the innovation system must operate in a coordinated and compatible way, in order to generate a positive effect on enterprises and, then, induce them to increase investments. For doing so, it is crucial that a public policy on innovation be in place, incorporating the national dimension as priority.

In the discussion of this specific issue, financing and NIS, some authors have already made some relevant analysis. Zysman (1983 and 1986) discussed the impacts of different kinds of financial systems — dominated either by credit or by capital market — on the dynamics of innovations and industrial sectors. Zysman (1983) systematised a typology of financial systems according to distinct links, the institutionality between banks, industry and finances based on the study of several countries. In the capital market–based system, stocks and debentures are the predominant sources of long-term funding for enterprises. In this system, the key function of bank loans is for short-term purposes (finance). The entry and exit of distinct financial operations are relatively simple processes (even more in the presence of elaborate secondary markets). This model would, then, put banks, enterprises and the government at distinct spheres, which would risk meeting as autonomous partners in exchanges. The special characteristics of investments in innovation led to the development of specific financial institutions, which interact with the financial markets. An example is the financing via VC for technology-based enterprises (electronics, information technology, telecommunications, biotechnology) in US and the constitution of a specific market for negotiating stock shares of these enterprises, National Association of Securities Dealers Automated Quotations (NASDAQ).

In the credit-based financial system, the capital market is underdeveloped and enterprises strongly rely on credit to obtain further financing. The absence of adequate mechanisms for financing investments makes enterprises rapidly increase their indebtedness in order to follow development. The credit-based financial system is, therefore, extremely vulnerable to changes in credit conditions in growth periods. If the interest rate increases, it causes an increase in firms' financial expenses. The latter will try to adjust by cutting other expenditures. This will start up a vicious cycle of financial reactions which may cause financial instability and drag the economy into recession.

Mayer (2002) questions the so-called financial pre-conditions to the development of a high-technology sector. He criticises the almost unanimous response that these pre-conditions involve the existence of an active sector of VC connected to a capital market able to provide much liquidity. It can be said that Mayer (2002) and Chesnais and Sauviat (2005) line up in their conclusions, even if they are based on distinct theoretical assumptions. Venture capital, as a system for financing innovation, is an innovation adequate to US, but which other countries have difficulties imitating.

The financial systems that intend to positively influence the innovation process must, first of all, confer a major importance to firms' long-term performance. Second, they must acquire the knowledge of firms and retain the competence for assessing firms' intangible assets. The Brazilian financial system does not meet any of these requirements.

The close relationship between enterprises and financial institutions allows for better knowledge on the part of these latter on enterprises' strategy, their management and their sources of competitiveness. Conversely, short-term firms' evaluation by financial institutions, based on conventional instruments of financial and economic analysis, is completely inadequate for this task. Innovation is an asset constituted by uncertainty, long period of time until producing results, continuous investment in intangible factors, and it is carried out without any precise idea about future market demand. The conventional criteria of economic-financial analysis assess these factors negatively, since they only take into account results already obtained and not the changing processes within enterprise for implementing its innovation strategy.

If the conventional criteria are uncritically applied, they will result in sub-investment in innovation, privileging those activities closer to the market and characterised by lesser uncertainty. In spite of this, the use of such inadequate financial instruments is a consequence, not the cause of theoretical models and myopic institutional structure, biased towards the short term.

A Schumpeterian and Keynesian approach emphasises the role of institutions and conventions for relieving uncertainties of the decision-making process in monetary economies.

Brazil built an extremely sophisticated financial system, able to perform financial operations of high complexity. However, as aforementioned, such technical capability of the financial system derived, first, from the need of agility for financial application of cash balances of the enterprises under a regime of high inflation. Later, this technical capability was used to take advantage of the regime of high interest rates. That is, this technical capability showed to be practically ineffective for improving the articulation with NIS and the financing to innovation.

It was not for lacking financial instruments. In this aspect Brazil has been quite creative. At the end of the 1970s and beginning of the 1980s, VC enterprises already existed, supported by FINEP and BNDES (Melo 1988 and 1994). BNDES already had a portfolio of direct investments of participation in the equity capital of enterprises listed at the Stock Exchange. FINEP already operated directly the investment in innovative enterprises via VC (Melo 1988).

However, the extremely high economic volatility that followed the Mexico moratorium in 1982 has practically paralysed all these initiatives. Only after the implementation of the Real Plan were they were systematically resumed. More recently, the sectorial funds expanded this range of instruments.

The main deficiency in the relation between the financial system and the NIS is that it does not get to provide long-term financing. Even when the instruments for this do exist, they are limited to the public financial institutions. In addition, among these latter there is poor coordination and integration of activities; and, within them, there is no strategic guidance for integrating these instruments.

Understanding this process as a systemic one means to claim that existing financial instruments must operate in an integrated way. Today, in Brazil, there are three instruments for this task: equalisation of interest rates, VC and subvention. The disconnected use of such instruments leads to a fragmented and non-systemic policy.

Such institutional disarticulation reflects with more intensity on the absence of a policy based on state purchase. Brazilian legislation, Law no. 8666/93, in practice impedes any criterion for purchasing by public power, if not by lower price or lower tariff. Preference for national enterprises has been incorporated in the 2010 revision of the law, but it only offers a margin for price divergence. Technical and quality criteria are subordinated to lower price criteria.

Therefore, in order to meet the requirements of a systemic, integrated operation, directed to national innovative enterprises in NIS, it is necessary to have a policy for industrial innovation which can combine the state's purchasing power, demand with supply, financial instruments. Only thus will it be possible to reduce the negative impacts of implicit policies and, concomitantly, reduce uncertainty and the costs of investments in innovation.

Conclusions and Policy Suggestions for Required Changes Aimed at Improving Innovation Financing in the Country

The Brazilian industrialisation process, led by multinationals and by the state, which pulled, in its expansion, complementary and subordinate investments by national capital in the industrial, agro-industrial and civil construction sectors, exhausted in the 1908s. This depletion left exposed all the contradictions which comprise the framework of structural heterogeneity of Brazilian capitalism, constituted by several asymmetries, two out of which concern directly to the present work. The first one, the financial asymmetry, exposes the lack of interaction between banks and the national manufacturing enterprises, as well as the humble dimension of these latter in international terms, with the few exceptions of PETROBRAS, Vale do Rio Doce and EMBRAER. It is worth noting that all these either were or still are state companies. The existence of large international groups, leaders in the more dynamic markets, makes them independent and disconnected from the Brazilian financial institutions, whose capital is predominantly national. At the same time, the large national groups stay, in general, closed, avoiding opening their capital for concerns of losing control on their enterprises. The disconnection between the banking system and the large industrial capital, blocks the conglomeration of the firms by failing to make the articulation between the financial and the productive circuits, impeding the national groups to overcome their financial fragility.

The Brazilian state, in spite of being the owner of the largest banks of the country, cannot operate actively for articulating the financial and the productive systems, and promoting the process of conglomeration and monopolisation of the capital, since it would involve a broad process of statisation of the economy. Thus, their role is passive, through mechanisms of long-term credit and with partial results.

The financial asymmetry is responsible for the inexistence of large private national groups, of international magnitude, with financial capacity and capability to productive conglomeration, able to face competition at the international market in equal conditions as the large groups from developed countries and even from other emerging countries such as South Korea and China.

The second, the technological asymmetry, results from the problems of international insertion subordinated to the Brazilian economy. The first is the lack of leadership by Brazilian enterprises in the dynamic sectors, which prevents the complete internalisation of industrial innovation, causing a rupture between the capacity for generating knowledge, forming human resources for R&D and the effective introduction in the productive innovation system. The issue is not solved, therefore, only with the increase in resources for innovation. They are important and necessary, but do not solve the central question — the separation of R&D produced outside the country by multinational companies, leaders in the dynamic sectors, and introduced in the country without the need for an internal effort of innovation.

Thus, the NSI undergoes a congenital defect, the weak economic and technological competence of Brazilian enterprises that should be their central and strongest element.

The central problem that must be considered by the innovation policy is not the support to sectors, but technologies that are pervasive to all sectors and firms, such as information technology, biotechnology and nanotechnology. These technologies have a pervasive effect in the economy as a whole, permeating the networks constituted between the enterprises for sharing and using knowledge in production. Thus, the question is how to set a national scale which would allow for the use of these technologies by the national enterprises. Thence the importance of purchasing power of the state, as used by the Petrobras system until now and, formerly, in the constitution of Embraer, now privatised, but with '*golden share*' of Brazilian state.

We can imply, specifically from the analysis on the relation between the financial system and the financing to innovation, the following:

i) the need for strengthening the entrepreneurial capacity of large Brazilian groups, by creating mechanisms for approach to private banks. A possible alternative for the advancement of this approach would be the use of assets of public banks and financial institutions, as a securitisation of operations between private banks and national enterprises, aiming at their productive conglomeration.

ii) organising for emerging enterprises, with direct participation of public financial institutions, especially the National Bank of Social and Economic Development and the Finance Agency of Studies and Projects, a system of VC exempting them from the responsibility of collaterals, because they do not have these, and enhancing their financial capacity. On this point, it is worth noting a crucial problem that concerns the entrepreneurial competence of these entrepreneurs and innovators, who have no experience of organisation and man-agement of firms.

iii) financing of innovation must aim, principally, at reducing the technological heterogeneity of enterprises, of their production chains and of local production arrangements, aiming at enhancing the use of generic technologies.

iv) an area where the government has intervened in a timid manner, in order to develop the financial system, is that of institutional investors, pension funds, insurance funds and programmes of social security. Such a segment is able to provide and to mobilise high amounts of stable and large-scale resources, which must be channeled to long-term financing, constituting *funding* for financial institutions.

Developing countries, characterised by scarcity of capital, particularly for long-term investments, cannot count solely on the action of private businessmen or on the invisible hand of the market in the search for a sustainable economic development. The institutional infrastructure built by the state represents, unequivocally, a positive externality for the private enterprises.

The intervention and participation, in the period of startup of industrialisation, were fundamental in the face of the scarcity of capital and of the natural resistance by private entrepreneurs to adventure in high-risk and low-return investments. In the new historical phase of development of countries of recent industrialisation, the support of the public power becomes, once more, essential for promoting the national technological capacity and for providing better stability to the private enterprise.

In brief, the increase in resources for the financial allocation, participation, equalisation, subvention and guarantee of credit and liquidity, with the respective reduction and elimination in resources allocated to contingency reserves, is important. FINEP will need to build its capacity for operating all forms of participation in the risk of innovative enterprises. Now, it is almost exclusively limited to the participation in funds of VC for startup technology-based enterprises. It is an indirect form, perhaps less risky, but that is not compatible with the strategic institutional role that a public financial institution may play in the creation of these enterprises and in sharing the risks of investment in innovation.

Finally, the integrated and articulated operation of NIS relies upon the definition of an innovation policy that faces the problems of articulation between institutions that comprise it, that integrates its subsystems and, thus, reduces the uncertainty inherent to contradictions between implicit and explicit innovation policies, building a trustful institutional environment for investors.

Notes

1. In this period, the strategies of the Banks may be summed up as follows: (a) increased participation of public bonds (short term) in the asset; (b) relative shrinking of credit operations; (c) heavy investments in information technology aiming at reducing operational costs of banking services; and (d) outward diversification — towards non-banking sectors (Hermann 2003: 8).
2. In 1984, the Brazilian government signed a contract with the World Bank for the Program in Support to Scientific and Technological Development (PADCT). The funding of this programme would be comprised by a loan from the World Bank and a counterpart from the FNDCT. The impact of this programme's resources was very low and did not reach the 5 per cent of total resources managed by FINEP. Its major mark was the new model for managing its resources and applications, through the advisory committees, that would become the basis for the managerial model of the Sectoral Funds (Bastos 2003 and Milanez 2007).
3. The information on FNDCT and FINEP in the tables and graphs was retrieved from FINEP's budget area. The author thanks the kindness of the researchers André Amaral de Araújo, Marilena Ferraz Andrade and Jose Antonio Bustamante in attending to the data requests for this work. The responsibility for the analyses and concepts emitted based on this information is exclusive to the author.

4. The survey comprises: (a) expenditures with innovative activities; (b) sources of financing innovation expenditures; (c) impact of innovations in enterprises' performance; (d) sources of information used; (e) cooperative arrangements used; (f) role of governmental incentives; (g) obstacles to innovation activities.

References

Arthur, B. W., 1996. 'Increasing Returns and the New World of Business', *Havard Business Review*, 74(4): 100–109.

Banco Central do Brasil (Brazilian Central Bank, BACEN), 1993–2004. 'Estatísticas sobre o SFN', http://www.bcb.gov.br/?ESTATSFN (accessed 1 May 2012).

———, 1996–2008. 'Estatísticas sobre o SFN', http://www.bcb.gov.br/?ESTATSFN (accessed 1 May 2012).

———, 2002. *O Banco Central e as novas técnicas de saneamento do Sistema Financeiro Nacional após a estabilização monetária*. Brasília: Brazilian Central Bank.

Banco Nacional do Desenvolvimento Econômico e Social (Brazilian Development Bank, BNDES), 1991–2009. 'Acesso à Informação–Ações e programas', http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/acesso_a_informacao/acoes_e_programas/index.html (accessed 1 May 2013).

Barker, W. J., 1990. 'Os bancos, a indústria e o Estado no Brasil', *Revista de Economia Política*, 10(2): 132–46.

Bastos, J. R. M., J. A. Scheinkman, L. L. Cantidiano, L. Goldstein, T. M. F. D. Silva and A. G. Carvalho, 2000. 'Desafios e oportunidades para o Mercado de Capitais Brasileiro', in BOVESPA, *Estudos para o Desenvolvimento do Mercado de Capitais.* São Paulo: BOVESPA, 48–60.

BASTOS, V. D., 2003. 'Fundos públicos para ciência e tecnologia', *Revista do BNDES*, 10(20), December: 229–60.

Belluzzo, L. G., 2009. 'Plano Real, 15 anos', *Carta Capital*, 3–10 July, p. 20.

Britto, J., M. Vargas and J. E. Cassiolato, 2001. 'Formatos organizacionais para financiamentos de arranjos e sistemas de MPME'. *Nota Técnica 1.9*. Proposição de Políticas para a promoção de sistemas produtivos locais de micro, pequenas e médias empresas. Rede de Pesquisa em Sistemas e Arranjos Produtivos e Inovativos Locais (RedeSist), Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.

Cavalcante, L. R., 2002. 'Sistema financeiro no Brasil: uma breve análise de sua evolução', *Bahia Análise & Dados*, 12(3): 199–210.

Chandler, A. D., 1990. *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge: Harvard University Press.

Chesnais F. and C. Sauviat, 2005. 'O financiamento da inovação no regime global de acumulação dominado pelo capital financeiro', in H. M. Lastres, J. E. Cassiolato and A. Arroio (eds), *Conhecimento, Sistemas de Inovação e Desenvolvimento*. Rio de Janeiro: Editora UFRJ/Contraponto, 161–220.

Christensen, J., 1992. 'The Role of Finance in National Systems of Innovation', in L. B. Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter, 146–68.

Corder, S. and S. Salles-Filho, 2006. 'Aspectos Conceituais do Financiamento da Inovação', *Revista Brasileira de Inovação*, 5(1): 33–76.

Corraza, G., 2000. 'Crise e Reestruturação Bancária no Brasil', *Texto para Discussão*. Porto Alegre: UFRGS.

Cruz, P. R. D., 1994. 'Notas sobre o financiamento de longo prazo na economia brasileira do após-guerra', *Economia e Sociedade*, 3: 65–80.

De Paula, T. B., M. C. P. Freitas, M. C. Rossi and A. J. J. Botelho, 2003. *Capital de risco no Brasil — Marco legal e experiência internacional*. Brasilia: Centro de Gestão e Estudos Estratégicos (CGEE).

Dosi, G., 1990. 'Finance, Innovation, and Industrial Change', *Journal of Economic Behavior and Organization*, 13: 299–329.

Economic Applied Research Institute (IPEA), 2009. 'Transformações na indústria bancária brasileira e o cenário de crise'. *20º Comunicado da Presidência do Ipea*. Brasília: Economic Applied Research Institute.

Erber, F., 1999. 'O sistema de inovações em uma economia monetária — uma agenda de pesquisas', in J. E. Cassiolato and H. M. M. Lastres (eds), *Globalização e Inovação Localizada: Experiências de Sistemas Locais no Mercosul*. National Council for Scientific and Technological Development/ Brazilian Institute of Science and Technology (IBICT): Brasília, 168–80.

Financiadora de Estudos e Projetos (Brazilian Innovation Agency, FINEP), 1967–97. 'Acesso à Informação', http://www.finep.gov.br/pagina.asp?pag=institucional_acesso_informacao#sic (accessed 1 May 2013).

———, 1991–2009. 'Acesso à Informação', http://www.finep.gov.br/pagina.asp?pag=institucional_acesso_informacao#sic (accessed 1 May 2013).

———, 1997–2009. 'Acesso à Informação', http://www.finep.gov.br/pagina.asp?pag=institucional_acesso_informacao#sic (accessed 1 May 2013).

———, 1998–2006. 'Acesso à Informação', http://www.finep.gov.br/pagina.asp?pag=institucional_acesso_informacao#sic (accessed 1 May 2013).

Fingerl, E. R., 2007. 'Considerando os Intangíveis: Brasil e BNDES', *Dissertação de Mestrado*, Coordenação dos Programas de Pós-Graduação em Engenharia (COPPE)/ Federal University of Rio de Janeiro (UFRJ).

Freeman, C., 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Frances Pinter.

———, 1994. 'The Economics of Technical Change', *Cambridge Journal of Economics*, 18(5): 463–518.

Foundation for Administrative Development (FUNDAP), 2008. *O Mercado de capitais brasileiro no periodo 2003- 2007: evolução e tendência*. São Paulo: Foundation for Administrative Development.

Gershenkron, A., 1962. *Economic Backwardness in Historical Perspective*. Cambridge: Harvard University Press.

Gorgulho, L., 1997. 'Capital de risco: uma alternativa de financiaemento às pequenas e médias empresas de base tecnologica — o caso do Contec', *Revista do BNDES*, 7: 1–41.

Guimarães, E. A., 2008. 'Politicas de Inovação: Financiamento e Incentivos', in J. De Negri and L. C. Kubota (eds), *Politicas de Incentivo à Inovação Tecnológica no Brasil*. Brasilia: Economic Applied Research Institute (IPEA), 150–216.

Hermann, J., 2002. 'Financial Structure and Financing Models: The Brazilian Experience over the 1964–1997 Period', *Journal of Latin American Studies*, 34(1): 71–114.

———, 2003. 'Financiamento de longo prazo: revisão do debate e propostas para o Brasil', in J. Sicsú, J. L. Oreiro and L. F. Paula (eds), *Agenda Brasil — Políticas econômicas para o crescimento com estabilidade de preços*. Barueri: Ed. Marole, 131–52.

Instituto Brasileiro de Geografia e Estatística (IBGE), 2007. *Pesquisa de Inovação Tecnológica na Indústria–PINTEC, 2000, 2003 e 2005*. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística.

———, 2000, 2003, 2005, 2008. Pesquisa de Inovação — PINTEC (Brazilian Innovation Survey), http://www.pintec.ibge.gov.br (accessed 1 May 2012).

———, 2010. *Brazilian Innovation Survey*, http://www.pintec.ibge.gov.br (accessed 5 March 2012).

Interamerican Development Bank (IDB), 2007. *Living with Debt*. Washington D.C.: IDB.

Keynes, J. M., 1936. *The General Theory of Employment, Interest, and Money*. London: Macmillan Cambridge University Press.

Levine, R. and S. Zervos, 1998. 'Stock Markets, Banks, and Economic Growth', *The American Economic Review*, 88(3): 537–58.

Mani, S., 2001. 'Government and Innovation Policy — An Analysis of the South African Experience since 1994', *Intech Discussion Paper Series*, Maastrich: The Netherlands.

Mayer, C., 2002. 'The Financing and Governance of New Technologies', Paper presented at the UN University/EU DG Research Conference on Financial Systems, Corporate Investment in Innovation and Venture Capital in Brussels, 7–8 November 2002.

Melo, L. M., n.d. 'O Financiamento ao Desenvolvimento Científico e Tecnológico: a experiência da Finep — 1967 a 1988'. Unpulished Ms.C. dissertation, Universidade Federal do Rio de Janeiro.

Melo, L. M., 1988. 'O Financiamento ao Desenvolvimento Científico e Technológico: A Experiência da FINEP — 1967 a 1988'. Master Dissertation, Economics Institute, Federal University of Rio de Janeiro (IE/UFRJ).

———, 1994. 'O Financiamento da Inovação Industrial'. Unpublished Ph.D. dissertation, Universidade Federal do Rio de Janeiro.

———, 1996. 'Sistema Nacional de Inovação (SNI): Uma Proposta de Abordagem Teórica', *Texto para Discussão*. Institute of Economics/ Universidade Federal do Rio de Janeiro, n. 357, April.

———, 2003. 'Inovação, Financiamento e Sistemas Locais de Produção', Anais do First Globelics Conference: Innovation Systems and Development Strategies for the Third Millenium, Rio de Janeiro.

Melo, L. M., 2009. 'Financiamento à Inovação no Brasil: análise da aplicação dos recursos do Fundo Nacional de Desenvolvimento Científico e Tecnológico (FNDCT) e da Financiadora de Estudos e Projetos (FINEP) de 1967 a 2006', *Revista Brasileira de Inovação*, 8(1): 87–120.

Milanez, A. Y., 2007. 'Os Fundos Setoriais São Instituições Adequadas para Promover o Desenvolvimento Industrial do Brasil?' *Revista do BNDES*, 14(27): 123–40.

Ministério da Ciência e Tecnologia (MCT), 2008. *Relatório Anual da Utilização dos Incentivos Fiscais — ano base 2007*. Brasília: Ministério da Ciência e Tecnologia.

Ministério de Ciência, Tecnologia e Inovação (Ministry of Science, Technology and Innovation, MCTI), 1991–2009. 'Indicadores consolidados', http://www.mcti.gov.br/index.php/content/view/2068.html (accessed 1 May 2013).

———, 1997–2009. 'Indicadores consolidados', http://www.mcti.gov.br/index.php/content/view/2068.html (accessed 1 May 2013).

———, 1998–2006. 'Indicadores consolidados', http://www.mcti.gov.br/index.php/content/view/2068.html (accessed 1 May 2013).

Minsky, H. P., 1982. 'The Financial-instability Hypothesis: Capitalist Processes and the Behaviour of the Economy', in C. P, Kindleberger and J. P. Lafargue (eds), *Financial Crises*. Cambridge: Cambridge University Press, 13–47.

Miranda, J. C. and M. C. Tavares, 1999. 'Brasil: Estratégias de Conglomeração', in J. L. Fiori (ed.), *Estados e Moedas no Desenvolvimento das Nações*. Petrópolis: Editora Vozes, 327–50.

Mowery, D. C., 1992. 'Finance and Corporate Evolution in Five Industrial Economies, 1900–1950', *Industrial and Corporate Change*, 1(1): 1–36.

Netto, A. D., 2008. 'O câmbio e a inflação', *Valor Econômico*, 5 August.

Organisation for Economic Cooperation and Development (OECD), 1996. *Venture Capital and Innovation*. Paris: Organisation for Economic Cooperation and Development.

Pacheco, C. A., 2007. 'As Reformas da Política Nacional de Ciência, Tecnologia e Inovação no Brasil (1999–2002)', in *Manual de Políticas Públicas*. Santiago: United Nations Economic Commission for Latin America and the Caribbean (ECLAC).

Pinheiro, A. C., 2006. 'Bancos Públicos no Brasil'. Paper presented at the III Seminário ANBID de Mercado de Capitais, Novembro, Associação Brasileira das Entidades dos Mercados Financeiro e de Capitais (ANBIMA), Sao Paulo.

Prates, D. M., 1999. 'Investimentos de portfólio no mercado financeiro doméstico', in M. C. P. Freitas (ed.), *Abertura do Sistema Financeiro no Brasil nos anos 90.* São Paulo: Fundap/Fapesp, 17–60.

Puga, F. P., 1999. 'Sistema financeiro brasileiro: reestruturação recente, comparações internacionais e vulnerabilidade à crise cambial', *Textos para Discussão*, no. 68, Rio de Janeiro: National Bank of Economic and Social Development.

———, 2006. 'Câmbio Afeta Exportadores de forma Diferenciada', *Visão do desenvolvimento*, 9, Rio de Janeiro: National Bank of Economic and Social Development.

———, 2008. 'Balança comercial brasileira: muito além das commodities', *Visão do Desenvolvimento*, no. 54, 24 set, Rio de Janeiro: BNDES.

Puga, F. P. and M. M. Nascimento, 2008. 'Como as empresas financiam investimentos em meio à crise financeira internacional', *Visão do desenvolvimento*, 58, Rio de Janeiro: National Bank of Economic and Social Development.

Ribeiro, A., 2009. 'Déficit Externo Tem Forte Alta', *Valor Econômico*, 25 June.

Schumpeter, J. A., 1982. *A Teoria do Desenvolvimento Econômico.* São Paulo: Abril Cultural.

Sant'Anna, A. A., 2008. 'Decisões de financiamento via mercado de capitais no periodo 2004–2006', *Revista do BNDES*, 12(30): 161–79.

Sant'Anna, A. A. and A. I. G. Cruz, 2008. 'Composição da Dívida Pública é fundamental para o Financiamento de Longo Prazo', *Visão do Desenvolvimento*, 57, Rio de Janeiro: National Bank of Economic and Social Development.

São Paulo Stock Exchange (BOVESPA), 2009. *Boletim Informativo*. Year 8, no. 143, April.

Studart, R., 1993. 'Financial Repression and Economic Development: Towards a Post-Keynesian Alternative', *Review of Political Economy*, 5(3): 277–98.

———, 2000. 'Financial Opening and Deregulation in Brazil in the 1990s. Moving towards a New Pattern of Development Financing', *The Quarterly Review of Economics and Finance*, 40: 24–44.

Studart, R. and J. Hermann, 2001. 'Estrutura e Operação dos Sistemas Financeiros no MERCOSUL: Perspectivas a Partir das Reformas Institucionais dos Anos 1990', *Texto para Discussão do IPEA*, no. 799. Brasilia: Economic Applied Research Institute.

Zysman, J., 1983. *Governments, Markets, and Growth: Financial Systems and the Politics of Industrial Growth, Oxford: Martin Robertson.*

———, 1986. 'Financial Systems and Technological Innovation'. Paper presented at the Conference on Innovation Diffusion, Venice, 17–21 March.

3

The Russian Federation

Natalia Gorodnikova

The increasing role of innovations in the economy, the changing speed, trends and mechanisms of innovation activities are major factors causing radical shifts in the economies of developed (and of many developing) countries. These include increased investments in education and science in technological and organisational innovations; faster development of high-tech industries accompanied by overall increase of traditional industries' technological level; and the emergence of new industries.

Certain specific features of innovation activities — such as uncertain and delayed results, mismatch between overall social and specific individual effects, between information available to researchers, innovators, potential investors and consumers; high investment risks; and particular requirements regarding workforce skills and management quality increase the role of the innovative 'component' of public administration. The scale of and the mechanisms for providing government support to Research and Development (R&D) and innovation in countries change along with the country's development, shifting priorities and even changing political fashion. At the same time the high 'average' level of such support and the wide range of relevant tools define the paradigm of modern innovation policy in countries with a developed market economy.

The main attributes of this paradigm include:

- Orientation towards long-term technological priorities identified taking into account global trends and internal socio-economic objectives connected with sustainable development, increased competitiveness and national security;
- Pursuit of optimal balance between direct government funding and targeted support of R&D and innovation activities;

- Encouraging innovative development in the broad economic context, including creation of favourable conditions, promoting innovative behaviour of all economic players. Particular attention is paid to increasing efficiency of public institutions and government agencies responsible for development and implementation of efficient models and mechanisms, customised regulation techniques and tools;
- Building up effort aimed at development of new efficient tools and mechanisms of public–private sector partnership (PPP). Facilitating and supporting such alliances, the governments sends 'innovative development signals' to business, helps to implement company innovation strategies and major innovative projects (co-investment, infrastructure building, promoting transfer of technology and R&D results), and at the same time increase returns on their own investments;
- Growing interest in research-intensive services and non-technological innovations (i.e. organisational, management, marketing, consumer innovations), largely defined by the recognised crucial role of information and communications technologies.

During the last 10–15 years virtually all industrially developed and newly industrialised countries including China have set their R&D and innovation goals through strategic programme documents. This in itself serves as a motivation for R&D and innovation activities, in both the public and private sectors.

Two major trends profoundly affect the long-term prospects of innovative development — and, accordingly, development of innovation strategies. The first is globalisation and global competition which speeds up introduction of new technologies and products to the markets and forces companies and entire countries to boost their innovation activities. The emergence of new global players in the international science and technology (S&T) 'space' also increasingly affects innovation activities. International technology transfer, transnational corporations, labour mobility and other factors play an increasingly important role. At the same time proposed solutions for global problems are also becoming more innovative (e.g. cures for various diseases, power generation, climate change, etc.).

The second trend is increasingly more complex innovations whose interdisciplinary, cross-sector nature demands more and more substantial — and more risky — investments. Most companies already cannot afford to carry on innovation activities on their own — funding all the relevant research, obtaining market-related information, etc. The challenge is to join forces, attract outside knowledge without losing independence and harming one's own interests.

Emphasis is now being placed on open innovations which ensure not just quick recovery of R&D and innovation activity expenditures but also the involvement of talented people with diverse skills (the increasing need for the latter is another sign of the current times). The ability to adapt quickly, use knowledge acquired from external sources in a flexible way, becomes the key to successful innovation and making profits out of in-house generated knowledge (Chesbrough 2003).

The need to adapt innovation policy to the complex, spatially distributed, changing nature of innovations directly affects such policy areas and tools as taxation; support for human and social capital development; regulation of labour and investment markets; conducting R&D; promotion of best practices in corporate strategy development, finance and management. Recent Russian government policy papers on strategy development connected with switching the economy to an innovation-based model clearly demonstrate that the government has a serious, firm agenda. At the same time the exact motivation of the innovation-driven scenario, values of certain target indicators, the list of policy areas and specific measures to be taken to implement those policies with minimum social costs, may be questioned. An illustration of that is the debate on the draft 'Concept for long-term socio-economic development of the Russian Federation', and the long-term forecast of the Russian Federation S&T development until 2025, which is taking place in various government agencies and in the expert community. The authors and critics of these documents agree about one thing: their implementation would require truly unprecedented efforts by the government, to support and coordinate all participants of innovation activities and achieve significant progress in reforming the National Innovation System (NIS) to substantially improve its basic parameters and increase efficiency of innovation policy.

Recent Development of the Financial System's Structure and Its Role in Financing the Production Sector

The contemporary system of S&T and innovation funding in Russia should be regarded as an outcome of the transition from the Soviet centralised model to the market economy. Therefore two stages must be specified: the Soviet 'context' period of 1985–91 and the transition stage of the 1990s. Over 1985–99 and especially during the second half of the period, one socio-economic or political crisis followed another; it was a very hard time for the science sector as well as for the whole economy. Government support to the R&D sphere was reduced greatly. Research organisations were forced to spend most of their time looking for other sources of funding, trying to adapt to a radically new environment. It became much harder to survive, to find partners, to keep skilled personnel. During the last years before the collapse of the USSR (the late 1980s) R&D expenditures funded from the government and other sources grew steadily. Over 1985–89 their total amount increased from 3.7 to 4.7 per cent of the GDP (USSR Goskomstat 1990: 290).

In a situation of rapidly deteriorating macroeconomic conditions made worse by a series of political crises, all players engaged in S&T processes (from government agencies to individual enterprises and organisations) became unable to finance their R&D on the previous years' level. Accordingly, the amount of internal R&D expenditures started to drop sharply; over 1989–95 it decreased by 3.8 times in constant prices (HSE 2005; 55). In the situation of radical market reforms the science sector was seriously affected by high inflation, greatly reduced government support and low demand by industries and enterprises and by lack of consistent national S&T and innovation policy (at least at the beginning of the period in question).

The development of the Soviet and post-Soviet economy was largely determined by the military–industrial complex's potential and by mining, metallurgy and heavy engineering industries. Accordingly, the industrial sector had always prevailed in the R&D sphere (later on to be replaced by the enterprise sector), i.e. industrial research institutes and designed bureaus oriented towards the demand by specific industries. However, while market-based mechanisms were actively implemented in the economy (during 1989–95), the sector's R&D expenditures have reduced fivefold, from 8,498.6 to 1,702.8 million roubles in 1989 prices. At the same time the sector's share in the total internal R&D expenditures has dropped from 80 to 68.5 per cent (HSE 2005: 114). Until 1992 the public sector share (mainly represented by state academic institutes) never exceeded 17 per cent, about five times lower than the industrial (enterprise) sectors. In the course of winding up industrial R&D activities, the public sector's share of expenditures started to grow. One of the reasons was the political clout of the state academies of science (especially the Russian Academy of Science) that actively lobbied their vested interests. Second, in post-Soviet Russia a full-fledged corporate (private) segment of the R&D sector never developed. Another unusual feature is the weak R&D divisions of higher education institutes and universities. Their R&D work (unlike R&D conducted by research institutes) was not included in the centralised planning and funding system. These projects were financed mainly through contracts with industrial enterprises and research organisations. Before the collapse of the USSR the higher education sector's science accounted for just 7 per cent of the total internal R&D expenditures. By the end of the 1990s this figure dropped even further, to 4.8 per cent — an almost marginal amount for a developed country. Thus the increased role of the public sector wasn't due to the quality of its R&D products but, rather, to the weakness of other segments of the science sphere.

The period of the country's R&D system transformation was characterised not just by financial cutbacks but also by shifts in the funding structure. In the planned economy the whole R&D system functioned in the environment of centralised accumulation and allocation of financial resources via the government budget (whose share in the total amount of funds allocated for R&D purposes until 1991 never went below 91 per cent). Financial support for R&D work provided by enterprises out of their own funds was insignificant. It should be noted that the centralised R&D funding system survived almost until the mid-1990s. The main barriers to development of alternative funding sources during that period were macroeconomic problems: failed expectations of the research community who believed that the reforms started in the country would encourage demand for innovations, which in turn would increase investments into R&D. However, industrial enterprises were affected by the overall recession no less heavily than the R&D organisations. Detailed statistics on funding sources (which have become available since 1994) demonstrate total dominance of the government budget whose share of the country's internal R&D expenditures reached 61 per cent; the enterprise sector provided less than 20 per cent while organisations' own funds accounted for just over 10 per cent (HSE 2005: 117–18).

A distinctive feature of the Soviet (and later on the Russian) science is its weak innovative orientation. Market failures in the innovation field can be explained not only (and not so much) by the economic recession of the 1990s as by mismatch between the subject areas of the R&D, institutional structures and organisational mechanisms of the science sector on the one hand, and the needs of the economy on the other. Even in the situation of investment growth at the turn of the 21st century there wasn't any significant inflow of funds into the R&D sector.

Separation of applied science from enterprises and departmental barriers resulted in a gap between R&D and innovation activities. The economic mechanism on the basis of which research institutes and design bureaus used to function was oriented primarily towards encouraging research, not innovation. The misbalance between them resulted in a radical decline of productivity and quality of research, in low technological level of the Russian industry and other sectors of the economy, poor state of production equipment and ultimately, low competitiveness of Russian products.

Another weakness of the planned economy (and of the transitional economic mechanism) is dissemination of innovations. Even when the country was a leader in developing major innovations, it lagged behind in terms of implementing them; examples include steel making and processing technologies. The reverse side of this phenomenon is (often) unjustified adoption of imported technologies when efficient domestic alternatives were available. Accordingly, instead of integration into global innovation processes the country became stuck with the 'catching up' paradigm of S&T development. Low prices for domestic technologies (compared with imported ones), more favourable prospects for internal cooperation (as opposed to international) on the one hand, and tough competition on international markets, enterprises' lack of funds and experience necessary to promote Russian R&D products abroad and patent them in foreign countries on the other, resulted in a certain isolation of the Russian domestic technology market.

After the socio-economic transformations of the early 1990s, the Russian NIS remains unbalanced; its major components — such as the S&T sphere, enterprises and innovation infrastructure — exist in isolation from each other. In the situation of vague economic prospects, the industrial sector's strategy is not oriented towards innovation development and application of Russian R&D results. Russia will not be able to sustain its R&D potential if it doesn't maintain close links with the national economy, while the economy won't become competitive if it doesn't rely on R&D. Currently the S&T sector is not a growth factor for the national economy; rather, the whole economy of post-Soviet Russia (and unbalanced R&D and innovation funding mechanisms in particular) is a factor of decline in the S&T sector. In the long run it can lead to irreversible degradation both of the R&D sphere and the high-technology industries; accordingly, fast modernisation of the NIS becomes top priority for creating the 'new economy'.

Considerable growth of R&D expenditure (measured at constant prices) started only in 2006. In 2007, the gross expenditure on R&D (GERD) at current prices amounted to RUB 371.1 billion (Figure 3.1).

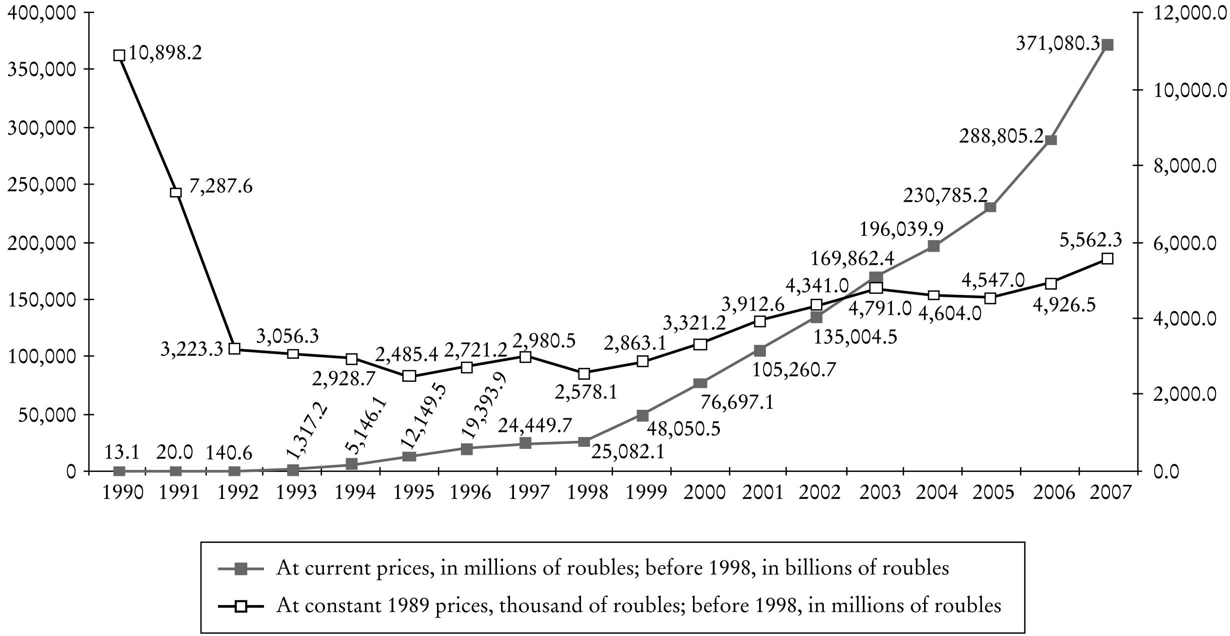
At comparable prices, these costs reached 76.3 per cent of the 1991 level but remained almost twice lower than in 1990. The breakdown of expenditures by source of funding and by sector of performance has changed little since the early 1990s. Due to many years of insufficient funding, absence of modern funding and motivation mechanisms, Russia did not manage to catch up with the world leaders neither in terms of volume nor comparable cost indicators (Table 3.1).

One of the key indicators of S&T development is the share of R&D expenditure in the GDP. In Russia this indicator grew over the period of 1995–2003 from 0.85 per cent to 1.28 per cent; in 2004 it again decreased to the level of 1.07 per cent, which remained until 2006, and started growing again in 2007. In line with targets of the S&T and Innovation Strategy of the Russian Federation for the period until 2015 (Ministry of Education and Science of the Russian Federation 2006) this key indicator should have grown much faster: in 2006 to 1.51 per cent and in 2007 to 1.62 per cent of GDP. However, its actual value proved to be considerably lower than the targets (Table 3.2), which in turn must have influenced other indicators mentioned in the document.

The analysis of R&D expenditure distribution by sector shows that the largest — like in other countries — was the business sector. The share of public sector in overall expenditure fluctuated in the past years from 24.3 to 29.1 per cent — the top value was reached in 2007. This is quite different from the Organisation for Economic Cooperation and Development (OECD) countries (on average 11.4 per cent in 2006) and the EU-27 (13.8 per cent).

The breakdown of Russian R&D expenditure by sector has changed little during the period 1995–2007. The greatest share (64–70 per cent) is concentrated in the business sector, with a little more than a quarter of the total being spent in the public sector. The main difference

Figure 3.1: *Gross Domestic Expenditure on R&D*



Source: HSE (2005, 2009b). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

Table 3.1: *Gross Domestic Expenditure on R&D (million current PPP US$)*

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*
Gross Domestic Expenditure on R&D	19,991.3	9,662.6	9,331.9	9,024.1	8,122.3	8,779.5	9,650.0	8,831.7	9,083.3
	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	
Gross Domestic Expenditure on R&D	10,726.9	12,852.3	14,563.6	16,317.2	16,487.8	18,115.0	20,210.3	23,501.0	

Source: HSE (2005, 2009b). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

Table 3.2: *GERD as a Percentage of GDP*

	2005	*2006*	*2007*
With consideration of S&T and Innovation Strategy implementation	1.36	1.51	1.62
Actual figures	1.07	1.07	1.12

Source: HSE (2005, 2009b). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

between Russia and other developed countries is the role of the public sector and higher education sector. The share of the Russian public sector in R&D expenditure is twice as high, while the share of higher education sector is nearly three times lower than the OECD average. The state budget has been the key funding source for Russia's S&T sphere. In 2007, the state budget covered 62.6 per cent of all R&D expenditure. The system of public S&T funding has been heavily dominated by the federal budget.[1] In the course of previous years preserving (and in some years even increasing) the government budget's share of R&D expenditure has been more or less necessary. This reflects not only the priority of S&T development objectives set by the government but also the low share of other S&T funding sources, especially the businesses. In 2007, the share of non-public expenditure in the total volume of internal S&T costs amounted to 37.4 per cent — less than the figure set in the S&T and Innovation Strategy. The funds allocated to universities (almost all of which are earmarked for educational purposes) are little used for R&D purposes (in 2007, they constituted only 0.2 per cent of total R&D expenditure).

In 1995–2007, the GERD financed from government sources grew 2.3 times (at constant prices). At current prices their volume reached RUB 232.4 billion — twice as much as the funds provided by the business sector which in 2007 grew to RUB 109.3 billion (29.4 per cent of the total expenditure).[2] The ratio of public/private investment in the S&T sphere describes the core element of the national S&T system and its place among other countries.

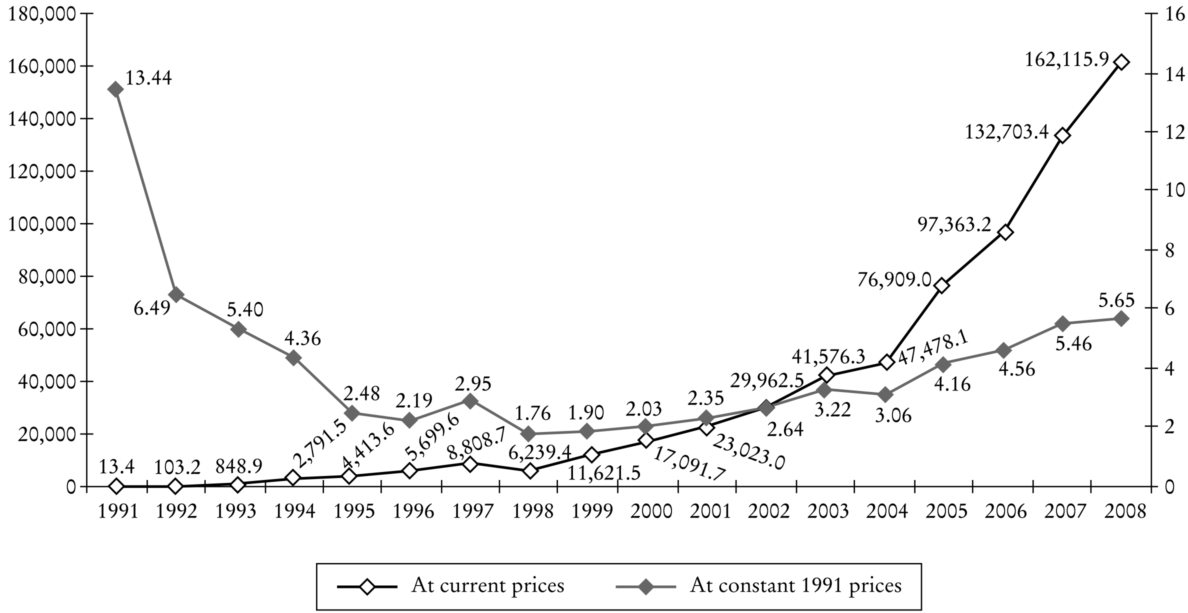
The civil R&D budget appropriations are another key indicator of S&T funding. Their total volume in Russia in 2008 amounted to RUB 162.1 billion at current prices (Table 3.3). In 2007 this indicator amounted to RUB 132.7 billion, which at constant prices is 2.4 times lower than in 1991. The consequences of reduced budgetary support to S&T in 1991–96 in the situation of rapidly growing inflation and the economic crisis of 1998 explain the lack of effect from the later budget increase. The 3.1 times increase of budgetary appropriations from 1998 to 2007 (at constant prices) only allowed the attainment of the 1993 level, when the level of appropriations was 60 per cent less than in 1991. Civil R&D federal budget appropriations as a share of the GDP show similar dynamics: in 1991–98 they decreased from 0.96 per cent to 0.24 per cent and then grew to 0.40 per cent not even reaching the 1994 level.

Table 3.3: *Indicators of Innovation Activities of Industrial Enterprises: Federal Budget Appropriations on Civil Science and Technology*

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*
Federal budget appropriations on civil science and technology	13,440.0	7,092.8	6,014.2	4,895.1	2,950.6	2,580.2	3,476.7	2,197.0	2,196.9
	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Federal budget appropriations on civil science and technology	2,390.4	2,811.1	3,232.2	3993.9	3,993.1	6,036.8	6,813.4	8,404.3	8,801.1

Source: HSE (2009a). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

Figure 3.2: *Federal Budget Appropriations on Civil Science and Technology (million roubles, before 1998 — billion roubles)*



Source: HSE (2005, 2009b). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

In 2007, the share of non-public funds in the total volume of GERD amounted to 37.4 per cent — less than the figure set in the S&T and Innovation Strategy. The share of foreign fund sources shows rather shaky dynamics: in 1995–2007 this value varied between 4.6–16.9 per cent, in 2007 it was 7.2 per cent.

It should be noted that the Russian R&D expenditure structure provides specific data not just on higher education institutions but industrial enterprises as well. Unlike most foreign countries where universities and industrial companies play a leading role in S&T development, in Russia these organisations are less important in this area. For example, the number of industrial enterprises performing R&D activities in 2007 was 265, or just 6.7 per cent of the total (they employed 7.1 per cent of R&D personnel). Industrial enterprises' share in GERD is comparable with these figures — only 6.8 per cent (RUB 25.3 billion at current prices). Note that the breakdown of industrial enterprises' R&D expenditure by funding source is different from the overall picture. Just under 50 per cent of the total costs are covered by public funds (coming from government budgets of all levels); slightly more than 25 per cent of expenditures were covered by enterprises' own funds; and the rest came from business enterprise sector organisations (11 per cent), public sector organisations (4 per cent), non-budget foundations (2.8 per cent), higher education institutions (0.2 per cent) and foreign organisations (6.8 per cent).

Innovation Activities in Russia and their Funding

Current trends of innovation activities in Russia do not fully match expectations in line with the creation of innovation-based economy, achieving dynamic sustainable growth, increased competitiveness of products and higher quality of life. So far there are no grounds for talking about technological breakthroughs in industry or active implementation of R&D results. Businesses' demand for and interest in innovations, especially technological ones, remains low. Furthermore, the latest data suggests there is stagnation in this area (Table 3.4).

So far innovations have had little real effect on the economy. On the other hand, the macroeconomic situation and the institutional framework are hindering enterprises' innovation activities. Their level is low in all industries and sectors of the economy — industrial

Table 3.4: *Main Indicators of Innovation Activities of Industrial Enterprises*

	1995	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Enterprises engaged in technological innovation (% of all industrial enterprises)	5.5	5.2	4.7	5.0	6.2	10.6	9.6	9.8	10.3	10.5	9.3	9.4	9.4
Sales of innovative products at current prices, *billion roubles, before 1998 — trillion roubles*	39.8	35.3	54.9	45.8	84.4	154.1	181.8	206.3	312.7	433.0	545.5	714.0	916.1
Sales of innovative products, *billion current PPP US$*	26.6	16.0	21.7	16.1	16.0	21.6	22.2	22.3	30.0	36.4	42.8	50.0	58.0
Innovative products as a per cent of total sales of industrial enterprises	4.7	3..3	4.7	3.8	3.7	4.4	4.2	4.3	4.7	5.4	5.0	5.5	5.5

Source: HSE (2009a). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

production including small businesses and services, and for all types of innovations — technological, organisational, marketing. The crises of the late 1980s–early 1990s led to a significant drop of innovation activities' level, from 60–70 per cent to 5–6 per cent in the post-reform years. Growth of this figure coincided with the growth of macroeconomic indicators.[3] The peak was achieved in 2000 due to the short-term import substitution boom following the financial crisis of 1998. Then the indicator's dynamics stabilised at 9–11 per cent. In 2007 2,485 industrial enterprises performed development and implementation of technological innovations, or 9.4 per cent of their total number — not an impressive figure compared with the EU members including Eastern European countries. The closest to Russia in this respect are Latvia (17 per cent) and Bulgaria (18 per cent). Germany, Ireland and the Czech Republic show much higher figures: 73 per cent, 61 per cent and 41 per cent, respectively.

To analyse the current situation let's take a look at the factors affecting enterprisers' demand for innovations and their success in implementing innovations. The analysis shows that the highest demand for innovations demonstrates large, economically sound enterprises with sufficient financial, labour and intellectual resources. Note that the bigger the companies in a group, the higher share of innovators the group shows. Half of the Russian industrial enterprises engaged in technological innovations employ more than 500 workers.

But it's not just about size. High-tech companies with not especially large output — or especially high level of investments — demonstrate impressive results. Their innovation activities are above 30.4 per cent, which is close to the European average.[4] In this case important factors include highly developed R&D potential, skilled workforce, highly efficient innovation expenditures, orientation towards international markets, various forms of government support. Unfortunately, due to their limited output these companies' activities so far have little effect on the overall innovation activities indicators for the Russian economy. In medium-technology industries the level of innovation activities is 1.5–2.5 times lower; in low-tech industries it's five times lower.

Small enterprises play an important role in development of innovation activities — due to their willingness to take initiative, flexibility and ability to adapt to changing environments quickly. In the situation of growing diversification and customisation of production, small companies show better results in developing and producing small-lot innovative products. In Russia, due to the generally weak small business support infrastructure, these companies cannot yet contribute to the overall increase of the innovation activities' level. The current situation is largely caused by insufficient level of small business development in the Russian economy generally.

The share of small enterprises engaged in technological innovations in 1999–2005 remained under 1.6 per cent; in 2007 it increased to 4.3 per cent (see Table 3.5).

Small firms lack the required financial resources, adequate R&D potential, skilled personnel needed to implement even modest innovative projects, much less radical innovations — or the time necessary to introduce new technological processes and wait until they pay enough to cover the costs. Normally they need comprehensive support (financial, intellectual, information) by the government, large parent enterprises or external investors. In developed countries the tune for innovation activities is usually set by large companies, while small enterprises are commonly used as testing grounds to try innovations out. In Russia the inertia of large and medium enterprises, their lack of enthusiasm for implementing innovative solutions, cast their shadow on innovation activities of small firms as well. The statistical 'leap' of 2007 in small companies' innovation activities was probably due to the different sample of the surveyed enterprises in this group. That would also explain the mismatch between the actual and planned in the Science and Innovation Strategy increase of the number of small enterprises: in 2007 this figure amounted to just 39. Apparently, utilising innovative potential of small enterprises requires serious effort by government agencies.

Non-technological innovations (i.e., organisational and marketing ones) are playing an increasingly important role in increasing production efficiency and boosting innovation activities. However, that kind of innovation hasn't yet taken its proper place in the Russian practice: the overall level of innovation activities (calculated taking into account all types of innovations) in 2007 amounted to just 10.8 per cent — only slightly higher than the figure for technological innovations.

Organisational innovations include introduction of advanced corporate management techniques as a recognised factor contributing to increased competitiveness; development of new and improvement of existing mechanisms and forms for organising production and labour. Normally such techniques and methods involve development of more advanced corporate strategies — entry into new markets, mergers

Table 3.5: *Innovation Activities of Small Industrial Enterprises*

	2001	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Small enterprises engaged in technological innovation, *number*	729	…	779	…	919	…	996
Increase of the number of small enterprises engaged in technological enterprises, *units per year*	56	25	25	58	82	38	39
Enterprises engaged in technological innovation (% of all small industrial enterprises)	1.5	…	1.6	…	1.6	…	4.3
Innovative products as a per cent of total sales of small industrial enterprises	0.6	…	0.3	…	0.3	…	2.0

Source: HSE (2009a). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

and acquisitions, adoption of international management and product certification standards. Since 2006, the share of organisations which implemented organisational innovations in the reporting year is used as an indicator for measuring these types of innovation activities, calculated in line with international statistical standards. In 2007 in Russia this figure was at 3.5 per cent.

Success of innovative projects largely depends on how clearly company management sees the market situation — market potential, trends, competition, efficient advertising techniques, etc. Accordingly, marketing innovations are being actively developed around the world, aimed at adapting products and services to the clients' needs to increase production and sales. In Russia the role of marketing in corporate management has been ignored for quite a long time. This, combined with lack of skilled personnel, is hindering the innovation process even further. In 2007, 656 Russian industrial organisations were engaged in marketing innovations (2.5 per cent). In high-tech industries this figure was three times higher. Today Russian companies are beginning to realise the importance not just of specific marketing tools and techniques but of implementing them as a wholesome integrated business management concept.

In the overall national economy the effect of innovation activities is not especially apparent. In 2007 large- and medium-size enterprises produced 916.1 billion roubles' worth of innovative products; their share of the total amount of industrial products' sales remained under 5.5 per cent. Small enterprises manufactured 12.6 billion roubles' worth of innovative products, or 2 per cent of all shipped industrial products. Despite the fact that appropriate overall figures for the whole industrial production show certain growth (3.3 per cent in 1996, 3.7 per cent in 1999), it's certainly a very small contribution which doesn't have any appreciable effect on production development, competitiveness and export potential. According to calculations, in the EU countries the total share of innovative products was in excess of 60 per cent, and in some industries even higher.

The ratio of total sales by innovative and non-innovative companies in Russia is 48.2 and 51.8 per cent. Compared with the EU domestic innovative enterprises are ahead only of Bulgaria (39.7 per cent); their figure is twice lower than that of Germany's which is the leader at 91.3 per cent. Thus, despite all efforts the overall efficiency of Russian industrial companies' innovation activities remains low.

This is confirmed by dynamics of innovative products' output: in 1995–2007 the absolute figure increased only by 77 per cent while innovation-related expenditures during the same period grew more than twice. Accordingly, the return on investment (ROI) dropped from 5.5 to 4.4 roubles per rouble spent on technological innovations.

Low efficiency of innovation activities significantly weakens competitiveness of Russian producers on international markets. Most of their export is made by products which haven't been subjected to technological change. Export of innovative products (services) in 2007 was estimated at 276.3 billion roubles; despite significant growth in the last two years, the share of such products (services) in the total export of industrial enterprises amounted to just 7.9 per cent (see Table 3.6).

The actual value of this indicator exceeded the target figure set in the strategy. The discrepancy is due to increased exports of high-level medium-technology industries, primarily chemicals (21.6 per cent against 16.2 per cent in 2006), and mining (except fuel and energy resources) (6 per cent).

The domestic market demonstrates a decline of interest in innovative products, caused among other factors by growing inflation, growing internal commodity prices and highly competitive foreign-made analogues. The share of innovative products and services in the total domestic sales amounted to 3.8 per cent — almost 1.5 times less than in 2005. Companies' demand for innovations is largely determined by the availability of resources. The level of investments in innovations usually is not adequate to the objective of switching the economy to the new development model. Insufficient funding slows down implementation of efficient projects, which lowers the overall innovation activity level even further. The quality of innovations deteriorates too; opportunities to innovate on an ongoing basis are not provided. Implementing radical full-cycle innovations — from performing specialised R&D to manufacturing fundamentally new products — becomes increasingly more expensive, so enterprises are less and less able to afford it.

Overall expenditures on technological innovations during 1995–2007 show positive trends: their volume (at constant prices) has doubled (see Table 3.7). Note that growth was performed both in high-tech and low-tech industries. At the same time the absolute amount of these investments was just 207.5 billion roubles — almost

Table 3.6: *Sales of Innovative Products of Industrial Enterprises*

	1995	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Innovative products as a percentage of total sales in industry	4.7	3.3	4.7	3.8	3.7	4.4	4.2	4.3	4.7	5.4	5.0	5.5	5.5
Innovative products as a percentage of total sales of industrial products at national market	…	…	…	…	…	4.1	3.7	4.1	4.6	5.6	4.4	5.0	3.8
Innovative products as a percentage of exports of industrial products	…	…	…	…	…	5.8	7.0	5.2	4.9	4.7	8.2	7.7	7.9

Source: HSE (2009a). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

Table 3.7: *Expenditure on Technological Innovation of Industrial Enterprises*

	1995	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Expenditure on technological innovation at current prices, *billion roubles, before 1998 — trillion rouble*	7.3	9.2	9.0	13.9	24.5	49.4	61.3	86.4	105.4	122.9	125.7	188.5	207.5
Of which: R&D, %	26.9	15.7	21.0	21.5	15.3	14.3	17.3	13.6	13.9	16.4	15.7	18.6	17.3
Acquisition of machinery and equipment, %	43.5	56.9	44.8	44.4	48.9	57.4	59.3	50.6	44.8	55.6	60.3	54.6	57.5
Expenditure on technological innovation, *billion current PPP US$*	4.8	4.1	3.6	4.9	4.2	6.9	7.5	9.3	10.1	10.3	9.9	13.2	13.1
Expenditure on technological innovation as a per cent of total sales in industry	0.9	0.9	0.8	1.1	1.1	1.4	1.4	1.8	1.6	1.5	1.2	1.4	1.2

Source: HSE (2009a). Original data: Institute for Statistical Studies and Economics of Knowledge (ISSEK). Available at http://issek.hse.ru/en/dep_scieninnovat (accessed 3 June 2010).

two times less than R&D expenditure. This is an indirect evidence of insufficient use of national S&T potential for development of the real sector of the economy.

The level of investments in technological innovations is not comparable with the economy's needs for modernisation of capital assets and increasing the range of new competitive products. The rate of such investments (their share in the total industrial output) in 2007 was no higher than 1.2 per cent. Note that since 2002 when this indicator had reached its peak (1.8 per cent compared with 0.9 per cent in 1995) it steadily dropped lagging behind the growth rate of industrial production in the country. The gap with developed countries is also growing: only Malta, Spain, Portugal, Norway and Bulgaria show even lower values (0.9–1.4 per cent). In France this indicator reaches 3.4 per cent, in Germany 4.6 per cent, in Sweden 5.6 per cent, in Baltic countries 1.8–2.8 per cent.

This stagnation in the innovation sphere is largely due to insufficient attention the government pays to implementation of innovations in the real economy (sluggishness and inconsistency of institutional reforms, lack of integrated approach to indirect motivation, insufficient financial support). Despite the wide variety of funding mechanisms and forms, enterprises' own funds still remain the main source: 87 per cent in 1995 and 79.6 per cent in 2007. Share of credits and loans in 2005–7 dropped from 17.5 to 13.7 per cent; note that only 4 per cent of all credits and loans have been provided on preferential terms. This is explained both by the banks' lack of confidence in proposed innovative projects and by the overall problems with the banking system — insufficient credit resources, inability to offer syndicated credit services, high interest rates, short terms of loans, and limited range of breaks and incentives offered to clients.

Combined public funding covers just 4 per cent of total expenditures on innovations. More than 50 per cent of the federal budget funds are channelled into high-tech industries, which increase the rate of their innovation expenditures. Three-quarters of funds provided out of regional and local budgets go into low-level medium-technology industries, mostly metallurgy. Other funding sources (non-budgetary foundations, foreign investors, venture funds) amount to 0.04–0.3 per cent of the total. Foreign investments (0.6 billion roubles) mostly go into food production (47.6 per cent) and manufacturing of cars, trailers and semitrailers (31.2 per cent of the total). Venture investments into innovation projects by large and medium enterprises in 2007 amounted to 76.2 million roubles (0.04 per cent of the total expenditures on technological innovations), and were made only in one sector — non-metal mineral products.

A breakdown of expenditures by type of innovation activity reveals a serious misbalance against investments in knowledge and human capital. Most of the funds are spent on acquisition of machinery and equipment (57.5 per cent). Then (with manifold gap) come expenditures on R&D (17.3 per cent) and industrial designs (7 per cent). Expenditures on acquiring patent licenses (0.8 per cent), staff training and retraining (0.5 per cent), marketing research (0.3 per cent) also can hardly be considered sufficient. On top of that, during the recent years there was a steady trend to increase investments in machinery and equipment (by 3.3 times in constant prices in 1995–2007), and reduce R&D expenditure.

International comparison reveals quite different proportions between types of innovation activities. In most of the economically developed European countries R&D expenditure are 1.5–2 times (or even more) higher than investments in machinery and equipment. For example, in France this ratio is 9:1, in Denmark and Norway 5:1. In some Eastern European countries — like in Russia — it has shifted towards machinery and equipment expenditures: in Bulgaria (8 and 89 per cent), Slovenia (10 and 89 per cent), Poland (10 and 86 per cent).

Innovation activities in the EU countries are performed on a different, more advanced technological basis. Enterprises strive to increase the novelty level of innovations and their competitiveness, so they invest in R&D — which is mostly conducted in-house. On the other hand, in Russia innovation activities primarily amount to the modernisation of active capital assets. This situation has an overall negative effect on the whole innovation process, leading to degradation of industrial S&T potential, poorer quality and low novelty of innovative products and services. Enterprises are losing the ability to innovate and, accordingly, are becoming less competitive in the markets of new high-tech products.

Survey of Existing Funding Mechanisms and Tools

Sustainable development of S&T and innovation activities can be achieved through creation of efficient funding tools regulated by a system of coordinated legislation. Quite a number of different funding mechanisms can be used, including budget appropriations, credits and loans, targeted funding, public, private or joint investments in R&D and innovative projects. The following section describes the most important Russian funding instruments.

The federal budget is the main funding source for Russian R&D, and remained such during the whole post-Soviet period. Regardless of the absolute budget appropriations, the share of budget funding remains more or less constant — at about 60 per cent of GERD.

By law public budget funds can only be used to finance services provided in the interest of the whole society or to support public structures and organisations created for the same purposes. There are two forms of budget funding of R&D: basic funding (funds are allocated as a specific budget article) and grants. Baseline funding is provided to specific R&D organisations based on the number of their staff and last year's level of expenditures. R&D expenditure amounts to at least 95 per cent of total public expenditures on S&T; the remaining 3–5 per cent of GERD are invested in capital assets.

Programme funding can be tender-based or allocated to specific organisations to implement specific projects. Such funds are provided through government programmes of various levels. Usually the programme mechanism is used to finance projects aimed at solving specific (mostly major) S&T problems (e.g. in airspace industry, nuclear physics and aircraft construction).

An important tool for dealing with priority national objectives — and a mechanism for public funding of R&D — are the Federal Goal-oriented Programmes (FGP). In the 1990s the number of FGPs was exceedingly large: between 96 and 155 such programmes were financed out of the government budget. As a result, the burden on the budget became too much and, accordingly, budget money — albeit allocated routinely — was not actually paid. The problem was made even worse by equally frequent failures to receive funds due from other, non-budgetary sources. The first victims of this lack of funds were R&D projects. The introduction (in 1996) of officially approved lists of priority S&T areas and crucial technologies had practically no effect on existing approaches to composing S&T sections of FGPs. All it actually amounted to was identifying such priority areas in S&T sections of existing FGPs.

Due to all of these reasons, R&D provided for in FGPs was only loosely related to the programmes' goals and objectives. Some FGPs supported R&D projects whose contribution to the programmes' ultimate goals was far from obvious. In 2004, the framework of FGPs was radically reconsidered; the total number of these programmes was significantly reduced, and by 2005 only 54 FGPs were funded out of the government budget. This restructuring was continued in 2006. Currently, 52 FGPs are being implemented. Essentially, FGPs are being merged together into larger programmes. This initiative was proposed by the Ministry for Economic Development, which suggested reducing the number of FGPs while increasing their share of budget appropriations and more closely monitoring how the money was spent. Thus it was recognised that targeted funding was more efficient than basic budget funding, so increasing its share should also increase returns on public investments.

In 2005, R&D funding was provided through 33 FGPs; in 2006 the number of FGPs was 23 (accordingly, innovative projects were financed through 21 and 29 FGPs). Despite the reduction of FGPs with S&T components, the amount of federal budget appropriations to finance them has increased in 2006. However, some of the programmes were seriously underfinanced. For example, FGP 'Electronic Russia' received only 20 per cent of the approved funds, while FGP 'Development of Unified General Education Information Environment in 2001–2005' received 52 per cent of the allocated money.

Grant funding is tender-based; grants are provided to support the best projects and the most productive research teams. Grants are allocated through the system of public foundations: the Russian Basic Research Foundation (RBRF), the Russian Foundation for Humanities (RFH), and the Russian Foundation for Assistance to Small Innovative Enterprises (FASIE). These foundations receive a (specified by legislation) percentage of total budget appropriations to finance civil research. The percentage hasn't been changed in about 10 years, which is an evidence of stagnation of this funding mechanism. Research foundations finance small basic research projects which usually have unpredictable results.

The FASIE is a good subject for evaluation of commercial R&D projects. This foundation was established by the RF government regulation no. 65 of 3 February 1994 as a public non-profit organisation. In effect, FASIE is a public research institution that has the mandate to:

- Implement government policy to develop and support small innovative enterprises (SIE);
- Provide direct financial, information and other support to SIE pursuing projects to develop and manufacture new research-intensive products and technologies based on own intellectual property;
- Create and develop infrastructure to support small innovative entrepreneurship.

The foundation conducts ongoing monitoring of SIE in the country, analyses the situation, prepares reports about the state of affairs and its own activities for the general public and the RF government, and makes relevant suggestions. The foundation's analytical materials are in public domain, divided into three categories: innovation activities, intellectual property and venture financing. The foundation also holds regular tenders to finance applied research projects within the framework of its own programmes.

The foundations mentioned here have many functions and responsibilities in the areas of R&D, S&T and innovation activities. FASIE, the Russian Foundation for Technological Development (RFTD) and industrial non-budgetary foundations for funding R&D established by federal executive authorities and commercial organisations support a whole host of projects to promote innovation activities and commercialisation of technologies. FASIE provides financial support to SIE that pursue projects to develop and manufacture new research-intensive products and technologies based on their own intellectual property (the main tender organised by the foundation); supports innovative projects during their early stages (START programme); and helps to set up SIE to apply own R&D results. Four hundred and thirty SIE were established in 2004 through this programme. The TEMP programme helps SIE to enter licensing agreements for intellectual property owned by state R&D organisations. RFTD provides support to research organisations and innovative enterprises at all stages of the applied research — prototype to pilot production cycle.

The bulk of government budget allocations to R&D organisations come in the form of basic funding. This is provided through the system of ministries and departments administering research and higher education institutions. The other two forms of budget funding account for about 30 per cent of the total budget appropriations.

Programme funding reached its peak in 2000 at 24.9 per cent, and then its share started to decline. However by 2007, when the new budgeting principles were adopted, the programmes' share of funding was radically increased.

Private Financing Mechanisms

The law 'On Science and State S&T Policy' allows other public, private and international foundations to support R&D and/or S&T activities. One such foundation is the Innovation Support Foundation created in 2002 by the Bashkortostan Cabinet of Ministers as a non-profit organisation. The law also provides for the establishment of non-budgetary industrial and inter-industry foundations not registered as legal entities, to finance R&D. Such foundations can be created by federal executive agencies or commercial organisations.

One of the first such foundations was the non-budgetary RFTD of the Russian Federation Ministry of Science, Higher Education and Technology Policy, created in 1992. The foundation was financed through voluntary contributions by government ministries, departments, concerns, corporations and associations that could contribute 25 per cent of their own non-budgetary funds earmarked for financing R&D and development of new research-intensive products. The sources of these funds, in turn, were payments by enterprises at the rate of 1.5 per cent of their product costs.

The PPP mechanism for R&D funding was first tried by the Russian government in 2002. It was decided that the priority was to support major innovative projects of national importance (so-called mega-projects) — large-scale innovative projects implemented by teams comprising representatives of R&D and industrial organisations. According to 'Main Areas of the RF Government Investment Policy in Science and Technology Sphere' (Government of the Russian Federation 2002), major innovative projects are based on world-level R&D results obtained through conducting research in priority areas, and allow the establishment of large-scale high-technology production of research-intensive competitive products, financed by non-public funds. This initiative was based on the idea that by supporting major innovative projects the state takes financial risks and thus encourages development of high-tech business. The projects were supposed to deal with key aspects of increasing competitiveness, such as cost reduction through resource-saving. Among other matters project participants were obliged to guarantee that revenues from sales of the new products would be at least five times higher than the amount of funding provided by the government.

The first tender for major innovative projects was announced in May 2002. Twelve mega-projects were selected; each was to receive US$ 20 million for two years — an impressive sum for the R&D and innovation sphere. Public funds were supposed to amount to no more than half of each project's total budget, with the rest being provided by interested investors. However, in reality two-thirds of the projects received more than 50 per cent of their funds from the government budget.

One of the main selection criteria for the projects was that scientific interests should coincide with those of the business: the selection board included not just officials and scientists but representatives of major corporations. This was supposed to ensure that only commercially attractive projects would be selected.

After the administrative reform and introduction of new budget classification, the mega-project costs Article was divided equally between two ministries which to a certain extent became successors to the former Ministry of Industry and Science: the Ministry of Education and Science and Ministry of Industry and Power Generation. The division across two ministries disrupted coordination of this work since it was no longer possible to manage it as a single programme.

By the beginning of 2006 two of the mega-projects had reached investment-worthy level and were sent for evaluation to the Ministry of Economic Development and Trade. Total government funding allocated to the mega-projects by then amounted to 2.56 billion roubles, plus more than 2.77 billion roubles of non-public money. Potential sales of the innovative products in 2006 were estimated at 5 billion roubles.

Obviously, the plan that revenues should amount to five times public investment did not happen. The board that selected mega-projects for funding was unable to resist lobbying, and the adopted funding scheme created certain problems that arose when volume and types of R&D were being agreed. Government funds are allocated to research or higher education institutions — partners of industrial enterprises. On the other hand, commercialisation of the generated R&D results is the responsibility of the enterprise. In reality it turned out that such a scheme made it rather hard to match the interests of the business and the R&D potential (or interests) of the research institution. Apparently, even innovation-oriented enterprises see cooperation with state-owned research institutions as an additional risk factor.

But there was a positive outcome — during implementation of some of the mega-projects management and monitoring functions were outsourced, and this approach brought good results. External management was allowed to monitor the activities in a more neutral way and quickly react when there was need to make necessary adjustments. It should be noted that the PPP mechanism can be used only in certain situations, since such partnerships are not specifically provided for in the legal framework. Russian laws (including the federal law 'On Science and State S&T Policy') made no mention of cooperative agreements to conduct R&D.

In international practice, public funding provided for applied research via PPPs is often allocated on the basis of priority areas of S&T. Projects selected for funding always must have a high social potential. When the mega-projects were selected in Russia, their subject areas and social importance didn't play a particularly important role.

Since one of the major selection criteria was significant growth of product sales within a short period of time, in some cases projects were selected for funding though they were aimed at dealing with small technical problems not on the mega-project level at all — exactly because they guaranteed rapid growth of sales. When new mega-projects are selected it would make sense to shift the accent to supporting basic technologies. Also, in the course of mega-projects' implementation the possibility to provide public funding for R&D not to research institutions but to private enterprises should be considered, on condition they contract state-owned research and higher education institutes to perform the relevant R&D. This might help to balance the private sector's demand for and the public R&D sector's supply of R&D products. As long as public sector research organ-isations are largely oriented towards public funding, their interest in PPPs will not be high. But if the customer role is taken from the state and given to private business, it would contribute to 'soft' adjustment of the state R&D sector to the needs of the market economy.

There are more than 40 venture funds in Russia, investing in innovative projects; however, only about 1 per cent of all venture funding is spent directly on development of high technologies. Most of the projects supported by venture funds include research or early-stage development that explains the low level of subsequent commercialisation. The Venture Innovation Fund (VIF) established with government participation in 2000 did not manage to expand due to financial and legal barriers and lack of motivation for investing in high-risk projects. At the end of 2006, a new 'fund of funds' was created, the Russian Venture Company.[5] It is supposed to concentrate on encouraging venture investments in and providing financial support to the high-tech sector of the economy. The company was registered as a 100 per cent state-owned corporation; the authorised capital was provided out of the federal budget.

Since 2005, the Russian Ministry for Economic Development supports tender-based creation of regional venture funds and closed unit funds with participation of regional authorities. Currently the regional governments that have won the first stage of the tender for federal budget subsidies have completed registration of the so-called 'intermediary' funds who — jointly with private investors — will establish venture funds on a 50/50 financial basis.

Another Russian venture funding institution is the Russian Venture Fair, an annual event where dozens of companies selected from a large number of candidates present their projects to investors and consulting firms. Russian Venture Fair is one of the mechanisms for attracting investments into the innovation sector. Russian Venture Fair's objectives include encouraging financial institution interest in promising small innovative high-tech enterprises; assisting company owners and managers in their dealings with venture investors; and helping participating companies in securing external capital for their growth and development. The fairs include various events such as conferences, workshops, presentations, round tables and briefings on the practical experience of venture funding in Russia, development of the Russian venture industry and switching the Russian industry to an innovation-based development model. Participants include innovative companies with an annual turnover between US$ 50,000 and US$ 8 million and investment needs between US$ 100,000 and US$ 10 million.

Investment credit is also used in a somewhat different form than in industrially developed countries. The international practice of providing investment credits (debt financing) is based on average-term loans (three to seven years) with LIBOR interest rates (2–4 per cent). The rate may be adjusted depending on the actual circumstances. Russian financial organisations see the above terms and conditions rather like long-term ones. Standard terms for providing investment credits in Russia are for one to five years.

Russian banks define investment credits as participation (in the form of providing a loan) in an investment project for the period of no longer than one year. Loans are secured by all assets of the borrower including revenues generated in the course of the project. For loans provided for the period up to three years the interest rate is usually over 15 per cent a year, in hard currency. The actual rates are calculated depending on the term of the loan, estimated risks of the project, quality and liquidity of the security. The rate may also directly depend on the amount of money in covered letter accounts or the company's circulating assets (the higher the amount, the lower the rate). Creditors also demand that all project-related operations must be transparent, though they promise not to interfere with the project management.

Credit organisations do not see themselves as venture capitalists investing in R&D and innovations. Creditors do not take any risks associated with the projects; still, that kind of scheme is available for funding innovative projects.

Orientation towards the borrower in such cases implies that their assets and reputation must match the creditor's requirements. Lack of financial transparency and the ambiguous taxation rules have a negative effect on companies' dealings with investors, especially foreign ones. Attracting all possible funding sources to finance innovative technology projects would require improved financial accounting, preferably in line with international standards.

Financial organisations may consider yet another project funding scheme — project financing. Pay-off and returns on investment are received out of profits generated through sales of products/services created in the course of the project. The main difference between project financing and investment credits is that in the former case the project serves as the primary loan security. Calculating interest rates and the repayment schedule of the loan, creditors pay particular attention to expected project returns. The term 'project financing' is understood differently in various countries. For example, in the OECD countries project financing means providing investment resources to companies when money for servicing the loan is taken out of the company's regular cash flow while 'access to the company's assets' serves as loan security.

Project characteristics, participants, partners and guarantors, and the distribution of associated risks become particularly important considerations if the project financing scheme is used. The level of project-related risks defines potential investors' willingness to provide funding. Accordingly, in the case of innovative projects the project financing scheme has certain limitations. Unlike venture capital (VC) that can be attracted at any stage of S&T activities, creditors who consider project financing will not take that high a risk since the money invested in the project will be repaid only if the project is successfully completed.

Indirect Financing Mechanisms

Tax legislation is a very powerful tool for encouraging R&D and innovations. In Russia, after a relatively favourable period for organisations acting in this sphere, approval of Part 2 of the Russian Federation Tax Code has significantly increased the tax burden they bear. Specifically, reversal of the law on value-added tax eliminated VAT breaks for imported machinery and equipment intended for R&D, and for patent and licensing operations involving industrial property. Negative effects of these developments on R&D activities, including cooperation with foreign partners (and international organisations, foundations, etc.) became immediately apparent. We now examine the Russian system for indirect encouragement of R&D and innovation activities.

Sustainable development of the S&T complex and strengthening its innovative orientation should be based on an efficient regulation system, including direct funding and indirect motivation. Indirect motivation techniques include tax breaks, discounts, and special procedures for property depreciation. International experience suggests that a sensible taxation system may serve as a very efficient incentive to develop an innovation-based economy.

Currently Russian innovation policy is being shaped in an incomplete legal framework for R&D and innovation activities. Taxation law does not include provisions for an efficient system of tax breaks and benefits, similar to those existing in advanced economies countries.

Inconsistency of legal reforms, and lack of continuity of legal provisions have brought about the situation when many of the previous taxation rules that have proved their efficiency did not find a place in the new Russian Federation Tax Code. That, in turn, caused problems hindering the growth of innovation activity and efficient use of the country's intellectual and economic potential.

According to the current tax code, R&D expenditures are subtracted from revenues when the tax base is calculated, which encourages organisations to make them. At the same time tax legislation in effect discourages participation of R&D organisations in the practical implementation of knowledge and technologies they generate and develop, or organisations funding R&D and innovation projects.

After introduction of the Russian Federation Tax Code in 2000–2001, tax breaks for hardware imported into Russia for R&D purposes and for periodic scientific publications were cancelled. Only technological equipment, components and spare parts for them are tax-exempt as investment in organisations' authorised capital, as also publications received by state libraries and museums as part of international book exchange. Since 2002, sales of periodic publications as well as their editing, publishing and printing are subject to VAT. The tax code no longer has provision for preferential taxation of patent and licensing operations connected with industrial property.

Accordingly, to set up mechanisms for indirect motivation of R&D and innovation activity the following amendments to the Russian Federation Tax Code are proposed:

1. VAT breaks should be extended to cover SIE and individual entrepreneurs engaged in R&D and innovation activity, regardless of their revenues.
2. The following operations should be exempted from VAT:
   - R&D;
   - Sale of scientific and training printed materials, periodic publications of scientific and educational nature, and relevant services.
3. In article 150 of the Russian Federation Tax Code, the importation of technological equipment, components and spare parts and import of printed materials of scientific and educational nature should be exempted from VAT.
4. Patent and licensing operations (except brokerage) connected with industrial property (excluding trademarks and service marks) should be exempted from VAT.

An important condition for the development of Russian R&D and increasing the efficiency of government policy aimed at increasing and preserving Russia's intellectual potential is the improvement of the well-being of scientists and ensuring their income remains stable in an unstable market economy. One way to achieve this is to exempt certain kinds of personal income from income tax. Another way is to introduce income deductions to reduce taxpayer's total taxable revenue.

Since researchers often bear no significant R&D costs, it seems that in Russia it would be more efficient to put the accent on tax benefits for appropriate groups of people. Accordingly, the following amendments to the Russian Federation Tax Code to exempt individuals' income from taxation could be implemented:

1. Income earned through R&D contracts with individuals named as contractors;
2. Income earned through licensing contracts transferring exclusive right to use industrial property objects;
3. Income received from employer as fee for creation of industrial property;
4. Fees for scientific, educational and training publications;
5. Income earned through all grants, including the ones made available to public and private R&D support foundations.

The use of tax incentives to promote R&D and innovation plays an important role in the development of the S&T sector. However, the current state of laws on taxation of organisations is unsatisfactory from the point of view of supporting R&D and innovation activity. To improve the situation in the near future, it would be reasonable to make the following changes to the Tax Code, to introduce preferential taxation of profits of:

1. Organisations through innovation activities;
2. Banks through crediting start-up innovation companies;
3. Insurance companies through insuring entrepreneurial risks of companies engaged in innovation activities.

Gratuitous transfers of funds for R&D (target funding) in the form of grants received from foreign and international organisations not included in a special list are also subjected to profit tax.

The list of foreign and international organisations that are allowed to make such grants tax-free should be abandoned, and all grants provided by foreign and international organisations should be exempt from taxation. Another possible step is to exempt small innovation enterprises from all taxation for the first two years of their operations. The list of foundations included in the Tax Code whose target funding is not considered as profits, is unreasonably short. The Tax Code does not take into account specific features of expenditures made in the course of R&D and innovation activity, and does not consider as direct expenditures certain significant costs such as expenditures on special equipment for R&D, expenditures to buy or use new kinds of hardware and materials, etc. Reducing tax base by writing off these expenditures involves serious discussions with tax authorities, which is a lengthy and arduous process with no guaranteed results.

Taxpayers' expenditures in the form of donations cannot currently be written of the profit tax base. However, to encourage provision of R&D resources as gifts such contributions should not be taxed.

As already noted, R&D expenditures are included in taxpayers' total expenditures for two or three years (depending on results). It is reasonable to include these costs in total expenditures for one year, regardless of actual R&D results.

It would also make sense to remove all limitations on interest for promissory notes for credits received to finance R&D, which reduce the profit tax base.

Unified social tax is paid by legal entities that make payments to individuals, mainly by organisations and individual entrepreneurs. The standard tax rate is 26 per cent. Various special rates are used to tax agricultural producers, organisations engaged in popular arts and crafts, small native communities in the far north who live off traditional industries, individual entrepreneurs and advocates. To encourage R&D activity, it would be useful to apply a special rate of 14 per cent to the unified social tax paid by R&D organisations.

In 2003, during the reform of tax legislation, the majority of R&D organisations lost their property tax breaks. Currently the property of state-owned research centres and state academies of science are exempt from tax. To encourage R&D activity by these organisations, it would be reasonable to exempt from tax their property used to conduct R&D. It would also make sense to exempt machinery, equipment, etc. received by these organisations for testing and experimental purposes, or given to them for free according to R&D contracts.

According to tax law, R&D organisations owned by academies of science were exempted from land tax on the land occupied by buildings used for R&D. However, this tax break was cancelled as of 1 January 2006. This should be reversed to apply to all land owned by all R&D organisations and used for R&D purposes.

Simplified taxation rules apply to small enterprises. The maximum revenues that allow an organisation to use simplified taxation rules established by the current legislation do not apply to venture companies set up specifically for innovation activities. In order to foster the creation of venture companies and make investment in their operations more attractive, they should be allowed to opt for the taxation system they prefer. It would make sense to amend the law in such a way that R&D expenditures and the costs of patenting R&D products could be included in the list of expenditures subject to simplified taxation.

In 2006, another tax break for intellectual property was added: taxpayer's expenditures on R&D for the creation of new or improved products, including expenditures connected with inventions; payments made to the Russian Technological Development Foundation and other industrial and inter-industry foundations for financing R&D registered according to provisions of the law 'On Science and State S&T Policy' (Council of the Federation 1996), were counted as 'other expenditures' for two years (for research that generated positive results) or for three years (for research that didn't generate positive results).

Also, depreciation costs included the original cost of depreciated intangible assets calculated as actual expenditures to acquire (create) them and turn them into a usable state, except VAT and excise duty. The cost of intangible assets created by the organisation was defined as actual expenditures in their creation (manufacturing), including personnel costs, outsourcing and contracting costs, patent duties, and excluding taxes paid in the course of these expenditures.

Intangible assets to be included in depreciation costs (concerning the subject in question) comprised (exclusive rights to) intellectual property acquired (created) by the taxpayer, utilised for production of products (provision of services) or for managerial purposes of the organisation for a long period of time (in excess of 12 months). To include an intangible asset, it should have the potential to generate economic benefits (profits) to the taxpayer; the taxpayer also must have valid documents confirming existence of the intangible asset and/or their exclusive rights to intellectual property (such as patents, certificates, other titles of protection, and the cessation (acquisition) contracts for patents or trademarks. In particular, intangible assets included the following:

1. Exclusive rights of patent holder to invention, industrial design, utility model;
2. Exclusive rights of author or other right holder to use computer software or database;
3. Exclusive rights of author or other right holder to use integrated circuit topology;
4. Exclusive rights to trademark, service mark, products' place of origin and brand name;
5. Exclusive rights of patent holder to selective achievements;
6. Possession of know-how, secret formula or process, information about industrial, commercial or scientific experiment.

Intangible assets do not include the following:

1. R&D and technological activities which did not generate positive results;
2. Intellectual or business abilities of organisation's personnel, their skills and competences.

The Tax Code also allowed the use of intellectual property rights as a contribution to the authorised capital of corporations that was in the interest of S&T products developers.

A whole set of legislations is currently being discussed in Russia, in particular, bills on preferential taxation of R&D and S&T activities. Some of these laws were passed in 2006–7 and became valid in 2008. Specifically, these concern the reduction of the period for which R&D expenditures (reduced tax base) can be included in the 'other costs' category to one year, and exemption from VAT of all organisations engaged in R&D, regardless of their sources of funding. The transfer of exclusive rights to inventions, utility models, industrial designs, computer software, databases, integrated circuit topologies, know-how (and licensing all of these types of intellectual property) are now tax-exempt.

The overall effect of this legislation will depend on the actual amount of proposed breaks and benefits (taking into account the organisational sensitivity threshold to tax reduction), as well as on their organisational culture (producers — consumers of R&D results and new technologies; R&D and educational organisations — their funding sources; innovators — investors in innovation activities, staff training and so on).

Specific S&T and Innovation Policies and their Effects on Entrepreneurial Investments in Innovation Activities

Russian laws provide for various forms of financial support to S&T and innovation activities, which are used with varying efficiency and frequency. Currently the state mostly finances R&D and innovation activities directly, including the Federal Goal-oriented Programmes (FGPs). The FGPs' 'R&D in priority areas for development of Russian S&T complex in 2007–2012' sets the goal of development and application of S&T potential, while its objectives include the development of efficient innovation infrastructure, promotion of small R&D organisations and their integration into the system of S&T cooperation.

As of 2003, the federal budget had a new targeted article: Funding of scientific support to major innovative projects of national significance. This article is used to finance R&D connected with major promising innovation activities. The state's ultimate goal in supporting such projects is the creation of innovation clusters and the large-scale production of research-intensive products; increasing the competitiveness of Russian manufacturers on internal and international markets; and encouraging entrepreneurial initiative, partnership between science and industry, public and private sectors, large and small businesses.

The Role of the Financial System in the National Innovation System

Like other developed countries, the main source of innovation investments in Russia is the organisations' own funds, which is natural for a market economy. For internal R&D expenditures the share of industrial enterprises' funds amounts to about 30 per cent; in the case of technological innovations this figure rises to 86 per cent. However, this high (compared to other countries) value in Russia is explained not so much by market economy 'laws' or abundance of company capital as by the unavailability (due to various reasons) of other funding sources that should be present in a developed market economy. We now consider these barriers.

Foreign sources play a minor role in funding R&D and innovation activities. Compared with the 1990s figures, their share has dropped from 7 per cent to 2.3 per cent of GERD.

The credit and the loan market for investing in innovation activities and innovative projects is limited. Access to credit is possible but only for companies with an established business reputation and serious assets that can be used as securities. The cost of credit (in most cases provided only for a short term) is quite high.

Apart from subsidies and credits, funds for innovative projects can be attracted by increasing the authorised share capital of the organisation that holds the main responsibility for the project. Increasing the authorised capital (or capital stock) is an attractive option because it doesn't involve the burdens of assuming credit-related obligations. The price (dividends on additionally issued shares, etc.) can be adjusted according to the financial situation. Shareholders may decide to reinvest the profits into further development of production. However, using this funding source one should take into account the interests of the new shareholders, their influence on the project implementation and the possibility that they may assume a certain degree of control.

The main limitations hindering the use of this scheme are high interest rates and the need to provide loan security. In a situation when credit-related risks are brought to the minimum it's hard to expect that financial organisations would opt for other investment opportunities. That's why in our opinion venture funding in Russia did not live up to expectations. The advantage of this approach — shareholder value — doesn't look very attractive to most of the financial market players, compared with the significant benefits of providing low-risk loans.

Innovative projects can obtain funding if they promise to produce products (technologies) already in demand in the market. In other words, improved products and processes expected by the market. In that case the creditor is willing to accept some of the risk. So to financial institutions of a general profile, crediting innovative projects aimed at development and implementation of new products and technologies seems unreasonable.

Another way to widen funding opportunities for innovative projects is by attracting sponsors. Russian law allows state guaranties to participants of innovation activities for investment credits made available by Russian or foreign financial organisations. The state can act as a source of guaranteed investments in more important projects, where the project financing scheme is optimal from the point of view of expected project efficiency. By sharing project-related risks, the state smoothes the way for other creditors providing project financing for innovation activities.

Choosing specific funding schemes with government participation for innovative projects is a special task which involves assessment of the extent of such participation at one of the most important stages of project preparation and implementation. International experience of financing innovative projects has to be significantly adapted to Russian conditions, taking into account specific features and institutional maturity of the national economy. In particular, adoption of venture financing schemes widespread in many countries should be adjusted to Russian realities — such as lack of entrepreneurial skills among the majority of the population and lack of innovative culture among the majority of entrepreneurs; and the domination of mining industries in the economy.

Project financing schemes, all other matters being equal, can affect the amount of profits, current expenses, and returns on their own capital. Normally these characteristics improve if financing is provided as investments in capital stock of the company that implements the project. Choosing the best funding scheme for the project involves finding the best balance between high cost of credit and the cost of attracting capital — which amounts not only to profit sharing but to providing new partners access to project management. In reality, choosing one funding scheme doesn't exclude using another as well.

International experience includes examples of mixed funding especially with venture financing when some money is invested in the capital stock while other funds are provided as investment credits. In Russian practice most schemes (even attracting VC) only start working when the innovation is ready for commercialisation. The role of the Russian Venture Company is to promote venture investment and provision of financial support for S&T activities all over the country.

When it became clear that the Russian high-tech sector is unable to attract enough investment, the state intervention concept emerged. The Russian Venture Company invests in closed-end investment funds only (established under legislation and regulated by the Federal Financial Markets Service). A special management company manages each fund. The management companies compete for the right to sell the fund investment shares to the Russian Venture Company. Eight to 15 such funds are to be established, strictly in accordance with the principle 'one company — one fund'. Of course companies may create other venture funds, but the Russian Venture Company will participate only in one of them.

After the venture fund is created (i.e. the investment money is in place), the fund management company can start investment activities (launch innovative companies in such areas as microelectronics, information, telecommunication, bio-, medical technologies, environment-friendly power generation and nanotechnologies). Each fund management company can finance from 10 to 15 innovative companies for several years. Thus the end result may add up to 15 venture funds and 150 innovative companies. The resources for the Russian Venture Company capital were to be allocated from the Russian Federation Investment Fund — up to 5 billion roubles in 2006 and 10 billion in 2007 (a total of 15 billion roubles). In any country the activity level of venture investors directly depends on efficiency and consistency of government policy. In Russia, the government does not provide full and regular support to the creation of intellectual products even at the early stages of this process, and does not develop efficient institutional infrastructure for innovation activities. Accordingly, it would seem logical to provide various motivations for private investors to take part in innovative projects at just such stages — i.e. involve them at the development, start-up and early expansion stage. This approach would be efficient not just in terms of widening the range of available funding sources but for the balanced development of the Russian venture funding business.

Despite the growing number of industrial parks and innovation technology centres in Russia, the number of SIE is not increasing. Experts believe that the main reason is the lack of infrastructure that would support such small companies at the start-up and early development stage.

To summarise, the following problems with venture funding are hindering its development in Russia:

- Government participation in venture funding schemes for high-tech companies remains unregulated by Russian legislation;
- Existing infrastructure to support venture funding remains weak and cannot perform its main function — encourage emergence of new and development of existing small innovative companies and R&D organisations;
- Insufficient participation of VC;
- Insufficient development of stock market makes it difficult to venture funds to leave the organisations they've financed, and also hinders re-financing;
- Development of legislation to regulate the creation and activities of venture funds goes quite slowly;
- The problem of providing support to new innovative companies at the start-up and early development stages remains unresolved.

As to research and innovation support foundations, the small size of grants determines the modest level of the projects they finance, and forces scientists to pursue insignificant, easily reachable objectives.

The foundations' activities mostly amounted to increasing the number of programmes. Apart from supporting innovative R&D projects they also financed other programmes like the development of libraries, telecommunications, scientific book publishing, provision of machinery and equipment to R&D organisations, establishment of shared equipment and instrumentation centres, support to young researchers, innovative projects, regional tenders, etc. The foundations tried to fill various gaps in the R&D sphere, which appeared due to insufficient funding. For example, in 1997 the Russian Federation Board for Research started organising regional tenders whose winner projects were funded jointly by the foundation and the regional authorities. That was an important initiative since it provided a new mechanism to attract funding for the R&D sphere. At that time regional authorities did not provide much support to science: on average just 0.06–0.07 per cent of their budgets were allocated for these purposes. Now the situation has somewhat improved, though not much: regional authorities channel on average 0.1–0.2 per cent of their total expenditures to support science; the maximum figure is 0.7 per cent. The regional tenders held by various foundations certainly had a positive effect over regional administrations, who agreed to support R&D organisations on a parity basis.

The main problems hindering the foundations' operations, reducing their efficiency and undermining the trust of the research community to them, include the following:

- Insufficient transparency of the foundations' activities including project selection, lack of information about the reasons for turning down applications;
- Insufficient promotion of foundations' activities and programmes;
- Some of the programmes have age limits for potential participants;
- Lack of feedback after implementation of the projects (no evaluation of results);
- Exceedingly complex application forms and numerous papers one must prepare and produce to apply for a grant;
- Exceedingly complex accounting and reporting system for grant recipients;
- Lack of anonymity in project selection: selection board members know applicants' names, selection process is based on applicants' names;
- Untimely and incomplete financing of the projects.

Certain basic regulatory, legal and institutional frameworks for PPPs are in place in Russia. Increased attention to the PPP concept at a high political level led to the development of a system enabling implementation of PPP projects. At present PPP activities are regulated by general legislation (Civil Code, Budget Code and others), federal laws on concession agreements, on free Economic Zones as well as certain specific laws and by-laws such as the law for Special Features of Governance and Disposal of Property of Railway Transport. On the whole, the regulatory and legal basis for PPPs is in its initial phase of development but is advancing rapidly. Adoption of the federal law on concession agreements in 2005 created conditions for Russia to use one of the most popular PPP forms in Western Europe, namely concessions. This law has a number of important provisions for further PPP advancement but is not sufficient in itself. Due to many unresolved issues the law still does not function properly. No concession agreements were concluded in 2005–6. In the institutional sphere, the Investment Fund of the Russian Federation, Russian Venture Company and special economic zones were created. Now companies planning large-scale investment projects have the possibility to obtain government support through a range of PPP tools at the federal and regional levels. One of the main obstacles hindering PPP development in Russia is the absence of an integrated governance system. Other major problems in this area include the following:

- Lack of an integrated approach. There's no systematic work on developing PPP in the country which would cover legal, economic and social aspects and specific issues of the mechanism for establishing and regulating PPPs. Note that the problem here is not about one or several laws; it's a complex, institutional problem and it must be dealt with through a systematic approach.
- Lack of a coordinating and supervising body. Currently a lot of various organisations participate in drafting PPP-related legislation: legislative bodies' committees, ministries and federal services, research institutes, foundations, private individuals. All of them develop draft laws based on their own ideas about PPP, without any common conceptual ground.

Further development of the legal framework to increase the role of the financial system in advancement of the NIS should include drafting and passing of the following laws:

1. 'On Government Support of Innovation Activity'. This law should define the comprehensive, cross-sector nature of innovation activity; the need for all executive authorities to take part in the encouragement and regulation of innovation activity; establish specific and targeted measures to support innovation activity. This law would not serve as a universal legal act in the innovation activities area; it is not likely that such a universal law could ever be created at all. The law would establish specific forms of government support to innovation activity, and clear instructions for federal executive agencies (both in terms of steps to be taken and the timeframes), regarding drafting and approving regulations aimed at providing appropriate support to innovation activity.
2. 'On Government Financial Support of R&D and Innovation Activity', to establish procedures for government funding of

innovative projects; and other bills to improve other forms of government financial support of R&D and innovation activities.
3. 'On Venture Funding', to regulate the creation and activities of venture companies.

In addition to these, legislation that does not specifically deal with innovation activities but could promote their development, should also be improved and amended. The most important areas include the following:

- Organisational forms and legal framework for R&D and innovation activity, including legal status of academic R&D organisations, clarifying relationship with founders, R&D organisations' property rights, etc.
- Private–public sector partnership in R&D and innovation activity;
- Foundations to provide support to R&D and innovation activity;
- Clarification of R&D concept, so that organisations engaged in innovation activity could obtain tax benefits.

To summarise, to ensure the successful development of innovation activities in Russia the existing financial rules and mechanisms must be changed. Lack of motivation to invest in high-risk innovative projects, and high interest rates for loans seriously limit the range of available sources of capital for venture funding. New financial stimuli are required such as preferential credits, and differentiated tax breaks that would take into account the activity level of investors and project initiators, the specific stage of the innovation cycle, industry-specific characteristics. The interest of potential investors could be increased by government participation in innovative projects as co-investor and/or sponsor.

Conclusions and Policy Suggestions to Improve the Financing of Innovation Activities in Russia

In the situation of the global economic crisis the Russian economy has had to deal with two problems at the same time: to minimise the negative effects of the crisis and create the potential for future post-crisis development. An innovative socially oriented economy was chosen as the model for this future post-crisis development. The appropriate goal is formulated in the Concept for Russia's Long-term Socio-economic Development until 2020 (Ministry of Economic Development and Trade 2008).

The most important characteristics of the innovative socially oriented economy model include a high level of innovation activities by all economic actors, ongoing development and implementation of new technologies and products, a big share of high-tech sectors in the GDP and exports, and some other indicators. To build such a model, a system of measures must be implemented, aimed at encouraging investments in innovations, technological upgrade and implementation of innovative products and solutions in all sectors of economy and areas of social life. These measures must include both general system-wide steps aimed at long-term development of the NIS, and specific steps tailored to the current crisis situation. Possible ways to increase the level of industry's innovation activities and promote technological modernisation of the economy can be grouped into three major blocks

Keeping in mind that the technological basis of Russian industrial production has been degrading for many years and its overall technological level remains low, launching technological modernisation as quickly as possible would be of key importance. During the crisis and post-crisis recovery the government should carefully select the priority areas for technological shifts and ensure flexible comprehensive support on a network basis. Potentially efficient steps include changing the orientation of government procurement, by 'natural monopolies', state-owned corporations and large state-controlled companies, and initiating programmes for technological modernisation of public sector organisations including health care, education, and culture. The point is to radically change the underlying ideology of government and public sector procurement. Government procurement must be seen not just as means to deal with specific issues but as an important tool of industrial and innovation policy. In particular, to contribute to technological modernisation the accent should be placed on programmes and projects whose implementation involves either procurement of high-tech products and services from Russian producers (certainly of adequate quality), or technological modernisation of specific enterprises or industries. Special attention should be paid to increasing innovation orientation of defence procurement, including conversion of dual-purpose technologies for implementation into civil sectors.

It seems that serious adjustment of the legislation regulating government procurement and related activities is in order, in particular:

- Setting priorities for technological modernisation, selecting industries where introduction of advanced technologies would have the biggest effect and which have the potential to achieve technological level on par with the most highly developed countries. Then it would make sense to concentrate effort and resources in such high-priority industries and at specific enterprises. At first glance these should include power generation, nature management, environment protection, transport and some other industries;
- Development of a technological and tax regulation system to encourage faster upgrade of enterprises' technological basis (including introduction of resource- and energy-saving technologies);
- Development and implementation of programmes to liquidate or replace technologically obsolete production facilities. Paradoxically, this problem is more easily dealt with during a crisis, by speeding up bankruptcy procedures to liquidate companies using obsolete technologies or by including in restructuring programmes provisions on replacement of obsolete production processes;
- Targeted support (government procurement, special tariffs for 'natural monopolies' services, government sponsorship of loans, preferential credits) to enterprises (including small- and medium-size firms) who invest significant sums in innovation, implement technological modernisation programmes on their own initiative (especially in industries contributing to improved quality of life and environment) and conduct staff training;
- Additional support to enterprises exporting high-tech products and services, in particular by creating a system for promotion of such products in international markets, establishing specialised leasing companies with government participation, and financially supporting export of such products.

The second block of proposals includes measures aimed at improving the institutional environment and framework for innovative business through elimination of excessive administrative, legal and other obstacles, creation of advanced efficient market institutes and competitive environment, and encouraging demand for innovations by various economic players. The following steps are suggested:

- Increasing the range of tax breaks (tax vacations) for companies participating in innovation activities and technological modernisation, including new high-tech businesses; for companies conducting R&D at their own cost and acquiring technologies in the course of government-initiated programmes and projects; for financial organisations crediting innovation activities;
- Improving tax administration concerning application of existing tax breaks and preferences for R&D and innovation activities, to provide better conditions for economic actors involved in innovation activities.

Public funds should be used to finance the following:

- Funding of major innovative projects whose objectives were set taking into account business interests and the results of national technological foresight analysis. Specifically, public funds should be used to secure the successful launch of such projects;
- Introduction of grants (subsidies, compensation systems, etc.) for enterprises who develop, design and implement new innovative products;
- Introduction of targeted subventions paid out of the federal and regional budgets to organisations, implementing major innovative programmes (projects) which form regional innovation clusters;
- Support of industrial technological projects provided the bulk of their funding comes from private investors, and public funds are used exclusively to reduce financial risks;
- Promote participation of Russian enterprises and organisations in international initiatives, projects, alliances in the R&D, S&T and innovation spheres, including elimination of existing administrative, legal, customs and other barriers hindering Russia's integration into international R&D and innovation cooperation;
- Promoting internal consumption of domestic innovative products and services including a system for providing government

support to acquire expensive durable consumer goods made in Russia (e.g. subsidising credit interest rates);

- Promote development of regional innovation clusters by providing tender-based financial support to Russian regional and local authorities to fund regional (local) innovative development programmes; these funds should be used to eliminate existing 'bottlenecks' hindering development of regional innovation clusters to support cooperation programmes for enterprises — the members of such clusters;
- Supporting institutes which ensure continuous assistance to innovative projects from their start to conclusion (including completion of federal- and regional-level information and technological infrastructure — centres for sharing unique or expensive R&D equipment, information, analytical and business centres, foundations), to promote cooperation between research organisations, universities and industrial companies and to encourage innovative motivation (potential demand) of the population.

It would also be desirable to improve procedures for attracting public and private budget, non-budgetary and venture funds to financing innovative projects, to contribute to a radically increased supply of new technologies and innovations in Russia. This would link with obliging 'natural monopolies', state-owned companies, 'backbone' enterprises receiving government support in the course of anti-crisis programmes to develop and implement innovative strategies (innovation-based development programmes). In addition one should increase the range of forms and techniques for encouraging potential participants of PPPs established to develop and implement innovative projects (public investments in authorised capital of companies, compensate expenditures on obtaining and servicing international patents, and improve the legal basis for PPP).

To create conditions for accelerated technological development of enterprises, a set of additional tax breaks is required. The first task is to encourage acquisition and implementation of intellectual property, by giving taxpayers an option for early depreciation of intangible assets which are important for the development of S&T and innovation activities. The second objective is to reduce the tax burden on personnel costs for companies in the intellectual services sector, among other things by compensating extra tax expenditures due to cancellation of the unified social tax through insurance payments to information technology and engineering companies whose advanced development is a necessary requirement for increased level of overall innovation activities in the economy. Also, to provide additional support to companies, VAT on packaged software should be cancelled. Appropriate changes to tax laws are also needed to prevent increased tax pressure (due to cancellation of the unified social tax and introduction of insurance premium) on companies which enjoyed unified social tax breaks as residents of technology implementation zones and special economic zones.

The third task is to encourage technological modernisation of enterprises and increase the level of their innovation activities by exempting them from property tax during the first year after installation of new energy-efficient equipment. For the same purpose, the list of R&D approved by the RF government regulation of 24 December 2008 (according to which taxpayers' expenditures on specific R&D were counted as 'other expenditures' at the actual amount multiplied by 1.5) should be extended, to include production technologies widely used by Russian industries. Procedures for paying land tax and property tax for state educational and R&D organisations also should be amended.

For private high-tech, medium-sized and small firms with limited own resources (especially in the crisis situation) procedures for providing public grants (subsidies) should be adopted, to finance their innovation activities in priority areas including R&D, design and development of new innovative industrial products; to compensate expenditures on engineering services and international patenting costs. Supporting the establishment of new innovative businesses should first of all include a wider range of support mechanisms for innovative companies at early stages of their operations, promoting the creation of innovative firms on the basis of leading R&D and educational institutes; providing opportunities for accelerated commercialisation of intellectual property owned by the state, created before Section 4 of the Russian Federation Civil Code became effective. To provide additional financial support to innovative companies at early stages of their development, a number of seed funds should be created, with participation of the Russian Venture Company and Rusnano. Proposals for launching the operations of Rosinfocominvest also should be prepared.

Direct support to the creation of small innovative companies on the basis of leading R&D and educational institutions, including with the participation of students and post-graduates, should be provided through new programmes administered by FASIE. Establishment of business incubators for students should also be considered — these would provide employment opportunities for young professionals in the crisis situation. These support measures might also be implemented in the framework of a small- and medium-size entrepreneurship support programme.

Also, to extend opportunities for securing long-term funding for research-intensive projects from Vnesheconombank, procedures for regular evaluation of projects requiring funding of at least 1 billion roubles per year by the bank's supervisory board should be developed — for projects undertaken by Russian high-tech companies in priority sectors and industries.

To increase the level of enterprises' innovation activities, laws regulating venture funding and corporate contractual laws should be developed further. Steps should also be taken to increase efficiency of foundations operating in the R&D and S&T spheres.

Taking steps to implement the technological modernisation of the economy and increase the level of economic agents' innovation activities involves introduction of new, tougher requirements to the R&D sector. Though its development doesn't directly come within the scope of chapter, without an advanced and efficient R&D system one cannot expect to achieve innovative growth or long-term technological breakthroughs, increase national security and competitiveness. Whatever may be said about the specific experiences of China, Korea, Taiwan, and Singapore's innovative development, these countries do have national R&D potential, and (judging by the internationally compatible statistical data) these potentials are quite high, which allows these countries not just to borrow R&D results and technologies but actively use their own S&T and innovation capacities.

In the context of innovation activities and technological modernisation, three groups of problems are of particular importance. First, the slow institutional reform of the R&D sector demands immediate attention (including elimination of departmental fragmentation, lowering the barriers between science, education and the real sector, revitalising the network of research organisations). Implementation of real reforms on the principles of identifying and providing targeted support to centres of excellence, while carrying out all relevant social obligations could allow for savings especially in the large network of state R&D institutes that are funded regardless of the actual results they produce.

In effect, only one restructuring scenario for the R&D network is being considered now making the most of the research institutes' autonomy and adopting more efficient forms of providing financial support. However, there are other opportunities which should be considered, including the following:

- Liquidation of R&D organisations which have lost their identities or show low efficiency (after obtaining a reliable independent assessment of the results they produce);
- In appropriate cases changing departmental ownership of R&D organisations, including those belonging to state academies of science — not forgetting about certain specific nationally important functions they might perform;
- Restructuring R&D organisations using all ways and forms allowed by the valid legislation (mergers, acquisitions, division, separation or transformation); extending the scope of non-profit organisations to transform R&D institutions into, e.g., state-owned autonomous non-profit organisations;
- Confiscation of surplus, unused or inappropriately used property (including land). Obviously this measure must be applied very carefully. Confiscation procedures are mentioned in valid legislation but the exact steps to be taken should be described in more detail, taking into account specific aspects of R&D, S&T and innovation activities.

Financial resources and public property saved through these steps should be channelled exclusively to advance the R&D sector, for acquisition of machinery and equipment, development of human resources (salaries, staff training and retraining), and attracting young talent (including graduates of higher education institutions). The money may also be used to set up a special national fund to invest in the development of R&D and higher professional education.

Second, cooperation between the R&D and industrial production sectors must be promoted, and state R&D organisations must have wider opportunities to participate in innovation activities. It is not just about creating small innovative companies (spin-off firms) or technology transfer centres — equally important is the creation of favourable conditions for commercialisation of intellectual property generated through use of public money, establishing and developing stable alliances between R&D organisations and businesses, participating in targeted investment foundations, and widening the range of available funding sources.

Another suggestion is to consider opportunities for improving the laws regulating the activities of FASIE — widening the scope and scale of its operations. Of particular importance is providing support to innovative entrepreneurship, specifically supporting highly skilled professionals laid off due to cutbacks, with the help of micro-financing and micro-crediting tools. This is especially relevant in the crisis situation and during the post-crisis period (and steps should be taken to get ready for it well in advance). Also, favourable conditions for other public R&D support foundations should be created, as well as for inter-industry non-budgetary foundations which finance R&D, and prototype design.

Third, a whole range of measures to support and develop human potential is of key importance, including the following:

- Development and implementation of a programme to support the internal mobility of highly skilled personnel, primarily young researchers and engineers (including training opportunities for young researchers at industrial enterprises);
- Elimination of excessive administrative barriers (e.g. limitations on joint use of property by R&D and educational organisations), hindering integration of science, higher professional education and business regardless of legal and property status of the parties;
- Creation of a business incubator network attached to higher education institutions. This activity may be funded with the money allocated in the framework of the anti-crisis programme to increase the number of master and post-graduate places. Enrolling more master and postgraduate students will result in more personnel oriented towards R&D. However, there's no guarantee that numbers and specifics of the newly trained personnel would match the needs of the post-crisis economy. On the other hand, creation of a business incubator network would

involve graduates and teachers in practical business activities — including implementation of R&D results generated at higher education institutes — with minimum costs.

More efficient planning and monitoring of public funds expenditures in the S&T sphere can be achieved by including an appendix to the federal budget, with a detailed breakdown of appropriations for civil R&D.

Major tools for implementing these measures include:

1. Setting priorities for the state innovation policy clearly understandable by business and the society, including major technology-related initiatives in priority development areas, connected with long-term national socio-economic goals.
2. Government procurement and programmes, as a tool for creating demand for innovative products and technologies.
3. Budget subsidies (grants) as a tool to encourage modernisation and increase efficiency of enterprises' innovation activities. At the same time expenditures of this money must be closely monitored to ensure its appropriate use.
4. Tax breaks tailored to support clearly defined types of innovative behaviour, allowing efficient and low-cost (to the state and the businesses alike) implementation and administration with minimum loss of budget revenues.
5. The PPP in the innovative and technological development sphere (government participation in funding business projects aimed at development of new technologies and products, encouraging high-tech exports, increasing efficiency of existing institutions responsible for development of innovation infrastructure.
6. Introduction of obligatory requirements (administrative, technical, environmental, energy saving, etc.) to encourage innovation activities by enterprises.

The accent should be placed primarily on promotion of innovation activities of the real sector enterprises — which, combined with the steps to increase efficiency of the knowledge-generating sector and the S&T sphere, should create an integrated system for short-term national innovation policy of the Russian Federation.

Notes

1. State budget funds include budget appropriations for universities and funds of state sector organisations (including own funds). In 2007 the federal budget covered 97.2 per cent of all budget funds spent for R&D, while the regional budget share amounted only to 2.8 per cent.
2. The funds of business sector regroup the funds of extra budgetary funds and businesses (including own funds).
3. In 1999–2005 Russia was one of five countries showing the highest GDP growth rate in the world (10 per cent in 2000, 6–7 per cent in 2003–6).
4. The highest level is noted in sectors like manufacturing of radio, TV and communication equipment — 39.9 per cent; aircraft and spacecraft manufacturing — 34.3 per cent.
5. The official web page is http://www.rusventure.ru (accessed 4 May 2010).

References

Chesbrough, H., 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston, MA: Harvard Business School Press.

Council of the Federation, 1996. 'On Science and State S&T Policy', Federal Law No. 127-FZ, 23.08.1996, Moscow (in Russian).

———, 2005a. 'On Concession Agreements', Federal Law No. 115-FZ, 21.07.2005, Moscow (in Russian).

———, 2005b. 'On Special Economic Zones', Federal Law No. 116-FZ, 22.07.2005, Moscow (in Russian).

European Commission, 2008. *European Innovation Scoreboard 2007 — Comparative Analysis of Innovation Performance*. Luxembourg: Office for Official Publications of the European Communities.

Government of the Russian Federation, 2002. 'Main Areas of the RF Government Investment Policy in Science and Technology Sphere', Statement of the Government of the Russian Federation No. 1764-R, 11.12.2002, Moscow (in Russian).

Higher School of Economics, 2005. *Science in the Russian Federation. Data Book*. Moscow: Higher School of Economics (in Russian).

———, 2009a. *Indicators of Innovation: 2009. Data Book*. Moscow: Higher School of Economics (in Russian).

———, 2009b. *Science Indicators: 2009. Data Book*. Moscow: Higher School of Economics (in Russian).

Ministry of Economic Development and Trade, 2008. *Concept for Russia's Long-Term Socio-Economic Development Until 2020*. Approved by the Government of the Russian Federation, Moscow (in Russian).

Ministry of Education and Science of the Russian Federation, 2006. *S&T and Innovation Strategy of the Russian Federation for the Period Until 2015*. Approved by Inter-Departmental Commission on S&T and Innovation Policy, Moscow (in Russian).

USSR Goskomstat, 1990. *The USSR National Economy in 1989: Statistical Yearbook*. Moscow: Finance and Statistics, USSR Goskomstat (in Russian).

4

India

Sunil Mani

The government in India is on a major innovation drive like most governments across the developing world and especially that of China.[1] This drive can be found in several policy measures enunciated over the past 10 years or so and especially in the Science and Technology Policy of 2003, wherein it is stated that the government targets the expenditure on Science and Technology (S&T) to be about 2 per cent of Gross Domestic Product (GDP) and this is to be largely contributed by the industry through significant increases in industrial Research and Development (R&D). Industrial R&D, therefore, may have to be incentivised through the provision of a variety of fiscal incentives such as tax incentives. This thinking again reflects the worldwide move towards using non-interventionist, but market-friendly forms of increasing investments in industrial R&D, and within this scheme of things tax incentives form an important instrument.

In India, even as early as 2001, the existing tax treatment of R&D had undergone some upward revisions, but these were targeted more specifically to around eight high and medium technology–based industries. Although a few studies are available on the financing of industrial innovation, with rare exceptions, most of these have been descriptive, merely cataloguing the various schemes available for encouraging investments in industrial R&D. However, no analytical studies on the effectiveness of these incentives in the specific Indian context are available. This is significant as recent estimates by the Ministry of Finance showed that the amount of corporate tax foregone consequent to the tax treatment of R&D has been increasing at a rate of 2.4 per cent per annum over the last four fiscal years until 2007–8: in 2004–5 about ₹23,180 million of corporate tax revenue had been foregone as a result of the operation of this scheme, but this is expected to come down marginally to about ₹20,240 million in 2007–8. It has been seen that about 10 per cent of the corporate income tax has been foregone as result of various tax concessions of which one is the R&D tax incentive. In this context, the purpose of the present study is to analyse the effectiveness of a specific tax scheme that has been in operation since 2001. In very specific terms, this is accomplished by computing the elasticity of industrial R&D expenditure in India in response to a unit reduction in the cost of performing R&D. Such estimates of elasticity of R&D will be very helpful in judging whether the tax incentive for R&D is effective in stimulating proportionate investments in R&D.

This study is structured into four sections. Section 1 analyses the innovative performance of India by employing a number of conventional and new indicators. The second section surveys the various financial instruments that are available for financing of innovation. The third section measures the effectiveness of tax incentives for financing R&D expenditures. The fourth and final section sums up the main findings of the study and identifies the policy conclusions that may emanate from this exercise.

India's Innovative Performance

India is generally referred to as an emerging knowledge superpower although her current record on this issue is rather mixed. We seek to analyse this record by employing a variety of conventional indicators as new indicators such as those emanating from innovation surveys are not available in the Indian context for the present.[2] Three conventional indicators are considered:

- Trends in R&D investment;
- Trends in patenting; and
- Trends in technology trade balance

To the extent possible, the analysis is conducted in a comparative fashion by taking China as the country of comparison.

Pre-reform refers to the period 1980–81 through 1990–91 and post-reform refers to the period 1991–92 through 2007–08; for the pre-reform period we study the Gross Expenditure on Research and Development (GERD) to Gross National Product (GNP) ratio, but given the fact that in India the ratio of GDP to GNP works out to unity, it does not really matter whether one takes into account the ratio of GERD to GDP or GNP. The following inferences can be drawn from Table 4.1:

Table 4.1: *Trends in R&D Investment, 1980–81 through 2007–08 (₹ in millions)*

	GERD Current	Nominal Growth Rates (%)	GERD Constant	Real Growth Rates (%)	GERD to GDP Ratio
1980–81	7,610.0		36,863		0.57
1981–82	9,410.0	23.65	41,121	12	0.61
1982–83	12,060.0	28.16	48,554	18	0.70
1983–84	13,810.0	14.51	51,267	6	0.66
1984–85	17,820.0	29.04	61,239	19	0.78
1985–86	20,690.0	16.11	66,280	8	0.81
1986–87	24,350.0	17.69	72,979	10	0.86
1987–88	28,530.0	17.17	78,094	7	0.89
1988–89	33,470.0	17.32	84,567	8	0.87
1989–90	37,260.0	11.32	86,732	3	0.84
1990–91	39,741.7	6.66	83,612	–4	0.77
Average		**18.16**		**9**	**0.76**
1991–92	45,128.1	13.55	83,476	0	0.76
1992–93	50,046.0	10.90	85,038	2	0.73
1993–94	60,730.2	21.35	93,824	10	0.77
1994–95	66,224.4	9.05	93,197	–1	0.72
1995–96	74,838.8	13.01	96,510	4	0.69
1996–97	89,136.1	19.10	106,647	11	0.71
1997–98	106,113.4	19.05	119,081	12	0.76
1998–99	124,731.7	17.55	129,542	9	0.77
1999–2000	143,976.0	15.43	143,976	11	0.81
2000–01	161,988.0	12.51	156,879	9	0.84
2001–02	170,381.5	5.18	160,219	2	0.81
2002–03	180,001.6	5.65	163,037	2	0.80
2003–04	197,269.9	9.59	172,756	6	0.78
2004–05	216,395.8	9.70	179,600	4	0.75
2005–06	287,766.5	32.98	229,538	28	0.88
2006–07	329,416.4	14.47	248,954	8	0.87
2007–08	377,779.0	14.68	274,128	10	0.88
Average		**15.84**		**7**	**0.78**

Source: Department of Science and Technology (2006 and 2008).

(a) Both in nominal and in real terms, there has been a decline in the overall GERD; and (b) Even the GERD to GDP ratio has declined during the post-reform period. From this, one has to be very cautious in drawing any strong inferences about the innovative potential of the country. This is because much of the overall R&D (GERD) of the country is performed in the public sector in defense, space, atomic energy, health and agriculture. Industrial R&D forms only about

20 per cent of the GERD. However, the share of the industrial sector has shown a significant increase during the period.

In India much of the R&D is actually performed by the government or public sector (Table 4.2). However, the share of the business enterprises sector has shown some sharp increases. It now accounts for about 30 per cent of the R&D. The corresponding figure for China is as much as 70 per cent. The higher education sector represented by universities and research institutes accounts for only 5 per cent of total R&D performed in the country. Notwithstanding data problems, it is clear that the share of this sector has only shown some slight increases during this period.

Table 4.2: *Sector-wide Performance of R&D in India, 1990–91 through 2007–08 (percentage shares)*

	Government	*Industry*	*Higher Education*
1970–71	89.55	10.45	
1975–76	88.13	11.87	
1980–81	84.13	15.87	
1985–86	87.82	12.18	
1990–91	86.16	13.84	
1995–96	78.26	21.74	
1998–99	75.79	21.17	3.04
1999–2000	77.21	18.46	4.33
2000–01	77.94	18.05	4.02
2001–02	76.48	19.33	4.20
2002–03	76.51	19.34	4.15
2003–04	73.31	22.26	4.43
2004–05	70.58	25.04	4.38
2005–06	69.77	25.87	4.36
2006–07	67.91	27.71	4.38
2007–08	65.98	29.63	4.40

Source: Department of Science and Technology (2006 and 2008).

Mani (2007) has shown that increasingly much of the industrial R&D is actually expended by private sector enterprises. I extend this analysis to the most recent period for which data is available (Table 4.3) and find that this is indeed the case. An important hypothesis that this data implies is that one sees a decline in the growth rate of industrial R&D when increasingly that R&D is performed by private sector enterprises. Does this mean that the private sector is experiencing *Arrowian appropriability* problems? This hypothesis makes the study

Table 4.3: *Growing Privatisation of Industrial R&D in India, 1985–86 to 2002–03 (₹ in millions at current prices)*

	Public Sector Enterprises	*Government Research Institutes*	*Private Sector Enterprises*	*Ratio of Private Sector to Public Sector Enterprises*	*Ratio of Private Sector to Government Research Institutes*
1985–86	1,986.18	1,622.70	2,519.44	1.27	1.553
1986–87	2,356.99	1,723.36	2,916.33	1.24	1.692
1987–88	2,884.66	1,851.29	3,102.67	1.08	1.676
1988–89	3,421.24	2,093.28	4,176.25	1.22	1.995
1989–90	4,129.01	2,395.21	4,905.94	1.19	2.048
1990–91	4,145.33	2,491.88	5,499.81	1.33	2.207
1991–92	4,843.88	2,745.50	6,369.44	1.31	2.320
1992–93	5,139.50	2,993.65	8,362.47	1.63	2.793
1993–94	5,428.11	NA	9,825.37	1.81	
1994–95	4,146.09	3,564.00	13,188.70	3.18	3.701
1995–96	4,275.76	4,116.99	16,270.69	3.81	3.952
1996–97	5,360.52	4,440.00	23,307.50	4.35	5.249
1997–98	5,392.40	5,641.30	24,382.50	4.52	4.322
1998–99	6,738.70	7,133.20	21,766.10	3.23	3.051
1999–2000	7,576.30	7,808.82	21,781.10	2.87	2.789
2000–01	8,428.80	8,641.20	24,114.00	2.86	2.791
2001–02	7,673.70	8,922.60	27,874.80	3.63	3.124
2002–03	8,089.50	9,512.50	30,649.30	3.79	3.222

Source: Department of Science and Technology (2006 and 2008).

of external financing of industrial R&D in India a relevant one. During this phase when investments in R&D are declining one sees that the government is putting in place a number of financial support measures that seek to reverse this declining trend. A study of the effectiveness of these financial measures thus assumes much significance.

Within the industrial sector six industries (pharmaceutical, automotive, electrical and electronics, chemicals and defence) account for about two-thirds of the total industrial R&D (Table 4.4).

Among these various industries one stands out from the rest, namely the pharmaceutical industry, as the industry alone accounts for about 20 per cent of the total R&D expenditures. In fact later on I will show that even in the case of output indicators it is the pharmaceutical industry that is the best. In short it may not be incorrect to say that India's national system of innovation (NSI) is dominated by the sectoral system of innovation of the pharmaceutical industry.

Table 4.4: *Industry-wise Distribution of R&D (cumulative share in per cent 1998–99 through 2002–03)*

Industry	*Share*
Drugs & Pharmaceuticals	19.30
Transportation	15.16
Electricals & Electronic Equipment	8.94
Chemicals (other than fertilizers)	8.35
Defence Industries	8.32
Fuels	6.12
Information Technology	4.69
Metallurgical Industries	4.21
Telecommunications	3.75
Miscellaneous Industries	2.38
Soaps, Cosmetics & Toilet Preparations	2.37
Industrial Machinery	1.84
Biotechnology	1.59
Food Processing Industries	1.39
Agricultural Machinery	1.33
Miscellaneous Mechanical Engineering Industries	1.22
Textiles (Dyed, Printed, Processed)	1.21
Consultancy Services	1.05
Other Industries	6.77
Total	100.00

Source: Department of Science and Technology (2006).

Second in line is the automotive industry. This industry is composed of both the vehicle manufacturers and the auto parts subsectors. Both the industries are also characterised by competitive structures with a number of foreign and domestic manufacturers co-existing and competing with each other. The auto parts subsector of the industry has a rather high export intensity of nearly 20 per cent and this means that the subsector has been continuously investing in technology to upgrade it and meeting the technological challenges posed by its foreign buyers.

I consider both US and triadic patents secured by Indian inventors. I start with the US patents. Among the BRICS countries, India has registered the highest growth rate in patenting (Table 4.5). From an earlier analysis by Mani (2007), it is seen that most of the Indian patents are by domestic companies and that too in the pharmaceutical area.[3] However, in the more recent period, the share of patents secured by affiliates of Multinational Corporations (MNCs) based in India is on the increase.

Table 4.5: *US Patenting of Indian Inventors Compared to Those from BRICS, 1963–2008 (number of utility patents)*

	Brazil	*Russian Federation*	*People's Republic of China*	*India*	*South Africa*	*Total BRICS*	*Ratio of India to*	
							BRICS	*China*
1963	17	0	4	4	30	55	0.07	1.00
1964	10	0	3	7	37	57	0.12	2.33
1965	11	0	4	8	69	92	0.09	2.00
1966	17	0	2	5	48	72	0.07	2.50
1967	12	0	5	10	52	83	0.12	1.11
1968	13	0	5	15	35	68	0.22	3.00
1969	18	0	5	18	65	106	0.17	3.60
1970	17	0	6	16	50	89	0.18	2.67
1971	14	0	15	10	71	110	0.09	0.67
1972	16	0	8	19	54	97	0.20	2.38
1973	18	0	10	21	86	135	0.16	2.10
1974	21	0	22	17	86	146	0.12	0.77
1975	17	0	1	13	74	105	0.12	13.00
1976	18	0	5	17	83	123	0.14	3.40
1977	21	0	1	13	68	103	0.13	13.00
1978	24	0	0	14	81	119	0.12	
1979	19	0	1	14	64	98	0.14	14.00
1980	24	0	1	4	74	103	0.04	4.00
1981	23	0	3	6	111	143	0.04	2.00
1982	27	0	0	4	73	104	0.04	
1983	19	0	1	14	60	94	0.15	14.00
1984	20	0	2	12	82	118	0.10	8.00

1985	30	0	1	10	96	137	0.07	10.00
1986	27	0	9	18	88	142	0.13	2.00
1987	34	0	23	12	107	176	0.07	0.52
1988	29	0	47	14	103	193	0.07	0.30
1989	36	0	52	14	134	236	0.06	0.27
1990	41	0	47	23	114	225	0.10	0.49
1991	62	0	50	22	105	239	0.09	0.44
1992	40	0	41	24	97	202	0.12	0.59
1993	57	3	53	30	93	236	0.13	0.57
1994	60	38	48	27	101	274	0.10	0.56
1995	63	98	62	37	123	383	0.10	0.60
1996	63	116	46	35	111	371	0.09	0.76
1997	62	111	62	47	101	383	0.12	0.76
1998	74	189	72	85	115	535	0.18	1.18
1999	91	181	90	112	110	584	0.19	1.24
2000	98	183	119	131	111	642	0.20	1.10
2001	110	234	195	178	120	837	0.21	0.91
2002	96	200	289	249	113	947	0.26	0.86
2003	130	203	297	342	112	1,084	0.32	1.15
2004	106	169	404	363	100	1,142	0.32	0.90
2005	77	148	402	384	87	1,088	0.35	0.96
2006	121	172	661	481	109	1,544	0.31	0.73
2007	90	188	772	546	82	1,678	0.33	0.71
2008	101	176	1,225	634	91	227	0.28	0.52

Source: USPTO (2012).

Triadic patent data (patents secured by an inventor from three different patent offices (namely the United States Patent and Trademark Office (USPTO), European Patent Office and Japanese Patent Office) also shows that India has registered one of the highest growth rates in Triadic patent grants during the period 1975 through 1995.

The performance of the country in patenting thus confirms the results obtained in R&D investments, namely, that most of the patents are secured by domestic private sector companies, that too in the area of pharmaceutical technologies. In other words the patenting data further supports the evidence that I found earlier in terms of India's innovation system being dominated by the sectoral system of innovation of her pharmaceutical industry.

India's technology trade balance has been negative and rising all through the more recent years (Figure 4.1).

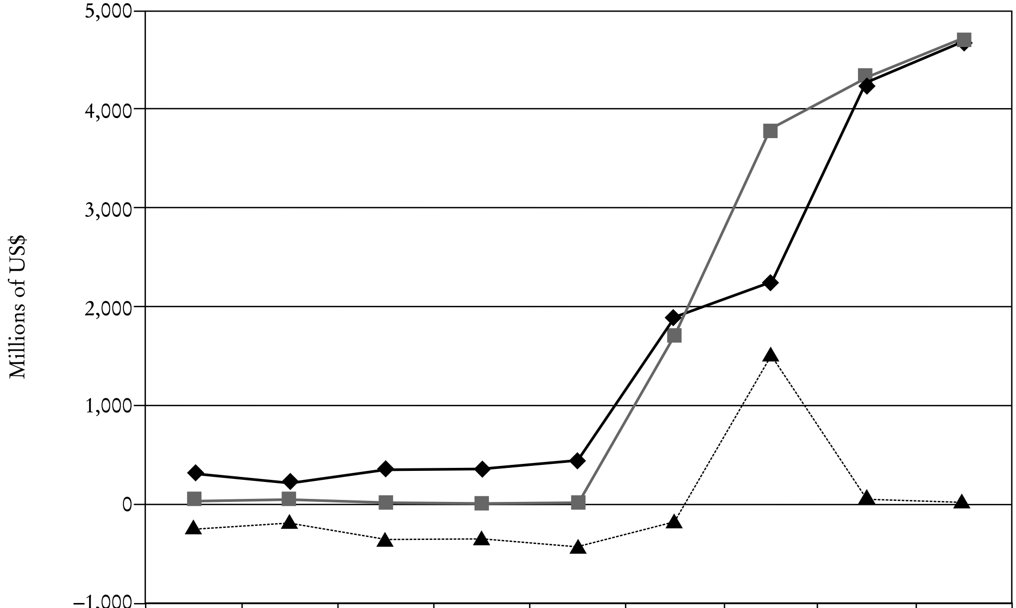
However, during the period since 2005, it has turned positive essentially due to the receipts under R&D outsourcing. India, along with China has now become a major recipient of R&D outsourcing deals. Most of India's R&D outsourcing deals are in the areas of pharmaceutical and telecommunications industries.

Thus, based on the evidence presented it can safely be concluded that India's innovation performance has actually improved if one takes the output measure of R&D. But the investments in R&D, both in the country as a whole and in the industrial sector have actually declined. Another point that came out of the analysis was that the country's innovative performance is concentrated in certain specific industries such as the pharmaceutical one and as such is not widespread. In fact, we tend to demonstrate that the government too has targeted this industry for enhancing its innovative output by offering a variety of financial incentives. In the following section we survey these various instruments for financing innovation.

Survey of Instruments for Financing Innovations

The country has three different types of financial arrangements for financing innovations. They are: (*a*) research grants; (*b*) tax incentives; and (*c*) venture capital (VC). The former two are almost entirely provided by various governmental agencies while the latter is now very much in the private sector. Implicitly the innovation policy makers in the country have adopted a linear view of innovation with three

Figure 4.1: *India's Technology Balance of Payments, 1999–2000 to 2007–08*



	1999–2000	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08
Total payments	311	235	361	352	444	1,880	2,259	4,256	4,666
Total exports	54	60	22	23	32	1,109	3,719	4,314	4,696
TBoP	–251	–115	–339	–329	–412	–171	1,520	58	30

Source: Reserve Bank of India (2000, 2005 and 2008).

distinct phases: birth, survival and growth phases All the research grants and VC are in the birth phase of the innovation chain while the tax incentives are almost entirely in the growth phase (Figure 4.2).

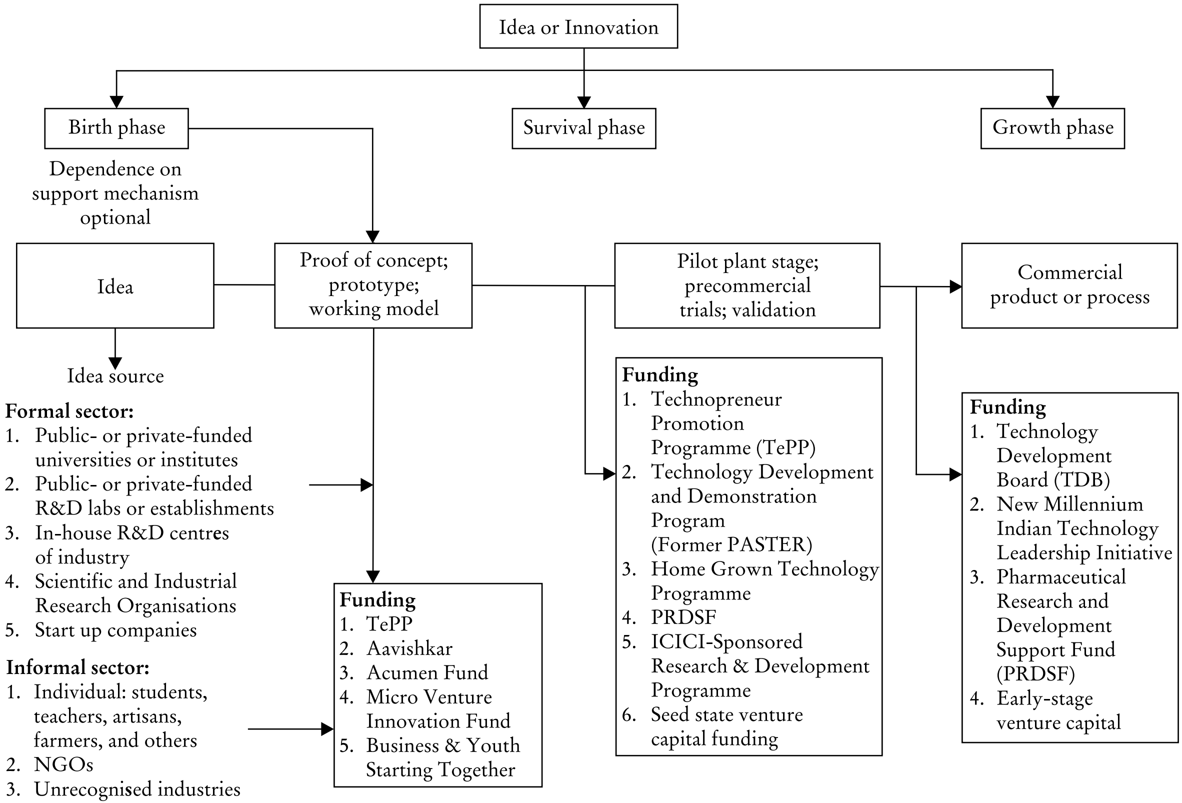
Although this might appear to be a very idealistic picture from the financing of innovation point of view that research grants and VC are at the birth stage where the market failures are great and tax incentives are at the growth phase when firms have established themselves and are in a position to engage in formal intramural R&D activities, in actual operation the research grants and VC financing does address only a small segment. Most of the research grants are either addressed to public sector enterprises or individual researchers. There are of course notable exceptions to this. The VC in the industry although growing by leaps and bounds is increasingly intertwined with the private equity (PE) industry and therefore cannot be taken in its entirety as equivalent to technology financing. With these caveats we attempt a survey of the various instruments that are available. The purpose here is to just map out the plethora of instruments that for technology financing actually available in the country at present. In the next section, we take up one of these, namely the tax instruments, for some in-depth examination in terms of its effectiveness in driving up R&D investments.

We organise our discussion of these schemes into three broad areas by type of instruments, namely, (*a*) research grants; (*b*) VC; and (*c*) tax incentives.

Under this section we consider three grant or loan schemes. They are: (*a*) Finances from the Technology Development Board (TDB); (*b*) Techno-entrepreneurs Promotion Programme (TePP); and (*c*) the New Millennium India Technology Leadership Initiative (NMTLI).

The TDB was created by an Act of the Parliament in 1995 and commenced operation from 1996. It basically seeks to financially support the commercialisation of indigenous technology, whether developed in-house by the firm or acquired from a government research institute. Even projects that involve adaptation of imported technology to suit the requirements of the local markets are eligible to apply for funding from the TDB. The TDB provides financial support through: (*a*) a loan of up to 50 per cent of the project costs at simple interest (6 per cent earlier and now lowered to 5 per cent) with repayment in five years after project completion (and a royalty payment during the period of loan, which has now been dropped); (*b*) participation in

Figure 4.2: *Financing of Innovation in India, 2007*



Source: Dutz (2007).

equity of companies up to 25 per cent of paid up capital; and (*c*) grants-in-aid. As of March 2005, TDB had supported around 141 projects with an estimated project cost of ₹20,450 million (of which TDB-sanctioned assistance is of around only ₹6,650 million). This means that the TDB assistance works out to only a third of the total project costs. The TDB has predominantly used the loan instrument for support; it has participated in equity of only one company and given just three grants-in-aid. The grant of ₹540 million by TDB to National Aerospace Laboratories (NAL) for development and type certification of a 14-seater aircraft is the largest project support ever made by TDB — normally no private sector VC fund would have financed the NAL development. The TDB's reluctant use of equity as a mechanism for support is a clear indication that it has been risk averse in funding start-ups and new ventures.

The health and medical sector accounts for 25 per cent of TDB funding followed by engineering (15 per cent) and road transport (14 per cent). Some successful projects supported by TDB are: development and production of Hepatitis B vaccine (as a result of which the domestic price has dropped to one-tenth), Recombinant Streptokinase (second in the world), corDECT, the Wireless in Local Loop access technology, Bharat II variant of the Indian car Indica, the first Indian electric vehicle REVA, and so on.

Hitherto there has been only one review of its first five years of operation — by the Administrative Staff College of India (ASCI), Hyderabad. The ASCI survey showed that around 50 per cent of the agreements were successful, i.e. products released in the markets and repayments to TDB commenced; another about 12 per cent were foreclosed but payments were committed/received, 8 per cent were failures and the rest about 20 per cent were those where success was doubtful. Of the successful projects, in over 70 per cent of the cases, the technology originated outside of the publicly funded R&D system.

The TePP programme was launched in 1998 to help realise the vast latent innovative potential of individual innovators in the country. The basic objective of TePP is for individual innovators to emerge as technopreneurs — technology-oriented entrepreneurs. TePP support is provided for all areas except software development for which there are other avenues of support. It helps the inventor to identify and network with an appropriate R&D/academic institution for guidance, technical consultancy, development of models/prototypes, etc., assists in filing and securing of intellectual property rights (IPRs) and finally linking up with appropriate source of finances for commercialisation of the product. By itself TePP provides financial support of up to ₹1 million as a grant-in-aid to prove the feasibility of the idea and a similar amount for the second phase for commercialisation. Since its inception seven years ago, the programme has received over 5,500 applications of which around 1,200 have been assessed, and of these, 207 projects supported.

The NMTLI scheme was announced at the dawn of the millennium in February 2000 by the then finance minister in his budget speech of 2000. The objective was to catalyse innovation-centred scientific and technological developments as a vehicle for select Indian industries to attain a global leadership position. The state-run Council of Scientific and Industrial Research (CSIR) was assigned to manage the scheme. The scheme departed from the past practice and policy and adopted a strategy of identifying, selecting and supporting technological and industry winners. The government funds the entire project (in most cases) as a grant-in-aid for publicly funded R&D/academic partners and as a soft loan (3 per cent simple interest payable in ten installments) to the industry partner and also underwrites the risk of failure. IPR aspects are equitably managed — generally IPRs belong to the group(s) developing it, which are licensed on a first right of refusal basis to the industrial partner on mutually agreed terms with NMTLI managers as the umpires.

During 2000–06, it has funded 42 projects with an outlay of about ₹3,000 million, involving 222 publicly funded R&D/academia groups and 65 industrial firms as partners. Predominantly the projects have been in the broad area of biotechnology (40 per cent) and drugs and pharmaceuticals and chemicals (15 per cent each) — areas in which CSIR has recognised core competencies. The NMTLI projects which are wholly funded by the government, enjoy an average of about ₹70 million project funding — the highest of all government technology development programmes. From the projects funded four products have been developed:

- Biosuite,
- a versatile portable software for bioinformatics,
- a PC-based high-end 3D visualisation platform for computational biology; and
- Sofcomp, a simple and cost-effective office-computing platform under ₹10,000 ($220 or so)

Globally PE and VC have been the main source of risk capital for technology-based entrepreneurs. But there are some differences between the two, namely that VC focuses on investing in private, young, fast growing companies. Buyout and mezzanine investing focuses on investing in mature companies. The history of the VC industry in India can be traced to the late 1980s (Mani 1997), and since then the history of the fledgling industry can be divided into four phases (Indian Venture Capital Association 2008):

- Phase I — Formation of TDICI in the 1980s and regional funds such as the Gujarat Venture Finance Limited (GVFL) and Andhra Pradesh Industrial Development Corporation (APIDC) in the early 1990s.
- Phase II — Entry of Foreign Venture Capital funds (VCF) between 1995–99;
- Phase III — (2000–07). Emergence of successful India-centric VC firms;
- Phase IV — (2007). Global VCs and PE firms actively investing in India

At this point it is necessary to point out that there no official sources of data on VC in the country, but what is available in the public domain is from the website of Indian Venture Capital Association and it clubs both VC and PE deals together (Table 4.6).

Table 4.6: *Growth of the Private Equity/Venture Capital Industry in India, 2000–07 (value in US$ millions)*

	No. of Deals	*Value of Deals*	*Average Per Deal*
2000	280	1,160	4.14
2001	110	937	8.52
2002	78	591	7.58
2003	56	470	8.39
2004	71	1,650	23.24
2005	146	2,200	15.07
2006	299(92)	7,500(508)	25.08(5.52)
2007	387(98)*	14,234(543)*	36.78(5.54)

Source: Indian Venture Capital Association (2008); US–IVCA/Venture Intelligence (2006 and 2007).

Note: *Figures in brackets are the VC deals.

However, we have obtained the share of VC in the total PE from another reliable private source of data (US–IVCA/Venture Intelligence 2006 and 2007). The phenomenal growth of the PE/VC industry can be gauged from the fact that the average size of a deal has shown an increase of 51 per cent per annum since 2000. However, based on the data provided in US–IVCA/Venture Intelligence (ibid.) real VC investments in 2007 were only 4 per cent in terms of total value of deals, but about 25 per cent if one takes them in terms of the number of deals.

About two-thirds of the value of deals have gone towards the IT and ITES industry. Although the VC industry is largely private and foreign owned, the government has played a very important role in establishing the industry and nurturing it through a variety of fiscal concessions (Mani 1997). Once again, the growth of the VC industry has provided some financial support to knowledge-intensive entrepreneurship and is thus a market-based solution to market failure in the financing of knowledge-based entrepreneurship.

Entrepreneurs who have untested business models or innovative ideas typically get their first round of funding from angel investors. If and when their business model works and they are ready for scale up, they approach venture capitalists who usually invest more money (at least ₹250 million) in the company in return for an equity stake. Angel investors broadly differ from venture capitalists in the scale of funding. Besides, angels invest their personal wealth as opposed to venture capitalists who mostly work as fund managers. The size of the angel investments has been variously estimated to about ₹10 billion in 2007. There is an inexorable link between the growth of angel investment and the growth of High Networth Individuals (HNIs).[4] This is further explained in the following paragraphs.

Though the risk with start-ups is much higher than other asset classes such as real estate, equity, mutual funds, commodities and sometimes even art funds, HNIs are betting on the opportunity of considerably higher returns associated with start-ups. To institutionalise this process of channeling funding from HNIs to technology-oriented start-ups, the Indian Angel Network (IAN) was founded in 2006.[5] Around 80 HNIs are part of this network today, up from about six when they started in 2006. In the recent past, the angel community has grown considerably in India. A typical investment by an HNI in a start-up falls in the range of ₹1 to 5 million and the exit duration is usually between four to seven years. The returns, on the other hand, can vary from 400 per cent to even zero if the investment goes bad. Hitherto the network has supported around 12 technology-oriented ventures primarily in the arena of IT software.

In a bid to promote funding for start-ups, the government plans to offer tax breaks to angel investors, who provide a part of their personal wealth as seed capital for such firms. A proposed legislation, the National Innovation Act, envisages doing away with the stamp duty currently levied on shares held by angel investors and the tax imposed on profits they make in early-stage firms.[6] However, these tax breaks would apply only to companies that are incubated in designated areas — called special innovation zones (SIZs) — and are likely to include technology parks and incubation facilities of academic institutions such as the Indian Institutes of Technology, or IITs.[7]

India offers a variety of tax incentives to enterprises for committing resources to domestic R&D, both intramural and extramural. They can broadly be classified into those which are input-based and those which are output-based (Table 4.7). Of these two broad categories,

Table 4.7: *Input- and Output-based Tax Incentives for R&D in India, 2008*

	A. Input-based tax incentives
a weighted deduction of 150 per cent on any expenditure on in-house scientific research	
(a)	weighted tax deduction for sponsored research in publicly funded R&D and on approved in-house R&D projects;
(b)	customs duty exemption on capital equipment, spares, accessories and consumables imported for R&D by approved R&D units, institutions and SIROs;
(c)	excise duty waiver on indigenous items purchased by approved institutions/ SIROs for R&D;
(d)	accelerated depreciation allowance on plant and machinery setup based on indigenous technology;
(e)	customs duty exemption on imports for R&D projects supported by the Government;
(f)	ten year tax holiday for commercial R&D companies; and
(g)	a weighted deduction of 125 per cent on any payment made to companies engaged in R&D
	B. Outcome-based tax incentive
(h)	excise duty waiver for three years on goods produced based on indigenously developed technologies and duly patented in any two of the following countries: India, European Union (one country), US and Japan.

Source: Department of Scientific and Industrial Research (2007); and Ministry of Finance (2008).

the input-based ones are more popular. Within the input-based category, although there are eight different types of tax incentives, the one which has a long history and which is enjoyed by the maximum number of companies is the one that provides a weighted deduction of 150 per cent on any expenditure on intramural R&D (see A (a) in Table 4.7). This has been in operation in its present form since 1998 and it applies to pharmaceuticals, biotechnology, chemicals other than pharmaceuticals, electronic equipment, computers, telecommunications equipments, automobiles, auto parts, seeds and agricultural implements, although the ninth and the tenth industries (namely seeds and agricultural implements) were added only in the budget for the fiscal year 2008–09. Further, in the union budget of 2009–10 the tax subsidy was extended to all manufacturing industries, and subsequently in 2010–11, the weighted deduction on expenditure incurred on in-house R&D was enhanced from 150 per cent to 200 per cent.

This is not a permanent scheme and the incentives under this head are available according to the term stipulated in the successive union budgets. Given the fact that this is the most comprehensive tax scheme for R&D, we undertake an analysis of its effectiveness.

Effectiveness of R&D tax incentives in India

Excellent reviews of the evidence on effectiveness of tax incentives for R&D and the methodologies used are found in Hall and John Van Reenen (2000), and Mohnen (2007). However much of this evidence is based on the experience of Organisation for Economic Cooperation and Development (OECD) countries and notably that of the US. The authors both describe and criticise the methodologies used to evaluate the effect of the tax system on R&D behaviour and the results from different studies. In the current (imperfect) state of knowledge Hall and Van Reenen conclude that a dollar in tax credit for R&D stimulates a dollar of additional R&D. Studies on the effectiveness of tax incentives in the context of developing countries are rare.[8]

The specific type of R&D tax incentive followed in India conforms to those that are in proportion to the level of the expenses on R&D. Further it manifests itself as an immediate write-off or expensing.

Within the specific context of India no such studies are available. The government itself has been rather concerned with the revenue foregone as a result of various tax concessions given to the corporate sector. Consequently, beginning with the Union Budget for 2004–05, the government has been publishing data on the amount of tax revenue foregone as result of various tax incentives or concessions given to the corporate sector. The revenue foregone as a result of R&D tax incentives has been computed (by the Ministry of Finance) and this is presented in Table 4.8.

Table 4.8: *Tax Foregone Due to R&D Tax Incentives in India (₹ in millions)*

Column 1	*Revenue Foregone Due to R&D Tax Incentives*	*Growth Rate*	*Revenue Foregone Due to All Tax Incentives*	*Share (%)*
2004–05	2,318		82,680	2.80
2005–06	2,839	22.48	101,277	2.80
2006–07	1,554	–45.26	144,318	1.08
2007–08	2,024	30.24	186,125	1.09

Source: Government of India, Ministry of Finance (2004–5 through 2007–8).

With the exception of 2005–6, it has averaged around ₹2 billion per year and works out to about 1.08 to 2.80 per cent of the total revenue foregone. As result of the operation of these tax incentives the effective corporate tax rate for some of the industries covered under the scheme is significantly lower with the pharmaceutical industry garnering much of the incentives (Table 4.9).

Table 4.9: *Effective Corporate Income Tax Rate for Those Industries Covered under the R&D Tax Incentive Scheme, 2006–07*

S. No.	*Industry*	*Statutory Corporate Income Tax Rate (%)*	*Effective Tax Rate (%)*
1	Drugs and pharmaceuticals	33.66	13.91
2	Electronics, including computer hardware	33.66	17.04
3	Fertilizer, chemicals and paints	33.66	22.17
4	Automobile and auto parts	33.66	26.03

Source: Government of India, Ministry of Finance (2008: 59).

Based on this data, our hypothesis is that the effect of this tax incentive will vary across industries according to the effective tax rate. Although the incentive is the same across the targeted ten industries the effective rate can vary according to whether the firms in the industry have actually taken advantage of this scheme or not. Further, it must also be borne in mind that the effective rate is a function of the sum of tax incentives enjoyed by a particular industry. It may be because of the fact that the pharmaceutical industry also enjoys a number of other tax concessions that their overall tax commitment is much lower than other industries in our sample.

In order to see whether the tax incentives have really led to increased investments in R&D, we have done two exercises. First, we compile data on R&D expenditures of seven of the eight original industries (Table 4.10).[9] The only industry that is left out is the biotechnology industry as the data on this industry is not available.[10] The growth rate of the R&D expenditure of this sample is then compared with the growth rate of the R&D investments of the entire private corporate business enterprise sector. The resulting analysis shows that the average growth rate of the industries receiving tax incentives is much higher than all the industries (with the sole exception of 2000 — the decline in R&D expenditure of all the firms enjoying R&D tax incentives in that year may purely be a statistical artifact).[11]

This of course does not mean that the incentive is effective. All that it implies is that the government appears to have targeted the right sort of industries for granting this concession. Second, we compute the elasticity of R&D expenditure with respect to the tax foregone. Although in its actual operation, the tax incentive does not lead to any flow of resources from the government to the enterprise receiving the incentive; it leads to tax foregone by the exchequer. If the percentage change in the R&D is greater than the change in the tax foregone, the tax incentive is deemed to have been successful, provided that the tax incentive accounts for a significant share of the R&D done by the enterprise. In the following paragraphs we will study this aspect.

The first step is to estimate the tax foregone due to the operation of this specific R&D tax incentive scheme. This is done in two stages. In the first stage or instance, we estimate the total tax foregone (denoted as tf1) due to the operation of all tax incentives. This is based on the difference between the statutory corporate income tax rate and its effective rate (see the estimates of tf1 in the preceding text). Two caveats have to be borne in mind. First, the estimates are available only for four broad industry groups although it can be seen that it covers almost seven of the eight industries receiving tax incentives.[12] In the second stage we estimate the tax foregone (denoted as tf2) due to just R&D tax incentives alone. This estimation was done under

Table 4.10: *R&D Expenditure of Firms Receiving R&D Tax Incentives, 1996–2006 (₹ in millions)*

Industry	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Pharmaceuticals	3,954.1	7,110.1	4,627.3	6,075	5,674.7	7,610.8	8,937	11,218.4	16,609.5	22,928.1	29,595
Chemical industry other than Pharmaceutical	1,997.8	4,842.9	2,377.2	3,178.3	2,275	2,368.2	2,094.9	2,407.6	2,697.1	3,303	4,791
Electronics including computer	88.4	132.7	41.4	39.2	87.3	108	57.3	12.6	349.6	71.5	417.9
Communication Equipments	112.9	499.9	395.5	383.1	429	641.1	750.4	603.7	1,025.1	896.3	727.4
Automobiles	1,552.2	2,459.6	2,856	2,143.8	1,453.1	1,742.9	2,878.2	3,357.9	4,183	7,506.9	8,848.1
Autoparts	407.2	516	682.9	757.7	947.2	1,081.7	1,121.1	1,485.7	1,691.3	2,194.6	2,505.9
Aircrafts	NA	NA	NA	NA	NA	NA	NA	2,650.6	3,091.4	3,066.3	4,336.2
Total	8,112.6	15,561.2	10,980.3	12,577.1	10,866.3	13,552.7	15,838.9	21,736.5	29,647	39,966.7	51,221.5
Growth Rate (%)		91.82	–29.44	145.1	–13.6	24.72	16.87	37.23	36.39	34.81	28.16
Growth Rate of all Industries (%)		18.01	34.24	6.97	0.63	4.29	10.81	7.98	8.5		
Ratio		5.1	–0.086	22.09	–21.72	5.77	1.56	4.67	4.28		

Source: Author compilation based on Prowess database published by Centre for Monitoring Indian Economy (CMIE), Mumbai. Available at http://www. cmie.com (accessed 15 August 2010).

an assumption. It was found that the revenue foregone due to R&D tax incentives worked out, on an average, 1.94 per cent of revenue foregone due to all kinds of tax incentives. We, therefore took 1.94 per cent of total tax foregone (tf1) to arrive at tax foregone due to R&D tax incentives (tf2). In other words:

$$\text{tf2} = \text{tf1}*0.0194 \qquad (1)$$

For estimating the elasticity, we fitted the following functional form:

$$\ln \text{R\&D}_{it} = a + b_1 \ln\text{Sales}_{it} + b_2\text{tf2}_{it} + b_3\ln\text{Export} + u_{it} \qquad (2)$$

For the estimation of elasticity, we create a panel data of firms reporting R&D expenditures in four of the broad industry groups for the years 2002 through 2006. The data is taken from the Prowess database published by the Centre for Monitoring Indian Economy (CMIE). The unit of reference is therefore the firms and the firms are arranged by any of the four industries to which they belong. For each of the firms we have the data on R&D investments, tf1, tf2, Profit before Tax, Sales and Exports.

Given the industry specificities we estimate (2) for each of the four industries under consideration. Before going into the estimation procedure for (2), we report the summary descriptive statistics of the important variables. See Table 4.11.

Sales and exports are taken as additional determinants of R&D. Sales is a proxy for the size of the firm and the assumption is that firms with larger sales devote large amounts to R&D. Exports on the contrary also encourage firms to commit more resources to R&D as sales in an international market require that your product matches with the best in the world for that specific product. Further in the regression equation (2), the explanatory variable tf2 depends on the amount of R&D spending. This implies that this explanatory variable is endogenous and Ordinary Least Squares (OLS) estimates are not consistent. Therefore, we estimate the model using Generalised Method of Moments (GMM) as suggested by Blundell and Bond (1998). In this method, the equation is first differenced to eliminate the firm specific fixed effect and endogenous variables are then instrumented. The estimation uses two types of instruments; for equation in differences lagged level variables from second lag onwards are valid

Table 4.11: *Mean Values of Important Variables*

(values are in ₹crores, intensities are in percentages)

	R&D Expenditure	*Research Intensity*	*Sales*	*Tax Foregone 2*	*Exports*	*Subsidy Intensity*
Automotive	12.25(39.50)	1.13	1,088.42(2,668.18)	1.653(4.299)	87.95(265.01)	13.50
Chemicals	2.07(4.17)	0.46	449.24(151.04)	0.133(0.431)	55.61(137.43)	6.43
Electronics	7.4(21.52)	2.41	306.58(289.69)	0.218(0.898)	40.71(151.04)	2.95
Pharmaceuticals	19.05(52.91)	5.99	318.09(289.69)	0.23(0.43)	122.05(289.69)	1.21

Source: Authors' compilation.

Note: (i) R&D intensity is R&D as a per cent of Sales; and (ii) Subsidy intensity is Tax foregone 2 as a per cent of R&D; (iii) Figures in parentheses indicate standard deviation.

instruments and for equation in level first lag of the endogenous variable in difference is valid instrument. In our estimation, we consider all explanatory variables as endogenous and therefore instrument them. The results are reported in Table 4.12. The table shows that Sargan statistics validate the over-identifying restrictions. The results on AR 2 suggest the absence of second order correlation. And thereby imply the validity of the instruments used.

Table 4.12: *Regression Results*

	Automotive	*Chemicals (other than Pharmaceuticals)*	*Electronics*	*Pharmaceuticals*
ln tf2	–0.0045	0.429**	–0.138	0.261
	(–0.017)	(3.08)	(–0.59)	(1.37)
ln sales	1.244**	0.470*	0.816**	0.394
	(2.93)	(1.78)	(1.93)	(1.10)
ln exports	–0.0734	–0.028	0.091	0.553*
	(–2.92)	(0.246)	(0.624)	(1.89)
Constant	–6.262**	–1.126	–4.26	–2.01
	(–2.48)	(–0.703)	(–1.55)	(–1.08)
Sargan	30.12	26.03	23.34	27.67
	(0.181)	(0.352)	(0.50)	(0.274)
AR (1)	–1.362	–2.516	–1.678	–1.944
	(0.173)	(0.012)	(0.093)	(0.52)
AR (2)	–1.699	–0.326	–0.01	–0.266
	(0.089)	(0.74)	(0.992)	(0.79)

Source: Authors' compilation.
Notes: *Significant at 5 per cent level; **Significant at 10 per cent level.
AR = autoregressive errors.

The following inferences can be drawn from this exercise:

(*a*) The elasticity of R&D expenditure with respect to tax foregone as a result of the operation of the R&D tax incentive is less than unity for all the four industries, although it is significant only in the case of the chemicals industry. In two of the industries, namely in automotive and electronic industries the elasticity is even negative, although not significant. From this the reasonable interpretation that is possible is that tax incentive does not have any influence on R&D, excepting possibly in the chemicals industry where it has some influence although even in this case the change in R&D as a result of tax incentive is less than the amount of tax foregone. This lack of significant relationship between R&D and tax foregone can be rationalised by the fact that the tax subsidy covers only a very small percentage share (on an average, 6 per cent) of R&D undertaken by the enterprises in the four broad industry groups. This is indicated by the column on subsidy intensity in Table 4.5. So our conclusion is that for tax incentive to be effective in raising R&D expenditures it must form a significant portion of R&D investments by an enterprise. It is not thus a determinant of R&D investments by enterprises. In fact this result corroborates the results of innovation surveys done in the context of such diverse countries such as Brazil and South Africa where innovating firms did not find government funds for innovation as an important instrument for financing their respective innovation efforts. In the Indian case even though 150 per cent of weighted deduction of R&D expenditure is allowed, the taxable income the firm has is not much. For firms to benefit from this specific incentive, their profit before tax has to be large. Maybe an incremental tax incentive of the type followed in the US and other western countries is likely to be more beneficial;

(*b*) Sales (a proxy for size) is found to be a more important determinant. This is in line with the Schumpeterian hypothesis that large-sized firms are able to devote more investments on R&D. Surprisingly, exports turned out to have a positive and significant influence on R&D only in the case of the pharmaceutical industry. The other two industries are much more inward looking where the domestic market is more important than the export one. In the case of the pharmaceutical industry much of the R&D is in the development of generic versions of known drugs which are then exported. So exports act as an important fillip.

One of the most important conclusions that emanate from our study is that tax incentives are not that effective in raising R&D expenditures because the amount of subsidy that the firm receives is not much. The market itself, domestic sales and in some cases exports are important determinants for the enterprises to commit more resources to R&D. But despite this the Union Budget for 2008–09 has extended this tax treatment of R&D to two more industries, namely the production of seeds and the manufacture of agricultural implements.[13] It may be that public policy making in this area is not informed by sufficient empirical exercises of this sort.

Conclusions

Our study has shown that there have been improvements in the innovative output of Indian industry during the recent period since economic liberalisation. However, this has been restricted to a few industries such as the pharmaceutical industry. India has three different types of financial incentives for R&D: research grants and loans, VC and tax incentives. Our analysis showed that the pharmaceutical industry has been a target of most of these financial incentives. There is thus a fine targeting of innovation financing in India. We endeavoured to estimate the coefficient of elasticity of R&D with respect to tax foregone as result of this incentive scheme. The resulting exercise showed that R&D expenditure of the concerned industries was inelastic. We also found that the incentives did not form a significant portion of R&D. It is therefore not prudent to make any comments on the effectiveness of R&D tax incentives. But we see that the size of the firm does appear to be an important determinant of R&D, at least, in the case of some of the industries. Allowing firms to become larger and through that process of growth enabling them to become larger investors in R&D may be a better policy than providing them directly with subsidies. It is also that the total number of firms enjoying these incentives is not too many. It remains to be seen whether this is due to any bureaucratic delays or difficulties in the actual administration of this incentive.

Notes

1. The initial discussions that I had with Pinaki Chakraborti were very useful. I received excellent help from M. Parameswaran for estimating the coefficients of elasticity of R&D expenditure with respect to tax foregone. An initial version of this chapter was presented as a lecture at the PGP-PMP course at the Indian Institute of Management, Ahmedabad on 5 February 2007 and at the Second International Conference on

Micro Evidence on Innovation and Development (MEIDE), Beijing, China, 21–23 April 2008. The comments received from the participants and especially Pierre Mohnen are gratefully acknowledged. I also received valuable comments from (late) Professor K. K. Subrahmanian. Research assistance was provided by Riju Prakash J. S. But none of them are to be implicated for any errors that may still remain. An earlier version of the chapter was published as 'Financing of Industrial Innovations in India: How Effective Are Tax Incentives for R&D?' *International Journal of Technological Learning, Innovation and Development*, 3(2), 2010: 109–31.

2. The Department of Science and Technology (DST), Government of India, has conducted a CIS-compliant national innovation survey. The results of the survey have been published in installments on the website of the National Innovation Survey, http://www.nationalinnovationsurvey.in (accessed 18 June 2013). It refers to the three-year period beginning 2004–05.
3. The bulk of the US patents granted to Indian inventors are in two US patent classes, namely, in 532 Organic Compounds (includes Classes 532–70), and in 424 Drug, Bio-Affecting and Body Treating Compositions (includes Class 514).
4. High net worth individuals (HNIs) hold at least US$1 million in financial assets, excluding collectibles, consumables, consumer durables and primary residences. According to World Wealth Report 2008 prepared by Capgemini and Merril Lynch, the number of HNIs in India has gone up by 23 per cent in 2007 compared to 2006 and there were about 123,000 HNIs in India as of 2007. Further, the report said that the combined wealth of the HNIs has increased to $440 billion in 2007. The rapid expansion of economy, increased foreign investment, increase in the savings rates and gains in the country's stock markets are the prime factors responsible for the increase in the number of Indian HNIs. As of December 2007, HNIs in India had an investible surplus of more than $1 million.
5. The Indian Angel Network is India's first and largest angel network with successful entrepreneurs and high profile CEOs interested in investing in early stage businesses across India, which have the potential to create disproportionate value. The network has invested in multiple sectors like information technology, intellectual property, hospitality, mobile, education, internet, etc.
6. For details of the draft National Innovation Act, see the website of the Government of India's Department of Science and Technology at http://dst.gov.in/draftinnovationlaw.pdf (accessed 7 December 2008).
7. Although the government is yet to notify the so-called Special Innovation Zones (SIZs), the recently established biotechnology cluster at Mohali in Punjab, and the IIT Madras Research Park, etc. will qualify for this status.

8. There is a recent study evaluating the performance of R&D support programmes in the context of Turkey. See Özçelik and Taymaz (2008).
9. The data on R&D expenditure is compiled from the Prowess database of the CMIE, Mumbai.
10. We do not consider this as a major problem as much of the Indian biotechnology industry is made up of the biopharmaceutical industry and since we have the data on R&D expenditures of the pharmaceutical industry, the data on R&D expenditures of the biotechnology industry is included as well.
11. Pharmaceuticals, automotive and autoparts, chemicals other than pharmaceuticals, electronics and information technology account for over 50 per cent of the total R&D expenditure of the industrial sector a whole.
12. The only industry that is left out is the aircraft industry. The Prowess database itself has started picking up data on R&D expenditure of the industry only since 2003.
13. See the Budget Speech of Mr P. Chidambaram for 2008–09, http://indiabudget.nic.in/ub2008-09/bs/speecha.htm, paragraph 168 (accessed 22 May 2008).

References

Blundell, R. and S. Bond, 1998. 'Initial Conditions and Moment Restrictions in Dynamic Panel Data Models', *Journal of Econometrics*, 87(1): 115–43.

Department of Scientific and Industrial Research, 2007. *Research and Development in Industry: An Overview*. New Delhi: Ministry of Science and Technology.

Department of Science and Technology (DST), 2006 and 2008. *Research and Development Statistics 2004–05 and 2007–08*. New Delhi: National Science Technology Management Information System, Ministry of Science and Technology.

Dutz, Mark (ed.), 2007. *Unleashing India's Innovation, Towards Sustainable and Inclusive Growth*. Washington, D.C.: World Bank.

Government of India, 2004–05 through 2007–08. *Revenue Foregone under the Central Tax System, Annexure to the Union Budget for the Years Beginning 2004–05 through 2007–8*, Annexure 12. New Delhi: Government of India, 45–60.

Hall, B. and John Van Reenen, 2000. 'How Effective are Fiscal Incentives for R&D? A Review of the Evidence', *Research Policy*, 29(4–5): 449–69.

Indian Venture Capital Association, 2008. 'Venture Capital and Private Equity in India', Presentation Slides. Mumbai: Indian Venture Capital Association.

Mani, S., 1997. 'Financial Barriers to Domestic Technology Development and Venture Capital', *Science, Technology and Development*, 15(2–3): 227–40.

———, 2007. 'Government Support for a Knowledge-based Economy, An Examination of India's Technology Policy Initiatives, 1990–2005', in A. Vaidyanathan and K. L. Krishna (eds), *Institutions and Markets in India's Development*. New Delhi: Oxford University Press, 137–64.

Ministry of Finance, 2008, 'Budget 2008–09', Speech of Mr P. Chidambaram, Minister of Finance, Government of India, Paragraph 168.

Mohnen, Pierre, 2007. 'R&D Tax Incentives: Issue and Evidence', Presentation Slides, Design and Evaluation of Innovation Policy Programme (DEIP), 22 October, Maastricht: UNU-MERIT. Available at http://tiny.cc/2HIzP (accessed 18 June 2013).

Özçelik, Emre and Erol Taymaz, 2008. 'R&D Support Programs in Developing Countries: The Turkish Experience', *Research Policy*, 37(2): 258–75.

Reserve Bank of India, 2000, 2005, 2008. 'Invisibles in India's Balance of Payments, An Analysis of Trade in Services, Remittances, and Income', New Delhi: Reserve Bank of India Bulletin.

US–India Venture Capital Association (US–IVCA)/Venture Intelligence, 2006 and 2007. *India Venture Capital Report — 2006 and 2007*. Chennai: Venture Intelligence.

United States Patent and Trademark Office (USPTO), 2012. *Patents by Country, State, and Year — Utility Patent*. Available at http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utl.htm (accessed 18 June 2013).

The World Wealth Reports, 2007–11. Capgemini Consulting. Available at http://www.capgemini.com/thought-leadership/world-wealth-report-2012/world-wealth-report-archive (accessed 18 June 2013).

5

China

Jian Gao and Xielin Liu

Innovation financing is a key part of a national innovation system (NIS). By creating innovation financing sources and designing innovation financing tools and mechanisms, the innovation capability of a nation can be dramatically improved. The NIS concept is used as a means of explaining the competitive advantage of national systems and is relatively new, appearing only from the 1980s. There is no single accepted definition of a national system of innovation.

Freeman (1987: 1) first defined the NIS as 'the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies'. Lundvall (1992: 12) described the NIS as 'the elements and relationships that interact in the production, diffusion and use of new, and economically useful, knowledge . . . and are either located within or rooted inside the borders of a nation state'. Nelson (1993: 5) proposed a simple definition that 'NIS is a set of institutions whose interactions determine the innovative performance . . . of national firms'. Patel and Pavitt (1994: 12) viewed NIS as 'the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country'.

Combining these definitions and the current state of NIS development, we suggest that the NIS can be defined as a set of institutions in a country that determine innovative performance and that can be impacted through financial resource allocations in different ways, such as innovation in financial services, infrastructure, education, and governance.

The Chinese government has paid considerable attention to science and technology (S&T) as a core competence of economic and national security. However, due to the centrally planned economy innovation in economic development fell far behind innovations in military and defence. As a matter of fact, China's real innovation financing system only emerged after China's economic reforms and opening up in the late 1970s. Even so it took long for a sound innovation financing system to be established. This chapter focuses on the evolution process, construction and function of China's financing system and its interaction with the NIS. Based on the analysis, some recommendations are then given on China's NIS future development and the role of the government.

The innovation financing system is analysed from three aspects. First, the historic antecedents of China's innovation financing system are examined to understand why reform was needed to stimulate innovation and the function of the Chinese government in this evolution. China's innovation system began to evolve from policy-oriented to commercial, from government as the single source of capital to a range of financing resources including venture capital (VC) input and other sources of private capital.

Second, the recent improvement and structure of the innovation financing system is demonstrated. There are four sources for enterprise development: (i) special funds from central government, (ii) incubators, high-tech zones and university Science Parks, (iii) VC firms, and (iv) banks.

The third aspect shows how these changes in innovation financing accelerated enterprise innovation and cultivated new ventures. We then try to link China's innovation performance and Research and Development (R&D) inputs. The achievements are displayed separately for the four financing sources. The results are supported with government and research institute data.

Based on this previous analysis, we offer some conclusions. The first concerns the role of the four financing sources in enterprise innovation and new venture promotion. We then put forward some suggestions for the government on its future role in improving the innovation financing system. The government still has much work to do in strengthening and clarifying the regulatory, legal and other elements of the institutional systems that have an important impact on the VC system and its effectiveness in supporting new ventures and economic development.

This study first presents background information on the innovation system and methodology and framework. It then describes China's NIS, including a review of relevant policy, the current situation, the drivers of R&D input and the nature of the output. The next section demonstrates the establishment and improvement of China's innovation financing system. It consists of two sub-sections: the innovation financing system within the National Innovation System of China (NISC) and institutional evolution. The four financing sources for entrepreneurship enterprises are elaborated in this part. The fourth part concerns the innovation financing system's achievements organised according to the four financing sources. The concluding remarks include some suggestions for the government.

China's National Innovation System

There are three different stages in the evolution of China's NIS. In the 1950s, China followed the economic system of the Soviet model in which S&T activities and industrial activities were separated. State-owned enterprises (SOEs) were expected to concentrate on production activities with public research institutions (PRIs) supplying new technologies, and therefore did not have an incentive to conduct in-house R&D. This feature was to be a primary focus of China's innovation system reform (Motohashi 2006).

In the late 1980s, PRIs continued as the major R&D performers in the innovation system, but shifted toward application with the government imposing stringent requirements on the PRIs to generate applied research. By the mid-1990s, 1,181 PRIs out of 5,074 had disappeared, but many institutes survived as private entities offering technology services. The function of this type of PRI was later substituted by enterprise R&D departments as the market-based economy became more mature.

After Deng Xiaoping's so-called 'South Talk' in 1992, innovation system reform entered a new era: active interactions between science and industry sectors required an appropriate incentive system for both players. In 1993, a 'Technology Progress Law' was introduced that targeted S&T development as one of most important elements of China's economic development. Subsequently, in 1996, the Technology Transfer Law was enacted, which encouraged the science sector to transfer its technology, by setting rules for technology market transactions.

The reform of the innovation system was further accelerated after 1998 when Jiang Zemin announced the 'State Development through

Promoting Science Technology and Education' policy at the 15th Congress of the Communist Party. Rules on intellectual property rights (IPR) for technology and technology transfer were established to facilitate market-based technology transactions. For example, a law 'Decisions on Technology Innovation, Development of High-tech, and Industrialisation' was issued in 1999. In addition, the government set up public institutions to promote technology diffusion, such as productivity centres and engineering research centres.

With the 2006 publication of the *National Long and Medium Range Programming for S&T Development* (State Council of China 2006), China sought to position itself as an innovative country, encouraging the whole of society to make innovations. In 2007 the government announced the 'science-based development' policy that sought to accelerate the reform of the S&T system, promote independent innovation, and advance technology to be applied in industrial production.

In the report 'Welcoming the Era of Knowledge Economy and Building Up a National System of Innovation', issued by the Chinese Academy of Sciences (CAS 1997) and supported strongly by the central government, the concept of China's NIS was explicated. Here the NIS is understood to be a network system made up of knowledge and technology innovation related institutes and organisations, which consists of enterprises (mainly large companies and high-tech companies), research institutes (including national, local and non-profit research institutions) and universities; the generalised NIS also includes the government sector, other education institutes, intermediaries and supporting infrastructure. The official definition shows that China's NIS emphasises both knowledge and technology innovation.

The origin of this articulation of the innovation system can be traced back to the mid-1980s when reform of the S&T system was included in the broader agenda of economic reforms (OECD 2007). The S&T industrial parks, university science parks and technology business incubators were started under the Torch Programme as new infrastructural forms to encourage industry–science relationships.

The development of China's NIS concentrates on several key issues. First, it is based on China's special situation and the needs of economic development. The NIS not only adopts and develops the most advanced worldwide technology, but also focuses on key areas necessary for China's economy, such as developing high-tech industry and utilising high technology to reform traditional industry and the agricultural economy. Second, the NIS should solve the problem of combining technology supply and demands of business of the system. The key issue of innovation is to promote the commercialisation of technology and to accelerate economic development. Third, the NIS is a network that promotes the creation, attainment, transfer and application of knowledge and technology, to coordinate and synthesise the innovation elements in the system. Fourth, the NIS emphasises the cultivation of human talent, especially innovation. Its vision is to generate highly educated people who can contribute to national innovation.

China's NIS may be thought of as comprising four parts: the knowledge innovation system (KIS); technology innovation system (TIS); knowledge distribution system (KDS); and knowledge application system (KAS).

The core of KIS is the national research institutes and research-oriented universities. Its function is knowledge production, its diffusion and transfer under government direction. China has implemented several projects to enhance the KIS, such as the National Basic Research Programme of China, knowledge innovation project, etc.

The TIS's core element is companies, as they have the incentive to innovate and generate profits. To stimulate this the government set up a series of projects to support technology innovation, such as the National Engineering Research Center Plan, 'Industry-Academics' Develop Engineering Project, and the Technology Innovation Project.

The KDS refers to the higher education and professional training system. It aims to cultivate human talent with new knowledge, high technical skill and innovation ability. The government set up a number of projects to support KDS, such as the '211' project, cross-century talent cultivation project.

The KAS works on the interaction between research institutes and companies. Its main function is the application of knowledge and technology to the economic system. For KAS to work, the government has set up a number of projects including the Spark Programme, Torch Programme and Technology Key Achievement Promotion Programme.

China's scientific achievement improved significantly in recent years. In 2007, the Science Citation Index (SCI) indexed 89,100 papers from mainland China, which ranks fifth by volume in the world. From 1998 to 2008 researchers published 573,500 papers indexed by SCI, ranked fifth in the world. The total citations of Chinese papers now stands at 2.65 million, ranked tenth in the world, compared to thirteenth in 2006. The Engineering Index (EI) indexes 76,000 papers from China, which exceeds America and ranks first in the world. The Index to Scientific & Technical Proceedings (ISTP) indexes 43,000 papers from China, and ranks second worldwide (MOST 2008).

Patent applications of which 35.4 per cent are invention patents reached 694,000 in 2007, increasing 21.1 per cent from 2006. High technology industry output was 5.05 trillion RMB in 2007, increasing 20.2 per cent from 2006. The R&D intensity in high technology is 6.01 per cent, which is much higher than the average level of the manufacturing industry (MOST 2008).

So how does China's innovation system work to promote innovation? The drivers of innovation are different across different areas of China. Generally, China can be separated into the East area, Middle area and West area in terms of economic development. According to Xielin Liu's research in 2005, if we use patenting as a proxy for innovation, we find the following results (Liu 2006): The most important three drivers for the East area are 'industry-university-research' cooperation, Foreign Direct Investment (FDI) and education funds, while the contribution of companies' research is very limited. For the Middle area, the key drivers are the government's research input, FDI and companies' research input. For the West area, the most important driver is the government's research input. The result demonstrates that the innovation drivers of three areas differ significantly from each other. It shows a linkage between the level of economic development and international cooperation for innovation in the area. So in the East area, companies are more open to cooperate with university and research institutes and emphasise attracting foreign investment. In the West and Middle areas, companies are more self-reliant and their innovation is not as active as companies in the East area. On the whole, China's innovation is mainly driven by the government's research input, FDI and industry-university-research cooperation. But recently companies' independent research institutions have played a more important role in the NIS.

China is already a major S&T player in terms of inputs to R&D. It has ranked second in the world after the US and ahead of Japan in a number of researches since 2000 (OECD 2007). R&D spending has increased at a stunning annual rate of almost 19 per cent since 1995 and reached US$ 48.8 billion (at current exchange rates) in 2007, the fifth largest worldwide, after America, Japan, Germany and France (ibid.).

The Gross Expenditure on Research and Development (GERD)/ Gross Domestic Product (GDP) ratio has more than doubled in a decade and reached 1.49 per cent in 2007 compared to only 0.6 per cent in 1995. This is a spectacular achievement but does not mean that the innovation capabilities of the Chinese economy are already on par with those of Organisation for Economic Cooperation and Development (OECD) countries which have a similar R&D intensity of production (MOST 2008).

In aggregate, the social and economic returns to R&D investment, as measured by available input and output indicators, are currently lower in China than in advanced OECD countries (OECD 2007). There are several reasons for this.

First, China's R&D investment has increased quickly from a level of lagging behind to a world leading level in terms of absolute money, which may trigger inefficiency if not well controlled and guided properly. For example, there is much more investment in development than basic research, that is, there are more projects on product development so that the foundation of innovation is not solid enough.

Second, a large proportion of the innovation expenditure is devoted to buying machines and software, less for the in-house R&D expenditure. In 2006, 55.8 per cent of total innovation expenditure by companies was used to buy machinery and software; 32.4 per cent was devoted to R&D activities; 8.1 per cent was used to buy relevant technology (Gao 2007). This shows that innovation relies on the introduction of imported technology and machinery; basic and applied research is still not sufficient. So the stock of intellectual capital does not grow as quickly.

Third, to a great extent innovation is driven by government guidance, and enterprises are mainly reactive. But companies are the ones that know which technology can create good output and where the resource should be allocated in the most efficient way. The government should give companies more autonomy to conduct the innovation process.

As of 2005, there were 750 multinational R&D centres in China and foreign R&D now accounts for 25–30 per cent of total business R&D in China (OECD 2007). Beijing and Shanghai are the preferred locations, but more recently, Guangdong, Jiangsu and Tianjin have appeared on the map of foreign R&D investors. Eighty per cent of the staff in foreign R&D centres are from China, so they cultivate local research talent and improve the whole research capability of China. The foreign R&D centres are set up for three reasons. First, they can stay more close to the local market and respond fast to demand changes. Second, they can reduce R&D costs as China's labour cost is relatively low. Third, they can obtain policy support as local government encourages their establishment with cheap land and other means. This may promote technology spillover and local economic development.

The public research system has been downsized and rebalanced in favour of universities to a considerable extent by a series of reforms that started in the mid-1980s. Today, government research institutes still play a key role in supporting basic and strategic research, as well as mission-oriented research, mainly in the natural sciences and high-technology-related disciplines. Since the wave of reforms, the number of institutions reduced from 791 in 1998 to 319 in 2007; employees reduced from 281,600 to 92,600; technology and science researchers reduced from 169,600 to 65,500. Public research organisations have exited from industry marketable areas (MOST 2008).

The higher education system, mainly consisting of universities, is the key player in basic research activity. As a research performer, the higher education system has expanded considerably over the last decade. Almost 700 higher education institutions are recorded as active in R&D. Because they receive some relevant public support, the number of significant players is much smaller, and only a few of these enjoy international visibility and reputation as major research universities. Funding for R&D activity in universities is 8.68 billion RMB that increased 21.7 per cent from 2006. The basic research activities of higher education account for 49.7 per cent of that of the whole country. Funding comes from the government and companies. The government provides 17.77 billion and companies provide 11.03 billion. The proportion of companies increased substantially from below 5 per cent before 1990s to more than one-third now (MOST 2008).

Companies have increased their R&D input in a bid to enhance innovation ability. The number of R&D practitioners in large and medium companies was 2,202,000 in 2007, which is 5 per cent of all staff. The number of scientific engineers reached 1,401,000, which is 63.6 per cent of all technological staff. According to the 2008 Innovation Survey in 2007, R&D expenditure was 0.81 per cent of main business cost, which is higher than the 0.77 per cent found in 2006, indicating that China's large and medium companies pay most attention to innovation (NBS 2008). At the same time, reliance on imported technology reduced over the decade. In 2007 the proportion of purchase foreign technology to domestic technology was 0.28, a decline from 1.00 in 1999 (MOST 2008).

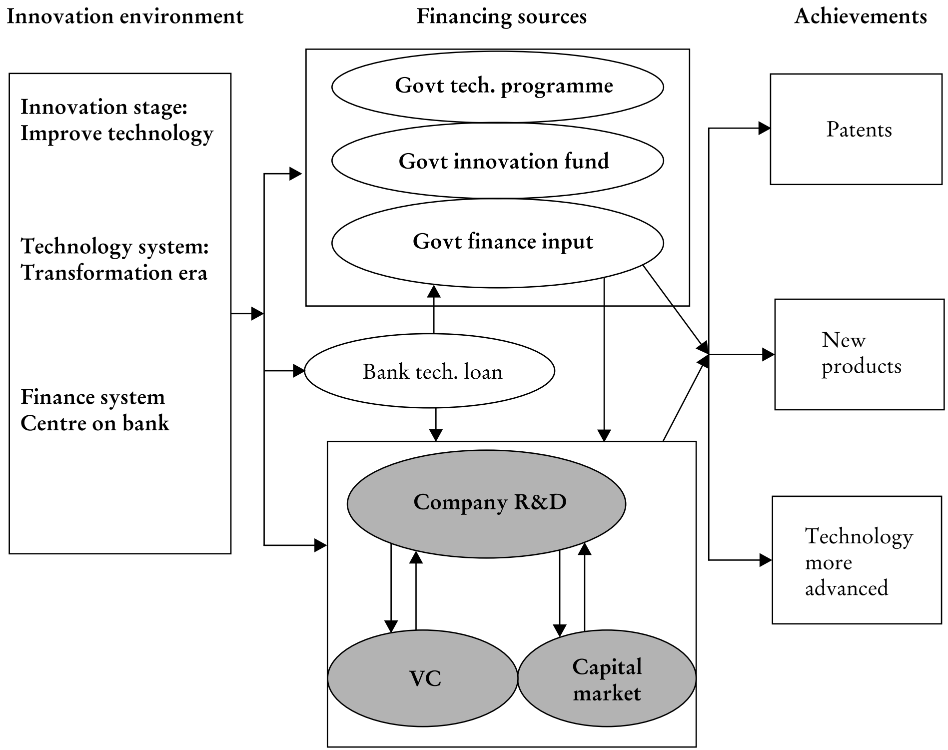
The rapid expansion of China's R&D is explained by this illustration of relevant policy and history. First, China's government realised that the market is much more efficient than the planned economy and thus launched the transformation of the economic regime. This is the main reason for R&D flourishing. Second, the government put forward several important policies to promote innovation, such as NIS reform in 1992 based upon Deng Xiaoping's so-called 'South Talk' and the 'State Development through Promoting Science Technology and Education' policy in 1998. These specific strategies greatly facilitated the innovation process. Third, the open door policy has drawn in many multinational enterprises that have advanced technology. They established joint ventures, set up factories, research centres and sold products in China. Therefore, China's enterprises' innovation ability and the nationwide R&D input increased. Fourth, China's enterprises dedicate more to indigenous innovation and play an important role in NIS. Several famous innovative enterprises emerged such as Lenovo and Huawei.

The Establishment and Improvement of China's Innovation Financing System

The Chinese government has long seen S&T as a critical part of its search for economic development and national security. Innovation was primarily initiated by central government ministries and bureaus and within the guidelines of the State Planning Commission's (SPC) national plans. These bureaucracies claimed both authority and responsibility for initiative such as technological development, adoption, upgrade or transfer, in addition to directing production output and distribution.

From then on, the Chinese government began to consciously establish and improve China's innovation financing system. We explain the system evolution with reference to schematic in Figure 5.1. The innovation environment is illustrated from three aspects. Initially, the

Figure 5.1: *Innovation Financing System*



Source: Authors.

innovation stage that most companies lie in is improving technology. They were in the transformation era from the aspect of the technology system, with financing resources centred on banks. As shown in Figure 5.1, the financing sources consist of three parts. The first resource is government support in terms of technology programmes, innovation funds and financial inputs. The second resource is the bank loans for technology innovation, which is the main source of financing. The last source is VC and capital market, which emerged later when the government established the first VC fund in 1985.

The following section provides more details about the origins of China's innovation financing system.

A critical antecedent to the later emergence of a VC system was the shift in the dominant ideology in the late 1970s, when Deng Xiaoping and other pragmatic Chinese leaders recognised the inefficiencies and lower effectiveness of a centrally planned economy in practice, especially in the area of technology development and diffusion. There emerged a major wave of reforms in the 1980s with two objectives. The first was to increase S&T outputs, based on the assumption that a greater supply of technology would lead to greater diffusion and implementation that would, in turn, support both technological and economic development objectives. The second, and part of the larger reforms underway in China from the early 1980s, was for the government to begin to shift responsibility and, more gradually, authority for resource allocation decisions from the central government bureaucracies to functional organisations (research institutes, manufacturers and distributors). This was accompanied by increased responsibility and alternatives for improving financial performance, either by generating or increasing revenues or winning competitive project funds from the government (Naughton 1994; Child 1994; Liu and White 2001).

During this period, three sets of actors emerged as the primary providers of support to new ventures. First, R&D institutes and universities played the most important role at the start-up stage, providing both the original technology and seed capital for a venture. The technology that was the substance of these projects was typically embodied in the spin-off of an entire institute, one of its sub-units, or a group of individuals. Various estimates suggest that such institute-initiated new ventures represented half of such ventures operating in technology zones, or over a thousand such ventures, by 1993 (Gu 1999: 83).

The source institution, using its new authority to allocate resources, would also provide financial support. For example, of the new technology enterprises founded in Beijing, an average of 85 emerged of their start-up capital came from the originating institution.

The next set of actors who played an important role in new ventures was the banks, which were the primary source of financing. They, rather than the government bureaus, provided the majority of the investment in spin-off projects under the Torch Programme.

Although representing only 10 emerged of that investment in 1988 when the Torch Programme began, their share increased to 50 emerged by 1990 and 70 emerged by 1991 (Gu 1999: 352). The banks themselves did not have the capability or access to critical information to assess risk at this initial start-up stage. Instead, they relied on a project's designation as a recipient of Torch Programme support for policy guidance. The majority of bank financing, however, was available only at the expansion and later stages of a venture's development, with local governments acting as guarantors. Even into the mid-1990s, banks were the main financers of new venture expansion, but essentially absent as financers at the seed capital and start-up stages of these ventures.

Technology zones were the third source of support for new ventures, first appearing as local experiments in the mid-1980s (in Shenzhen and Wuhan) and officially sanctioned by the central government in 1988 with the founding of the Beijing Experimental Zone, the first national-level high and new technology industry development zone. By 1991, there were 26 national level development zones, 25 more in 1992, and now 53 such zones dispersed across the country. These zones became a key source of support for new technology ventures. Gu (1999) has described them as an institutional interface between the new ventures and the broader, and in some ways inadequate, socio-economic system into which the ventures were founded. First, they provided incubator functions, including physical space and infrastructure. Second, they licensed the new ventures in order for them to qualify for preferential treatment under the Torch Programme and other government policies, and to access funding from various sources, especially banks and VC firms. From the mid-1990s, some of these zones even tried to set up their own VC firms to serve resident firms. Local governments supported these firms because, by locating in these zones, the new ventures were seen as contributing to local economic development; for example, Lenovo is one of the spin-off companies in the Zhongguancun science park.

The policies, institutions and actions over the 1980s and early 1990s resulted in a large number of new ventures being funded in China even before an institutionalised VC system had emerged. By the mid-1990s, however, central government leaders recognised that the current system for funding and promoting new ventures as a means of pursuing broader national developmental objectives had reached its limits. We can identify several factors that created this situation, framed in terms of the primary activities we have earlier identified as fundamental to a VC system. First, the system was not effective in pooling funds. The supply of initial stage seed capital was too small, in effect dependent on indirect government budget allocations. Research institutes and universities, which are funded by the government, had limited financial resources for supporting new ventures. Banks, also operating essentially as disbursement agents of the government, were strapped by their non-performing loans, and increasing loans to inherently high-risk ventures was not yet politically acceptable or even commercially advisable. Similarly, neither the central nor local governments had the surplus funds to step in as direct financers of new ventures. An institutional bias against financing individual private ventures also represented a barrier to possibly promising new ventures being established.

Second, in addition to the limits of the existing system to pool significant funds to finance new ventures, the system also did not provide the legal, regulatory and other institutional support necessary to identify and channel available funds to new ventures effectively from an investment perspective. The government did not recognise venture finance organisations — i.e., VC firms — as a legitimate organisational type, nor VC financing as a legitimate commercial activity. Until it did, such financing was either internal, as the institutes and universities allocated their own resources to new ventures, or a category of central or local government funding, whether through the Torch Programme, zone incubators or other funds targeted to new technology venture support.

The Technology Venture Investment Corporation, formed in 1986 by the State Science and Technology Commission and the Ministry of Finance, was an attempt to replicate the US system that Chinese policymakers saw as the means by which new technology ventures were financed in Silicon Valley and Route 128 in the US. It was managed and operated like a state-owned enterprise (SOE); however, it was essentially a central government agency with the mandate to support national technology venture policy objectives, rather than a profit-oriented private enterprise. The lack of an adequate legal framework and enforcement to govern the pooling and channeling of funds from new sources of capital (cash-rich listed companies and other actors besides central and local government bureaucracies) was particularly critical for new venture investment. If parties do not have confidence in formal or informal institutional safeguards, such as contract law or recognition of goodwill, they will rationally avoid exposing themselves to the resulting risk of a transaction. This weakness was exacerbated by the generally murky state of property rights in China regarding who has what rights over the use, rent extraction and transfer of assets (Steinfeld 1998). Lack of a legal definition and protection of ownership over a new venture's assets clearly inhibited the ability of profit-oriented actors to invest and channel funds to new ventures.

Due to the weakness of the pre-institutionalised innovation financing system and seeing the great success of Silicon Valley, Chinese policymakers and political authorities changed their perception of venture financing from it being a type of government funding to it being a commercial activity necessary to support the commercialisation of new technology. China's innovation system began to evolve from policy-oriented to commercialisation, from government as the single source of capital to various financing resources including VC and other private capital. The following paragraphs will illustrate the changes of the government's role in innovation financing and the incremental financing channels.

The central government has now taken a more indirect approach and allowed the system to develop. First, its transition-era policy of decentralisation of responsibility and authority has created the institutional space for lower level actors — both local governments and S&T organisations (i.e., research institutes and universities) — to act entrepreneurially and undertake new activities. This has allowed research institutes and universities to spin-off organisational sub-units and even whole organisations to become the basis of new venture firms, and allowed individuals to establish new firms. Second, the government has legitimised VC as well as private entrepreneurship, especially through regulations that allow new organisational forms to be established as legal entities. It has also channeled small grants and funds to new ventures, signaling to local governments, banks and other potential investors that the venture is politically and socially legitimate and a qualified recipient of further financial and other support.

Finally, the central government has created an institutional environment conducive to investment in new ventures. Although still developing, the government has made impressive strides towards aligning the legal and financial systems more closely to the goal of establishing a market-oriented business system. For the activities of a VC system, key institutional elements include corporate law governing the status and activities of legal entities, investment, contracts and intellectual property; regulation of foreign capital and enterprises; and the stock market and other elements of the capital market.

Compared to the central government, local governments have played a much more direct role in the development of new ventures and supporting infrastructure, including their involvement in several basic activities of the venture capital system. One reason that local governments have responded so positively to the central government's initiatives in this area is the still considerable control of the central government over key rewards to individuals and organisations that stand out as supporters and implementers of policy initiatives. This is exercised through the major role that the central government and Communist Party have in upper-level personnel appointments, both in government and large enterprises. These are the characteristics of the Chinese socialist market economy.

For these reasons — pursuit of recognition, seeking revenues and employment opportunities — local governments have responded enthusiastically to the incentives and opportunities to foster new technology-based ventures in their regions. They have allowed these firms greater operating autonomy, including offering competitive compensation to their employees. In addition, the local departments of finance, bureaus of the S&T ministry and high-tech zone administration departments have provided a range of direct support to new ventures. These government actors are directly involved in pooling funds, identifying investments and channeling funds into new ventures. For example, the departments of finance have created government-backed guaranty companies to guarantee bank loans to local ventures, in addition to their direct financial support of new ventures. Local governments have also used high-tech zones and specific incubator organisations within these zones to support the development of new technology ventures. They provide various forms of support to new firms, including tax exemptions and reductions, physical space at low rental rates, leasing, better social services, and other preferential conditions.

The central and local governments continue to be involved in the VC system, especially the pooling of funds, identifying investments and channeling funds. With regulatory changes in the 1990s, however, VC firms entered the system as a new organisational form and now account for most of the activities related to pooling funds, identifying investments, channeling and monitoring funds and pursuing returns through exits. Among the approximately 200 registered VC firms, four distinct categories of VC firms can be identified.

The first type of specialised VC firms to appear in China was government VC firms (GVCFs). Although the first such venture capital firm was established by the central government in 1985 and began operations in 1986, those that followed were all controlled by local governments, usually led by the local bureau of the S&T commission and supported by the finance department of the local government. Although local governments were their initial source of financing, they have diversified their funding sources over time and with changes in the regulatory environment. Indeed, they are increasingly dependent on listed and cash-rich enterprises to keep up their investment capacity.

University VC firms (UVCFs) began to emerge in 2000 from the major universities in China that have strong R&D bases, such as Tsinghua, Shanghai Jiao Tong, Fu Dan, Harbin Institute of Technology and Zhejiang. They benefit tremendously from their university ties, giving them privileged access to new venture investment opportunities, as well as intimate information about the ventures. On the other hand, they also suffer from some of the same weaknesses as the GVCFs. Specifically, their investment opportunities are in practice limited to those that emerge from the university, and they do not have the managerial expertise related to VC investing. Another weakness is that the universities usually are not cash-rich, so they depend more and more on other sources of investment capital; as in the case of GVCFs, publicly listed and cash-rich enterprises have become their primary backers.

A wave of corporate VC firms (CVCFs) were founded in response to the No. 1 Proposal of 1998, and they now represent the majority of VC firms operating in China. Beijing High-Tech Venture Capital Ltd and Beijing Venture Capital Ltd were the first CVCFs, founded in October 1998. Their strong government backing, however, causes many to perceive them as firms under the Beijing government's commercial holding company. From early 1999, there was a wave of true corporate-backed CVCFs, although they still sought local government support. Their managers typically came from securities firms, banks or industry.

Finally, foreign VC firms (FVCFs) have entered China and become a major source of new venture financing. As of 2001, eight of the top 10 VC investors in China were foreign firms and 14 of the top 20. Like the domestic CVCFs, most of the FVCFs are backed by multiple investors, although a few (e.g., Intel Capital) are the investment arms of single firms. More recently, domestic VC funds have been raising funds from outside China (White et al. 2005).

The reform and opening of China's innovation system displays three transitions:

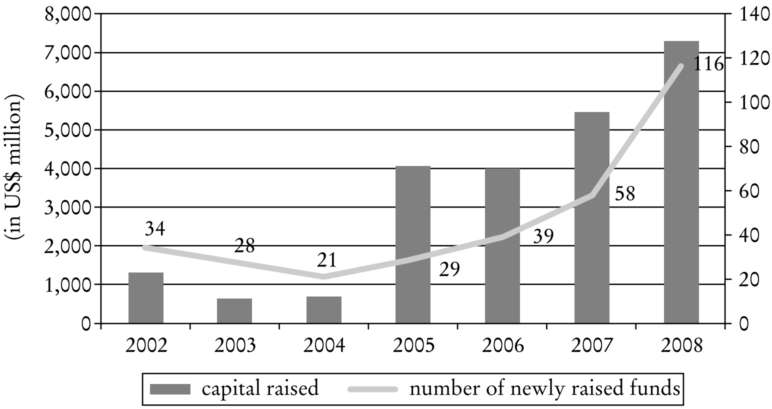
- The shift of the leading role in technological innovation from research institutes and universities to enterprises;
- The shift from mainly using existing technology to improving and creating new technology;
- The shift from encouraging technology transfer to technology innovation in and among enterprises, universities and research institutes.

The innovation financing system has triggered the acceleration of innovation. We can illustrate this from R&D and VC aspects. First, R&D input increased dramatically in recent decades. At US$ 73.5 billion in purchasing power parity (PPPs), China's GERD was the third largest worldwide in 2006, after the United States and Japan. The R&D intensity — the ratio of GERD to GDP — of China's economy has increased spectacularly. It reached 1.43 per cent of GDP in 2006, up from 0.6 per cent in 1995 (OECD 2007). However, China's spending on R&D remains heavily focused on experimental development; only 5.2 per cent of all R&D in 2006 was aimed at basic research, compared to 10–20 per cent in OECD countries (Data from OECD 2007.)

Second, VC is an important factor in accelerating innovation. From 2002 to 2008, China's VC industry expanded rapidly. From

Figure 5.2, we see capital raised by VC institutions increased from US$ 1,298 million in 2002 to US$ 7,310.07 million in 2008. The compound growth rate is 28 per cent (Zero2 Initial Public Offering [IPO] Research Center 2008).

Figure 5.2: *Capital Raised by VC Institutions, 2002–08*

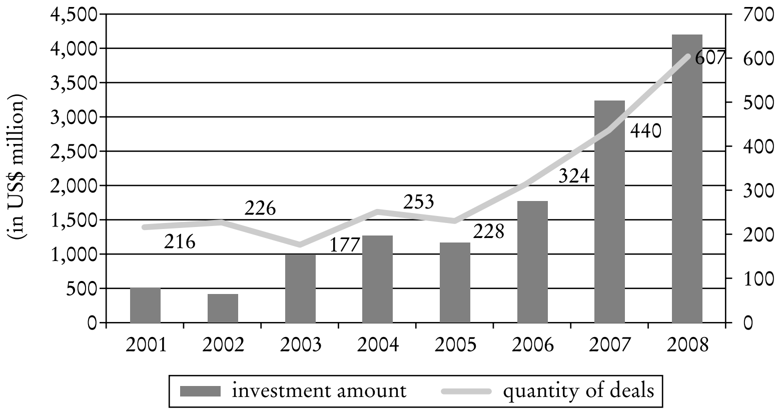


Source: Zero2 IPO Research Center (2008).

On the other hand, total investment in the Chinese VC market increased from US$ 518 million in 2002 to US$ 4210 million in 2008 with a compound growth rate of 35 per cent (Figure 5.3) (Zero2 IPO Research Center 2008).

It is not only enhancing the funding resources and increasing the innovation capital that will accelerate innovation, but also the institutional innovation that can accelerate innovation and guarantee the innovation continuity fundamentally. The institutionalisation of China's VC system is simultaneously an extension of transition-era policy trajectories and an attempt to answer problems that could not be solved within the framework of other institutional systems. It is marked by the mid-1990s shift in attitude among the government leaders regarding VC. Specifically, policymakers and political authorities changed their perception of venture financing from its being a type of government funding to its being a commercial activity necessary to support the commercialisation of new technology. The founding of domestic VC firms began with the establishment of local government-financed VC firms, first in 1991–93 in Guangdong, Jiangsu, Zhejiang, and Shanghai, and in other provinces by the late

Figure 5.3: *Total Investments in Chinese VC Market, 2001–08*



Source: Zero2 IPO Research Center (2008).

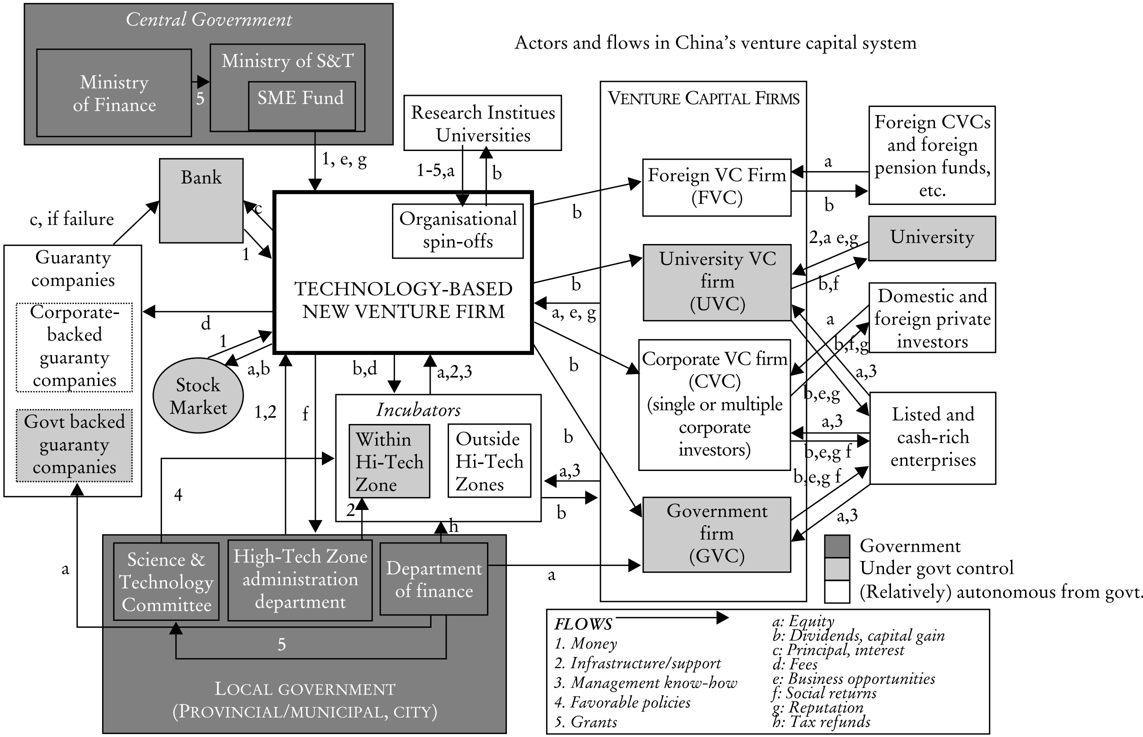
1990s and early 2000s. Then followed the university-backed VC firms. Although foreign VC and private equity (PE) firms had already been allowed to register as commercial enterprises in China in the 1980s, their investment activities were extremely limited by the lack of suitable investment projects.

With Announcement No. 1 at the Ninth Conference of the NPC in the spring of 1998, however, corporate-backed VC firms could be established, and there was a wave of funding involving government, corporate and foreign capital. From that point, venture capital shifted from being a topic of policy research, discussion and experimentation or a form of government subsidisation of new technology ventures, to becoming a coherent institutional system. It now represents the current, albeit evolving 'solution' in China for funding and nurturing new technology-based firms.

The system that has emerged so far is highly complex in terms of the variety and number of organisational actors, as well the multiple dimensions on which these actors are linked (Figure 5.4). This complexity is increased because all of the organisational and institutional elements are themselves changing in response to policy, technological and other developments.

The central government legitimated the system of VC by setting up a fund for middle and small innovation firms, which is operated

Figure 5.4: *Actors and Flows in China's Innovation Financing System*



Source: White et al. (2005).

by the Ministry of Finance and Ministry of S&T. New ventures also get support from banks, local government, university research institutes and VCs. Local government may establish local S&T Committees, High-Tech zones, while their departments of finance directly subsidise new ventures and can also guarantee bank loans to new ventures. Now in China, there are four types of VC firms: Foreign VC firms, University VC firms, Corporate VC firms, and government VC firms (Figure 5.4).

Besides VC, the Chinese government has established high-tech zones, incubators and university science parks to accelerate innovation. In 2005, there were a total of 53 high-tech zones, 534 incubators and 50 university science parks. Banks also play an important role in innovation system. Banks were the main financers of new venture expansion, but essentially absent as financers at the seed capital and start-up stages of these ventures.

The government also revised the Patent Law in 2000 and 2008 for two purposes, to encourage innovation and to protect intellectual achievements. To shorten the period and increase the channels for capital to exit from an invested company, the Chinese government established a second board on the Shenzhen stock exchange for listing new ventures. This second board institution will reduce VC's risk of investment in ventures and encourage VCs to participate more in new ventures. According to the Zero2 IPO Research Center 2008 report of VCs, exits by IPO are the most frequently used method. It is expected that the opening of a second board will stimulate the VC market as well as technology innovation.

A special fund, the Innovation Fund for technology-based SMEs was established by the Chinese Ministry of Science and Technology in May 1999. As a policy guided fund, the Innovation Fund facilitates and encourages the innovation activities of SMEs and the transformation of research achievements by means of financing. From year 1999 to 2005, the Innovation Fund accepted 30,623 applications and approved 7,962 projects. During that period it disbursed 5.2 billion CNY (US$ 650 million) with average project funding of 650,000 CNY (US$ 81,250).

Application criteria for Innovation Fund financing are:

- Independent business entity
- Involvement in high-tech R&D, production/services
- R&D investment/sales > 5 per cent
- Technological personnel/total employees > 30 per cent

- Various ownership (Chinese equity 50 per cent up)
- Less than 500 employees

The Innovation Fund lays the foundation for industrial expansion and introduction of commercial funds, targets 'market failure' where government support is needed, bridges the gap with the capital market, and incubates innovative start-ups. The Fund invests in firms at start-up and thus suffers high risk (Figure 5.5).

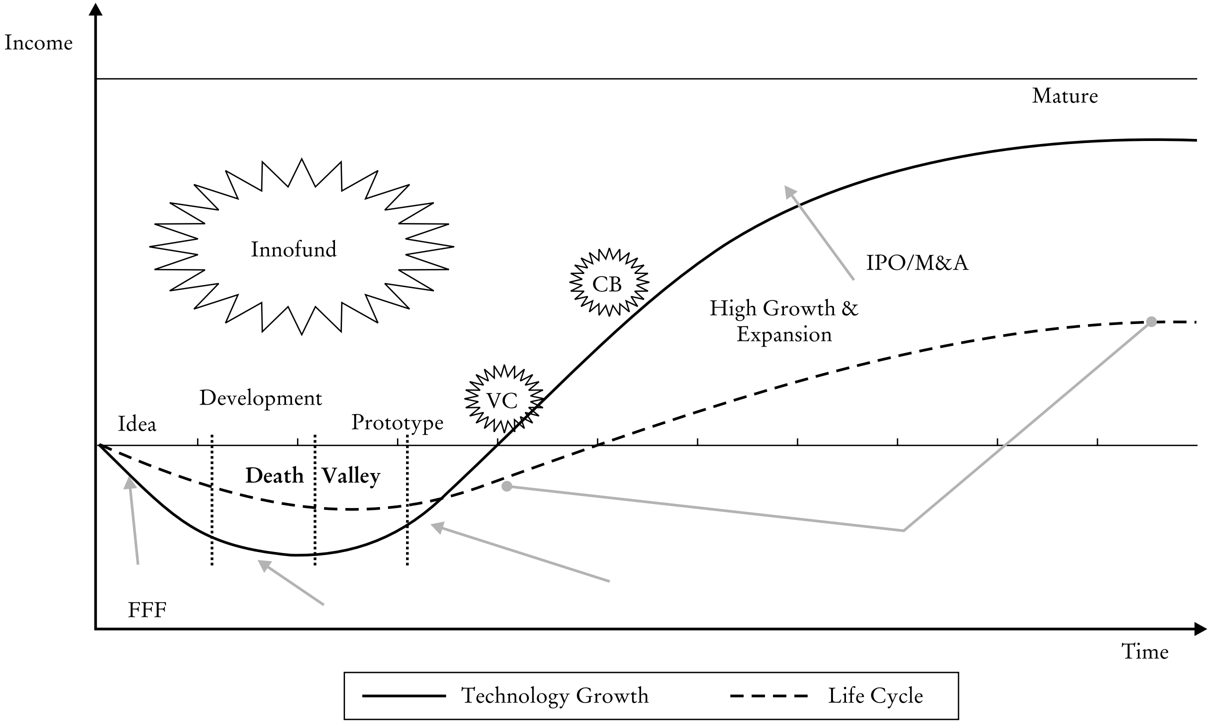
From 1998 to 2008, the innovation fund set up 14,450 projects and provided 8.84 billion RMB for small and medium technology enterprises. According to the survey, for more than 95 per cent of the funded enterprises, the Innovation Fund was the first financial aid from the government. Among all the companies listed in the SME Board, nearly one-third have received support from the Innovation Fund. Of the 28 companies that were first listed in the Growth Enterprise Market, 11 companies have undertaken projects from the Innovation Fund.

High-tech zones and incubators are created by local governments to support new technology ventures. For the companies in the zone or served by incubators, local government provides various forms of support to new firms, including tax exemptions and reductions, physical space at low rental rates, leasing, better social services, and other preferential conditions.

By 1992, there were 52 high-tech zones established throughout China, 5,569 new technology ventures were registered, and their combined output was estimated at RMB 23 billion (Gu 1999: 39). By 2000, the number of new ventures in these zones had exceeded 20,000.

From MOST's perspective, these zones have generated benefits in two areas. First, they have provided the structure in which local governments can express their creativity by adopting and improving the policies and activities related to these zones. They have allowed experimentation in terms of administrative structure, market-oriented operations and human resource management, all in line with the overall thrust of economic reforms underway in China. Second, the zones have contributed significantly to the commercialisation of China's S&T outputs by non-government S&T firms, as well as by serving as an important base for training and education. They have also helped enhance the competitiveness of these firms by supporting their continual innovation capabilities. Coinciding with the development of S&T zones in the early 1990s, incubators emerged in force. They

Figure 5.5: *Innovation Fund: Filling the Market Gap*



Source: Authors.

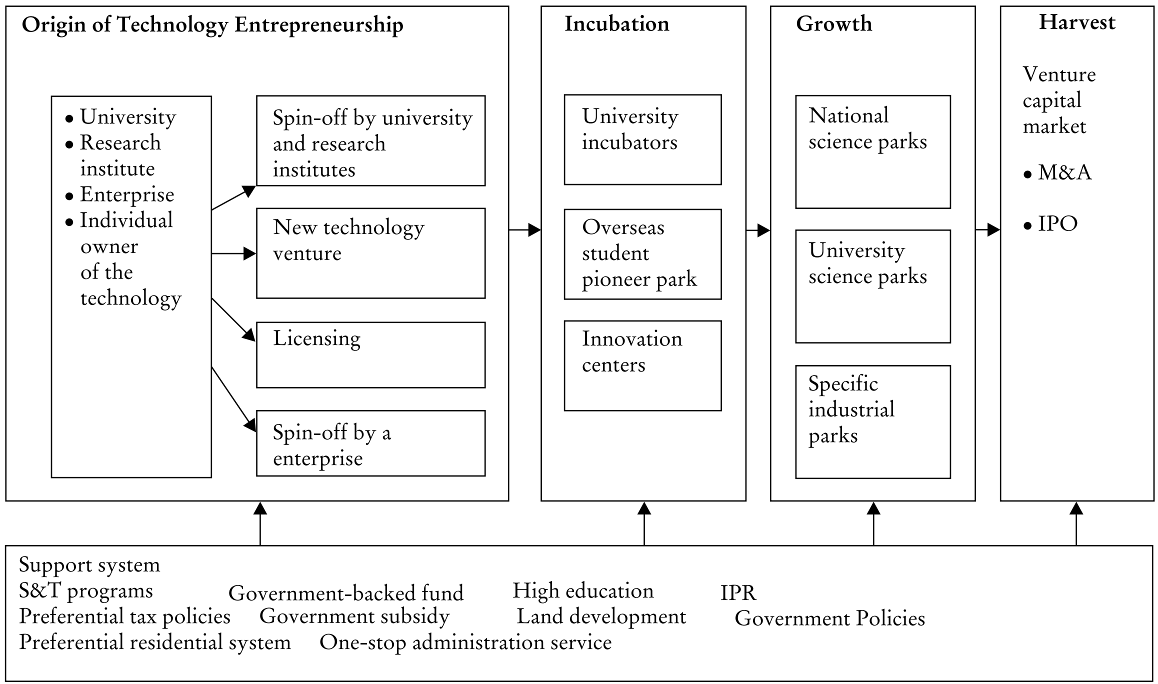
were first founded within zones as extensions of the original services provided by the zone administration within the local government. The 465 incubators registered nationwide are now found both within and outside zones, and receive funding from all of the sources that also fund VC firms. Indeed, some of these incubators are even treated as a category of new technology venture firms by their investors. The outputs of these incubators are impressive; by 2000, nearly 4,000 firms had emerged from them, including 32 that had been listed on the stock market.

The local government usually provides incubators — whether within or outside S&T zones — with physical infrastructure and favourable policies, such as those related to leasing space, tax incentives and basic services. A number go even further, acting as intermediaries and providing training and management services. This could even be to the extent of providing platform software services, although usually through a larger industrial firm with those resources and capabilities.

Many zone or government-backed incubators are actually state entities, with many of the managers coming from the government. As a result, in many of these organisations, incentives are inadequate, and their managers do not have the expertise to provide strong support and expanded value-added services. University-based incubators are better than pure government-backed incubators in terms of both their internal systems and human resources. Corporate backed incubators are even more strongly focused on creating profit and value than the other types. They are more likely, however, to emphasise short-term profits at the expense of longer term investment and development. Although university, corporate and purely private incubators may not be under direct government control, most still seek local government support, especially related to physical space, infrastructure supply and tax incentives.

The innovation process under the support of incubators, high-tech zones and university science parks is shown in Figure 5.6. First, when universities, research institutes or enterprises invent new technology, and scientists can set up their own spin-off ventures under their university or research institutes. Then incubators, high-tech zones and university science parks will provide capital and other resources to the enterprises and the enterprises will grow and expand in this stage. The final step is to harvest in three channels: VC market, mergers and acquisitions and IPO.

Figure 5.6: *Innovation Process Supported by Incubators*



Source: Authors.

China's VC system has developed rapidly, but this development is uneven across activities. The system is not mature in terms of regulatory and related institutions. Currently, domestic and foreign funds are being effectively pooled by the different types of VC firms. These firms are also taking over the primary role of identifying and evaluating investment targets, a role previously played by bureaucracies within the central and local governments. On the other hand, these VC firms (especially domestic firms) are biased towards late-stage investment projects, and are not acting as a channel of funds to true start-ups to the extent desired by the government.

Rather than the government bureaus directly, banks provided the majority of the investment in spin-off projects under the Torch Programme. Although representing only 10 per cent of that investment in 1988 when the Torch Programme began, their share increased to 50 per cent by 1990 and 70 per cent by 1991 (Gu 1999: 352). The banks themselves did not have the capability or access to critical information to assess risk at this initial start-up stage. Instead, they relied on a project's designation as a recipient of Torch Programme support as policy guidance. The majority of bank financing, however, was available only at the expansion and later stages of a venture's development, with local governments acting as guarantors. Even into the mid-1990s, banks were the main financers of new venture expansion, but essentially absent as financers at the seed capital and start-up stages of these ventures.

Innovation Financing System's Achievements

This section will use data to illustrate how the innovation financing system functions in enterprise innovation from three aspects: innovation fund from central government, high-tech zones and incubators, and VCs.

Although China's innovation financing system has been established and improved significantly, its real effectiveness has to be verified through its assistance in enterprise innovation and new venture growth.

Table 5.1 shows China's innovation improvement from 1987 to 2005 under the innovation financing system.

Table 5.1: *China's Innovation Performance, 1987–2005*

	1987	*1997*	*2000*	*2005*
R&D expenditure (%)				
University	15.95[1]	11.3[2]	8.6[2]	10[5]
Research institute	54.74[1]	40.5[2]	28.8[2]	21.1[5]
Enterprise	29.31[1]	48.2	60[2]	68.9[5]
Invention patents granted (item)[3]				
University	18 (1985)	258	652	4,453[5]
Research institute	11 (1985)	304	910	2,423[5]
Enterprise	3 (1985)	205	1,016	7,712[5]
Enterprise innovation capability (billion)				
R&D expenditure[2]	5.86	18.83	35.36	125.03
Technology acquisition [2]	9.02	23.65	24.54	29.68
Expenditure of technology absorption[2]	0.41	1.36	1.82	6.94
Amounts of hi-tech enterprises [4]	2,587	13,681	20,796	41,990
Amounts of incubators [6]	NA	NA	131	534
Amounts of talents[6]	NA	NA	7,693	39,491

Source: MOST (1988, 2001 and 2008).

The Innovation Fund supports projects in early stage commercialisation with innovative technology and good market potential but unattractive for commercial capital. The achievements of the Innovation Fund are demonstrated in the following paragraphs. Of the total early-stage companies supported by the fund, 31 per cent are start-up companies (<18 months), 60 per cent are companies with less than 100 people, 41 per cent are companies with less than 50 people. There are 4,946 projects funded during 1999–2003 and 17 per cent of the projects hold IPR, which indicates the innovation fund promotes innovation. The innovation fund investment also broadens the fund-raising channels for tech-based SMEs and the statistics show the Innofund funding expanded by 17 times by investment. The direct social welfare brought by the innovation fund lies in the creation of employment opportunities. On average each project created 63 new jobs.

There are now 53 high-tech zones, with 41,990 tenant enterprises and 5,212 million employees. The enterprises create RMB 3441.56 billion revenue, RMB 111.65 billion exports and RMB 32.19 billion taxes. High-tech zones cover different industries: Electronics and Information; New Materials; Optical, Mechanical and Electronic Integration; Biotechnology; New Energy; High Efficient and Energy Saving Technology; Environment Protection Technology. High-tech zones contributed a great deal to the local economy: there are 10 hi-tech industries development zones that account for more than 20 per cent of the geographic GDP.

The zones absorb government funds — Innovation Fund for Technology-Based Firms (RMB 1.2 billion); government commitment capital flowed into government-backed VC (RMB 3.02 billion); and capital in government-backed guaranty companies (RMB 4.35 billion). The zones also absorb foreign investment in the amount US$ 9.94.

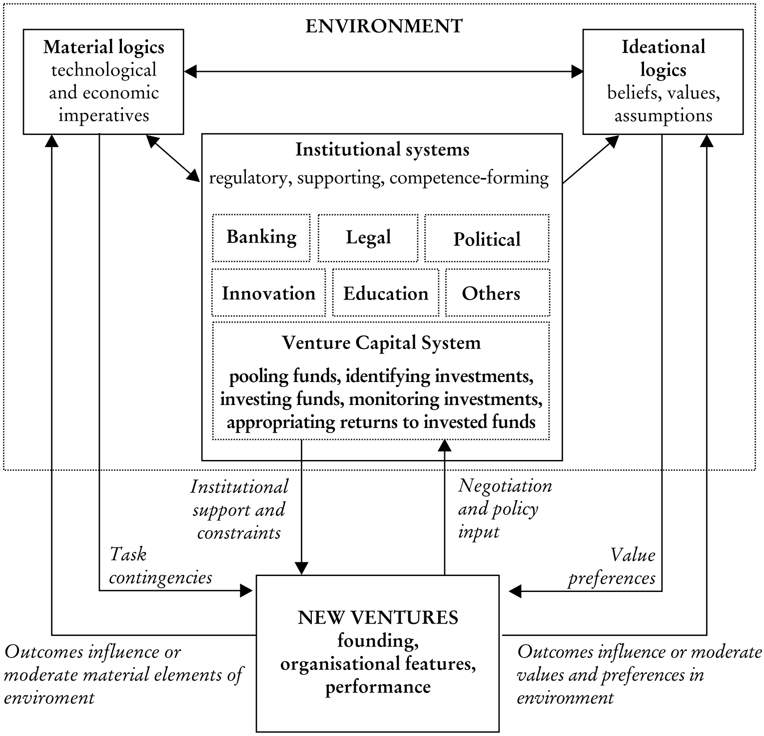
The zones' incubators hold 354 public listed companies, which account for 25.6 per cent of all public listed companies. The zones attract talent, with 2.12 million degree holders including: 140,000 with masters' degrees, 23,000 doctoral degrees and 21,000 overseas students. R&D/revenue ratio of the zones' enterprises reached 2.3 per cent, and accounts for one-third of total national R&D expenditures. There are now 534 incubators in China, with 39,491 tenant enterprises and 717,281 employees. Enterprises numbering 9,714 have graduated from the incubators. The incubators are supported by more than 14 national programmes, such as the National Natural Science Foundation, National Basic Research Programme of China, National High-tech R&D Programme, National Key Technology R&D Programme, and National Torch Programme.

There are 50 university science parks in China, with 6,075 tenants and 110,240 employees. The parks attract students: 80,000 higher education students, 11,000 masters' degree students and 1,706 overseas students. A total of 1,320 enterprises have graduated from the parks. The parks have created a total of 27.2 billion RMB revenue, 3 billion RMB profit and US$ 180 million exports. They host 1,084 research institutes and have generated 1,211 invention patent applications, of which 760 were granted. The parks received considerable support from government programmes: 201 projects and 200 million RMB. Of all the programmes, the Innovation Fund for technology-based firms is the most important: 103 projects account for 51 per cent of the funds received.

The VC investment is distributed across the country with the three most important areas being Beijing, Shanghai and Shenzhen. According to the China VC 2007 annual report (CVCRI 2007), there was US$ 1,007 million VC investment in Beijing, US$ 900 million in Shanghai and US$ 138 million in Shenzhen. Figure 5.7 shows the relationship between VC system, logics, institutional systems and new ventures. The VCs are in the big institutional systems including banking, legal, political, innovation. The VC system pools fund, identifies investments, invests funds, monitors investments and gains appropriate returns to invested funds. It provides institutional support to new ventures and also puts constraints on them.

China's recent improvement of venture policy shows the government pays much attention to the VC industry. The improved policies focus more on new and high-technology-based firms; reduce administrative burden of regulatory compliance; encourage incubation and increase fiscal incentives. In 2006, there were 319 registered PE firms. Figures 5.8 and 5.9 show the VC exit channels and the classification of exit by industry. They show that IPO takes up 31.9 per cent of total exits, trade sale occupies 20 per cent and secondary offers takes up 19.3 per cent. These three methods are the frequent VC exit channels. From the industry's perspective, 33.3 per cent exits are from Broad IT, another 33.3 per cent are from traditional industry, and the rest are from biotechnology, clean technology, services, etc.

Figure 5.7: *Framework Linking Institutions, Logics and New Ventures*

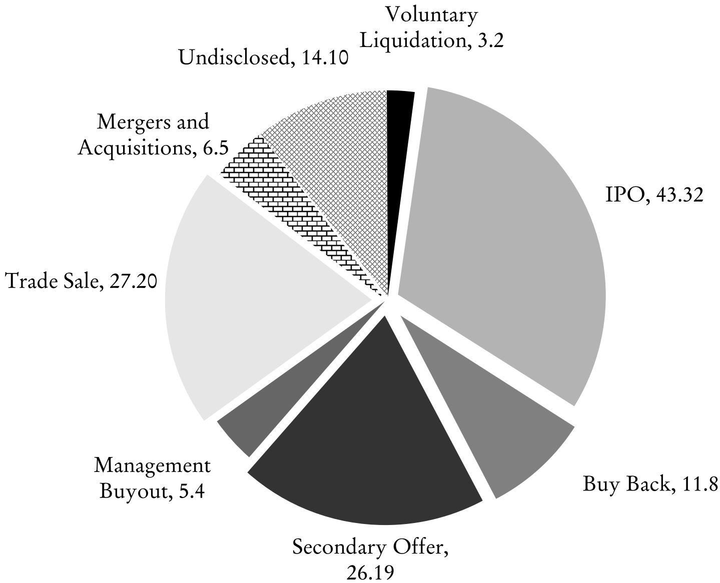


Source: White et al. (2005).

The role of VC in technology innovation is to help new firms overcome shortage in R&D investment, and shorten the time for technology transfer. Technology innovation with VC's input can be shortened to one to two years, comparing with general firms without VCs that took three–five years for technology commercialisation. Venture capital's participation can help build a better platform for further financing. The next case will demonstrate the VC's role in technology innovation.

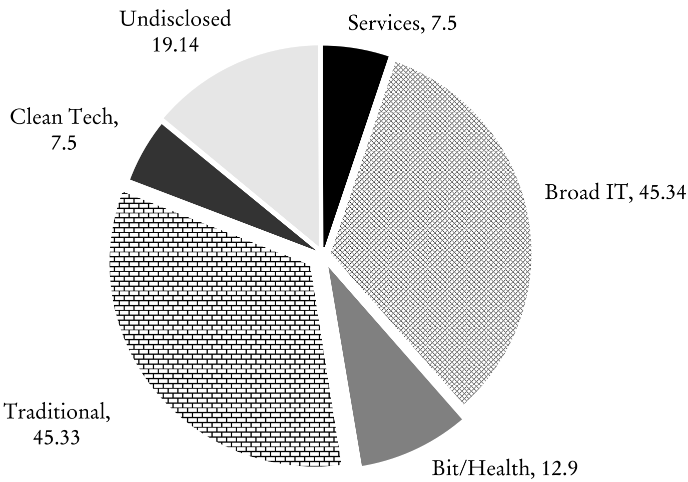
How VC promotes SME growth can be seen from the case of Vimicro, a technology company that is now listed in National Association of Securities Dealers Automated Quotation (NASDAQ). During October 1999–November 2005 Vimicro had three rounds of financing in six years. In October 1999, the Ministry of Information invested RMB10 million and Vimicro got an angel investment from

Figure 5.8: *VC Exits by Options and Case Number, 2008 (percentage)*



Source: Zero2 IPO Research Center (2008).

Figure 5.9: *VC Exits by Industry and Case Number, 2008 (percentage)*



Source: Zero2 IPO Research Center (2008).

a former president of UC Berkeley. In May 2000, there was second round investment of CAN$3.5 million by Canadian Power Pacific Venture Capital, and finally US$25 million investment from General Atlantic Partners in US and Fujitsu in Japan.

In this case VC provided four advantages for Vimicro: (*a*) Good reputation and finance platform for next financing; (*b*) Capital, reputation, good business model and ideas. (*c*) Acquiring senior talents. (*d*) Improved access to social resources.

In line with the National Innovation Fund, all the local governments in China established Local Innovation Funds on the basis of their actual situations. In Shanghai for example, 1,173 projects have been sponsored by the National Innovation Fund since 1999, amounting to 0.7 billion RMB. Meanwhile, the Shanghai Innovation Fund was established in 2000 and sponsored 3,166 projects by the end of 2008, amounting to more than 770 million RMB (Yu and Yang 2009). The Shanghai government has also established a high-tech SMEs Innovation Fund and introduced corresponding management measures to support the technology innovation of Shanghai high-tech SMEs.

Private capital refers to the savings of residents and the money in enterprises which hasn't been used for a long time and hasn't been transferred into investments and business activities. In recent years, China's actual private financial activities are rather active. And its volume is expanding gradually, which is accompanied by the following characteristics:

According to different transactions, financing purposes and rates, private financing can be divided into four types; low-rate mutual-aid loans; higher-rate credit loans; irregular intermediary loans; disguised internal fund-raising of enterprises. Some are large scale. In 2003, the absolute scale of national informal credit was between 745 billion RMB to 830 billion RMB according to the Central University of Finance and Economics' project group to 20 provinces in China. Data from rural fixed observation stations of the Rural Economy Research Centre, Ministry of Agriculture, showed that loans from banks and credit unions only accounted for 26 per cent of loan resources nationwide to farmers, while the loans from private sources accounted for 71 per cent in 2003.

Wenzhou, a city in Zhejiang province of China, has become one of the fastest growing regions for private capital. Incomplete statistics show that private capital flows have already reached 600 billion, increasing at an annual rate of 14 per cent (Zhang 2010). At present, private capital in Wenzhou is gradually shifting from industrial investment (real estate and energy) to financial investment (VC, PE) further expanding the channel for SMEs' financing.

The Second Board encourages SMEs to get money from the public and was established in late 2009. By February 2010, there were 54 listed SMEs; most of them are concentrated in four high-tech industries, namely, ICT, biopharmaceuticals, professional equipment manufacturing and electronics. Among them are 16 start-ups in ICT, accounting for 29.63 per cent of total listed enterprises; the numbers of listed enterprises engaged in areas of pharmaceuticals and biotechnology and professional equipment manufacturing were nine respectively, their shares reached 33.36 per cent; eight listed enterprises engaged in the area of electronics, accounting for 14.80 per cent of total listed enterprises; and six listed enterprises engaged in the area of petrochemicals, accounting for 11.11 per cent of total listed enterprises; while there were only six listed enterprises engaged in areas of social services, stationery and sports goods manufacturing and other industries, accounting for 11.10 per cent of total listed enterprises. There is no listed enterprise engaged in the areas of resource and environment technology, aeronautical and aerospace technology and so on (Luo 2010). We can see from the distributed architecture of listed enterprises that the majority are high-tech enterprises.

On 5 May 2009, the China Banking Regulatory Commission and the Ministry of Science and Technology jointly issued 'Guidance on Further Increasing the Credit Support for SMEs'. Intellectual Property Mortgage was defined as a financing measure that IP holders need to use property rights of invention patents, utility model patents, design patents which have been granted a patent certificate by State Intellectual Property Office as pledges, or, the brand-advantage enterprises use the exclusive rights of using a trademark which have been approved in strict accordance with the law by SAIC Trademark Office. This form of collateral allows the raising of bank loans in the usual way.

The State Intellectual Property Office has selected Haidian Intellectual Property Office of Beijing, Changchun Intellectual Property Office of Jilin and four other local intellectual property offices as the first pilot units for Intellectual Property Mortgage in order to help innovative SMEs solve financial stress and other problems (Song et al. 2010). The pilot units expect to reduce enterprises' financing costs of utilising intellectual property and build up a financing service platform of Intellectual Property (IP) between evaluating institutions and banks, mainly by using intellectual property as collateral, and providing supporting intermediary services as well as other measures.

Conclusions

This analysis shows how China's innovation financing system has been established and the way it has evolved over time. The four kinds of funding sources provide capital for companies at different stages. Innovation funds, high-tech zones, incubators and university science parks enter in the earliest period — the seed stage. In this stage the entrepreneurs may only have vague ideas of the future product space or be developing new technology that still hasn't been applied. Most companies in this stage spend much more than they generate revenues and thus display negative profit, which needs sufficient capital support. Innovation funds, high-tech zones, incubators and parks are not for the purpose of earning, but are to support innovation corresponding to the government's policy.

The VC funds invest in companies in the second period of the start-up stage, when the company shows market growth potential and has positive cash flow. The VC helps the company to expand more rapidly and shorten the time for technology transfer. Now the opening of the Second Board offers more opportunities for venture capital firms.

The majority of bank financing, however, is only available at the expansion and later stages of company development, with local governments acting as guarantors. As risk-averse institutions, banks were the main financers of new venture expansion, but essentially absent as financers at the seed capital and start-up stages of these ventures.

Two factors suggest that the role of the government in developing VC systems such as China's will continue to be significant and extend beyond simply creating appropriate institutions. First, the government has a strongly paternalistic view of the economy, and assumes that it both should and is able to provide direct guidance to emerging actors, such as VC firms. This takes the form, for example, of its identifying particular industries as priority sectors and providing incentives for investment in those sectors. As in other areas, the government is also concerned about foreign dominance, and will continue to do what it considers to be supportive of local VC firms.

Second, the lingering role of the government itself as an economic actor is still strong, as evidenced by the still significant number of enterprises held by local government holding companies. Local governments will continue to create direct and indirect ownership and control linkages to new firms being established in their jurisdictions. Rather than a clear separation of government from business, China is more likely to develop a business system similar to Singapore's 'state capitalism' with its government-linked companies (e.g. Lim 1996; Carney and Gedajlovic 2004). Local governments, rather than simply regulating activities within the VC system, will also participate in those activities through various forms of holding companies and investment agencies.

The new organisational forms that have emerged in China — the various forms of domestic VC firms, in particular — are not yet as effective as those in more developed VC systems in the US and Europe. They lack experience and expertise in selecting, monitoring and adding value to the ventures in which they invest. The government- and university-backed firms in particular must further align their internal structures and management systems with their business activities and requirements as investment managers. Such improvements are also critical for them to compete with the increasing number of foreign venture capital firms operating within China.

The government still has much work to do in strengthening and clarifying the regulatory, legal and other elements of the institutional systems that have an important impact on the VC system and its effectiveness in supporting new ventures and economic development. These include issuing relevant laws regulating VC firms, as well as carefully considering the types of policies for promoting VC and new ventures. We also recommend increasing coordination among government bureaus and reducing dysfunctional competition between, for example, MOST and the State Planning Commission.

From the perspective of R&D inputs and system output, China's innovation system still has a long way to go. The social and economic returns to R&D investment, as measured by available input and output indicators, are currently lower in China than in advanced OECD countries. Also the R&D input amount and practitioner number is low relative to China's economy and population. So we have some suggestions for China's NIS.

First, China should increase R&D inputs at a more rapid pace. China is almost the second largest economy in the world, while China's R&D input ranks only fifth. If one considers the population, the R&D per capital is much lower compared to advance countries. It indicates that although we have made much progress in the R&D input, we should increase the amount more rapidly.

Second, China should adjust the focus of R&D expenditure. Only about one-quarter of gross domestic expenditure on R&D (GERD) is devoted to basic research (6 per cent) and applied research; more than 70 per cent corresponds to experimental development. Also, a large proportion of the money invested in innovation is devoted to buy machines and software, the real R&D fund is less than one-third. The structure is unhealthy for sustainable and valuable innovation output. We should devote more to the basic and applied research from a long-term perspective, not only seek instant achievements through buying foreign technology and machines.

Third, the government should encourage companies to do independent innovation and support them through policy, funding and university cooperation. Companies are the main bodies to introduce innovation products and contribute to the society. They are the bridge between university and PRIs. The government can create a favourable environment for the companies to cooperate with universities and other institutions, to enhance innovation synergy. Also, the government can accelerate company innovation framework conditions including tax exemption or relief, IPRs protection and subsidies.

Fourth, the government should attach importance to human capital accumulation and the cultivation of high profile innovative talent. On the one hand, the government should enhance the input into education, especially innovative education, to cultivate students' innovation and practical abilities. On the other hand, companies should emphasise the cultivation of technological talents and build a long-term R&D team to support the company's technology innovation.

References

Carney, M. and E. Gedajlovic, 2004. 'Context, Configuration and Capability: Organizational Design and Competitive Advantage in Asian Firms', in K. Leung and S. White (eds), *Handbook of Asian Management*. New York: Kluwer, 85–127.

Child, J., 1994. *Management in China during the Age of Reform*. Cambridge: Cambridge University Press.

Chinese Academy of Sciences (CAS), 1997. 'Welcoming the Era of the Knowledge Economy and Building National Innovation System', working report, Beijing. Also in *CAS Bulletin* 3 (1998): 159–65 (in Chinese).

China Venture Capital Research Institute (CVCRI), 2007. *China VC Annual Report*. Beijing: Democracy and Construction Press (in Chinese).

Freeman, C., 1987. *Technology and Economic Performance: Lessons from Japan*. London: Pinter.

Gao, Jian, 2007. *Analysis of Innovation Activity in Chinese Companies*. Beijing: Tsinghua University Press (in Chinese).

Gu, S., 1999. *China's Industrial Technology: Market Reform and Organizational Change*. London: Routledge.

Lim, L., 1996. 'Southeast Asian Business Systems: the Dynamics of Diversity', in A. E. Safarian and William Dobson (eds), *East Asian Capitalism: Diversity and Dynamism*. Toronto: University of Toronto Press, 91–117.

Liu, Xielin, 2006. 'Dual Chinese Innovation System', *Science of Science and Management of S&T*, 27(2): 14–21.

Liu, Xielin and Steven White, 2001. 'Comparing Innovation Systems: A Framework and Application to China's Transitional Context', *Research Policy*, 30(7): 1091–114.

Lundvall, B-Å., 1992. *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.

Luo, Chan, 2010. 'The Development and Risk Analysis of Second Board', *Contemporary Economy* (in Chinese), 6(11): 125–27.

Ministry of Science and Technology (MOST), 1988. *China Science and Technology Indicators*. Beijing: China Statistics Press.

———, 2001. *Annual Report of Development on Hi-Tech Industry Development Zone 1991–2000*. Beijng: Scientific and Technical Documentation Press.

———, 2006. *China Statistical Yearbook on Science and Technology* (*2003–2006*). Beijing: China Statistics Press.

———, 2008. *China's Statistical Yearbook on Science and Technology*. Beijing: China Statistics Press.

Motohashi, Kazuyuki, 2006. 'China's National Innovation System Reform and Growing Science Industry Linkage', *Asian Journal of Technology Innovation*, 14(2): 49–65.

National Bureau of Statistics (NBS), 2008. *Report of National Innovation Survey of Industrial Companies (2007)*. Beijing: National Bureau of Statistics.

Naughton, B., 1994. *Growing Out of the Plan: China's Economic Reform, 1978–1992*. Cambridge: Cambridge University Press.

Nelson, R., 1993. *National Innovation Systems: A Comparative Analysis*. New York/Oxford: Oxford University Press.

Organisation for Economic Cooperation and Development (OECD), 2007. *Reviews of Innovation Policy: China*. Paris: Organisation for Economic Cooperation and Development.

Patel, P. and Keith Pavitt, 1994. 'The Nature and Economic Importance of National Innovation Systems', *STI Review*, 3(14): 9–32.

Song Wei, Jingjing Wang and Xiaoyan Song, 2010. 'Study on the Process and Solutions of Intellectual Property Pledge in China' (in Chinese), *S&T and Law*, (2): 62–65.

State Council of China, 2006. *National Long and Middle Range S&T Programming for 2006–2020*. 27 February. Beijing: State Council of China.

Steinfeld, E., 1998. *Forging Reform in China: The Fate of State-Owned Industry*. Cambridge: Cambridge University Press.

White, Steven, Jian Gao and Wei Zhang, 2005. 'Financing New Ventures in China: System Antecedents and Institutionalization', *Research Policy*, 34(6): 894–913.

Yu, Nan and Meng Yang, 2009. 'Local Innovation Fund Has Reached to 3.6 Billion in China', *Security Daily*, 16 December.

Zero2 IPO Research Center, 2008. *China Venture Capital Annual Report 2008*. Beijing: Zero2IPO Group.

Zhang, Heping, 2010. 'Private Capital in Wenzhou Has Reached 600 Billion', *Beijing Youth Daily*, 17 May.

6

South Africa

Michael Kahn

A significant part of the growth potential of the world economy for the coming decades resides in large emerging economies. Brazil, Russia, India, China and South Africa (BRICS) have such potential.[1] More than that, BRICS are thought of as having the capacity to 'change the world' by the threats and opportunities they represent from the economic, social and political points of views. The BRICS countries are of course heterogeneous in history, political, cultural and economic character. Three are commodity exporters: Brazil, Russia and South Africa; China is a large manufactory; India shows agility in software and services. Mexico, Egypt, Indonesia, Vietnam, the Philippines and Argentina wait in the wings.

The project 'National Innovation Systems of BRICS Countries' seeks to analyse the BRICS countries from the perspective of their development opportunities, as well as several common characteristics and challenges. Identifying and analysing these may help to uncover the possible paths for fulfilling their socio-political-economic development potential. The innovation system approach emphasises the role of actors and interactions in producing innovations and innovative activities. As such this is a return to the agency and linkage formalism of classical economics. The actors are anticipated to pursue rational agendas as they pursue market share and profit. The role of the state as actor and mediator is critically important in this discussion.

South Africa's system of innovation has deep roots back to the last quarter of the 19th century when the discovery of large diamond and gold deposits triggered its industrial revolution and codified its peculiar form of labour exploitation. Up to that time the Cape and Natal Colonies and the Boer Republics of the Orange Free State and the Transvaal had been largely agricultural in character.

The scientific and higher education institutions of the early 19th-century Cape Colony addressed health, the natural environment and the needs of administration. The challenges of mining, initially open-cast but later through the deepest shafts in the world posed new challenges of haulage, water management, energy and labour supply, and specific technical, scientific, health, logistical, and organisational skills. Local expertise in the science and technology (S&T) of ore separation developed. After the Anglo-Boer-South African War of 1899–1902 the Union of South Africa came into being as the political vehicle for minority dominance of the majority. The mining houses diversified into vertically and horizontally integrated empires that produced explosives, coal, mine equipment, food, and timber.

Participation in the First and Second World Wars further diversified the industrial base with the country becoming a supplier of material to both war efforts. Over the same period the state developed the infrastructure for energy supply, communications, and iron and steel production. It was as early as 1939 that capability in radar technology was initiated that laid the basis for future high-technology industries.

Uniquely among the Allies, 1948 saw the election to power of a right wing political party that had opposed entry into the War on the side of the Crown. The victory of the Afrikaner nationalists led to further codification of the racist agenda with consequent armed conflict and isolation.

The 'apartheid constructed crisis' (Kahn 2006) now began to evolve leading to four decades of low intensity civil war and regional conflict, at the end of which the country was self-sufficient in weapons of mass destruction and delivery systems, chemicals and munitions, military vehicles, energy, metals, wood, pulp and paper, and food.[2] Skills in reverse engineering proliferated, as for example, in enterprise software development and technologies to extend the lifetime of military aircraft. But the market for locally produced consumer durables remained limited in size as industry was constrained by the 'Dutch Disease' inherent in the sale of gold and other commodities, the mainstay of the 'minerals-energy complex' (Fine and Rustomjee 1997). Shielded by tariff walls and restricted by sanctions industry concentrated on medium-level technologies for import substitution.

Gross Domestic Product (GDP) per capita had been on a strong upward trend in the mid-1950s with the expectation of convergence with the wealthy countries of the north within a generation. This was not to be.

The reasons for this include rapid population growth, and state expenditure diverted to the inefficient duplication of infrastructure for 'separate development'. In addition was the cushion of Dutch Disease inherent with being the world's largest gold producer. The cushion was relative since rents were constrained by the gold standard. By the time the Rand was free to float the country was in the depths of financial and economic sanctions. Foreign and local fixed investment dried up. GDP per capita moved sideways. From 1970 real wages increased fourfold (Van der Berg 1989) and technological innovation substituted for the subsequent loss of labour (Fedderke 2001). This structural employment persists to the present day.

Nonetheless the financial services sector (today at 66 per cent the largest component of GDP) showed steady growth. The huge rents of gold production demanded particular skills of mine financing and risk management. The heart of early 20th-century Johannesburg was the Diagonal Street stock exchange, around the corner from 44 Main Street, the headquarters of the Anglo-American Corporation.

Triple helix interactions (Etzkowitz and Leydesdorff 2000) were a strong characteristic of the South African system of innovation, evidence being found in health research (animal and human), mining (Pogue 2006), and radar to list but three areas. Other examples of productive triple helix interactions were in agriculture generally and viticulture in particular so much so that the country is ranked 14th in the world for the registration of plant varieties. There was research cooperation across all sectors: state and academia; academia and private sector; state and private sector; sometimes all three. Actors and interactions were harnessed to prosecute a 'total strategy' for survival.

The government component of the triple helix largely resided in the science research councils, as well as some 50 department-based research institutes, including defence research and production facilities.[3] There were 36 higher education institutions divided by language, race and ethnicity but no engineering faculty for Africans.

The small system of innovation, driven by the apartheid constructed crisis of economic, social and educational exclusion produced world class science in a few fields such as catalysis, general and internal medicine, plant and animal sciences, mining engineering, metallurgy, electronic engineering and entomology and nurtured four Nobel Laureates in the early stages of their scientific careers. Two others obtained Nobel prizes in Literature and three for Peace.

Financial System Structure

The Mandela government assumed office in May 1994 with the task of redressing the legacy of apartheid and modernising the country's institutions and economy. It faced these challenges with a limited skills base, depleted treasury, the new rules of globalisation and open markets, and the high expectations of the electorate. Labour law was updated; affirmative action legalised; procurement policy oriented to require black participation; equity stakes in key sectors (public and private) were to be for 'designated groups'.

South Africa boasts an advanced and innovative financial services sector with the Johannesburg Securities Exchange (JSE) among the world top 20 in terms of market capitalisation. In addition to the JSE are the South African Futures Exchange (SAFEX) and the Bond Exchange. The Rand is a freely convertible currency with a daily carry trade running at up to five times the turnover of the JSE. Portfolio trading is an ever-present feature of the financial markets.

There is a well-developed system of law and contract, an independent judiciary and central bank, and a permanent Competition Commission. Tax collection is in the hands of the South African Revenue Services whose vigour and creativity saw a steady rise of the *fiscus* available to the democratic state.

With the ending of sanctions and the opening of markets the hope was that large volumes of foreign direct investment (FDI) would flow into the country.[4] To build an investor-friendly economy steps were taken towards macroeconomic stability, the reduction of real interest rates and inflation, and a less volatile exchange rate. The foreign chapter was closed and privatisation of state assets resumed with the government reducing its ownership in Telkom, and the Airports Company, as well as divesting itself of some smaller tourism, mining and forestry interests. Today the economy is regarded as strongly open, with the ratio of exports and imports to GDP standing at 70 per cent, a value that is high by world standards. If anything, capital exited the country as South African Multinational Corporations (MNCs) engaged in FDI in Africa and further afield, encouraged by changes in foreign exchange control, a desire to spread risk and falling rates of profit at home. Anglo-American moved its headquarters with its primary listing in London and the Johannesburg Securities Exchange is in Sandton, a suburb 10 kilometres to the north. Today there are no active mines beneath Main Street. Other listed companies such as

SASOL (Pty) Limited, SAPPI (Pty) Limited, Old Mutual, Naspers, and Standard Bank generate significant offshore revenues.

The country has not only lagged as a destination for FDI but inward FDI has mainly involved purchase of equity stakes or outright acquisitions as opposed to greenfield investment. The exceptions to this trend are in the automotive industries and iron and steel.

In essence, South Africa is a market economy that is in transition from four apartheid-era binding constraints:

1. Racialised job reservation and skills development
2. Foreign-exchange volatility and controls
3. Risk aversion
4. Anti-competitive behaviours

To these must be added the heavy burden of disease aggravated by the HIV/AIDS pandemic. Given the cultural and behavioral factors that have propelled the catastrophe it is an emotional matter to ask whether this should also be classed as a constructed crisis.

The constructed crisis facing South African society generally and industry in particular is the agenda of redress. This manifests through the Employment Equity Act (RSA 1998) and the Broad-based Black Economic Empowerment Act (RSA 2003). These Acts fall under categories 1 and 4 mentioned earlier.

Regarding skills one statistic suffices: in 2002 there were 246 black chartered accountants out of a national total of 19,757.[5] But by 2009 this number had soared to 4,145 of 28,483.[6]

In such straightened conditions every potential professional should be developed; no qualified professional should be lost. Regrettably neither of these conditions has been fulfilled; the flows from schooling remain constricted, many professionals have migrated to well-paying posts in the government, and skilled immigrants do not make up for the losses through emigration.

Until the late 19th century the colonial power had expected its Southern African dependencies to be largely self-financing. However, the rapid expansion of the diamond and gold mines generated demands for capital, labour and technology that could not be met locally. Large numbers of Europeans flocked into the Transvaal Republic and their political rights (or lack thereof) became the trigger for the Anglo-Boer-South African War fought to determine who would control this wealth. Once peace returned the necessary resources flowed into the now unified country to the extent that foreign capital acquired a two-thirds stake in the gold mines. Very close relations existed between the finance houses of the United States, Europe and South Africa from the earliest days. It is important to note that the bulk of mineral extraction was in private hands, with land ownership including mining rights. Mineral rights were not vested in the state.

The massive industrial undertakings of deep-level underground mining with its large workforce transformed the Witwatersrand and led to the growth of local financial service giants with massive concentration of wealth and power. By 1987, Anglo-American (mining, banking, insurance and diversified industrials) controlled 60.7 per cent of the Johannesburg Stock Exchange, Sanlam (insurance) 10.7 per cent and SA Mutual (insurance and banking) 8 per cent, a total of 79.5 per cent (McGregor et al. 2008: 55). Today these three giants still control 26 per cent. The large decline is the result of unbundling, application of competition law, relaxation of exchange controls and offshore transfers, the emergence of the state-owned Public Investment Corporation as a major shareholder in companies, and a steady increase in overt foreign ownership, up from 4.1 per cent to 21 per cent over the same period.

Concern with the power of monopoly capital has been a theme in South African politics for more than a century and has entertained theorists across the many political camps. The desire to put brakes on the mining houses led to the 1942 establishment of the Industrial Development Corporation (IDC) that continues to play an important role in assisting industrial start-ups.

A set of interviews with senior banking executives provides the following thumbnail sketch of the way that enterprises fund their expansion. The main source of company finance is from internal reserves; these may be used to leverage bank loans since the bank can value the assets of the firm as collateral. This implies that where fixed assets cannot be identified such (high-risk) loan finance will not be forthcoming. In practice, firms younger than three years will find it extremely difficult to access bank finance and will have to resort to self-financing. This typically takes the form of funds created by mortgaging a home, or borrowing from family and friends.

State financing of private sector activity today flows through a number of routes — the IDC, Land Bank, Public Investment Corporation, National Empowerment Fund (to promote the Broad-based Black Economic Empowerment Act, and Department of Trade and Industry (DTI) (Box 6.1).

Box 6.1: *DTI Incentive Schemes*

Enterprise Investment Programme (EIP)
It was launched on July 2008 and prospective applicants can now access the Programme Guidelines and Application Forms for the Tourism and Manufacturing sectors.

Black Business Supplier Development Programme (BBSDP)
The BBSDP is a 90:10 cost-sharing grant, which offers support to black-owned enterprises in South Africa.

Critical Infrastructure Programme (CIP)
CIP is a non-refundable, cash grant from 10% to 30% of the total development costs available upon completion of the infrastructure project.

Business Process Outsourcing and Offshoring (BPO and O)
The BPO and O Investment incentive comprises an investment grant ranging between R37,000 and R6,000 per seat and a training support grant towards costs of company specific training up to a maximum of R12,000 per agent. The BPO Investment incentive is effective from 6 December 2006 to 31 March 2011.

Sector Specific Assistance Scheme (SSAS)
The SSAS is a reimbursable cost-sharing grant scheme whereby financial support is granted to nonprofit business organisations in sectors and sub-sectors of industries prioritised by the dti.

Co-operative Incentive Scheme (CIS)
The CIS is a 90:10 matching cash grant for registered co-operatives. The maximum grant that can be offered to one co-operative entity under the scheme is R300,000.

Source: DTI, http://thedti.gov.za (accessed 5 May 2010).

A second DTI thrust is the Small Enterprise Development Agency Technology Scheme. This brings together the functions of technology transfer and various technology incubators covering stainless steel, platinum, aluminium, base metals, furniture, medical devices, biotechnology, software, essential oils, bio-diesel and the automotive industries.

The third thrust (Box 6.2) constitutes the well-developed Technological Human Resources for Industry Programme (THRIP) founded in 1993 and the Support Programme for Industrial Innovation also of 1993.

Other DTI schemes are directed towards export promotion, attracting FDI and the Coega Industrial Development Zone on the southeast coats.

As mentioned earlier, over more than a century the state developed a range of key industries that today constitute the state-owned entities (SOEs), some of which have since been privatised. Perhaps the

Box 6.2: *DTI Support for Innovation Activities*

Technological Human Resources for Industry Programme (THRIP)
THRIP is managed by the National Research Foundation (NRF) on behalf of DTI. THRIP focuses on projects that specifically promote and facilitate scientific research, technology development and technology diffusion. Industry and the DTI share the costs on a R2 to R1 basis. DTI support may be doubled if a project supports certain THRIP priorities.

Support Programme for Industrial Innovation (SPII).
SPII is administered by the Industrial Development Corporation (IDC).
1. Matching Scheme (maximum grant R1.5 million)
Only small and medium sized companies (SMEs: as determined by the Small Business Act) qualify. 50% grant with no payback, for innovative development of new products and processes.
2. Partnership Scheme (PII) (grants larger than R1.5 million)
Open to all companies, which make provision for a 50% grant, and a payback mechanism based on sales from the new product or process. A nominal internal rate of return (IRR) of 19% to the Partnership Scheme is aimed at.
3. Product Process Development Scheme
This scheme is only for small enterprises per the National Small Business Amendment Act, 2003. Taxable non-repayable grant between 65% and 85% of the total qualifying costs incurred in pre-competitive development activity to maximum R500,000.

Source: DTI, http://thedti.gov.za (accessed 5 May 2010).

best-known of these were SASOL and ISCOR. SASOL started out in 1950 as a fully state-owned entity that used the Fischer-Tropsch process to synthesise liquid fuels from coal feedstock. It gradually achieved economies of scale as well as the local supply of all the necessary catalysts. The oil shocks of the late 1970s followed by the Iranian Revolution that restricted oil supply to South Africa led the government to embark on a 10-fold increase in SASOL's output. The cost of this expansion was beyond government capacity since it had committed its resources to armaments programmes. Accordingly, SASOL was privatised in 1979 through an Initial Public Offering (IPO).

In similar fashion the 1989 privatisation of the Iron and Steel Corporation (ISCOR) saw it eventually become part of the international Arcelor Mittal Group, while the state telecommunications utility Telkom is now 70 per cent privatised.The arms industries that operated under the Armaments Corporation of South Africa (ARMSCOR) were largely transferred to a new SOE, Denel (Pty) Ltd, and many of its subsidiaries are now partly foreign-owned by Saab, British Aerospace and Zeiss, to name but three. Other SOEs include electricity utility ESKOM, state transport utility Transnet, the Airports Company of SA (at one stage 30 per cent owned by Aeroporto di Roma), SA Ports Authority, SA Post Office, the State Information Technology Agency, IT service provider Arivia.kom and the Air Traffic Navigations Services. In theory, these entities are self-financing through the retention of profits. In practice, their losses and expansion needs are often made good by treasury grants.

Many of these entities have been the source of considerable research and development (R&D) and innovative product development with Denel, SASOL and ESKOM, as well as its ill-fated Pebble Bed Modular Reactor (PBMR) being leading sites with in-house laboratories and test facilities. Spillovers from ARMSCOR and Denel have made their way into local electronics, software development and system integration technology companies.

Innovation Activities

The broad input and output characteristics of the system of innovation are provided by the time series of Organisation for Economic Cooperation and Development (OECD) Frascati Manual–compliant R&D surveys (HSRC 2011a) and the 2002–2004 OECD/Eurostat compliant innovation survey (HSRC 2011b). In addition are the other output indicators from education statistics, patent and publication and plant varieties databases.

R&D is an important innovation activity. It is of course not a prerequisite for innovation to occur, but is certainly an indicator of where it is likely to occur. The series of R&D surveys provides useful insight into the way that activity and funding is shifting over time. In 1991–92 the gross expenditure on research and development (GERD) to GDP ratio stood at 1.04 per cent (DNE 1993) or 0.86 per cent if adjusted for changes in GDP (OECD 2008). In survey year 2006–07 GERD amounted to PPP$ 4.5 billion giving a GERD:GDP ratio of 0.95 per cent having risen from 0.73 per cent in 2001–02. In 2006–07 government laboratories accounted for 20 per cent of GERD, universities 20 per cent and the business sector 60 per cent. This may be compared with the 27 per cent, 25 per cent and 48 per cent of 1991–92 respectively. There is an apparent shift from the public sector towards the business sector though this may be less marked once the vast expenditure on the then technology demonstrator PBMR is set aside. This shows up in the large flow of funds from the government to the business sector in which PBMR is recorded.

As noted in the 1991–92 R&D survey the then increase in BERD was partly accounted for by improved business sector coverage. This large role of the business sector is unusual among emerging economies, the more so as the bulk of BERD is conducted by domestic firms, not MNCs as is the case in other emerging economies such as China, Hungary, Mexico and Poland. This process of incremental improvement in the register of R&D performers in the business sector is continuous. In particular the services sector has now been surveyed with the finding that it makes up a significant proportion (27 per cent) of business expenditure on R&D (Kahn and Hounwanou 2008).

The next matter for inquiry is to examine how the sources of funds for R&D have shifted over time. The 1991–92 survey shows that the government provided 52 per cent of funds, business 47 per cent and 'foreign/other' 1 per cent. For 2006–07 (Table 6.1) the situation is markedly different — while business funding at 46 per cent is essentially unchanged, the government share, PBMR included, is now smaller at 41 per cent while the 'foreign/other' stands at 15 per cent. The 'foreign/other' flow of funds is mainly towards business and higher education with a strong thrust for the funding of clinical trials phases 1 through 3. This suggests that the earlier speculation of a reduced public performance role is mirrored in reduced funding flows.

A number of comments are in order. The first is the large flow (ZAR 1.8 billions) from government to business. This is not an indication of R&D collaboration between government and business but is largely accounted for by the ZAR 1.2 billion transferred to PBMR through the Department of Public Enterprises. The second observation is the nearly ZAR 1 billion flowing to business from abroad, a quantum that largely goes towards clinical trials (Kahn and Gastrow 2008). The third aspect is the large flow from business to higher education at 20.6 per cent of higher education expenditure on R&D (HERD) in 2006–07, a value among the highest in the world. This reduced to 14 per cent in 2007–08 while government support to higher education rose to 76 per cent of HERD. Some of the funds from business are for clinical trials but a significant portion goes towards contract research and student support, in which role business substitutes for what in other countries is a government responsibility. The huge rise

Table 6.1: *Funders and Performers of R&D, 2006–07 (thousands of ZAR)*

Performer Source	*Business*	*Government Departments*	*Higher Education*	*Not-for-Profit*	*Science Councils*	*Total*
Own funds	6,185,887	549,896	1,759,499	14,974	305,577	8,815,833
Government	1,764,448	387,109	567,635	29,816	1,829,383	4,578,391
Grants	1,299,208	356,130	NA	17,352	1,146,192	2,818,882
Contracts	465,240	30,979	NA	12,464	683,191	1,191,874
Agency funding	NA	NA	567,635	NA	NA	567,635
Business	228,432	13,067	682,493	24,339	265,441	1,213,772
Other South African sources	87,311	19,623	10,473	24,736	23,449	165,592
Higher education	1,657	9,351	5,265	2,722	583	19,578
Not for profit	18,239	260	4,378	19,100	22,846	64,823
Individual donations	67,415	10,012	830	2,914	20	81,191
Foreign	977,087	51,660	278,708	118,673	320,868	1,746,996
Parent Company	337,919	NA	NA	NA	NA	337,919
Foundations	4	NA	NA	NA	NA	4
All sources	639164	51,660	278,708	118,673	320,868	639,164
Total	9,243,165	1,021,355	3,298,808	212,538	2,744,718	16,520,584

Source: HSRC (2011a).

in government support is reflected in a rise in basic research from 18 per cent to 20 per cent of the GERD over 2006–07 to 2007–08.

A third matter of interest is to search for obvious shifts of emphasis in the funding of the various fields of science (DNE 1993; HSRC 2011a). What this shows is that engineering sciences declined from 34 per cent to 21 per cent while health sciences increased from 7 per cent to 15 per cent. These are large changes indeed whose understanding requires further inquiry. Social sciences and humanities showed a small decline from 14 per cent in 1991–92 down to 11 per cent in 2006–07. The figure was 10.2 per cent in 2001–02.

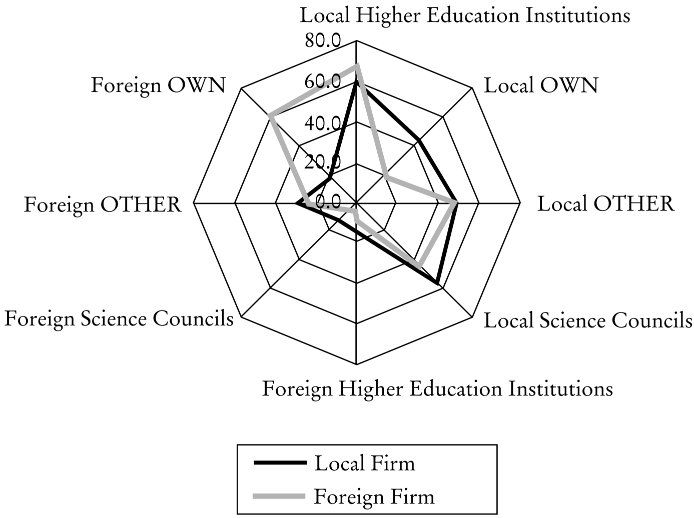
Another very useful indicator of R&D is its categorisation in terms of socio-economic objectives (SEOs). These speak to the purpose underlying R&D, so for example, a company might engage in software engineering R&D with applications to defence, or internet security or point-of-sale devices. There is no field of science labeled as defence. Unfortunately, however, the SEO categorisation of R&D of the 1991–92 survey is incompatible with those from 2001–02 onward. In particular, defence R&D was counted as part of 'manufacturing' and cannot be separately identified. Accordingly the longest time period across which one may compare SEOs is 2001–02 to 2006–07.

The SEO data is provided in the respective survey reports. Comparison shows a very sharp drop in mineral resources R&D from 12.7 per cent to 5.6 per cent; defence is down from 9.3 per cent to 6.6 per cent; commercial services up from 3.8 per cent to 8.4 per cent and surprisingly society up from 12.2 per cent to 16.5 per cent. The interpretation would be that defence is down is to be expected given the ongoing problems in the state defence production sector; the increase in commercial services R&D arises from improved survey coverage. But the huge drop in mineral resources is strange all the more so given the commodity boom in which local companies should have played a significant role. The rise in society is in large measure driven by social science research responses to the HIV pandemic.

Since 2004–05 the R&D surveys have included an item on collaboration in R&D between firms on the one side and higher education (local and foreign) and government laboratories (local and foreign) on the other (Figure 6.1).

The item on collaboration is designed to determine the existence of collaboration rather than its scale or purpose. For the firms that returned information on collaborative R&D one finds high levels of collaboration by both local and foreign firms with the universities and

Figure 6.1: *R&D Collaboration by Firms, 2004–05*



Source: Author.

government laboratories. Other behaviours are as might be expected, namely, that foreign firms tend to collaborate more with firms abroad than local firms; also that local firms have stronger connections with the local government laboratories than do foreign firms. This reflects both sectoral activity and historical relationships.

What of innovation itself? The macro-level picture from the Innovation Survey 2005 (DST 2008a) is that 52 per cent of firms claimed to disseminate innovations. This is a level higher than the European Union (EU) average with the country ranked third after Denmark and Ireland. These innovations are predominantly incremental in nature and largely involve changes in processes with industry rather more innovative than services. Ten per cent of innovating firms declare that they have introduced innovations 'new to the market', 12 per cent declare innovations 'new to the firm', and the remainder operate with marginally modified products and processes. As is similar in many Latin American countries, the bulk of innovation expenditure is devoted to the purchase of machinery, equipment and software (R8.5 billion and R9.6 billion for industry and services sectors respectively). Expenditure on R&D, whether intramural or extramural is at much lower levels (Table 6.2) with intramural expenditure totaling

Table 6.2: *Expenditure on Innovation (R millions)*

	Total	*Manufacturing*	*Services*
Intramural R&D	5.7	3.2	2.5
Extramural R&D	2.2	0.7	1.5
Machinery, equipment & software	18.1	8.5	9.6
Acquisition of other knowledge	1.8	0.2	1.6

Source: Blankley and Moses (2009).

R5.7 billion and extramural R2.2 billion. The intramural expenditure is lower than that recorded in the 2004–05 R&D survey that obtained a value of R6.8 billion. Such differences between innovation and R&D surveys are common, though the tendency is for innovation surveys to overestimate rather than underestimate. What is also interesting is to note the smaller extent of extramural R&D for manufacturing, at 23 per cent of the total, while for services the comparable figure is 38 per cent.

For other indicators of innovation activities, e.g. R&D, patenting, registration of designs and copyright, lower levels are reported than in the EU.

We move next to the factors that hinder innovation (Table 6.3). Of the top five factors three are financial — lack of funds within the firm;

Table 6.3: *Factors that Hinder Innovation as Reported by Innovative Enterprises*

Factor	*Total*	*Manufacturing*	*Services*
Lack of funds within enterprise or group	29.1	32.0	26.6
Lack of finance from external sources	18.7	16.3	20.7
Innovation costs too high	22.8	15.4	29.3
Lack of qualified personnel	20.4	15.0	25.1
Lack of information on technology	3.5	5.9	1.3
Lack of information of markets	3.3	1.0	5.2
Difficulty in finding cooperation partners	4.0	5.4	2.8
Market dominated by established enterprises	23.2	14.5	30.9
Uncertain demand for innovative goods or services	9.5	3.3	14.9
No need due to prior innovations	3.0	1.2	4.7
No need because of no demand for innovations	0.7	1.0	0.4

Source: Blankley and Moses (2009).

high costs of innovation, and lack of external sources of funds. The second factor is to a large extent covered in the funding limitations.

The matter of financial support received from the government is displayed in Table 6.4.

Table 6.4: *Innovative Firms that Access State Funds*

	Total	*Manufacturing*	*Services*
Metros and municipalities	0.0	0.0	0.1
Provincial government	0.2	0.3	0.1
National government	2.6	5.0	0.4
National funding agencies	3.6	6.4	1.1
Foreign government/public sources	0.1	0.1	0.0

Sources: Blankley and Moses (2009).

The survey reports extremely low levels of financial support reaching firms from the government, especially to the service industries, pointing to an innovation system that is isolated from provincial and local government. No data on the relative size of these contributions is available from the survey. Suffice it to note that 6.2 per cent of manufacturing firms claim to receive support from the government in one way or another. This linkage is much lower than in the EU.

These very low levels suggest a disconnect between firms and the government that is somewhat at odds with the findings in regard to R&D collaboration. Collaboration partners involved as sources of innovation mainly involve other firms, both as suppliers and customers. In line with the international pattern universities and government laboratories are mentioned as sources of innovation by fewer than 10 per cent of respondents.

Lastly we consider the claim that the majority of innovating firms have engaged in significant organisational changes. The proportion of firms claiming this type of innovation is the highest for all countries that report on their innovation surveys. An explanation for this phenomenon may lie in the considerable changes firms have faced under the modernising agenda of the state: the legislative changes include fundamental labour rights and dispute resolution, employment equity, unemployment insurance, preferential procurement, broad-based black economic empowerment, competition and environmental protection. This has pushed innovation as well as adding to the cost of doing business.

Financing Innovation Activity

There is considerable debate regarding 'what counts as innovation'. For our purposes innovation activities include both technological and non-technological innovation in the business sector. Following the OECD/Eurostat definitions, innovation activities include but are not limited to the following:

- R&D
- Commercialisation
- Product and process development
- Patenting and other forms of intellectual property protection
- Human resource development and specialised training

A range of innovation policy instruments supports such activity directly and indirectly, *ab initio* or *post facto*.

The government, through a 2007 amendment to the Income Tax Act, increased the tax deductibility of expenditure towards R&D. This is an indirect incentive intended to promote additionality and ultimately innovation. The Act specifies that capital expenditure for R&D may be written down in three years in the ratio (50:30:20), and that labour and current expenditure may be deducted at 150 per cent, up from the previous 100 per cent. The incentive excludes the following expenditures:

- Exploration or prospecting
- Management or internal business processes
- Trade marks
- The social sciences or humanities or
- Market research, sales or marketing promotion

The law requires the minister of S&T to report to Parliament on an annual basis advising it of the direct benefits of the R&D activities (that benefited from the incentive) in terms of economic growth, employment and other broader government objectives, as well as declaring the aggregate expenditure (DST 2009). Based on the value of business expenditure on R&D of the 2006–07 survey the subsidy inherent in this incentive could have been as high as R2.25 billion for that period. The first report on the effectiveness of the R&D tax incentive covered the period November 2006 to September 2008 and received 80 applications totaling R764m (of which R76 million is capital expenditure) with 56 per cent concentrated in the chemical sciences sector, or SASOL. If granted in full the applications would result in an incentive of R110 million, far below expectation.

It seems that the bureaucratic complexity of the claims procedure, and exclusion of social sciences and humanities, significantly reduces the claims of the service industries. In addition start-ups and prototype entities that have yet to declare a profit, e.g. the PBMR project, cannot claim for the tax rebate.

Until 2003 core funding from the Department of Education to higher education included a 'blind' component for the conduct of R&D of around 15 per cent of the total. This might be regarded as an indirect incentive towards R&D. When a new funding formula was instituted this component was terminated and the resulting shortfall made good by adjusting the value of the grants for scientific outputs: production of masters and doctoral students, and recognised publications. In the latter case the grant is payable against the dissemination of a publication in a journal on the approved list of the Department. This list is updated from time to time and includes a large number of peer-reviewed South African journals as well as those indexed to the Thomson-Reuters Web of Science. The current value of the subsidy is in excess of R100,000 per item that translates into more than R1 billion a year. The grant is only payable to higher education institutions and is an important source of their income. No such subsidy applies to the state laboratories or the private sector. The higher education institutions are free to allocate whatever proportion of this subsidy income to the research account of the staff person who produced the publication. No personal benefit may arise from the subsidy award. In a sense the universities now have to earn the research subsidy and they do this through the production of graduates and publications. One might say that the rules of academe have shifted: publish or perish has been replaced with 'publish or the university will perish'. Those academics that do not publish may face salary ossification.

The other instruments supporting innovation are all direct in nature. Two were mentioned previously, namely the DTI Technological Human Resources for Industry Programme (THRIP) and Support Programme for Industrial Innovation (SPII). We turn first to the programmes of DST.

> The Department of Arts, Culture, Science and Technology (DACST) introduced the Innovation Fund (IF) in 1997 and the Biotechnology

> Regional Innovation Centres (BRICs) in 2001, that are now merged into the Technology Innovation Agency (TIA). The IF and BRICs provide funds that are subject to open competition to any innovation system actors. 'The Innovation Fund is mandated to promote technological innovation through investing in late-stage research and development, Intellectual Property protection and commercialisation of novel and inventive South African technologies' (Innovation Fund 2010: 12).

Its main thrust is through the Technology Advancement Programme (TAP) that grants up to R 5 million annually for three years to projects involving technological innovation with a large component of R&D. The intention is to develop new industries, promote lateral migration of technologies from the commodity sectors, and enable health, social or infrastructure initiatives. TAP supports research consortia and seeks compliance with Black Economic Empowerment legislation.

In the early years of the IF key thematic areas were promoted with annual calls for proposals. Currently the fund is more catholic and accepts proposals on a continuous basis in all fields. Finance is in principle available for all stages of the development cycle including what are termed 'venture capital loans' (Seed Fund) and assistance towards the cost of patenting. Since inception the IF has invested some R 1.1 billion in 232 projects (Innovation Fund 2008) with the major beneficiaries being higher education (R318 million), science councils (R355 million) and manufacturing (R459 million).

The 2006–07 and 2007–08 Innovation Fund Annual Reports highlight investments in photovoltaics, an environmentally friendly high power laser paint stripper for aerospace application, the 'Joule' six-seater electric car, and Industrial Plant Simulation software. In 2007–08 35 projects were in operation and another eight new ones totaling R81 million of TAP resources were approved. This quantum may be compared with the more than R120 million committed annually a decade ago, suggesting evidence of a slowdown (Innovation Fund 2008: 37). There has been a marked shift of applications towards the private sector; in the early years the science councils took the major proportion of funding. The reasons for this shift may well lie in the weakening of scientific capacity in the science councils.

In 2007–08 the seed fund invested R72 million. Major investments include R57 million in Geratech and R40 million in Optimal Energy (the electric car). The first exit from a seed fund investment was the disposal of shares in Red Lab Five that yielded a claimed 65 per cent internal rate of return (IRR) on a R780,000 investment. This is the only published data on seed fund VC investment and it is unknown whether the IRR is based on discounted values or whether the full cost of investment was included.

Then there are the DST BRICs (not to be confused with the Goldman Sachs BRICS), the Biotechnology Regional Innovation Centres. The BRICs arose from the 2001 Biotechnology R&D Strategy and operate as trusts that annually disburse some R150 million to applicants from business, higher education and the science councils.

In late 2008 legislation was passed to set up a new statutory body — the Technology Innovation Agency (TIA) — intended to promote the commercialisation of R&D. At the time of writing the TIA was in the process of settling down and rationalising its inherited project portfolio of Innovation Fund projects, the four Biotechnology Trusts, four technology incubators, and a rapid prototyping facility. Not an easy task.

The VC industry and associated angel investors are small players in comparison with these levels of funding. The common wisdom is that VC such as it is seeks projects that are already revenue generating so that there is a swift prospect of capital return and exit.

> The KPMG/South African Venture Capital Association 2009 survey defines venture capital to involve seed capital, start-up and early stage funding for research, evaluation and development of a concept or business before the business starts trading. Such funding is 'for new companies being set up or for the development of those which have been in business for a short time (one to three years)' (KPMG/SAVCA 2009: 11).

The survey covers private equity (PE) investment, viz. investments into non-listed entities. The government (18 per cent) through Business Partners, the successor to the Small Business Development Corporation, and pension funds (18 per cent) is the largest source, with individuals at 3 per cent and banks only at 2 per cent. Of the total unrealised PE investments 2 per cent was targeted as seed capital and 4 per cent for early stage finance. New seed capital investment in 2008 was a mere R29 million. Private equity favours late stage investment where a return is assured; the money back multiple stands at 2.3 times.

The survey also repeats the concern that there remain ' … concerns that relate to certain tax and exchange control regulations which impact on the ability of our local Fund Managers to create value both in South Africa and the broader sub-Saharan Africa region. In addition, these regulations hamper the country's ability to attract FDI and retain and benefit from existing human capital. SAVCA is currently engaging with both the South African Reserve Bank and National Treasury on these matters' (KPMG/SAVCA 2009: 30).

For PE early stage VC is a minute consideration. A significant emerging player is the Industrial Development Corporation Venture Capital Strategic Business Unit (Box 6.3) that in 2007–08 invested some R62 million in five projects with the intention of committing a total of R250 million over five years.

The Industrial Development Corporation Venture Capital Small Business Unit (IDC VC SBU) works closely with the technology transfer offices of the universities. It selected the five projects out of a total of 132 enquiries and some 73 business plans.

The IDC VC SBU grew out of the previous Wholesale Venture Capital Department that developed three technology VC funds; a biotechnology-focused VC fund; the New Africa Mining Fund focused on early stage exploration and mining projects; and the

Box 6.3: *The Industrial Development Corporation Venture Capital SBU*

The SBU focuses specifically on technology-driven businesses in the very early seed or start-up phases of their development. The products or services being developed should be commercially viable and should present a unique solution to an existing, identified market need. Projects of interest are in:

- Information technology (mainly software development); E-commerce (software and hardware applications);
- Telecommunications (software and hardware applications in mobile, fixed-line, satellite and virtual communications networks);
- Electronics (e.g. in the hi-tech security industry and medical devices);
- Specialist engineering products (e.g. automotive industry applications, production systems);
- Financial services;
- Mining technology;
- Other selective technologies (e.g. chemistry, biotechnology).

Finance is provided as risk sharing equity contributions, with IDC acquiring a significant minority shareholding in the business in line with the risk assumed by IDC.

Source: http://www.idc.co.za (accessed 10 May 2010).

Women Private Equity Fund. During 2007–08 the funds exited from seven underlying investments, returning close on R500 million to investors. The IDC has been entirely self-funding since its inception six decades ago.

The second significant player is Bioventures in which IDC has an equity stake. Bioventures was founded in 2001 and enjoys other investors such as the International Finance Corporation, insurance giant Sanlam and Real Africa Holdings. By 2005 Bioventures declared itself closed having committed R55m of its R80m reserves to eight start-ups selected from 300 applicants. The start-ups include firms spun out of universities, the Council for Scientific and Industrial Research (CSIR) and wholly private ventures. Investments range from R2m to R12m.

Entrepreneur Mark Shuttleworth founded HBD Venture Capital in 2000 with some of the proceeds of the sale of Thawte to US Verisign. HBD invests in early stage South African companies with high growth potential. Given its origins HBD specialises in ICT solutions and has already exited from two: Mybeat and Red Five Labs. HBD launched a second fund in 2006 that invests between R10 m and R25m in companies that have no less than six months sales history and illustrate a sound equity growth prospect. HBD seeks to exit within five years.

Mention should be made of the company VenFin that was a stand-alone PE and VC investor with assets in the order of $1.1 billion mainly in South African ICTs and in China. VenFin de-listed from the JSE and is part of the publicly listed firm Remgro. Its portfolio included many well-known ICT companies and renewable and alternate energy start-ups seeking equity in businesses that;

- Possess proprietary intellectual property that provides barriers to entry;
- Have proven technologies or present minimal technology risk;
- Have the potential for internationalisation;
- Have a strong and committed management team with a proven track record;
- Venfin understands and where its team of investment professionals can add value; and
- Represents an opportunity that has the size, or has the potential to grow to a size, sufficient to have a meaningful impact on Venfin's net asset value.

Venfin was a major shareholder in Johanna Solar, a company based on research in photovoltaics originating at the University of Johannesburg and that benefited from early stage research Innovation Fund financing from the government. Robert Bosch of Germany is now the majority shareholder in Johanna Solar.

These examples show that financial instruments exist to support companies from their start-up phase, through the micro enterprise phase all the way up to large enterprises. Innovation Survey 2005 offers some further gradation regarding the availability of funds from the perspective of established firms. But a caveat is in order: innovation surveys by design exclude start-ups, and in the case of Innovation Survey 2005 that is based on a sample drawn from a taxpayers register, non-revenue generating firms are also excluded.

Size matters in respect of the propensity to conduct R&D and the propensity to innovate — the U-shaped curve of Aghion and Howitt (2006) provides the statistical evidence to support this claim. Interpreting Innovation Survey 2005's published data is not straightforward since one is dealing with weighted results from the sample frame (Blankley and Moses 2009). Table A2.20 (ibid.) provides information on the factors hampering innovation activities. Combining this data with Table A2.1 (ibid.) shows that the lack of internal funds is an obstacle to

- 16 per cent of innovating size class 1 firms
- 28 per cent of innovating size class 2/3/4 firms

This pattern is borne out at microdata level. Large firms are more able to finance innovation internally than smaller firms.

Second, lack of external funds is an obstacle to

- 14.6 per cent of innovating class 1 firms
- 18.9 per cent of innovating class 2/3/4 firms

This accords with their perceptions regarding the cost of innovation, namely that high cost of innovation is an obstacle to

- 16 per cent of innovating class 1firms
- 23 per cent of innovating class 2/3/4 firms

This discussion has already covered the topic of financing instruments and firm size.

The matter of financing start-ups, spinouts, expansion, innovation, and even mergers and acquisition gives rise to strong opinions in South Africa. One view has it that funds are simply unavailable; the counter is that the country is awash with money and it is simply lack of skill or risk appetite that leads potential entrepreneurs to claim they are strangled. Of course the truth lies somewhere between these extremes.

This picture that emerges suggests that funding instruments cover the entire swathe of funding requirements. If the project makes technical and business sense it will be funded. Entrepreneurs who abandon the hope of local funding and take their ideas abroad may be doing so through impatience or because of unhappiness with the country's foreign exchange regulations. It is worth diverting to this matter for a moment. Since the state of emergency of 1960 the Rand, though freely convertible has been subject to exchange control. While the exchange control limits on capital transfers have been raised core principles remain steadfast. Among these was the decision through a High Court precedent that a patent is capital and its disposal is thus subject to Reserve Bank control. This interference in the free flow of ideas was viewed by many as an unacceptable burden on business and is among the reasons why local inventors did not seek to exploit their ideas in the domestic market. A landmark judgement in early 2011 has overturned the interpretation that patents constitute financial capital, so that in principle the barriers have been removed. It is yet too soon to determine what the real effect of the ruling will be.

How effective are the individual instruments? Here one relies on the various self-assessments that the funders publish. Recalling that our definition of innovation activity included R&D and human resource development, we start with THRIP.

The Department of Trade and Industry set up THRIP in 1993 that is now managed by the National Research Foundation. Its original aim was to provide additional funding to boost enrolments in engineering departments and to reduce high failure rates through intervention from secondary school through to university. By 1995 these aims had broadened from a narrow focus on engineering studies to technology transfer from universities to industry. THRIP underwent external evaluations in 1997 and again in 2002. It has undergone successive adaptations as the general policy environment has shifted. A recent decision to restrict support to SMMEs brought strong representations from large firms and their partner universities and this decision was reversed. Table 6.5 shows the emphasis on firm size in 2005–06.

Table 6.5: *THRIP Contributions from Firms*

Firms	*Number*	*Contribution (R million)*
SMMEs	195	83.1
Large firms	143	135.4
Total	338	218.5

Source: NRF (2006).

Why do firms co-invest in THRIP? Part of the answer lies in Table 6.6 that shows the way THRIP is used to promote the diversification of potential staff.

Table 6.6: *THRIP Support for Students*

	Black Male	*Black Female*	*White Male*	*White Female*	*Total*
Undergraduate	15	18	7	10	50
Honours	181	84	105	147	517
Masters	401	153	372	310	1,236
Doctoral	210	91	196	263	760
Postdoctoral	15	5	18	18	56
Total	822	351	173	698	2,619

Source: NRF (2006: Table 13).

THRIP-supported students mainly conduct their work in university laboratories — they do of course have some interaction with the industrial partner, but in the main do not work in industrial settings. But this exposure is still sufficient for firms to interact with the students and to use THRIP as a screening process towards actual employment. This is a hidden benefit of THRIP.

Table 6.7 shows the claimed outputs attributable to THRIP. The way the data has been collated is misleading since it would imply that THRIP is alone responsible for a third of all university research outputs. 'Publications' in Table 6.7 almost certainly takes the widest possible interpretation of what a publication constitutes and would refer to the publication database that the Department of Education

Table 6.7: *Research Outputs: THRIP*

	2004/05	*2005/06*
Publications	1,740	3,052
Patents	39	117

Source: NRF (2006: Table 25).

maintains. This database includes both journals indexed to the Web of Science and local journals.

From interviews and discussions with stakeholders it seems that the major benefit of THRIP lies in human resource development and the provision of able and willing research postgraduate students to work alongside senior researchers. A second impact is that some 40 per cent of University–Industy Linkages (UILs) are still operating after the end of THRIP funding. The actual return on investment of the THRIP funding is not calculated according to standard methods and is merely a crude estimate. THRIP in fact makes up 20 per cent of the non-labour component of HERD and as such is a very important source of discretionary funding in the hands of principal investigators.

The other well-established funding instrument is the Support Programme for Industrial Innovation (SPII) that is part of the IDC stable. As already mentioned IDC operates on strict business principles. Unlike other state-owned enterprises (SOE), it has never been recapitalised in its entire industry. The approach to investment is thus hard-nosed with the intention of profitable exit. The SPII focuses on SMMEs with funding limited to companies with an asset base no greater than R50m. In terms of financial returns the following is claimed (SPII 2008: 19): 'Total funds advanced to completed and unsuccessful projects since the time of the SPII's inception to 31 March 2008 amounted to R461,0 million. This has resulted in approximately R6,3 billion in sales and R881,1 million in taxes paid to the South African Treasury.' This is not a true ROI since no attempt has been made to calculate the discounted cash flows in a period with inflation averaging 12 per cent.

There is one important implication buried in the data, namely the very slim connection between industry and the state insofar as funding and sources of innovation information are concerned. This means that the question of effectiveness cannot be addressed by looking at the funding instruments. It is rather a question of the way that firms grow and deploy their financial, physical, human and intellectual capital, in spite of the state, not because of its interventions.

Innovation Policy: Intended and on the Ground

The government seeks to promote innovation by ensuring an enabling policy environment. Innovation policy by its very nature is cross cutting and thus difficult to pin down in definitional terms. It includes policy for R&D, education and training, intellectual property rights, trade and industrial policy, tax law, financial regulations and telecommunications to name but a few (see, e.g. Arundel et al. 2007). The 'innovation systems approach' that arose through the work of Lundvall (1985) and Freeman (1987) emphasises the importance of the interaction among firms, universities and governments. The rapid dissemination of this conceptual device represents an innovation in its own right.

In a narrow sense the Department of Science and Technology (DST) (and its predecessor Department of Arts, Culture, Science and Technology) have done well in laying out the elements of innovation policy (see, e.g. Mani 2002). But there are serious inconsistencies and blockages in the system of innovation, some of which arise through direct innovation policy, some through the policies of other departments, and some through the law of unintended consequences.

In the domain of S&T the Government of National Unity established the Department of Arts, Culture, Science and Technology (DACST) that through its White Paper (DACST 1996) introduced the idea of the innovation system as its modernising break with past practice. This does not mean that the innovation system came into being in 1996. It existed before it was named. The same White Paper provided the motivation for setting up the Innovation Fund and the nominally independent National Advisory Council on Innovation. The next major policy statement was the National Research and Development Strategy (DST 2002) that served to declare five new technology missions to replace the strategic missions of the apartheid era. In other words, a further attempt to break with the past. The strategy also included structural changes in the governance of the state research institutions. (Separate laws apply to higher education.)

The new missions were broad in scope: information technology, biotechnology, resource exploitation, advanced manufacturing and poverty reduction, but came with little in the way of additional budget.

In terms of governance the strategy abolished the Science Vote, and changed the reporting lines of the Science Councils. The Department also sought and gained the mandate to coordinate government R&D activity and undertook to report to Parliament on annual R&D expenditures of the government departments.

Finally in 2008 came the ten-year plan 'Innovation Plan: Toward the Knowledge Economy' (DST 2008b) that proposed five 'Grand Challenges' — energy security, climate change, the farmer-to-pharma value chain (biotechnology), space science and technology, and human and social dynamics. At the stage of writing no detailed implementation plans were at hand. As it stands the Ten Year Plan reads less as a plan and more as a vision statement. It is short on detail and to a large extent the challenges constitute a re-working of the missions of the 2002 R&D strategy. Where the plan is detailed is in the identification of a set of key indicators with associated targets.

The other innovation policy instruments: Innovation Fund, BRICS, Intellectual Property Amendment Act, and the R&D tax incentive have been dealt with earlier.

On the higher education front the 36 ethnically defined higher education institutions were reduced to 15 universities, six universities of technology and two comprehensive institutions. They remain free to follow their own research agendas, as they adapt to the imperatives of globalisation and third stream income generation (Kishun 2007).

Business has modernised becoming compliant with the prescripts of the International Labour Organisation and World Trade Organisation. New technologies have been sourced and firms have extended their activities to the rest of Africa across the Limpopo River and further afield.

All actors in the system of innovation and broader society grapple with the social innovation of redress. This manifests in many forms including the application of employment equity and broad-based black economic empowerment legislation to the conduct of research. These new imperatives are mediated by the experience of the liberation struggle of the African majority and also that of other minorities that shook off colonial domination. There is a strong current of 'South African exceptionalism' that runs through the body politic and that colours social, cultural and financial interactions.

The innovation activities of firms occur in this milieu. To take a case in point: despite the commodities boom foreign mining companies have not made significant new investments in South Africa's mines in the last five years. The FDI and accompanying technology that failed to materialise constitutes a loss of innovation possibilities. Investors were apparently deterred by a set of negative factors including overstretched infrastructure (also true of Australia), and perceptions concerning the erosion of property rights and restrictive labour law.

In 2007 external reviews were conducted on the economy (Hausmann 2007) and on innovation policy (OECD 2008). The economic review led by a team of experts from Harvard University argued that sustained economic growth with job creation would depend on the country becoming an exporter of manufactured goods following the path of the East Asian tigers. The review noted the high-level skills nexus and made the case that this was the key constraint to growth. It also adduced evidence that the creation of high-level skilled jobs drew in unskilled labour so that the country's chronically high levels of unemployment would necessarily fall were the export strategy to succeed.

The OECD Review of Innovation Policy questioned the role that the government assigned to itself in the system of innovation arguing that other than through ensuring favourable framework conditions the government should leave innovation to the business sector. The Review echoed Harvard in emphasising the human resource bottleneck that holds back the country. Indeed the Innovation Survey 2005 reveals that lack of qualified personnel presented the same hindrance to large firms as SMMEs.

Now the Innovation Plan of DST is not about innovation per se: DST does not bring products to the market. That is the work of business, and to an extent other supporting government structures. The Innovation Plan is about pushing certain technological agendas that hold the promise of innovative developments sometime in the future. In other words, it is more of a science than an innovation plan. R&D represents an investment in the future and it is thus useful to examine in what fields scientific research is being conducted, and if in fact this has changed over the years of democratic government. And if it has changed, why?

Earlier mention was made of indirect support to R&D through the publication subsidy of the Department of Education. It is instructive therefore to observe the changing emphasis in the publications output of South African researchers — the party most immediately affected by the intentions of the Innovation Plan. There have been two major changes: a steep increase in the volume of publications and a marked shift towards the area of infectious diseases, with indications of a smaller shift towards the financial services cluster: computer science, economics and mathematics (Kahn 2009). The former probably reflects the HIV crisis; the latter possibly the nature of the economy. Neither shift in emphasis is a result of innovation policy per se.

Likewise, it is impossible to demonstrate how Science, Technology and Innovation (STI) policy has impacted on investments in innovation activity. There have been large FDI flows into established companies: ArcelorMittal into ISCOR, Barclays into ABSA, Vodacom into Vodafone, BMW, Ford, General Motors and Volkswagen into their local subsidiaries. All of these lead to innovative activity.

At a lower level media reports suggest that many smaller companies feel constrained by government policies — not innovation policy as such but the general operating environment and high cost of compliance. This really refers to investment climate impressions and general business confidence.

The decision to provide funds for investments, or to seek such funds requires both belief and commitment by the funder and the prospective recipient. The ensuing relationship in part resembles a marriage and as with the intention to marry, the external environment plays an important role. If there is a strong chance that expectations will not be met the vows will never be taken.

So what is it that holds back innovation in South Africa? Is it a lack of funding, a lack of ideas, lack of entrepreneurial spirit of investors and inventors, a lack of an enabling environment? Some or all? Aghion et al. (2006: 1) in a contribution to the *Harvard Review* have shown that 'the profitability margins as computed from the listed firms sample, are more than twice as large in South Africa than in other countries on average.' The high mark-ups act to reduce the competitiveness of South African manufactured goods. If this is indeed the case then innovative activity would entail unacceptable risk. One would expect to find low reported levels of innovation but instead find the contrary. Yet firms appear to be prepared to take the risk, and to fund that risk primarily from internal sources. Firms do not read economic journals.

Start-ups on the other hand do not seem to be emerging at the rate that policy makers expect them to appear. Thus the notion of the 'innovation chasm' that has become a DST mantra. One recalls the line from English poet Grey's *Elegy in a Country Churchyard*: 'Full many a flower is born to blush unseen and waste its sweetness on the desert air.' DST seems to fear that university corridors are part of that desert air, a complaint in many countries. Government officials may therefore feel motivated to fix both the failure and leakages of the ideas market.

This techno-nationalism echoes with what prevailed in the sanctions era. To stem the capital flight and rent-seeking behaviours, strict foreign exchange controls have been enforced for five decades. This regime includes the definition of a patent as 'capital' whose disposal is subject to exchange control regulations. The new law on intellectual property deriving from publicly funded research adds further complexity to the ownership of patent rights with further impact on the cost of doing business.

Implications for Policy

This chapter sought to understand the existing mechanism for the funding of innovation and their possible weaknesses. It performs that analysis in the context of both the modernising agenda expressed through 'constructed crisis' and contestation with regard to the distributive role of the state. Four binding constraints were noted:

- Racialised job reservation and skills development
- Foreign exchange volatility and controls
- Risk aversion
- Anti-competitive behaviours

All four of these involve financial decisions, though the first, other than the underlying financial provision refers to the specifics around human resource development. There is a deep-seated failure to set a realistic agenda for 'getting schooling right' (Taylor and Vingevold 1999) and to grapple with the hard choices around vocational and academic education. The first 15 years of democratic governance were spent in curriculum experimentation driven by the desire of organised labour that lifelong learning should be recognised in formal qualifications and that qualifications should be portable. This led to the destruction of the apprenticeship system and the imposition of outcomes-based education in schooling. The outcome was not an increase in quality nor an increase in the quantity of those able to proceed to more advanced studies be these in further or higher education. This failure is not financial and bears heavily on the innovation system. Apartheid plus the sheer complexities facing the democratic state have resulted in the loss of two generations of education. In the short term this is not reparable. Finance has to be applied selectively to fill the gaps. To repeat: in such straightened conditions every potential professional should be developed; no qualified professional should be lost.

The mini-budget of September 2009 further relaxed foreign exchange controls perhaps with the intention of weakening the rand and thereby compensating for Dutch Disease. This had but a short-term effect since the dollar weakened as the Eurozone showed signs of recovery. The exchange rate stands in the range 7.0 to 8.0 to the dollar that prices domestic labour out of competition with Central and Eastern Europe and South and Eastern Asia.

This brings the argument to risk aversion and anticompetitive behaviour. A visiting VC financier claims as follows: There is no shortage of funds available for good innovative ideas to be grown. Rather it is a case of a shortage of will to implement and seize the opportunities. Protracted decision-making both by the inventors and their accompanying bureaucrats raises the cost of entry to levels that may deter investment. The country has creative people and universities that stand proud among international peers. It is the operating environment that mitigates against commercialisation. Instead there might have been a shortage of viable ideas and associated business planning acumen. If so, then apparent low rates of commercialisation of R&D do not arise for financial reasons. This runs counter to the findings of the innovation survey that suggest the prime barrier to innovation is lack of internal funds, which refers to 'retained profit'. If retained profit, or the cash pile is growing, then this is a management decision where the business leadership is seeking optimal return on capital, and will seek the best way of achieving this, such as an acquisition. Placing new products in the market is one of the riskiest uses of capital and may not please shareholders who would perhaps prefer a larger dividend since these are essentially tax free in the hands of the recipient.

This leaves anticompetitive behaviours. Until 2006, South African industry enjoyed reliable and the third cheapest electricity in the world. This cheap electricity comes with a high environmental cost since it burns high sulphur coal so that South Africa is among the worst polluters per capita in the world. In effect government provided a hidden subsidy to mining and manufacturing, and tough luck on the environment. One man's subsidy is another man's involuntary externality. By late 2006 the lack of investment in new electrical infrastructure, poor maintenance of existing infrastructure, loss of skills through racialised job reservation, poorly implemented procurement value chains, the pressure of economic growth, and some bad luck created a perfect storm that saw brownouts and blackouts. To fix the disaster electricity costs are set to double if not triple thereby producing a constructed crisis for energy-hungry industry. While South Africa's own structural adjustment policies were gradual and seemed to amount to a 'third way', the electricity catastrophe represents what Naomi Klein (2007) termed 'shock doctrine'. Here then is a spur to innovation driven by the unintended consequences of structural adjustment. How does an agenda of zero emissions affect innovation policy and innovation?

The structural adjustment programme was designed to lure FDI but this has not happened in depth save for the few examples given in this chapter. Indeed if cheap energy was the draw card, that has turned out to be a knave. Repatriation of capital is no longer a negative for FDI: the main negatives are the cost of labour, security and uncertainties with regard to property rights. Again these are not issues to do with the financing of innovation. Policy needs to reconsider the prescriptions in the new patent act with regard to the disposal of IP to designated parties — surely a disincentive, and anticompetitive too.

The binding constraints will remain such unless government shifts gear towards more pragmatic solutions.

So for the energy constructed crisis, so for the ongoing constructed crisis of social inclusion. Placing poverty, education, health and the environment centrally, a set of financial incentives and disincentives could spur innovation. Such a grand agenda would require an overhaul of the somewhat tarnished jewels of the government sector, namely the Science Councils. Scoping that agenda would require a chapter of its own.

Notes

1. Goldman Sachs coined the acronym BRIC for the collection of emerging economies of Brazil, Russia, India and China as the large states most likely to influence the world economy in the 21st century. Each dominates the

GDP of its geographic region. South Africa with its pre-eminent status in Africa is added as the 'S'.
2. Kim (1998) had introduced the idea of 'constructed crisis' to explain how a firm could impose organisational changes to ward off competition. He points out that a '... [constructed] crisis may also be generated deliberately by an external principal. In developing countries, particularly where the state orchestrates industrialization, the government could impose a crisis by setting challenging goals for firms in a strategically designated industry.'
3. Agriculture Research Council, CSIR, Council for Geosciences, Foundation for Research Development, Human Sciences Research Council, Mintek, Medical Research Council, and South African Bureau of Standards.
4. An equity stake upward of 10 per cent is regarded as FDI since this confers a controlling interest; below this level the stake is regarded as portfolio investment.
5. See Johnson (2009).
6. See 'Black Accountants Come to the Fore', *Business Day*, 29 April 2009.

References

Aghion, P. and Peter Howitt, 2006. 'Joseph Schumpeter Lecture: Appropriate Growth Policy: A Unifying Framework', *Journal of the European Economic Association*, 4(2–3): 269–314.

Aghion, P., M. Braun and Johann Fedderke, 2006. 'Competition and Productivity Growth in South Africa', Harvard University Center for International Development Working Paper #132, Boston, MA.

Arundel, A., C. Bordoy, P. Mohnen and Keith Smith, 2007. 'Innovation Surveys and Policy: Lessons from the CIS', in C. Nauwelaers and R. Wintjes (eds), *Innovation Policy in Europe*. Cheltenham: Edward Elgar, 29–52.

Blankley, W. and C. Moses, 2009. *Main Results of the South African Innovation Survey 2005.* Cape Town: HSRC Press.

Department of Arts, Culture, Science and Technology (DACST), 1996. *White Paper on Science and Technology*. Pretoria: Department of Arts, Culture, Science and Technology.

Department of National Education (DNE), 1993. *Resources for R&D in the Republic of South Africa 1991/92: Results of Survey Programme No. 17*. Pretoria, Department of National Education.

Department of Science and Technology (DST), 2002. *The National Research and Development Strategy*. Pretoria, Department of Science and Technology.

———, 2008a. *South African Innovation Survey 2005 Highlights*. Pretoria: Department of Science and Technology.

Department of Science and Technology (DST), 2008b. *Innovation Plan: Toward the Knowledge Economy*. Pretoria: Department of Science and Technology.
———, 2009. *Report on the Research and Development Tax Incentive Programme and Trends in Research and Development Expenditure in South Africa 2007/08, Report to Parliament*. Pretoria: Department of Science and Technology.
Etzkowitz, H. and Luc Leydesdorff, 2000. 'The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government relations', *Research Policy*, 29(2): 109–23.
Fedderke, J., 2001. 'Technology, Human Capital and Growth: Evidence from a Middle Income Country Case Study, Applying Heterogeneous Panel Analysis', TIPS working paper, Cape Town.
Fine, B. and Zavareh Rustomjee, 1997. *The Political Economy of South Africa. From Minerals Energy Complex to Industrialization*. Johannesburg: Witwatersrand University Press.
Freeman, C., 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Frances Pinter.
Hausmann, R., 2007. *Final Recommendations of the International Panel on Growth*. Pretoria: National Treasury.
Human Sciences Research Council (HSRC), 2011a. *National R&D Survey 2008/09*. Available at http://www.hsrc.ac.za/Page-108.phtml (accessed 18 December 2011).
———, 2011b. *Innovation Survey 2002/04*. Available at http://www.hsrc.ac.za/Page-142.phtml (accessed 18 December 2011).
Innovation Fund, 2008. *Innovation Fund Annual Report 2008*. Pretoria: Innovation Fund.
———, 2010. *Innovation Fund Annual Report 2008/09*. Pretoria: Innovation Fund.
Johnson, R. W., 2009. *South Africa's Brave New World*. London: Allen Lane.
Kahn, M. J., 2006. 'After Apartheid: The South African National System of Innovation, from Constructed Crisis to Constructed Advantage?' *Science and Public Policy*, 33(2): 125–36.
———, 2009. 'Triple Helix Partnerships and South Africa's Innovation Plan: A Clue to Likely Success'. Paper presented at the 7th triple Helix International Conference, University of Strathclyde, Scotland, 17–19 June.
Kahn, M. J. and M. Gastrow, 2008. 'Pharmacologically Active: Clinical Trials and the Pharmaceutical Industry', *South African Medical Journal*, 98(2): 114–18.
Kahn, M. J. and L. Hounwanou, 2008. 'Research and Development in the Services Sector of an Emerging Economy: The Case of South Africa', *Science and Public Policy*, 35(7): 515–26.

Kim, L., 1997. *Imitation to Innovation. The Dynamics of Korea's Technological Learning.* Boston, Massachusetts: Harvard Business School Press.
———, 1998. 'Crisis Construction and Organization Learning: Capacity Building in Catching Up at Hyundai Motor', *Organization Science*, 9(4): 506–21.
Kishun, R. (ed.), 2007. *The Internationalisation of Higher Education in South Africa.* Durban: International Education Association of South Africa.
Klein, N. 2007. *The Shock Doctrine.* London: Allen Lane.
Klynveld Peat Marwick Goerdeler (KPMG) and South African Venture Capital and Private Equity Association (SAVCA),, 2009. *Venture Capital and Private Equity Performance Survey of South Africa for the Calendar Year 2008*. Johannesburg: Klynveld Peat Marwick Goerdeler (KPMG) and South African Venture Capital and Private Equity Association (SAVCA).
Lundvall, B.-Å., 1985. *Product Innovation and User-Producer Interaction*. Aalborg: Aalborg University Press.
Mani, S., 2002. 'The South African Experience since 1994', in S. Mani (ed.), *Government, Innovation and Technology Policy*. Cheltenham UK: Edward Elgar, 173–213.
McGregor, A., C. Mould, T. Smith, P. Ladell, R. Mcgregor and William Turner, 2008. *Who Owns Whom in South Africa 28th Edition.* Johannesburg: Who Owns Whom (Pty) Ltd.
National Research Foundation (NRF), 2006. *National Research Foundation Annual Report 2005/06.* Pretoria: National Research Foundation.
Organisation for Economic Cooperation and Development (OECD), 2007. *Review of South Africa's Innovation Policy*. Paris: Organisation for Economic Cooperation and Development.
———, 2008. *Main Science and Technology Indicators Volume 2008/1*. Paris: Organisation for Economic Cooperation and Development.
Pogue, T., 2006. *The Evolution of Research Collaboration in South African Gold Mining 1886–1933*. Maastricht: University of Maastricht.
Republic of South Africa (RSA), 1998. *Employment Equity Act No. 55 of 1998*. Pretoria: Republic of South Africa.
———, 2003. *Broad-based Black Economic Empowerment Act No. 53 of 2003*. Pretoria: Republic of South Africa.
Support Programme for Industrial Innovation (SPII), 2008. *Support Programme for Industrial Innovation Annual Report 2008.* Johannesburg: Industrial Development Corporation.
Taylor, N. and Penny Vingevold (eds), 1999. *Getting Learning Right.* Johannesburg: The Joint Education Trust.
Van der Berg, S., 1989. 'Long Term Economic Trends and Development Prospects South Africa', *African Affairs*, 88(351): 187–203.

This page intentionally left blank

About the Series Editors

José E. Cassiolato teaches Innovation Studies and is the coordinator of RedeSist (Research Network on Local Productive and Innovation Systems) at the Institute of Economics, Federal University of Rio de Janeiro, Brazil. During 2011–12 he was the President of the Scientific Board of Globelics, Global Research Network on the Economics of Learning, Innovation and Capacity building Systems where he coordinated the Research Project — A Comparative Study of the National Systems of Innovation of BRICS countries. He has been Visiting Professor at the Université de Rennes (since 2001) and teaches at the Globelics Academy — School on National Systems of Innovation and Economic Development, Portugal and Finland (since 2004).

Maria Clara Couto Soares is Senior Researcher, Research Network on Local Productive and Innovative Systems-RedeSist, Institute of Economics, Federal University of Rio de Janeiro, Brazil. At the Ministry of Science and Technology as well as at CNPq-National Council for Scientific and Technological Development, she worked as Science and Technology Policy Researcher, participating in planning activities and policy proposals for science and technology development in Brazil. Her focus was the development of comparative analyses on international public policies to foster science and technology. She has also been Head of Policy, ActionAid International Americas, SA, and Head of the Brazilian Biodiversity Fund (FUNBIO) sustainable development programme. She is coordinator — with Jose Eduardo Cassiolato — of the BRICS Project on the scope of the Global Network for the Economics of Learning, Innovation and Competence-building Systems. She has a Master's degree in Economics and a Bachelor's degree in Sociology and Political Science. Her main research area is the evolution of innovation systems specifically focusing on social, environment and development issues.

About the Editors

Michael Kahn is an independent policy analyst working on strategy, planning, measurement and evaluation in science, education and innovation. He is also Professor Extraordinaire at the University of Stellenbosch. He has been advisor to the South African Ministers of Education, and Science and Technology; a Chief Director in the Gauteng Provincial Government; education professor in Botswana and South Africa; and Executive Director of the Human Sciences Research Council. In 2002 he founded the Centre for Science, Technology and Innovation Indicators at the Human Sciences Research Council where he was responsible for developing South Africa's official R&D and Innovation surveys. Recent assignments include projects for the World Bank, UNESCO, the Inter-American Development Bank, the International Social Science Council, the International Gas Union, and European Science Foundation. He works closely with OECD, UNESCO and the UNESCO Institute for Statistics, as well as the African Union/NEPAD S&T initiatives. He is a member of the Academy of Science of South Africa, a board member of the Agriculture Research Council, and serves on the advisory board of *Research Policy.*

Luiz Martins de Melo is Associate Professor at the Economics Institute of the Federal University of Rio de Janeiro (IE/IFRH). He earned his Bachelor's degree in Economics from the Pontifical Catholic University of Rio de Janeiro (PUC-Rio, 1977), his MSc in Economics (1988) and his PhD in Economics (1994) from the Federal University of Rio de Janeiro (UFRJ). He did his PhD research at the Science Policy Research Unit of the University of Sussex, UK. He has developed research in economics, with emphasis on Industrial Economics, mainly in the following themes: innovation, sports, innovation funding and financing in national systems of innovation in Brazil and abroad. He is a former Planning Director of FINEP (Brazilian Innovation Agency).

Marcelo G. Pessoa de Matos is Adjunct Professor of Economics at the Economics Institute of the Federal University of Rio de Janeiro — IE/UFRJ in Brazil where he is also a Senior Research Fellow at the Research Network on Local Innovation and Production Systems — RedeSist. His research focus is on innovation systems and development, especially focusing on local innovation and production systems and their interface with social and economic sustained development.

Notes on Contributors

Jian Gao is Professor and Chair of Department of Innovation and Entrepreneurship and Strategy, School of Economics and Management, Tsinghua University. He received his PhD in Management from Tsinghua University in 1996. He teaches Corporate Finance, Theory of Entrepreneurial and Innovation, Entrepreneurial Finance, Venture Capital Management, and Entrepreneurial Opportunity Recognition and Business Plan New Venture Creation Studies for Entrepreneurship, Entrepreneurial Management.

Natalia Gorodnikova is a leading researcher at the Institute for Statistical Studies and Economics of Knowledge under auspice of the State University — Higher School of Economics, Moscow, and director of science programmes in the Centre for Science and Education Programmes. She is a PhD in Economics. Her experience in R&D statistics, science policy, studying of science potential and system of budget R&D funding includes the development and implementation in national practice the methodology of R&D statistics in line with international standards, the methodological and organisational providing with statistical and analytical monitoring for Russian science potential, and the participation in several international projects. She is member of the Methodological Council of State Committee on Statistics of the Russian Federation; observer to the OECD Group of National Experts on Science and Technology Indicators (NESTI) and Eurostat Working party on R&D and Innovation Statistics.

Xielin Liu is Professor and Associate Dean of the School of Management, Graduate University of Chinese Academy of Sciences, Beijing. He has been a research fellow in the Chinese Academy of Science and Technology for Development and a Professor in Tsinghua University. His research areas mainly cover innovation policy, management of technology and innovation.

Sunil Mani is Planning Commission Chair Professor in Development Economics at the Centre for Development Studies, Trivandrum.

Until 2004, he was a member of the faculty at the United Nations University-Institute for New Technologies (now known as UNU-MERIT) at Maastricht in the Netherlands. He obtained his MPhil and PhD in Economics from Jawaharlal Nehru University, New Delhi and has done postdoctoral research at the University of Oxford on a fellowship from the Ford Foundation, New York. He has also been a visiting research fellow at the Institute of Developing Economies in Tokyo. He has published extensively in his area of specialisation and is currently working on three new books.

Márcia Siqueira Rapini is Professor at CEDEPLAR of Federal University of Minas Gerais (UFMG). She is a Researcher in the 'Economics of Science and Technology' group in UFMG and a Research Associate with RedeSist, of the Federal University of Rio de Janeiro (UFRJ). She graduated from the UFMG in 2000, and has Master's and PhD degrees in Industrial Economics in the UFRJ. Her research interests within industrial economics and the economics of technology include: national systems innovation, university–industry interactions, and finance and innovation.

Index