

TECHNICAL CHANGE AND ECONOMIC GROWTH

Inside the Knowledge
Based Economy

SECOND EDITION

GEORGE M. KORRES



F150.43
K84
E.2

Technical Change and Economic Growth

Inside the Knowledge Based Economy

GEORGE M. KORRES
University of the Aegean, Greece
and
University of Leeds, UK

Second Edition



E2009002604

ASHGATE

© George M. Korres 2008

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

George M. Korres has asserted his moral right under the Copyright, Designs and Patents Act, 1988, to be identified as the author of this work.

Published by

Ashgate Publishing Limited
Wey Court East
Union Road
Farnham
Surrey GU9 7PT
England

Ashgate Publishing Company
Suite 420
101 Cherry Street
Burlington, VT 05401-4405
USA

www.ashgate.com

British Library Cataloguing in Publication Data

Korres, George M.

Technical change and economic growth : inside the knowledge based economy

1. Technological innovations - Economic aspects - European Union countries 2. European Union countries - Economic conditions

I. Title

338'.064'094

Library of Congress Cataloging-in-Publication Data

Korres, George M.

Technical change and economic growth : inside the knowledge based economy / by George M. Korres.
p. cm.

Includes bibliographical references and index.

ISBN 978-1-84014-992-0

1. Technological innovations--Economic aspects--European Union countries. 2. European Union countries--Economic conditions. 3. Technological innovations--Economic aspects--Greece. 4. Greece--Economic

Conditions--1974- 5. Production functions (Economic theory) I. Title.

HC240.9.T4K67 2008

338'.064094--dc22

2008007608

ISBN 978-1-84014-992-0



Mixed Sources

Product group from well-managed
forests and other controlled sources
www.fsc.org Cert no. SA-COC-1565
© 1996 Forest Stewardship Council

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

TECHNICAL CHANGE AND ECONOMIC GROWTH

*In memory of my parents
Aikaterini and Michael Korres*

Preface

The growing importance of technological change in world production and employment is one of the characteristics of the last four decades. Technological change does not only determine growth but also affects international competition and modernisation of an economy. It is difficult to record and analyse the results from research and technological policy. It is well known that the adoption and diffusion of new technologies affect structure and competitiveness of the whole economy. The choice of technology depends upon a good number of factors. It depends upon the availability of technologies, the availability of information to the decision maker, the availability of resources, the availability of technology itself and its ability to be successfully adopted in order to accommodate the particular needs and objectives.

Only recently technology has been distinguished from science policy. "Science policy" is concerned with education and knowledge. "Technological policy" is concerned with the adoption and use of techniques, innovation and diffusion of techniques. The division between the areas and variables of science policy and technology policy is not so clear. For instance, education and the stock of knowledge play an important role in influencing the rate of innovation and diffusion of technology. Usually, the technological policy should aim to create a favourable "psychological climate" for the development of research and innovations; such as: different financial incentives, support in education and training programmes, provision technical services etc.

Survey on technological innovation has adopted methodologies and definitions from the Oslo and Frascati Manuals on technological innovation. It should be helpful to recall the definition of technological innovation suggested to firms surveyed by: "the set of knowledge, professional skills, procedures, capabilities, equipment, technical solutions required to manufacture goods or provide services". Whereas, innovation in process is "the adoption of technologically new methods in production or new methods to provide services. Several changes concerning equipment, production organisation or both may be required".

UNESCO, OECD and EUROSTAT divisions organised the systematic collection, analysis publication and standardization of data concerning science and technological activities. The first experimental questionnaires were circulated to member states by UNESCO in 1966 and standardised periodical surveys were established in 1969. The collection of R&D data of regional statistics implied a lot of problems in comparison to data of national statistics. For the collection of regional statistics, we should consider local differences and difficulties. In addition, we can use either "local-units" or "local-economic-units". R&D and

innovation activities are directly related to economic and regional growth. The outcome of international innovation and diffusion process is uncertain; this process may generate either a pattern in which some countries may follow diverging trends or a pattern in which countries converge towards a common trend. Economic development may be analysed as a disequilibrium process characterized by two conflicting forces:

- innovation which tends to increase economic and technological differences between countries; and
- diffusion (or imitation) which tends to reduce them.

A causal reading of recent economic history suggests two important trends in world economy: firstly, technological change and innovations are becoming important contributors to economic growth and to well-being. Secondly, nations in the world economy are becoming increasingly open and interdependent. These two trends are related. Rapid communication and close contacts among innovations in different countries facilitate the process of invention and the spread of new ideas.

Rapid changes in technology imply some effects on socio-economic integration through world trading system. Therefore, it is not surprising that there is a relation among productivity and technology, on the one hand, while international competitiveness is closely related to world trading system on the other.

One of the most important economic events of the last decades in Europe has been the process of European economic integration. Economic theory, however, is unclear with respect to the effects of economic integration. There are many theories on economic integration, but their conclusions differ widely. Next to investigating the effects of integration from a theoretical point of view, it is also important to assess these effects empirically.

This book performs such an empirical analysis. It uses the unique example of the EU to analyse whether convergence or divergence occurred between the EU. Of course, convergence and divergence may occur in numerous ways. Regional conditions are dynamic. Furthermore, there is a wide range of circumstances. Some places may have little difficulty warranting public policy attention. Elsewhere, there are many different regional problems, such as: lagged adjustment to changing economic circumstances, cumulative decline of services, loss of environmental quality, excessive in-migration, community desire for faster economic expansion than currently prevails and temporary shocks.

Several other policy difficulties that policy-makers encounter are competitive federalism, inter and intra-governmental coordination, and the issue of policy instability. Regional development is a difficult policy arena in which all tiers of government have had limited success. Problems also differ according to the scale of analysis: federal, state or local. The factors that contribute to this diversity are themselves numerous and diverse.

The book argues that regional economic development ultimately depends on technical change, social and human capital and civic entrepreneurship, among

others. If so, technology in all its facets will be the crucial ingredient in regional improvement, in contrast with the usual regional pleas for better infrastructure, health care and banking facilities.

The long-term growth and employment depend less on the short-term allocative efficiency measures than on a set of long-term policies aimed at enhancing the knowledge base of economies, through increased investment in the knowledge infrastructure, the knowledge distribution system and the human knowledge component, human resources, education, training and organisational change. While different terminology is used in each country (electronic highways in the USA; information society in Europe), all the indicators point to a rapid increase in the knowledge base of economy is closely associated with (electronic) networking.

One important aspect is related to both distributional aspects of innovation and technical change and to some specific characteristics of information and communication technologies which "exclude" all those who are unconnected to information infrastructure. During 1990s, most technology employment analysis focused on the complexity of the many interactions linking the introduction of new technologies, changes in work organisation, skill mismatches and sectoral employment growth and displacement. Thus, to use Schumpeter's expression, the employment impact of technical change was associated with a process of "creative destruction", involving a process of job destruction in some of the older occupations, technologies, firms and industries. It could also involve changes in the international division of labour.

Based on past experience, however, job losses resulting from the application of new technologies always appeared to be more than compensated for by the parallel process of job creation in new occupations, technologies, firms, industries and services.

In other words, and from historical point of view, there has always been a process of employment growth in industrialised countries, albeit accompanied by a reduction in working hours. Ultimately, technical change has led to higher real incomes, greater employment opportunities and more leisure time. Knowledge can be implemented by human capital and is the key for economic and social development.

Technological gap models represent two conflicting forces: innovation, which tends to increase productivity differences among countries, and diffusion, which tends to reduce them. According to the Schumpeterian theory, growth differences are seen as the combined results of these forces. Research on why growth rates differ has a long history which goes well beyond growth accounting exercises.

Countries that are technologically backward have a potentiality to generate more rapid growth even greater than that of the advanced countries, if they are able to exploit new technologies which have already been employed by the technological leaders. The pace of catching up depends on diffusion of knowledge, rate of structural change, accumulation of capital and expansion of demand. Member states lagging behind in growth rates can succeed in catching up, if they are able to reduce the technological gap. An important aspect of this is that they

should not rely only on the combination of technology imports and investment, but they should also increase their innovation activities and improve locally produced technologies, such examples are new industrialised countries like Korea and Singapore.

The book is intended to provide a basic understanding of the current issues and the problems of knowledge economy, technical change, innovation activities; it will also examine many aspects and consequences of regional integration that are obscure or yet to be explored. Most of this research has been presented in variety conferences, seminars, and workshops; some sections have already been published as Departmental papers and in several Journals. After general issues in these fields have been addressed the discussion will turn to empirical and theoretical aspects of technical change, productivity, economic growth, European policy and technology policy. In particular, with its wide range of topics, methodologies and perspectives, the book offers stimulating and wide-ranging analyses that will be of interest to students, economic theorists, empirical social scientists, policy makers and the informed general reader.

The book consists of five main chapters. Chapter 1 is devoted to definitions and measurement of innovation activities and knowledge economy. Three main topics related to such matters will be discussed in this chapter and are as presented below:

- How the definitions of technological innovation and the knowledge based economy should be applied? Several factors should be actually taken into account, including: the relation between technological and non-technological innovations.
- What are the characteristics of research and development (R&D)?
- How can we apply and estimate the main implications and the effects of these variables?
- What do we want to measure?
- How do we want to measure it?
- Where do we want to measure it?: Technological product and process – TPP – innovations

Chapter 2 investigates the neoclassical growth theory and models of innovation activities and the knowledge based economy. This chapter attempts to analyse and model the new economy, within the framework of knowledge and innovation activities; It also attempts to estimate socio-economic effects of technical change, using both a theoretical and an empirical approach. Moreover, this chapter reviews the main statistical measures for research, scientific and technological activities, using various models, through the input-output analysis and the catching-up and production-cost function models, in order to measure the implication on productivity and the growth effects. We would like to tackle upon the following issues in this chapter:

- Why is innovation important for economic development?
- How can we model innovation activities and knowledge-based economy?
- How can we estimate the effects of innovation activities and the knowledge-based economy?

Chapter 3 deals with the main issues of: technical change, knowledge economy and productivity growth. This chapter attempts to identify the R&D activities and also to investigate the estimation-methods, the techniques of scientific and technological activities and the measurement problems for productivity growth. Some of the main questions addressed in this chapter try to answer the questions below:

- How can we model and measure innovation and knowledge for productivity growth?
- What are the main effects of innovation activities and knowledge-based economy on productivity growth?

Chapter 4 investigates the role of FDIs (Foreign Direct Investments) in the context of national systems of innovation. This chapter attempts to investigate how the way in which “knowledge” can be developed and disseminated and the particular effects on socio-economic effects on modernisation, competitiveness and integration process.

Finally, Chapter 5 deals with the challenges and the institutional matters for the European policy-makers encounter and the effects on regional growth and economic integration, including technology policy, other related policies, the distribution of EU funds, regional development and productivity problems. To do this, it examines critically the claims of regional disadvantage and examines the factors that influence regional economic and social conditions. We would also like to tackle upon the following four issues in this chapter:

- Why is innovation important for European regional economic development?
- Why is the regional dimension important for innovation promotion?
- What has our policy response been so far and what lessons have we learnt from it?
- Finally, what are our action lines for the future?

I would like to thank Dr. Ekaterini Nikolarea, University of the Aegean, for her help in English-proofing this project. Finally, I would also like to thank the anonymous reviewer of the volume, and above all, my publisher for the great encouragement and support.

George M. Korres
Leeds, UK
2007

List of Abbreviations

BERD	Business Expenditures in Research and Development
CEC	Commission of European Communities
CIS	Community Innovation Survey
CITP	Corporate Income Tax Rate
CSFs	Community Structural Funds
EAGGF	Guidance European Agricultural Guidance and Guarantee Fund
EC	European Community
EIMS	European Innovation Monitoring System
EMU	European Monetary Union
EPO	European Patent Office
ERA	European Research Area
ERDF	European Regional Development Fund
ESF	European Social Fund
EU	European Union
FDIs	Foreign Direct Investments
FIFG	Financial Instrument for Fisheries Guidance
GBAORD	Government Appropriations or Outlays for Research and Development
GDP	Gross Domestic Product
GERD	Gross Expenditures in Research and Development
GFCF	Gross Fixed Capital Formation
GNP	Gross National Product
GUF	General University Funds
HDI	Human Development Index
HRST	Human Researchers in Science and Technology
IC	Industrial Concentration
ICT	Information Technology and Communications
IDAs	Individual Development Accounts
IMF	International Monetary Fund
IMPs	Integrated Mediterranean Programmes
ISC	International Standard Classification
IT	Information Technology
KBE	Knowledge-based Economy
LD	Law Decree
LFRs	Less Favoured Regions
MERCOSUR	South American Common Market
MIPs	Million Instructions per Second

MNEs	Multinational Enterprises
NAFTA	North American Free Trade Agreement
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PAET	Five-year Plan for Research and Technology
PAVE	Programme for the Development of Industrial Research
PENED	Programme to Boost Scientific Potential
PPS	Purchase Power Parity
RCA	Revealed Comparative Advantage
R&D or (RD)	Research and Development
RDH	Research and Development Activities per Inhabitant
RDI	Research Development Intensity.
RDP	Regional Domestic Product
RSE	Research Scientists Engineers
R&T	Research and Technology
RTD	Research, Technology and Development
RTD&I	Research and Technological Development and Innovation
SEA	Single European Act
SGRT	Secretariat General of Research and Technology
SMEs	Small Medium Enterprises
SNSS	Secretariat of National Statistical Service
UN	United Nations
UNCTAD	United Nations Conferences on Trade and Development
WTO	World Trade Organization

Contents

<i>List of Figures</i>	vii
<i>List of Tables</i>	ix
<i>Preface</i>	xiii
<i>List of Abbreviations</i>	xix
1 Knowledge Economy and Innovation Activities: An Approach to Definitions and Measurement	1
1. <i>Introduction</i>	1
2. <i>Knowledge and Innovation Activities</i>	3
3. <i>Measurement of Leading Indicators of Knowledge and Innovation Activities</i>	20
4. <i>Policy Implications and Summary</i>	38
2 Modelling Knowledge Economy and Innovation Activities with the Context of New Growth Theory	41
1. <i>Introduction</i>	41
2. <i>New Growth Debate</i>	42
3. <i>Theoretical Approach to the Endogenous Theory</i>	44
4. <i>Modelling Knowledge and Estimation of Innovation and Scientific Activities</i>	50
5. <i>Policy Implications and Summary</i>	106
3 Knowledge Economy, Technical Change and Productivity Growth	109
1. <i>Introduction</i>	109
2. <i>Theory and Measurement of Productivity Growth</i>	110
3. <i>Innovation Activities, Growth and Productivity: Recent Trends and Evidence</i>	122
4. <i>Policy Implications and Summary</i>	147
4 Foreign Direct Investment (FDIs), National System of Innovations and Diffusion of Knowledge	149
1. <i>Introduction</i>	149
2. <i>Defining and Measuring Foreign Direct Investments (FDIs)</i>	152
3. <i>FDIs and Productivity Growth in the Context of National Systems of Innovation</i>	156
4. <i>Knowledge-based Economy and Innovation Policy</i>	186

5. <i>Leading Indicators and Methodology for Measurement of Knowledge-based Economy</i>	192
6. <i>Information Communication Technology (ICT) and Knowledge-based Economy</i>	200
7. <i>Knowledge-based Economy and the Firm</i>	213
8. <i>Managing Knowledge: Leaders and Laggards</i>	215
9. <i>Knowledge Generation and Diffusion</i>	216
10. <i>Modelling the Diffusion Model in the New Growth Theory</i>	217
11. <i>Inter-country and International Diffusion Approach: The Theoretical Framework</i>	226
12. <i>Policy Priorities and Summary</i>	242
5 <i>European Innovation Policy and Regional Cohesion</i>	259
1. <i>Introduction</i>	259
2. <i>The Framework of European Innovation Policy</i>	261
3. <i>New Economy and Knowledge-society in Europe</i>	270
4. <i>An Evaluation of European Technological Policy</i>	274
5. <i>European Innovation Policy and Lisbon Strategy towards Knowledge-based Economy</i>	285
6. <i>European Policy and the Regional Systems of Innovation</i>	299
7. <i>Conclusions</i>	306
<i>Appendix: Glossary of Definitions and Measurements</i>	315
<i>Bibliography</i>	321
<i>Index</i>	369

List of Figures

2.1	Technical change and innovation in production function	73
2.2	Trends in multi-factor productivity, business sector, 1990-1999	86
3.1	GDP per capita and GDP per hour worked (USA = 100), 2002	137
4.1	Cross border FDI and M&A activity	174
4.2	Medium rates of catch-up (1.2% annually): Catch-up and convergence in OECD income levels, 1950-1999 (USA = 100)	176
4.3	High catch-up (>1.2% annually): Catch-up and convergence in OECD income levels, 1950-1999 (USA = 100)	177
4.4	Rapid catch-up: Catch-up and convergence in OECD income levels, 1950-2002 (USA = 100)	178
4.5	Low rates of catch-up (1.2% annually): Catch-up and convergence in OECD income level, 1950-1999 (USA = 100)	179
4.6	Levels of research, science and technology	180
4.7	A simple model of national systems of innovation	183
4.8	Knowledge and learning economy	188
4.9	Learning and innovation	189
4.10	Main factors affecting learning and innovation in a national system of innovation	190
4.11	Regional strategy and policy interventions	191
4.12	ICT investment 1980-2001, as a percentage of non-residential gross fixed capital formation, total economy	202
4.13	ICT in manufacturing and services sectors	205
4.14	ICTs trade by area, 1990-2001, share of total manufacturing trade	207
4.15	Employment in the ICT sector as a percentage share (2000)	211
4.16	The contribution of ICT services to business sector in employment growth, as an average annual growth rate 1995-2000, index 1995 = 100	212
4.17	Cost functions	223
4.18	Diffusion paths	224
4.19	Process of technological change	229
4.20	Phases of growth	232
4.21	The logistic epidemic curve	234

4.22	The cumulative distribution	237
4.23	Diffusion paths	239
4.24	A general form of substitution model function	242
5.1	Propensity of the EU, US, and Japan to produce results	265
5.2	Gross domestic expenditures on research and development in relation to GDP for the EU mean	276
5.3	Business contribution to gross domestic on R&D (EU mean)	277
5.4	Gross domestic expenditures of R&D (percent of GDP)	280
5.5	Regional and innovation policies towards the learning economy	302
5.6	Total budget allocations for structural and cohesion funds, 2000-2006 (1999 prices)	303
5.7	GNP and operating budgetary balances, 1999	305
5.8	Main objectives for the regional policy planning	306

List of Tables

1.1	Innovation and non-innovation activities	5
1.2	Classification of R&D intensive products	10
1.3	Type of variables, titles and sources for the measurement of scientific and technological activities	15
1.4	Three types of research in social sciences and humanities	17
1.5	R&D intensity and export specialisation in high technology industries, 1999	21
1.6	Annual average growth rate of exports in high and medium-high technology industries, 1990-1999	23
1.7	High-tech exports: Exports of high technology products as a share of total exports	25
1.8	Researchers per thousand total employment, 2001	26
1.9	Estimates of the share of OECD gross domestic expenditure on R&D (GERD) and of total number of researchers by OECD country/zone	27
1.10	EPO (European Patent Office) Patent applications by priority year and by inventor's country of residence	28
1.11	Scientific publications per million population, 1999	30
1.12	Evolution of gross domestic expenditure on R&D, average annual growth rate for 1995-2001	31
1.13	R&D expenditures by source of financing, percentage share in national total (2001)	32
1.14	Growth of HRST occupations, average annual growth rate, 1995-2002	33
1.15	Researchers per thousand employed, full-time equivalent	34
1.16	Classification of scientific and research capabilities	35
2.1	Some insights and characteristics of endogenous growth rate	49
2.2	Decomposition formulas	54
2.3	Sources of output growth for selected countries	55
2.4	Sources of growth in real output of all industrial sectors	56
2.5	Sources of change in real output shares for manufacturing	57
2.6	Primary sources of change for fastest and slowest output growth industries	58
2.7	Relationship between productivity and innovation in EU member states, 1973-1997	60
2.8	The basic model tested for the EU member states, 1973-1997	62