

Economics of structural and technological change

Technology has long been seen as a path to economic growth. However, there is considerable debate about the exact nature of this relationship. *Economics of Structural and Technological Change* employs a wide range of theoretical and applied approaches to explore the concept of technological change.

The book begins with a series of in-depth discussions of the economic analysis of technological change. The second section contains a discussion of theoretical models of technological change, focusing on issues such as time and innovation. The third section brings together a number of applied analyses of technological change and examines the effect of factors such as human resource constraints, patenting and science and technology indicators.

Gilberto Antonelli is Professor of Economics at the University of Bologna and Director of IDSE-CNR, Milan.

Nicola De Liso is a full time researcher at IDSE-CNR, Milan.

F45
E19

9960192

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Edited by Gilberto Antonelli and
Nicola De Liso



E9960192



London and New York

First published 1997

by Routledge

11 New Fetter Lane, London EC4P 4EE

Simultaneously published in the USA and Canada

by Routledge

29 West 35th Street, New York, NY 10001

© 1997 Gilberto Antonelli and Nicola De Liso

Typeset in Times by J&L Composition Ltd, Filey, North Yorkshire

Printed and bound in Great Britain by TJ International, Padstow, Cornwall

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British Library Cataloguing in Publication Data

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

Library of Congress Cataloging in Publication Data

A catalogue record for this book has been requested

ISBN 0-415-16238-6

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List of contributors

Gilberto Antonelli, IDSE-CNR, via A. M. Ampère 56, 20131 Milan, Italy, and University of Bologna, Strada Maggiore 45, 40125 Bologna, Italy. e-mail: antonell@spbo.unibo.it.

Nicola De Liso, IDSE-CNR, via A. M. Ampère 56, 20131 Milan, Italy. e-mail: deliso@idse.mi.cnr.it.

Massimo Egidi, University of Trento, via Inama 1, 38100 Trento, Italy.

Luigi Filippini, Catholic University of Milan, via Necchi 5, 20123 Milan, Italy.

Riccardo Leoni, University of Bergamo, Piazza Rosate 2, 24100 Bergamo, Italy.

Mario A. Maggioni, IDSE-CNR, via A. M. Ampère 56, 20131 Milan, Italy.

John Stanley Metcalfe, School of Economic Studies, CRIC and PREST, University of Manchester, Oxford Road, Manchester M13 9PL, UK.

Raffaele Paci, University of Cagliari, via Santa Margherita 4, 09100 Cagliari, Italy.

Giovanni Pegoretti, University of Trento, via Inama 1, 38100 Trento, Italy.

Paolo Mario Piacentini, University of Cagliari, via Santa Margherita 4, 09100 Cagliari, Italy.

Paolo Pini, University of Udine, via Tomandini 30/a, 35100 Udine, Italy.

Alberto Quadrio Curzio, Catholic University of Milan, via Necchi 5, 20123 Milan, Italy.

Antonio Sassu, University of Cagliari, via Santa Margherita 4, 09100 Cagliari, Italy.

Pier Paolo Saviotti, INRA-SERD, Université Pierre Mendès-France, F-38040 Grenoble Cedex 9, France

Giorgio Sirilli, ISRDS-CNR, via Cesare De Lollis 12, 00185 Rome, Italy.

Foreword

Alberto Quadrio Curzio

The evolution of the world economy during the last few decades has made clear that there exists the need for understanding and modelling the economy by means of those analytical tools which explicitly refer to long-run structural economic dynamics. Such an approach seems to be the most appropriate to understand historical as well as current changes, in which economies follow an irregular pattern as sectors tend to move at different speeds as a consequence of technical innovation and resources scarcity.

Methodologies related to economic dynamics are particularly useful when policy-making is to be based on theoretical analyses in order to affect structural relationships within the economy, going beyond short-run policies. Applied analyses have sprung out continuously, particularly after the Second World War, trying to tackle and disentangle the determinants of growth. Recently a new wave of studies, which has stimulated the convergence–divergence debate, has emerged.

The present state of the studies concerned with economic dynamics, however, is rather fragmented and heterogeneous, the coexisting themes and theories being so different from each other. For instance, the problem of long-run unemployment in the more advanced countries is at present at the centre of many different interpretations, stressing one or more aspects or ‘truths’ such as the ongoing technological revolutions, institutional rigidities, international competition with particular emphasis on the emerging ‘tigers’, the underlying microeconomic processes, and so on. The same statements, to consider another example, hold *mutatis mutandis* as far as convergence between countries is concerned. New analytical tools and theories, as in the case of national systems of innovation or the renewed emphasis on local production systems – which come together with analyses of globalization – have been developed.

Many difficulties are on the way, and the point of view we adopt a priori is, of course, not neutral. The very definition of technical progress can be less clear than it seems at first sight, and it is not a mere coincidence that economists often prefer the use of the term ‘technological change’. When non-produced means of production are used, the order of efficiency

as well can be looked at from two different perspectives, the first physical, the second related to the price–distribution mechanisms; the two orders, however interrelated, do not coincide.

There emerges a variety of theories and themes which, in itself, constitutes a richness which, to become more productive, needs appropriate arenas for debate. The same holds in order to guarantee more effectiveness if policy-making is to be improved from these studies.

In the Italian context, the Research Institute on the Dynamics of Economic Systems of the National Research Council (IDSE-CNR) – to which the next lines are devoted – aimed, and aims, to be such a place. The first line of research of IDSE, in fact, has consisted of the promotion of studies concerned with structural economic dynamics, together with its diffusion and possibility of use for policy. Applied and theoretical studies have been carried out. A second line of research concentrates on studies related to structural economic dynamics and institutional change in Italy, both at the national and local level. Networking with other Italian and European institutions, by means of joint research, organization of seminars and exchange of researchers, constitutes a standard approach at IDSE. Finally, IDSE carries out consultancy activities and supplies indications for policy makers.

The chapters in this volume reflect part of the activities carried out at IDSE; they were first presented during an international conference organized at the CNR Research Area of Milan, and then re-elaborated according to the discussion that emerged. When the conference was organised the director of IDSE was Professor Carlo Beretta to whom – also on behalf of the contributors of this book and of the present director, Professor Gilberto Antonelli – I wish to acknowledge my gratitude.

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1 Introduction: An appraisal of the economic analysis of technological change

The path to the last decade

Gilberto Antonelli and Nicola De Liso¹

1 TECHNOLOGICAL CHANGE AND POLICY-MAKING

1.1 The relevance of technological change: a background to policy debate

Technological change has undoubtedly been one of the most important features of the economic history of the world at least since the occurrence of the first Industrial Revolution in the last quarter of the eighteenth century in England. Since then, technical change has shaped the development of economies through the continuous occurrence of both major and minor changes.

Technical change affects many aspects of both economic and social activity. It influences production in qualitative and quantitative ways, and affects employment, international trade, investment and consumption patterns. These widespread effects of technical change are such as to warrant the examination of the interaction of technical change, market forms and overall economic structure.

Given the quantitative and qualitative importance of technological change, it is easy to understand why during the last thirty years there has been an escalation of studies concerned with it. Techniques of production now last for shorter periods; changes, however small, follow one another, and the need to capture the essence of the processes connected with technological change is felt more and more urgently. Both theoretical and empirical developments in the 1980s represented a turning point for economic analysis.

It seems to us that these comments highlight fairly well the fact that any analysis of technological change is influenced by policy implications, which, as such, induce action shaped by political interests and values. Many questions can arise here.

The first we consider, given its social relevance and capability of shedding light on the chains activated by policies, is unemployment. The early 1990s have been characterized by a general concern as structural long-term unemployment seems to persist and increase, and when signs of growth are

visible we speak of jobless recovery. There thus emerges the question: what is the socially tolerable level of unemployment? Should governments intervene, and, if they should, how? The main alternatives in the policy arena are the following: (a) short-term flexibility as a cure mainly of labour market rigidities; (b) investment demand expansion combined with fiscal policy revitalization; (c) stimulation of new market opportunities and product innovation; (d) international competitiveness and strategic trade; (e) long-term flexibility based on the development of individual, social and technological capabilities. However, each of these solutions has a drawback, taking also into account the composite nature of unemployment: from the effectiveness of the policy prescription to the need of increasing taxation, the risk of increasing inflation, and so on. These last points make it clear that whenever policy action is undertaken there occurs a series of reactions in the economic system, not all of which are desirable. And economic analysis should be engaged in increasing the degree of awareness of this, showing the likely scenarios in which complementarities and feedbacks share the same importance as clear-cut alternatives.

Other relevant questions concern the relationship between market structure and innovation, the existence and validity of economic regularities, such as the Kaldor–Verdoorn’s law, the rate of adoption and diffusion and ways of influencing it, and so on. All of these topics have been characterized by theoretical, empirical and political debates, sometimes leading to opposite results according to the ‘lenses’, i.e. school of thought, used.

The aim in bringing the chapters in this volume together is to provide a timely non-sectarian picture of the main contemporary schools of thought and to provide a forum in which the concepts and theories can be compared. The focus will be on the basic elements which shape technological change; that is, rate, direction and diffusion. Such an analysis constitutes a background to policy debate in that its theoretical foundations are here laid.

Whilst the main interest of the book is the economic analysis of technological change in the last decade, in this introduction we also try to summarize some of the basic ideas concerning technical change which current economic analysis has inherited from the works of earlier periods. The analysis distinguishes *schools of thought* and *concepts*. Of course this short introduction does not have pretensions to completeness; it simply aims to introduce a set of ideas that should be clarified and developed by reading the chapters in this volume.²

Finally a ‘bias’ should be declared from the start. In this introduction, as well as in the selection of chapters collected in the volume, we are led to attach more importance to the approaches conceiving of technological innovation as ‘interacting learning’ than the ones dealing with it as mere ‘information’.

1.2 Some considerations on policy

The analytical framework recalled above and developed in the text lends itself to policy considerations that we sketch in this section. The first consideration relates to unemployment. Several studies have stressed important changes in the dynamic relationship between the volume of production and the level of employment. If there is much empirical evidence for a strong direct causal link between production and employment growth when a decrease in production occurs, the link does not appear in phases in which production increases. While the regime of economic growth for the 1950s and 1960s was characterized by sustained production growth, associated with high intensity of employment and sustained product innovation, the regime for the 1970s and 1980s seems marked by low product growth with low intensity of employment and sustained process innovation. The employment–unemployment dynamics cannot be explained only by short-run factors or analysed through traditional conceptual schemes of equilibrium, or even partial equilibrium. Similarly, short-run macroeconomic policies cannot alone be a sufficient response to the employment–unemployment problem. Low employment growth and the increase of unemployment in OECD, and in particular in European countries, are the result of long-run structural changes. The following points deserve attention.

- 1 Co-ordination between short- and long-run policies. Often in official documents we can find discussions based on the following reasoning, more or less explicitly stated. The inadequacy of existing macroeconomic models or a conscious division of labour between macroeconomic and stabilization policies on the one hand, and sectorial analyses and structural policies, on the other, provide the rationale for a clear-cut separation between structural policies and macroeconomic stabilization policies. This division of labour is often correlated to the span of different administrative and political jurisdictions.
- 2 Competition policy as a crucial component of industrial policy. New authorities monitoring the existence of real competition have been established even in countries with no previous traditions. However, amazingly enough, very little empirical work has been done on the effects of competition policies on the functioning of labour markets.³ The economic profession, as well as policy-makers, should be more concerned with this topic.
- 3 The evaluation policy. A similar complaint applies to policies for the evaluation of R&D, on the one hand, and of environmental impact, on the other. The interactions between demand side and supply side are often overruled in both cases and the same is true with regard to the impact on the labour market, unemployment and natural and environmental resources.
- 4 Variety and diversity. Variety is certainly an important asset which,

however, must be channelled through two polar needs, i.e. systemic coherence and regional specificities and autonomies. The economic constitution and the economic structure are containers of this polarization to be reaggregated within a specific institutional set up.

- 5 Solidarity. Solidarity could also assume a crucial economic role at a supranational level as a means to promote human resources skills, a primary asset, even more so, in modern economies, and to tone down the determinants of both the divergence in labour markets as well as instability in prices, labour costs and institutions. We cannot assume that compensation effects at a national level, on which the largest part of economic discussion has been concentrated, will operate with the same intensity at a supranational level with increasing variety in local systems of production.
- 6 Human resources and integration. If a strategy is to be found with a potential of integration similar to that implemented by the founders of the European Community in the 1950s then, related to raw materials and energy, we should focus on human resources, considered in their regional environment – and in this respect the Maastricht agreement is severely lacking.

By way of conclusion, let us say that the ‘knowledge-based economy’ needs new policy prescriptions rooted in a deep revisions of our theoretical background.

2 BASIC CLASSICAL CONCEPTS

2.1 Smith’s contribution

Adam Smith published his *Inquiry into the Nature and Causes of the Wealth of Nations* in 1776 and in it he analysed ‘technical change’ under the heading of the division of labour.

This was the first systematic of production and methods of production. According to Smith’s theory, what we today call technical change is an endogenous phenomenon with respect to the economy, and in the long run increasing returns prevail over decreasing returns. Furthermore, we might note that the division of labour is the structural means through which returns to scale can be modified.

The principles at work are: (1) the increase in dexterity of every worker; (2) the saving of the time which is commonly lost in passing from one type of work to another; (3) the invention of a great number of machines which facilitate and reduce the amount of labour, and enable one man to do the work of many.

- 1 *Dexterity*. Today we refer to this principle as *learning-by-doing*; however it was clearly expressed by Smith two centuries ago. The article by

Arrow (1962b) can be considered a formalized improvement of the Smithian principle of dexterity. Smith wrote that:

by reducing every man business to some one simple operation, and by making this operation the sole employment of his life, necessarily increases very much the dexterity of the workman.

(Smith, [1776] 1976, p. 18)

Smith was mainly concerned here with the manufacturing division of labour. However, the same principles apply when the other forms of division of labour occur (division of professions and division of production)⁴.

The principle of learning-by-doing was stated also by Cesare Beccaria in his *Elementi di Economia Pubblica* (Elements of Public Economy) in 1771 where he wrote that:

everybody knows by experience, that by applying one's hand and mind always to the same kind of works and products, one obtains easier, more abundant and better results than if everyone, on his own, produced all and only those things that he needs.

(Beccaria, [1771] 1958, pp. 387-388, our translation)⁵

- 2 *The saving of time.* The development of particular professions and trades generally implies a physical concentration of those activities, which saves time. Moreover, when the separation between different operations occurs inside the work process, there occurs a further saving of time.
- 3 *The invention of machines.* Smith considered mechanization as a by-product of the division of labour. To understand this statement we must remember that Smith was writing in the 1770s, so that, given the technology of the period, only simple operations could be mechanized. However, the development of technology at first, and of *scientific* technology in a second stage, rendered it possible to mechanize complex operations as well as whole phases and work processes.

Another Smithian concept that needs to be emphasized is that the division of labour is limited by the extent of the market. To operate, the above-mentioned principles need a market of *sufficient* size. However, the reverse is also true; that is, the extent of the market is limited by the extent of the division of labour.

Finally, Smith propounded, well before Keynes, the thesis of proportionality between variations in investment and employment (Sylos Labini, 1969, p. 151).

Two concluding remarks: first, Smith's is a disequilibrium theory, at least when he speaks of the division of labour; second, it involves a theory of endogenous technical change.⁶