THE INTERNATIONAL LIBRARY OF CRITICAL WRITINGS IN ECONOMICS 256

EDUCATION AND ECONOMIC PERFORMANCE

Alison Wolf and Sandra McNally

Education and Economic Performance

Edited by

Alison Wolf

Sir Roy Griffiths Professor of Public Sector Management,
King's College London, UK

and

Sandra McNally

Director of the Education Programme at the Centre for Economic Performance,
London School of Economics, UK

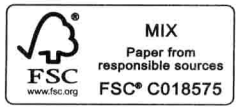
An Elgar Research Collection
Cheltenham, UK • Northampton, MA, USA

Published by
Edward Elgar Publishing Limited
The Lypiatts
15 Lansdown Road
Cheltenham
Glos GL50 2JA
UK

Edward Elgar Publishing, Inc.
William Pratt House
9 Dewey Court
Northampton
Massachusetts 01060
USA

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

Library of Congress Control Number: 2011930995



ISBN 978 1 84844 577 2

Printed and bound by MPG Books Group, UK

Acknowledgements

The editors and publishers wish to thank the authors and the following publishers who have kindly given permission for the use of copyright material.

American Economic Association for articles: Colm Harmon and Ian Walker (1995), 'Estimates of the Economic Return to Schooling for the United Kingdom', *American Economic Review*, **85** (5), December, 1278–86; Daron Acemoglu (1999), 'Changes in Unemployment and Wage Inequality: An Alternative Theory and Some Evidence', *American Economic Review*, **89** (5), December, 1259–78: Alan B. Krueger and Mikael Lindahl (2001), 'Education for Growth: Why and for Whom?', *Journal of Economic Literature*, **XXXIX** (4), December, 1101–36; Enrico Moretti (2004), 'Workers' Education, Spillovers, and Productivity: Evidence from Plant-level Production Functions', *American Economic Review*, **94** (3), June, 656–90.

Brookings Institution Press for article: Claudia Goldin and Lawrence F. Katz (2007), 'Long-run Changes in the Wage Structure: Narrowing, Widening, Polarizing', *Brookings Papers on Economic Activity*, **2**, 135–165.

Elsevier Ltd for articles: Jacob Mincer (1984), 'Human Capital and Economic Growth', *Economics of Education Review*, **3** (3), 195–205; Robert J. Barro and Jong-Wha Lee (1993), 'International Comparisons of Educational Attainment', *Journal of Monetary Economics*, **32** (3), 363–94; Robert J. Barro and Jong-Wha Lee (1994), 'Sources of Economic Growth', *Carnegie-Rochester Conference Series on Public Policy*, **40**, 1–46; Dirk Krueger and Krishna B. Kumar (2004), 'US–Europe Differences in Technology-driven Growth: Quantifying the Role of Education', *Journal of Monetary Economics*, **51** (1), January, 161–90; Ricardo Godoy, Dean S. Karlan, Shanti Rabindran and Tomas Huanca (2005), 'Do Modern Forms of Human Capital Matter in Primitive Economies? Comparative Evidence from Bolivia', *Economics of Education Review*, **24** (1), February, 45–53.

MIT Press for articles: Stephen Machin and John Van Reenen (1998), 'Technology and Changes in Skill Structure: Evidence from Seven OECD Countries', *Quarterly Journal of Economics*, **13** (4), November, 1215–44; Stacy Berg Dale and Alan B. Krueger (2002), 'Estimating the Payoff to Attending a More Selective College: An Application of Selection on Observables and Unobservables', *Quarterly Journal of Economics*, **117** (4), November, 1491–527; Rachel Griffith, Stephen Redding and John Van Reenen (2004), 'Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries', *Review of Economics and Statistics*, **86** (4), 883–95; Ofer Malamud and Cristian Pop-Eleches (2010), 'General Education Versus Vocational Training: Evidence from an Economy in Transition', *Review of Economics and Statistics*, **92** (1), February, 43–60.

Organisation for Economic Co-operation and Development for excerpt: Edward F. Denison (1964), 'Measuring the Contribution of Education (and the Residual) to Economic Growth', in Study Group in the Economics of Education, *The Residual Factor and Economic Growth*, 13–55.

Oxford University Press for articles: Lant Pritchett (2001), 'Where Has All The Education Gone?', *World Bank Economic Review*, **15** (3), 367–91; Alison Wolf (2004), 'Education and Economic Performance: Simplistic Theories and their Policy Consequences', *Oxford Review of Economic Policy*, **20** (2), 315–33; Anna Vignoles, Augustin De Coulon and Oscar Marcenaro-Gutierrez (2011), 'The Value of Basic Skills in the British Labour Market', *Oxford Economic Papers*, **63**, 27–48.

Princeton University Press for excerpt: Richard Blundell, Lorraine Dearden and Barbara Sianesi (2005), 'Measuring the Returns to Education', in Stephen Machin and Anna Vignoles (eds), *What's the Good of Education? The Economics of Education in the UK*, Chapter 7, 117–45.

Springer Science and Business Media for article: Barry R. Chiswick (2003), 'Jacob Mincer, Experience and the Distribution of Earnings', *Review of Economics of the Household*, **1** (4), 343–61.

RAND Journal of Economics for article: Saul Lach and Mark Schankerman (2008), 'Incentives and Invention in Universities', *RAND Journal of Economics*, **39** (2), Summer, 403–33.

University of Chicago Press for articles: Sharada Weir and John Knight (2004), 'Externality Effects of Education: Dynamics of the Adoption and Diffusion of an Innovation in Rural Ethiopia', *Economic Development and Cultural Change*, **53** (1), October, 93–113; Dan A. Black and Jeffrey A. Smith (2006), 'Estimating the Returns to College Quality with Multiple Proxies for Quality', *Journal of Labor Economics*, **24** (3), 701–28.

Every effort has been made to trace all the copyright holders but if any have been inadvertently overlooked the publishers will be pleased to make the necessary arrangement at the first opportunity.

In addition the publishers wish to thank the Library at the University of Warwick, UK, for their assistance in obtaining these articles.

Introduction

Alison Wolf and Sandra McNally

Understanding the Relationship between Education and Economic Growth: a Half-century's Experience

Today 'education' and 'growth' are terms that seem to belong naturally together. The funding of formal education, and intervention in how, when and where it is delivered, lie at the heart of governments' economic policies in bad times and in good. When (vast) China and (tiny) Singapore want to increase their penetration of innovative, high-tech sectors, they invest large amounts in university research facilities. When EU politicians developed the 'Lisbon agenda' as a way of increasing the productivity and growth rates of the European economy, education was at the heart of the strategy. This was because increased 'investment in human capital through education and skills' was seen as a precondition for the objectives of creating 'more and better jobs' and achieving full employment (Commission of the European Communities 2005: 2).

American commentators blame poor education, whether measured in international comparisons of student performance, or numbers of graduating engineers, for their country's shortcomings in economic growth, slow recovery from the recession, income inequality, or all three (see, for example, College Board 2008; Leonhardt 2009). The UK's Labour administrations of 1997–2010 made improvements in people's 'skills' the cornerstone of their policies to improve productivity (Keep et al. 2006). Developing countries have, for many decades, been urged by donors to prioritise education as a precondition for economic success (Wolf 2002).

In other words, the link between education and growth, and the central role this creates for governments, appear to most people as so obvious as barely to need justification. And yet this has not traditionally been the case.

For much of history, governments did not seek to promote 'growth' in our sense of the word. Technical progress frequently occurred without any conscious or directed activity on the part of the state: an obvious example is the development of the deep-blade plough during the 'Dark Ages' which allowed effective farming of the clay-lands of northern Europe and shifted the balance of wealth northwards in the process. Governments promoted economic welfare to the degree that they established peace, order, roads, law courts. Some were heavily involved in public works, such as irrigation, water supply and roads, which also had obvious economic benefits. But throughout most of history, plunder and conquest were seen as the obvious ways in which a country and people might become richer.

The idea that economic growth, with societies and individuals becoming steadily richer, was a normal state of affairs, is a very recent one; and so is the notion that this could be promoted, or guaranteed, by governments (see, for example, Finer 1997; North 1990). And no pre-modern government thought of education as a dependable way of making the whole population richer. Education was for the cultured elite; it was for lawyers and court bureaucrats; it was for clerics

and, in some countries and faiths, for the population at large, but as a way of giving them access to sacred learning and writing. It was not thought of as a substitute for (or even a complement to) more land, more mills and ploughs, or more labourers.

Modern growth theory starts with Adam Smith, but we are still a long way, here, from the idea that education spending is central to prosperity. Smith's theory of growth is one of division of labour: dividing up tasks means that each bit is done more efficiently, and more is produced in total. Technical progress does not feature, although Smith does describe the 'acquired and useful abilities' of a country's population as a form of capital, like machinery, or land (Smith 1776: Book II, chapter 1, para. 17). Moreover, while Smith was in favour of universal education, this was because he thought the boredom of work, in a world where division of labour flourished and was promoted yet further by trade and specialisation, would be very bad for people. He certainly did not see education as a totally reliable form of investment, for either the individual or the state.[1] A century later, Marx's emphasis was, on the contrary, overwhelmingly on technical advances as the creator of wealth; but advances in machinery, not people. 'The hand-mill gives you society with the feudal lord; the steam mill society with the industrial capitalist,' he wrote (Marx [1847] 1995).

Modern theories about growth, and the contributions made by education, were largely formulated in the second half of the twentieth century. The publications that were most important in forming today's dominant theories appeared in the 1960s. In 1964, the Nobel prize-winning economist Gary Becker published the first edition of his seminal book, *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*. And at much the same time, a growing number of the world's leading economists became increasingly interested in what came to be known as the 'residual factor' in economic growth: namely, the fact that levels of capital (land and machinery) and hours worked were manifestly inadequate as an explanation of how well a country's economy fared, and how much it grew. One line of research and debate focused on technical progress and innovation; another on education and human capital.

In 1964, the Organisation for Economic Co-operation and Development, the 'rich man's club' created in 1960, published an important collection of papers, entitled 'The Residual Factor and Economic Growth'. The OECD's then-Secretary-General, Thorkil Kristensen, wrote in the Preface:

> In November 1961, the first Ministerial Council of OECD set a growth target of 50 per cent in the Gross National Product of the twenty Member countries for the decade 1960–1970. For some of the Member countries, this goal was simply a modest extension of their successful experience of the past decade. But for many, this target was a challenge, a reminder of the need for new policies and perhaps a new theoretical framework for understanding economic growth...The classical division into 'labour' and 'capital' has recently seemed an inadequate explanation of the factors determining growth. More attention is being paid to the contributions which knowledge, education, research and development have made to the expansion of economic wealth...Simultaneously there have been rapid developments in the study of economics of education. In addition to the traditional recognition of the political and social advantages of a well educated population, there is a growing awareness of the economic advantages of the transmittal of information, skills and learning.[2]

Kristensen's remarks underline the belief that economic growth was something which governments, if competent, could deliver via rational and effective policy-making; and also highlight the switch in emphasis from the 'political and social advantages' of education to the

economic advantages. The first major paper in the collection, reproduced here (Chapter 1), was by Edward Denison, and is a path-breaking attempt to quantify those advantages. It was to be followed, over the years, by what another eminent economist of education, also represented here, has called a 'veritable tsunami' of empirical studies examining the 'returns' to education.[3]

The Denison paper, the comments on it, and Denison's response, also pre-figure the major themes and controversies surrounding 'education for growth' in the following half century. Denison goes beyond arguing for the general importance of education, whether by arguments from first principles or from empirical observation, to asking how much of an increase in the average length of education it would take to increase the growth rate by a given amount, and how that compares with achieving the same outcome via longer working weeks, lower unemployment, or other ways of increasing the size, or output, of the labour force. He does so by looking at the income differentials among individuals with different levels of education, and extrapolating from these – which is essentially what all later attempts to answer the same question also do. Denison also tries to take into account, and allow for, the possibility that the more educated may be, on average, more able, and that, as more people are educated, the average abilities of those with long periods of schooling will decline. This, again, is one of the issues that has continued to occupy analysts in this area ever since (see Blundell, Dearden and Sianesi, Chapter 12).

While Denison's seminal work developed the methodology which subsequent researchers have elaborated, the comments it generated at the time similarly pre-figure the continuing main points of debate around education's contribution to growth. Malinvaud, for example, notes that his calculations are highly dependent on the assumption that wages reflect someone's marginal productivity (Malinvaud in OECD 1964); while Lundberg queries the implicit assumption that growth can indeed be guaranteed and delivered by changing the supply of inputs (including education) irrespective of demand (Lundberg in OECD 1964). A few years later, Mark Blaug's work on educated unemployment (see Chapter 2) developed the debate further.

Blaug demonstrated that becoming more educated could make perfect economic sense for an individual even if there was no obvious 'need', or demand, for more educated manpower in a society. Looking at people's incentives and behaviour dynamically, over time, one could understand how and why developing countries were generating high levels of unemployment among the educated. Even with high unemployment, the private rate-of-return could be high since most educated people would get jobs eventually. This was true even when people paid their own tuition fees. When they did not, the gulf between private returns, and the benefit to society (social rate of return) might be large, and higher levels of education might be badly over-expanded.[4] Moreover, in many developing countries, graduates were overwhelmingly employed in the public sector, with wages that were not in any obvious sense determined by output or productivity levels, further attenuating the degree to which wages, and private rates of return were signalling education's contribution to growth. Again, these are issues which remain important to the debate today.

At the same time as growth theory was paying concerted attention to the 'residual factor', discussions of 'human capital' were elaborating on why and how we might expect education to increase productivity and, therefore, growth. The term human capital must rank as one of the most successful conceptual coinages of the past century. It owes much of its popularity and influence to the Nobel Prize winning economist Gary Becker, whose book by the name of *Human Capital* (1964, 1975, 1993) is directly concerned with the way in which individuals'

skills operate in parallel to the contributions made by other forms of capital. Capital may be defined as something which is not entirely used up in the production period under examination, but remains a source of future production. 'Human' capital is seen as something embodied in individuals, which contributes to production and economic growth and is similarly not exhausted in use. It is created through 'activities that influence future monetary and psychic income by increasing the resources in people. These activities are called investments in 'human capital' (Becker 1993: 11).

Becker's analysis emphasises the wide range of activities and locations that increase someone's skills and productivity. He discusses the importance of skills developed in formal education but also emphasises that a great deal of 'human capital formation' takes place not in a college or university but while people are actually at work. This, in turn, may involve a formal training process, but often will be very informal; although it will involve commitment of other people's time and attention and therefore costs the employer money. Becker argues that such informal learning is very important for economic productivity, and also in explaining why more experienced workers generally earn more.

However, this part of his argument has had relatively little policy impact. Instead, a growing determination to expand countries' 'human capital' has led politicians to concentrate on extending formal education, and, in addition, to subsidise and promote formal off-the-job training for employed workers (Wolf et al. 2006; Grubb and Lazerson 2004). This is partly because formal education and training can be observed and audited. For the same reason, research into the impact of human capital also concentrates on measurable, formal episodes of learning (for example years in school, number of days' training in the last 6 months) or formal attainments and qualifications.

A contemporary of Becker was Jacob Mincer who contributed to the analysis of earnings and the distribution of earnings through his pioneering focus on labour market experience or on-the-job training. This includes the development of the 'human capital earnings function'. Mincer's contribution and the way in which Becker and Mincer inspired one another are documented in Chiswick (2003: Chapter 3). Mincer's early work (1958) was the first time in which there was an explicit modelling of the relationship between earnings and both schooling and labour market experience. Of his many contributions, he is perhaps best remembered for the development of the 'human capital earnings function' which underpins the literature estimating the economic return to education and labour market experience. This is set out in Mincer's 1974 book (*Schooling, Experience and Earnings*).

In the micro-economic literature, researchers have focused on estimating the relationship between education and earnings.[5] The macro-economic equivalent is to estimate the relationship between education and growth of the economy (through a measure like GDP). Barro and Lee were particularly influential in advancing the empirical literature on the relationship between education and growth. In this volume, we include two of the studies (Chapters 4 and 5: Barro and Lee 1993, 1994) where they discuss how they build an international data set and estimate growth regressions. They found measures of educational attainment to have considerable explanatory power with respect to growth rates of GDP; the ratio of physical investment spending to GDP; the total fertility rate and tertiary school enrolment ratios.

The relationship between the micro- and macro-economic literature is brought out in the first of our overviews of the literature (Chapter 6, by Mincer). In this paper, Mincer (1984) draws out implications of the application of the human capital concept to economic growth

and to labour economics. (These were initially pioneered independently largely by Becker and Mincer himself respectively.) As Mincer writes, 'the concepts are the same, and are applied basically to the same problem: individual economic growth at the micro level and growth of the economy at the macro-level' (p.196).

In this paper, Mincer first describes how human capital is a personal investment, analogous to investment in physical capital and how rates of return to education may be computed and compared to rates of return on any other type of investment. He also explains how rates of return relate to both the demand and supply of human capital and the availability of physical capital. He argues that the scarcity of physical capital is one reason why estimated returns to human capital tend to be higher in developing countries than developed countries. He explains the distinction between private and social rates of return to education and argues that an assumption of public policy which is difficult to verify and quantify is that externalities are substantial and positive. Examples of these externalities include informed and responsible citizenship, communication skills, lawful behaviour and standards of health. However, this is not the only rationale for public intervention in education – the other is with 'helping children of the poor to acquire a minimal degree of earning power' (p.197). In the second major part of this review piece, Mincer explains how the micro-economic analysis of investment in education is the underpinning of our understanding of the contribution of human capital to the aggregate level of income and to its rate of growth.

However, whereas the micro-economic literature is consistent in finding positive effects of schooling on income, the parallel macro literature is more mixed. In the next of our overview chapters (Chapter 7), Krueger and Lindahl (2001) try to reconcile conflicting evidence from the micro and macro literature. They find that measurement error is a very big problem in studies that use cross-country data. Measurement error leads to downward bias when estimating the effect of education on growth. Krueger and Lindahl show that after correcting for measurement error, the effect of changes in educational attainment on income growth in cross-country data exceeds micro estimates of the returns to schooling. However, they caution against believing that larger estimates necessarily indicate the presence of externalities. A problem is that causality can work in both directions – growth in educational attainment can have a positive effect on economic growth; but countries with higher growth may expand their education systems. The difficulty of untangling the two has been just as apparent in the recently successful economies of East Asia as in Europe and the Americas.[6]

The point that the relationship between education and economic growth can be two-way is taken up by Wolf (2004) in the next overview chapter (Chapter 8). She also cautions against a simplistic interpretation of the empirical literature on the benefits of expanding education for economic growth. One of the themes discussed is that estimated 'returns to education' do not reflect human capital alone, but also the signalling value of educational credentials. Furthermore, in many contexts (particularly in the public sector), there is no necessary relationship between wages and workers' marginal product. Thus, it does not follow that expanding education is a sure path to increasing economic growth. Among the issues discussed is how the type of education matters for productivity and that an emphasis on quantitative targets (together with a funding regime that rewards crude output measures) can give perverse incentives for educators to encourage young people into courses that tick the box in terms of qualification but do not necessarily offer employers valuable skills (and hence can have no effect on economic growth).

Wolf (2004, Chapter 8) points out that many papers in the macro literature do not find a relationship between education and economic growth. While Krueger and Lindahl (Chapter 7) give a technical explanation for this finding (that is, measurement error and model misspecification), our final overview chapter by Pritchett (2001: Chapter 9) suggests three other types of explanation. First, schooling might not actually raise cognitive skills or productivity but nevertheless does raise the private wage because it serves as a signal to employers of some positive characteristic like application or innate ability. Second, expanding the supply of educated labour in the presence of stagnant demand for educated labour causes the rate of return on education to fall rapidly. Third, education does raise productivity but the demand comes from individually remunerative but socially wasteful or counter-productive activities so, while individual wages go up with education, aggregate output stagnates or even falls. As it turns out, Pritchett's view of the evidence is that education raises cognitive skills as well as having a large number of direct beneficial effects beyond raising economic output. However, his assessment, like that of Wolf, gives reason to reject a simple interpretation of the literature and policy measures that would increase education spending or supply regardless of the context in which this takes place or the type of education undertaken.

What Sort of Education Does What?

Most of the published literature focuses on formal education: years in school, or qualifications obtained. This is not because informal learning is irrelevant to growth. As Becker and others frequently emphasise, learning on the job is very important, and the skills that individuals obtain in this way are demonstrably valuable to them in their later careers (see especially the literature on apprenticeship, for example McIntosh 2004, 2007, and on returns to varied employment experience, for example Goldthorpe and Mills 2008).

However, formal education lends itself to analysis for the obvious reason that it can be measured and recorded in large-scale surveys. It is also of enormous interest to policy-makers because it is the recipient of enormous and growing public expenditure. Informal on-the-job learning takes place, by definition, in existing workplaces. Formal education, however, is 'about' the future, as well as under the control of governments which are expected to secure employment and prosperity for their citizens. And it therefore is, or should be, of major interest whether some types of education have different effects from others, and why.

Three key questions recur in this context. They have all been posed, with varying degrees of specificity, since the relationship between education and economic performance first became of major interest to researchers and policy-makers (see Part IA); but in recent years, major advances have been made in clarifying how they might be answered properly, and in offering well-founded empirical results.

First of all, does all education 'work'? Is the key issue simply how long people spend in formal education, since simply by being there they will generally acquire important skills? Or does the labour market actually rely on more formal signals, in the form of qualifications, in order to recognise and reward individuals' acquisition, during education, of specific skills? Qualifications provide employers with summary information, and so may in principle create far more efficient labour markets than if employers had to expend a large amount of effort finding out what skills individuals have actually acquired. But they may also be used by employers not as signals of specific skills acquired, but as signals of general underlying

capacities: whether someone is (relatively) intelligent, whether they are hard-working and conscientious.

This is a slightly different question from the one originally posed by Denison (Chapter 1), and recognised throughout the literature; namely, how far 'returns to education' are actually returns to underlying intelligence. But from the point of view of governments concerned with education's contribution to economic performance, it is very important to estimate how much education is being rewarded because of the specific skills imparted during schooling. Formal education costs money; and as Blundell et al. (Chapter 12) point out, the relevant question for policy-makers deciding how and where to spend money is not whether the educated earn more, but 'do people with more education earn more, on average, than if *they* had acquired less education' (2005: 125). And do they do so because of the skills they acquired? Or because their qualifications altered employers' perception of their *relative* desirability as employees?

Second, how much does it matter where someone is educated? Individuals and families believe that it matters very much, which is why there is such competition for 'elite' universities, and why, in countries which operate 'school choice' policies, there is very high demand for schools which are perceived to be good and effective. (This is reflected in house prices in surrounding areas: see Gibbons and Machin 2003.) But are individuals' later earnings really affected a great deal by where they went to school or university? Or are any apparent institutional effects actually just proxies for other factors? For example, if elite institutions exist, they will tend to admit the most intelligent and high-achieving students[7] so may not be adding anything to the latter's earning power compared to continued education in another institution. (And even if they do, this might be just because employers assume that the graduates of elite institutions are 'better' rather than because the quality of teaching, and learning, actually are better.)

Third, how much does it matter what people learn? The school curriculum, in particular, is concerned with much more than labour market skills. It has always been about inculcation of moral (and in many places and times religious) values and information; and the growth of compulsory schooling, and national curricula, has gone hand in hand with the development of the nation-state and its desire to develop loyal citizens (Green 1990). But from the point of view of economic performance, and individual careers and earnings, is all educational content the same? Put differently, does the labour market value only, or mostly, general skills that can be acquired by studying a wide variety of courses with specific content? Or are there specific skills that also matter? Does it make sense for individuals, or for the economy, to have highly specific, including vocational, curricula, which are deliberately aligned with occupational requirements? Or does it make more sense, economically, for education to focus on general content and leave specific training to employers?

All of these are extremely difficult questions to answer. Moreover, the answers may vary greatly with time and place. It seems implausible that, for example, all elite institutions, in all countries, are equally important, or irrelevant, in their contribution to graduates' economic success, or economic performance. It seems unlikely that all qualifications will be alike in providing (or failing to provide) the labour market with accurate information about holders' substantive skills, and thereby improve the efficiency of hiring decisions. And given the varied extent to which jobs require specialised knowledge and skills, it seems unlikely that there will be a simple universal answer to the question of whether schools and universities should offer general, or vocational, education.

Indeed, the growing empirical literature in this area produces quite varied estimates of how much impact different forms of education have – varying across countries, across time, across qualifications, institutions, subject matter. Much of this variability undoubtedly reflects differences in the institutional and economic environment. But it also reflects differences in the ability of analysts to isolate the impact of education, and separate it out from other variables. Analytical techniques have become increasingly sophisticated over the years; but many of the problems relate to the quality, range and availability of data, and some fundamental methodological problems are extremely difficult to tackle.

The articles in Part II of this volume have been selected because, in addressing these three questions, they explain and/or advance analytical techniques in a very clear way. Chapter 12, by Blundell, Dearden and Sianesi, provides a very thorough overview of methodological issues, including those (such as the relative importance of 'signalling') which are intrinsically very difficult to resolve; and surveys methods for tackling the most frequently recognised and potentially important problem in estimating returns, namely selection on unobservables. As already discussed, apparent returns to education are very likely to include the effect of unobservable factors, notably but not only ability. These unobservables are likely to be correlated with both the acquisition of education and with future earnings and so make it very difficult to isolate the effect of education alone. This chapter also summarises a range of important empirical results.

Chapter 10, by Vignoles, De Coulon and Marcenaro-Gutierrez is important empirically, because it provides evidence that rewards for skills and attainment are not captured entirely by returns to formal education and qualifications; but also because it discusses the extent to which unusually rich data sets allow researchers to resolve issues, and control for variables, in ways that are often impossible, and may lead to mis-estimation of effect sizes. And Harmon and Walker's article (Chapter 11) provides a good example of how researchers are able to use 'natural experiments' to isolate the impact of schooling from other factors, and address the problem of unobservable factors/the endogeneity of schooling. The authors describe other attempts to achieve this, while using the raising of the school-leaving age in the UK to estimate returns to schooling. They find high returns to schooling in their models, a result echoed in other studies using natural experiments (for example Maurin and McNally 2008).

Chapters 13 and 14 address the impact of institutions on earnings in rather different ways. Both deal with the impact of college on earnings. There is a large literature on the differential impact of different schools on pupils' attainments (measured through standardised tests or qualification passes) but in studying schools' later impact on earnings we rely more or less entirely on these attainment measures, and assume they capture all or most of what occurred. With colleges and universities the opposite is true. We do not have standardised attainment measures, but do have ways of classifying institutions in comparative terms.

The academic literature on this issue mainly relates to the USA, where the ability score of those attending the institution (the average SAT (Scholastic Aptitude Test) score) is typically taken as a proxy of quality. Chapter 13 (Black and Smith 2006) is typical of the methodological approach used in this literature, although they also investigate whether the quality proxy is influenced by other potential quality measures. The methodology relies on a 'selection on observables' assumption, meaning that all relevant variables affecting institutional quality and later wages are taken to be explicitly included in the regression. Such an assumption is untestable and can really only be invoked with any credibility when the data set is very rich.

If this assumption is accepted, then Black and Smith (2006) find that institutional quality has a wage return in the labour market that is economically important.

However, even with a rich data set, one can argue whether all relevant factors (such as student motivation) are really captured. Dale and Krueger (Chapter 14) note the burgeoning literature addressing whether the quality of the institution attended influences a student's later earnings. It appears to; but this may simply or largely reflect non-random selection. The students who attend highly selective elite institutions may be very different in a number of ways, not only academic, from those who do not. The Dale and Krueger article is important for its use of two new methodological approaches to this issue, and also because its findings underline the likelihood that the impact of a college will be different for different types of student. Their results suggest that the impact of attending an elite college is much less than generally supposed, once controls are introduced; but also that there is a significantly higher pay-off to attending a selective/elite college for students from low-income households.

Chapters 15 and 16 address the third key question: does it matter what people study? The two chapters have been selected because they illustrate, in different ways, the most politically relevant and disputed aspects of curriculum content, namely the balance between general and vocational.

Krueger and Kumar (Chapter 15) attempt to link educational content to economic performance at a continental level, contrasting the growth patterns and history of the USA with that of the continent of Europe. They focus on the 1980s and 1990s, when US growth became stronger relative to European countries (and Japan) in contrast to the previous decades. Most analyses of the period focus, as the authors note, on non-educational factors, such as labour market rigidities and the use of IT, but this article argues that the content of education also matters, and can account, in a quantitative model, for a large part of the growth differential. The argument is that the USA offered a general curriculum at secondary level, which was much better suited to a period of rapid technological change, and the need to adopt new technologies, than the vocational specialisation characterising European education.

The article highlights the way in which broad characteristics of an education system may have very wide-reaching effects in the labour market, and has been much discussed. However, to a European reader, its argument is undermined by a failure to recognise the enormous differences among European countries in the extent to which they impose early vocational specialisation (as well as in other aspects of their education system). Nor do these differences appear very well-aligned with the authors' overall thesis; growth has not obviously been lower in those European countries with more vocational education.[8]

Chapter 16, by Malamud and Pop-Eleches, is part of a much longer-established literature which examines the impact of different educational content within a country. This has been especially important in development economics, and in influencing development lending: specifically, an early enthusiasm for vocational education programmes in developing countries was reversed when rate-of-return analyses consistently indicated that they were far less valuable than general education. (See, for example, Middleton 1989; Psacharopoulos 1995. Note that vocational schooling is almost always more expensive than general education.)

Malamud and Pop-Eleches's analysis is another example of the benefits to researchers of a natural experiment. In this case, a major educational reform in Romania, in 1973, meant that any cohort born after 1959 received much less vocational education (on average) than those born earlier. The researchers found that those educated after the change were significantly less

likely to become craftsmen or manual workers than those born before; but no significant impact on likelihood of being unemployed or on income and wages was found. The authors note that, in this case at least, the large cross-sectional differences in labour market outcomes between vocational and general education graduates, which exist in Romania as in other countries, are driven mainly by selection.

What Impact Does Education Have on Innovation, the Wage Structure and Productivity in the Economy at Large?

There may be major differences in the level of benefit which individuals derive from education; but the general association is clear and undisputed. Better educated people earn more. For governments who wish to promote overall growth, however, this still leaves major questions unanswered: how much education they should pay for, how far they should base curriculum content on what individual rates-of-return appear to signal, and how far they should be thinking more in terms of social returns and externalities. Some of these issues are raised in the earlier chapters of this collection; Part III focuses on them more directly.

As the papers in Part I demonstrate, interest in the relationship between education and growth developed in the context of modern governments' commitment to deliver economic growth for their citizens. Yet, while the value for individuals of obtaining more education is amply and repeatedly demonstrated, the 'macro' picture is much less clear. Good education does indeed appear to be an important characteristic of successful and growing economies, but there is no simple relationship between educational inputs, regardless of type and quality, and growth.

A growing volume of research consequently attempts to unpack the ways in which education may (or may not) make direct contributions to economic growth and change, including attempts to identify whether or not the benefits of education are entirely captured by individuals, through what they earn, or spill over into benefits for the wider society. Analysis takes place in the context of widespread and very evident economic change: globalisation, involving expanded trade and the migration of manufacturing industry to low-wage emerging economies, rapid technological change and attendant changes in occupational structures, and changes in levels and patterns of income inequality. Do levels of education impact on these developments directly? And do they alter the level and patterns of returns to education and its potential role in supporting economic growth?

Chapter 17 (Machin and Van Reenen, 1998) is important for understanding the role of technological change, notably in explaining changes in the skills structure across several OECD countries. The authors show that there have been shifts in labour demand favouring skilled workers in all of these countries and the evidence is consistent with 'skill-biased technical change' being an important part of the explanation. 'Skill-biased technical change' refers to the introduction of new technologies that are 'biased' in the sense of being relatively (and absolutely) better, in income terms, for skilled than less skilled workers. The explanation derives from the hypothesis that employers' demand for different sorts of workers has been shaped by the kinds of technologies that are being introduced into modern workplaces. In the current environment, employers will value workers who are skilled enough to operate these new technologies. Consequently, their wages and employment probability will be higher than for less skilled workers.[9] And obtaining more skills (through formal education) will make excellent economic sense for individuals.

Machin and Van Reenen use R&D intensity as a proxy for new technologies; and also examine the consequences of technological change rather than its origins. In Chapter 18, Griffith, Redding and Van Reenen (2004) explore the 'two faces' of R&D. This refers to the role that R&D plays in stimulating innovation directly and its role in enhancing technology transfer by improving the ability of firms to learn about advances. They examine this issue empirically using a panel of industries across twelve OECD countries. They find that as well as the traditional view of R&D as stimulating growth through innovation, it is also the case that countries lagging behind the productivity frontier catch up particularly fast if they invest heavily in R&D. If R&D spending has a direct causal effect on growth, this suggests that education can too. For example, advanced university education and research is closely intertwined with firms' R&D activities, and may feed into innovation and the creation and adaptation, as well as the adoption, of new technologies. However it is easier to generalise from R&D findings to the likely impact of education at the high end, which produces R&D professionals, than to conclusions about how education in general might affect economic processes.

Goldin and Katz (Chapter 19) are very prominent among those economists who argue that education has a more general causal impact on growth across an economy, as well as on distribution of income. The difficulty of reaching firm and stable conclusions in this area is illustrated by the fact that Goldin and Katz believe that the USA's economic performance, and the structure of American occupations and wages, differ from Europe's for reasons which include, crucially, educational differences; but reach very different conclusions from Krueger and Kumar (Chapter 15) about the result. The latter argued that the USA was at an advantage because of offering more general and less vocational education content, which stimulated innovation. Goldin and Katz believe that educational differences, and specifically a relative decline in educational expansion compared to European countries, mean that US workers have been disadvantaged and less able to take advantage of technological advantages (Goldin and Katz 2008).[10]

In Chapter 19, Goldin and Katz (2007) document the way in which American wages have become more dispersed, and incomes more unequal, in recent decades. Much of this is the result of increased returns to postsecondary schooling. The authors argue that both the narrowing of the wage structure that occurred earlier in the twentieth century, and the increase in US wage inequality since 1980, can be understood in terms of the balance between demand for and supply of skills. Thus 'growth in the supply of skills slowed considerably after 1980, and the wage structure, in consequence, widened' (2007: 138).

In Chapter 20, Acemoglu (1999) sets out a theory that might explain observed market developments both in the USA and in other countries, involving higher relative wages of college graduates at the same time as higher unemployment for all education groups; something which is evident when comparing the 1970s to the mid-1990s. The theory involves a qualitative change in the composition of jobs whereby 'middling' jobs open both to skilled and unskilled workers might be replaced by high-quality jobs designed for the skilled and low-wage jobs targeted to the unskilled. In the model, the skill composition of the labour force affects the types of jobs that firms want to create. Such changes are indeed evident in much of the developed world (see, for example, Michaels et al. 2010); so too, albeit to varying degrees, are increases in earnings inequality and especially in top earnings (see especially Atkinson 2008).

In Chapter 18, we see that R&D is very important for generating productivity growth. And as already noted, one important driver of R&D is academic research – both directly and indirectly by stimulating private sector R&D. In Chapter 21, Lach and Schankerman (2008) explore what drives academic R&D licensing activity. Is this simply a response to non-pecuniary incentives (peer recognition and advancement of science) or do monetary incentives also matter? The authors use university-level data in the USA to explore this issue and find that high-powered, pecuniary incentives strongly affect university research and licensing outcomes. Their findings suggest that the design of intellectual property rights and other forms of incentives in academic institutions can have real effects on growth and productivity.

At the other end of the development spectrum, Chapter 22 by Godoy et al. provide evidence that education, in terms not only of schooling but of measured skills, increases individuals' productivity in very primitive economies. The researchers examined incomes among foragers–horticulturalists in the Bolivian lowlands, surveying households in 42 villages, some near and some a long way from market towns. Both cash incomes and production volumes (maize, rice and peanuts) were clearly and positively correlated with schooling and independently tested arithmetic skills.

This study looked at the direct impact of skills on household productivity. However, 'spillovers' are potentially very important for growth, and for decisions about where government spending should be directed. An important mechanism through which university R&D has an impact on growth is through its effect on R&D in the private sector (Zucker et al. 1998). Such spillovers may be of general importance outside this R&D context and are referred to in the literature as 'externalities'. Human capital externalities may arise if the presence of educated workers makes other workers more productive.

In Chapter 23, Moretti (2004) looks at this in the context of manufacturing plants. He looks at whether plants located in cities with high levels of human capital can produce a greater output with the same inputs than otherwise similar plants located in cities with lower levels of human capital. He finds evidence for a strong spillover effect although productivity gains are offset by higher labour costs. He also finds that spillovers are greater for industries that are 'economically close'.

Finally, in Chapter 24, Weir and Knight provide a detailed picture of the actual process by which externalities may be realised. Their study of rural Ethiopia focuses on the process by which new farming techniques get adopted, and in the process make agriculture more productive. Diffusion of new products and technologies typically follows an S-shaped curve, with a small proportion of early adopters, who often grow in numbers slowly; a take-off or tipping point at which adoption grows rapidly; and then a levelling off. However, there can be major differences in the speed of adoption, and final levels of participation. In the case of innovation diffusion among rural farmers, the authors find that the more educated adopt earlier; that people are much more likely to be influenced by someone richer (and almost never take the advice of someone poorer); that the more educated are more likely to learn from observation and discussion, rather than by being instructed by an extension agent; and that the more educated people there are in a community, the faster, by far, adoption becomes.

Such micro-level studies are relatively rare in the education and growth literature, and (as for Chapter 22) are easier to carry out in small rural communities where changes in specified techniques and output levels can be studied with reference to a single industry. They nonetheless illuminate the process by which education may indeed generate productivity gains; and, by