The impact of human capital on economic growth: a review

Rob A. Wilson, Geoff Briscoe

In:

Descy, P.; Tessaring, M. (eds)

Impact of education and training

Third report on vocational training research in Europe: background report.
Luxembourg: Office for Official Publications of the European Communities, 2004
(Cedefop Reference series, 54)

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  Bibliographical reference of the English version:
  Descy, P.; Tessaring, M. *Evaluation and impact of education and training: the value of learning*. Third report on vocational training research in Europe: synthesis report. Luxembourg: Office for Official Publications of the European Communities (Cedefop Reference series)
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Tel.: (30)2310 490 111
Fax: (30)2310 490 102
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The impact of human capital on economic growth: a review

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Abstract

This review provides an in-depth appraisal of a wide body of international research that examines the links between education and training in a country and its macroeconomic growth. An initial analysis of broad statistics for all EU Member States suggests a loose correlation between investment in human resources and growth in gross national product (GNP), but clear causal relationships are difficult to establish. Increased investment in education is shown to lead to higher productivity and earnings for the individual and similarly, such investment results in significant social rates of return. The returns on investment in vocational training are more difficult to demonstrate. This study reviews a large number of growth models that attempt to specify and quantify the GNP and human resource relationship. Wide differences are found in the model specifications, the quality of the data inputs and the results obtained. Other links between investment in human capital and economic performance are reviewed using diverse literature sources on human resource management, corporate market value, company size and industry structure. The indirect impact of education on non-economic benefits is also examined in the context of the technological, spatial and environmental gains to society. It is concluded that, overall, the impact of investment in education and training on national economic growth is positive and significant. Some policy conclusions are drawn and directions for future research in this area are suggested.

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1. Executive summary: key findings

1.1. Background

Various conceptual approaches have been used to explore the links between education and training and economic performance. The aim of the present review is to provide a critical assessment of this work, focusing primarily on the macroeconomic level. In order to reach a macro overview, it is necessary to consider many other branches of literature than those just concerned with macroeconomic growth models.

The study, therefore, presents an extensive international review into a number of strands of literature that focus on the link between investment in education, training and skills and economic performance at the macro level. This includes some micro level research, where training and education conducted by firms and industries is deemed to be an important contributor to overall economic growth. While a majority of the publications examined are in English, much European research is also incorporated in the form of empirical studies using European data and European authors publishing in UK and US publications.

All of the European Union (EU) 15 Member States have experienced significant growth over the past 30-year period. However, there is variation between countries, especially in the short term. Educational expenditure as a percentage of gross national product (GNP) has been maintained at roughly constant levels across all the Member States over the long term. This has ensured increased investment in human resources throughout the EU. Other data show a strong growth trend in the percentage of the eligible population entering tertiary education over the three decades. Consistent statistics on trends in EU vocational training prove more difficult to obtain, but there is evidence of significant vocational training inputs in a number of EU countries. A simple reading of these statistics indicates that increases in economic growth across the EU are associated with increases in both education and training. However, more detailed comparisons also illustrate the difficulties in establishing a causal link between educational and training inputs on the one hand and economic outputs (in form of growth in gross domestic product – GDP) on the other. Similar patterns are observed in other developed economies.

1.2. Rates of return on investment in human capital

A key body of literature relates to the rates of return for the individual (and for society in general) of investment in human capital, in the form of education and training. Much of this research draws on the seminal work by Becker (1964), Mincer (1974) and many others. This body of work is founded on a microeconomic approach. Nevertheless the results have important macroeconomic implications. They highlight the strong links observed between education, productivity and output levels. Although some have questioned the direction of causality and argued that much education simply acts as a screening device to help employers to identify more able individuals, the general consensus seems to be that education does result in higher individual productivity and earnings. On balance, the results suggest a strong and positive causal link between investment in education and training and earnings. This applies both at the level of the individual and also to the broader social returns on such investments, the evidence suggesting substantial social as well as private benefits. The implication is that what is good for the individual is also good for society at large at a macro level.

Evidence on social rates of return concentrates on the benefits to the economy arising from increased education by calculating all the costs of schooling and education compared to the relative pre-tax earnings of individuals in receipt of such education. Many qualifying assumptions need to be made in arriving at a quantifiable estimate, but several studies suggest a social rate of return in the range 6 to 12 %. This compares well with rates of return on other capital. Comparable studies to establish the social rate of return for

vocational training are hard to find, although there is some evidence that such training has a significant positive impact on productivity.

1.3. Skills and organisational performance

Another key focus of recent research has been the use and deployment of human resources and skills at an organisational level and how this is linked to the economic performance of organisations and economies more broadly. While much of this research lies outside main economic literature, research on the management of human resources suggests a range of results concerning various aspects of human capital and firm performance. This is not really surprising, as there is a widely held belief that people are a key source of an organisation's competitive advantage. It is the quality of the human resources that determines organisational performance. There are a number of different emphases in this research, including the role played by human resource management (HRM) in promoting such resources, and the role of management itself – particularly top managers. One important theme is the role of leadership, with a focus on the role of managers, especially top executives, in influencing company performance. Their skills, education and training are important in what are often very complex processes.

1.4. Macroeconomic performance and education

Literature on economic growth models explores directly the quantitative relationship between investments in education and training and the level and growth of per capita GDP. There are a large number of studies, beginning with the classical growth models first developed in the 1950s, through to the so-called endogenous growth models that are still widely applied in many current empirical studies. Both data sets and econometric modelling techniques have developed extensively over recent years and many different model specifications have been proposed and empirically tested. Typically, these models use data drawn from a cross-section of countries, sometimes only for developed countries but often for a wider set. Data difficulties commonly mean that consistent series of educational variables are hard to obtain over sufficiently long periods to facilitate econometric time series analyses. For developed countries over more recent years, cross-sectional and time series data are combined into panel sets to enable a more comprehensive testing of the relationship between human resources and economic growth.

This body of research can be divided up into a number of subsections. The so-called 'growth accounting' literature emphasises the importance of measuring changes in the quality of labour, as indicated by improved qualifications and higher skills, when trying to account for economic growth over the long term. The impact of the accumulation of knowledge though the undertaking of research and development (R&D) has also been a key feature of this body of research.

Other subsections focus on technical research into production and related functions, which are concerned with the relationships between factor inputs (both tangible and intangible, such as knowledge) and economic outputs. The so-called 'new growth theories' are also very relevant here. These highlight the determinants of economic growth in the broadest sense, concentrating on human capital inputs. There are a number of distinguishing features of the new growth models, but, essentially, they extend the existing models by endogenising technological change (hence, they are also sometimes referred to as endogenous growth theories). This contrasts with traditional neoclassical models, where economic growth is driven by the increase in factor inputs (i.e. population growth) and by the exogenous rate of (labour augmenting) technological change. The newer models often allow for increasing returns to scale, where growth is unbounded and in which growth rates can continue to increase indefinitely over time.

1.5. Other links between investment in human capital and performance

There are a number of other areas of research that have a bearing on economic growth issues. Further important evidence comes from market

value literature which is concerned with how intangible assets, such as technical knowledge, influence potential performance and net worth.

While macro growth models have developed the production function approach to explain macroeconomic growth, market valuation has developed the same approach to explain the growth of individual companies. This also has important macroeconomic consequences. Research studies in market value are concerned with how intangible assets, such as technical knowledge, influence potential performance and net worth. These are intimately tied up with investment in education and training as well as skills, which may often be necessary, if not sufficient, to improve such intangible assets. Research and development, patents and intellectual capital are identified as key determinants of corporate market value. These same variables were also found to be important contributors to macroeconomic growth in the new growth theory literature.

Other research has emphasised the importance of knowledge, intellectual capital and other intangible assets, in influencing the performance of companies at a micro level and economies at a macro level. The role of firm size, including insights from the structure-conduct-performance literature (which highlights the importance of size and monopoly power in exploiting new knowledge) and also the role of qualifications and quality of management in the performance of smaller firms, need to be considered. Work in this area has been carried out for some time and many of the studies emphasise the role of the small firm in economic growth. Such small firms are an extremely heterogeneous group, that have markedly different training needs from those of their larger counterparts. There is found to be far less emphasis on educational and training qualifications in small firm environments. Empirical studies suggest that conventional theories of company behaviour are far too simplistic for explaining the goals and aspirations of these smaller organisations.

1.6. Spill-over, external effects and non-economic benefits

The final strands of literature considered here detail some of the indirect effects of investment in human resources that are not normally captured in measured national economic growth. Such spill-overs and externalities can be technological, spatial or environmental and economic and non-economic. Each contributes significant social gains. Many of these effects are related to other areas of the literature covered in this review. The spatial externalities, that embrace city dynamics, demonstrate how geographical clustering of businesses employing highly qualified workers produces high productivity and strong local economic growth. Other significant spill-overs relate to health and life expectancy, which typically increases as a consequence of higher levels of education.

Such spill-over and related external effects are potentially very important. In making a training investment, an individual firm takes into account the impact of the training on its performance, given the current total stock of human capital in the economy. The higher the human capital in the economy, the greater is the firm's own performance. However, it does not take into account the effect of its own investment on the total human capital stock. As far as the individual firm is concerned, the impact of that investment is minuscule and need not be considered. However, from the perspective of the economy as a whole, the totality of training investments by firms can further increase economic output and economy-wide performance. These external effects can add considerably to the macroeconomic consequences of any initial investment in human capital.

External benefits are often not economic. They also include improvements to the environment, better health and reduced crime rates. Serious attempts are now being made to quantify these in economic terms. These are major areas of study in their own right and are only touched on here.

2. Introduction

2.1. Aims of the study

The main objective of this study is to provide a comprehensive and critical overview of the impact of education and training on economic performance, and, by implication, employment opportunities, at the macro level. In this context the term 'macro' is defined quite widely to incorporate firms and industries, as well as the general economy. It is argued that there is a wide range of different studies that have a bearing on the link between investment in human capital and economic growth. These studies need to be synthesised in order to obtain a comprehensive view of the many ways in which education, training and the accumulation and appropriate deployment of skills influence economic performance.

The review considers the implications for policy and practice, drawing general lessons for further improvement in the economies of member countries. While attention is given to the role of vocational education and training, it is much more difficult to find relevant evidence in this area than for more general education.

2.2. Content of the study

The expansion of formal education and training in developed economies in recent years has had substantial and easily observed implications for the skill levels and skill structures of the populations and employed workforces of these countries. However, the contribution of education and training to economic growth and other measures of performance is less clear.

Simple statistics can be produced to demonstrate a well-established correlation between investment in human capital and economic indicators such as GDP. However, the direction of causality remains the subject of heated debate. The implications for future education and training policies are the subject of continuing research and are addressed by this study.

A number of key areas can be identified, each of which has an important bearing on the issues considered here. The main ones include:

(a) rates of return on investment in human capital and the link between private rates of return from education and training and social returns for society at large;
(b) links between the use and deployment of human resources and economic performance, including literature on management skills and organisational performance and general literature on HRM, policy and performance;
(c) literature on the causes of economic growth, including the growth accounting studies, production and knowledge functions relating GDP to various determinants and the new growth theories which endogenise the sources of economic growth;
(d) literature on market valuation of companies and the role of R&D (a proxy for education and training in higher level skills) and intellectual capital;
(e) the role of firm size and structure-conduct-performance theories of growth, with an implied role for education and training;
(f) the spill-over effects and externalities that result from higher investments in human capital.

A key objective is to draw together these disparate strands and to identify the common messages about the links between education, training and skills and various indicators of performance.

2.3. Approach

The approach adopted is to conduct a series of extensive international literature reviews of research in each of these areas, covering economic, econometric, business organisation and other related disciplines. These each focus on different aspects of the relationship between investment in education, training and skills and economic performance. It is argued that it is also necessary to consider some micro level research, which has a bearing on outcomes at a broader macro level. In particular, research into firms and

industries is considered very important in understanding the contribution of education and training to overall economic growth. The paper builds upon and extends the analysis presented in the two previous Cedefop reports edited by Tessaring (1998) and Descy and Tessaring (2001).

The aim was to include as much material as possible from non-English speaking countries, as well as to provide a greater focus on VET as opposed to more general education. However, this proved much easier said than done and the present draft is heavily reliant on English language material (particularly American research) and the effects of more general education. This reflects the balance of studies currently available. In the country comparative analyses that are reported in the section on economic growth modelling, much of the analysis focuses on international comparisons, often based on OECD statistics. Although many of the authors emanate from non-English speaking countries, they publish in English.

2.4. Limitations of the study

The research explores the many diverse studies which touch upon the relationship between education, training and skills and performance in all its aspects. A variety of variables are used as indicators of investment in skills and investment in human capital. Measures of performance at a macroeconomic level are equally varied. The diversity of skills-performance literature is caused, in part, by the range of both performance and input measures used. These include differences in the level of aggregation and whether the focus of the research is concerned with private or social returns. The latter are potentially very wide, encompassing all kinds of spill-over and external effects, including impacts on the general environment. Many of these effects are especially difficult to quantify. The associated study by Green et al. (2003) into the non-material benefits of education, training and skills focuses more directly on these issues.

In investigating the relationships between economic performance and education, economists have focused on a range of measures such as the rate of economic growth, the level and rate of growth in income and wealth, the level and change in unemployment, export performance, and the like. At an individual level more emphasis is usually placed on the link with earnings. Empirical investigations have been undertaken at both micro and macro levels, including individual, establishment, firm, industry and economy-wide level studies. The present study covers all of these.

Education and training are key contributors to the development of skills and knowledge. Typically, but not always, the latter are reflected in the award of some form of qualification or credential. It is these measured qualifications that are normally used to capture the human resource input into the production and growth process. Where such measures are not available, years of completed schooling are often used instead.

At the organisational level, more complex indicators are often deployed. Higher levels of competences should result in superior performance by the individual and, other things being equal, by the organisation in which the individual works. When such organisations are aggregated together, the higher competences should be reflected in higher national growth. Campbell (2001) has recently argued, for example, that, for the UK, long-term studies show a considerable contribution by education to economic growth at a local level.

Most studies of economic performance at the level of individual establishments have been of private sector companies. While there are examples of economic studies of public organisations and institutions, these are relatively rare and it is usually necessary to go to other disciplines, such as HRM, to find more information. There are also other, more holistic, approaches to performance that focus mainly on geographical areas. For example, city dynamics forms a very large and growing area of research undertaken by economic geographers. This is given brief coverage in the present review, but the associated study by Izushi and Huggins (2003) analyses the impact of investment in human capital on regional growth across the EU.

It is important to emphasise that the present review does not attempt to assess the precise values of the parameters reported, although it is concerned with the direction and strength of the relationships. The focus is more on the nature of the key indicators and the variables used in studies and the general nature of the relationships established.

2.5. Structure of the present report

The remainder of this paper is divided into seven main sections, each dealing with a particular area of literature.

Chapter 3 presents a brief overview of statistics on economic growth, employment, unemployment and various measures of investment in education and training. While this highlights the strong correlation between some of these indicators, it also emphasises the difficulties in identifying and establishing causal relationships between the two.

Chapter 4 examines evidence of such links, focussing on the conventional rate of return on education and training. Although much of this literature is now based on the use of micro level, individual data sets on earnings, its conclusions have very important macroeconomic consequences. This includes the aggregate effects of investments by individuals as well as the wider social returns.

Chapter 5 concentrates on the links between investment in skills and performance at the level of the organisation or firm. This has focussed on the use and deployment of human resources in the broadest sense. While much of this research has a micro focus, in terms of the units of observation examined, it has crucial macro implications for the performance of economies at much broader sectoral and national levels.

Chapter 6 focuses more directly on macroeconomic literature. It highlights the increasing range of evidence of the links between investment in education and training and economic growth. This covers a range of different approaches from the classical growth models of the 1950s and 1960s, through growth accounting methods to the new endogenous growth theories, which place education and training and other forms of investment in human capital at the centre of things.

There are a number of other areas of research which have focussed on the link between investment in human capital and economic performance. These are covered in Chapter 7, which highlights, in particular, some of the insights from market value literature. It also covers other studies concerned with the value of intangible assets, much of which is tied up in some form of human capital.

Chapter 8 covers a further series of research areas, all of which have some bearing on this topic, including structure conduct performance literature. Chapter 9 provides a round-up of work that has emphasised the externalities and spill-over effects of investment in human capital. These encompass a large range of both economic and non-economic benefits. In total, these constitute very significant macro effects of many individual investments in education and training by individuals, companies and other organisations.

Chapter 10 gives an overall summary of the findings, draws some implications for policy and makes suggestions for possible future work.

3. Statistics of growth, education and training

Many international agencies collate data on GDP, employment and unemployment. Others provide a wide array of statistics on educational spending and qualifications within different countries. Generally there is good availability of this type of data for the Member States of the EU, covering the period after 1970. Some problems arise with consistency and comparability of the data sets through time. Quantitative measures of vocational training in Member States are much more difficult to obtain and, most commonly, such data are only available for a limited number of countries, and then only for more recent years.

3.1. Economic growth

Table 1 presents estimated annual GDP per capita growth rates ([1]) for the 15 Member States for various 5-year periods between 1970 and the year 2000. These data are based on the main economic indicators series published by OECD; the growth rates are based on GDP per capita estimates, all expressed in 1995 constant prices and using USD exchange rates for the same year. The average annual growth rate for the 30-year period is given in the right-hand column of Table 1. This shows how all countries have experienced significant

Table 1: **Estimated growth rates of GDP per capita**

EU Member States	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000	1970-2000
Belgium	3.46	2.91	0.08	2.99	0.90	2.81	**2.18**
Denmark	2.19	2.50	0.47	1.41	1.63	2.85	**1.84**
Germany*	2.25	3.34	0.68	2.91	-3.28	1.91	**1.28**
Greece	5.07	4.41	0.07	1.72	0.59	3.42	**2.53**
Spain	5.52	1.96	1.08	4.49	0.91	3.80	**2.95**
France	4.00	3.27	0.35	3.20	0.38	2.68	**2.30**
Ireland	4.93	4.48	0.27	4.48	3.56	9.90	**4.56**
Italy	2.41	3.85	0.81	3.03	1.08	0.11	**1.87**
Luxembourg	3.23	2.61	1.18	4.69	1.59	6.33	**3.26**
Netherlands	3.22	2.61	-0.54	3.11	0.93	3.68	**2.16**
Austria	3.94	3.41	1.05	3.00	1.50	2.57	**2.58**
Portugal	4.73	5.27	0.75	5.11	0.98	3.82	**3.43**
Finland	4.09	3.20	1.87	3.39	-1.51	2.07	**2.17**
Sweden	2.57	1.33	1.01	2.29	-0.54	2.96	**1.60**
United Kingdom	2.17	1.64	1.30	3.28	0.85	2.85	**2.01**
EU-15 (average)	**3.28**	**2.93**	**0.73**	**3.18**	**0.48**	**3.51**	**2.34**

* Discontinuity in German series between 1990 and 1995 is attributable to Unification.
Source: OECD main economic indicators

([1]) GDP per capita is the most widely adopted measure of economic growth, as it standardises for the size of country. Alternative growth measures, such as the growth of GDP without any adjustment for population size, may well show a different picture.

economic growth in recent decades, with an EU annual average growth rate of about 2.3 %. The average for Germany turns out to be artificially low as a result of much slower growth (decline) in the period after unification. Ireland, a relatively small country, has the highest growth rate of all the 15 Member States. There is significant variation around the EU long-term average. Sweden shows one of the lowest growth rates over this period.

Over time, economic growth rates differ across the respective five-year periods shown in Table 1. For most of these EU countries growth was relatively strong in the 1970s, but the period from 1980 to 1985 produced a marked slowdown for all countries, with average growth rates below 1 %. The second half of the 1980s resulted in much stronger economic growth, but the early 1990s produced relative stagnation for most Member States, with some countries experiencing GDP per capita declines. There was a return to significant growth in the most recent five-year period, although while Ireland averaged annual growth rates approaching 10 %, the comparable figure for Italy was only about 1 %.

3.2. Employment and unemployment

Associated with the growth in GDP are changes in national employment levels. Table 2, based on statistics provided by Eurostat, shows longer-term trends in average annual rates of growth in total national employment. Most of the Member States have experienced positive growth in employment over each of the past four decades, despite the variation in economic growth rates. Across all the Member States employment has grown over the longer term, although individual rates of growth show some variability. Table 3, using consistent Eurostat definitions, presents estimates of unemployment rates also averaged over decades. These show a significant upward trend, especially in the period after 1980. Lower rates of economic growth have brought about higher unemployment levels across the EU, as job creation has failed to keep pace with the numbers in the labour market. The difference in unemployment rates between Member States is very marked, especially in the 1990s.

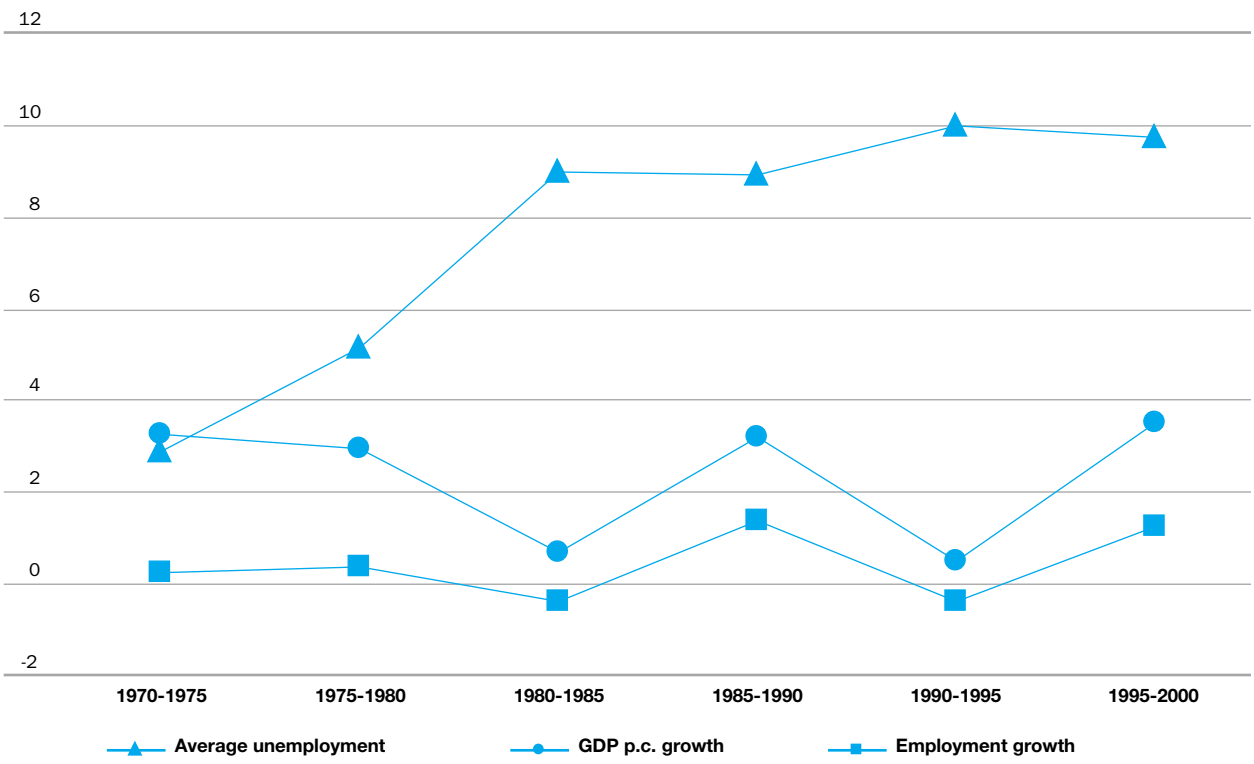
Table 2: **Growth in total employment – average annual percentage changes**

Country	1961-70	1971-80	1981-90	1991-2000
Belgium	0.5	0.2	0.1	0.5
Denmark	1.1	0.3	0.3	0.4
Germany	0.2	0.2	0.5	0.3
Greece	-0.8	0.7	1.0	0.4
Spain	0.6	-0.6	0.8	1.2
France	0.6	0.5	0.3	0.5
Ireland	0.0	0.9	-0.2	3.7
Italy	-0.5	0.7	0.6	0.2
Luxembourg	0.6	1.2	1.7	3.4
Netherlands	1.9	0.7	1.1	1.9
Austria	-0.4	0.7	0.1	0.3
Portugal	0.2	0.1	0.2	-0.1
Finland	0.4	0.3	0.5	-0.8
Sweden	0.7	0.8	0.7	-0.7
United Kingdom	0.3	0.3	0.5	0.2
EU-15 (average)	**0.3**	**0.3**	**0.5**	**0.4**
Source: Eurostat - European economy: 2001 review				

Table 3: **Unemployment rates – average percentages**

Country	1961-70	1971-80	1981-90	1991-2000
Belgium	1.9	4.6	9.7	8.7
Denmark	1.0	3.7	8.4	7.1
Germany	0.7	2.2	6.0	8.1
Greece	5.0	2.2	6.4	9.5
Spain	2.5	5.4	18.5	19.6
France	1.8	4.1	9.2	11.3
Ireland	5.4	7.7	14.7	11.1
Italy	4.8	6.1	8.7	10.7
Luxembourg	0.0	0.6	2.5	2.6
Netherlands	0.9	4.4	8.5	5.4
Austria	2.5	1.8	3.3	3.9
Portugal	2.5	5.1	7.3	5.6
Finland	2.3	4.0	4.7	12.5
Sweden	1.7	2.1	2.6	7.7
United Kingdom	1.7	3.8	9.8	8.1
EU-15 (average)	**2.2**	**4.0**	**9.0**	**9.9**
Source: Eurostat - European economy: 2001 review				

Figure 1: **Average growth and employment rates in EU**



Source: Eurostat statistics

Figure 1 provides a simple comparison of GDP per capita growth rates, total employment average annual growth rates and unemployment average percentages for the 15 Member States across six time intervals over the period 1970-2000. The graph shows how GDP and employment growth move closely together. Unemployment has risen steadily over the longer term.

3.3. Educational participation

International education statistics tend to be less readily comparable than economic growth data and employment data, but organisations such as Unesco and OECD have long published figures measuring educational variables. More recently, results from various European labour surveys have supplemented these sources of information. Unfortunately, in this area, different surveys often seem to produce statistics that can be significantly at odds with one another; see for example the discussion in Barro (2000). Table 4 reproduces data measuring total expenditure on education as a percentage of GNP; this is mainly derived from various Unesco Statistical Yearbooks. Since the statistics in Table 4 are only concerned with the 15 Member States, these data are considered to be relatively comparable.

Table 4 shows how, overall, EU countries have maintained educational expenditure as a more or less constant percentage of GNP. Given that these economies have been growing steadily over the period since 1970, educational investment has also been increasing in line with economic growth. Some Member States significantly increased their educational expenditures (as percentage of GNP) over the 30-year period; Greece, Spain, Ireland and Portugal are the best examples. The average percentage levels were consistently higher in Denmark, Finland and Sweden than in the other Member States. The data in Table 4 suggest some variability in education budgets over the five-year observation periods. This may be as a result of political policy changes or it could simply be a reflection of changing measurement practices in the different countries. International time series of education variables can sometimes be rather inaccurate and most studies, such as those described in Chapter 6 below, use broad average

Table 4: **Total expenditure on education as percentage of GNP**

Country	1970	1975	1980	1985	1990	1995	1998*
Belgium	6.0	6.2	6.0	6.0	5.0	5.0	4.7
Denmark	6.7	7.6	6.7	7.0	7.1	7.7	7.4
Germany						4.8	5.0
Greece	1.7	1.7	1.8	2.4	2.5	2.9	3.0
Spain	2.0	1.8	2.6	3.3	4.4	4.9	4.8
France	4.8	5.2	5.0	5.8	5.4	6.1	6.0
Ireland	4.8	5.8	6.3	6.4	5.6	6.0	5.8
Italy	3.7	4.1	4.4	5.0	5.2	4.7	4.3
Luxembourg	3.6	4.7	5.7	3.8	3.6	4.1	4.3
Netherlands	7.2	8.1	7.6	6.4	6.0	5.2	5.0
Austria	4.5	5.6	5.5	5.8	5.4	5.6	5.5
Portugal	1.5	3.5	3.8	4.0	4.2	5.3	5.7
Finland	5.9	6.4	5.3	5.4	5.7	7.5	7.9
Sweden	7.6	7.0	9.0	7.7	7.7	8.1	8.5
United Kingdom	5.3	6.6	5.6	4.9	4.9	5.3	5.3
EU-15 (average %)	**4.7**	**5.3**	**5.4**	**5.3**	**5.2**	**5.5**	**5.5**

NB: * Estimated percentage based on OECD *Education at a glance*, 2001
Source: Unesco statistical yearbooks

observations in cross-sectional comparisons, rather than time series analyses.

Comparison of the data in Tables 1 and 4 illustrates immediately some of the difficulties in establishing links between indicators of education and economic growth. There are no obvious patterns. Sweden, which has one of the highest percentages of expenditure on education, has one of the lowest growth rates. Ireland, the fastest growing country, cannot attribute this to a higher than average proportion of spending on education or growth in the percentage. The links between these variables are often complex and difficult to identify.

Educational expenditure provides only a very broad measure of investment in human resources. Other statistics are available on the percentage of those of eligible age in the population enrolled in various categories of education. For most Member States, primary and secondary education participation is virtually 100 % and trends over time have very little significance. However, the percentage of the eligible population in tertiary education shows marked variability between EU countries and changes over time are very apparent. Table 5 summarises this data, as derived from various Unesco statistical yearbooks. All the Member States show very significant increases in the percentages entering tertiary education over the 25-year period covered by the data. By 1995, the EU average was approaching 50 %, showing a strong trend growth, especially in the period since 1985. Again, there is no obvious link between these indicators and performance in terms of GDP growth.

Other indicators of educational investment are also available, such as statistics on the average number of years of education completed by members of the working population in different countries. Some detailed studies are available comparing qualification rates in particular areas of study, such as mathematics, sciences and foreign languages; see, for example, some of the data reproduced in Prais (1995). Further statistics that try to provide some measure of the quality of educational input detail the qualifications of those who carry out the teaching in schools and related educational establishments.

Virtually all published education statistics show

Table 5: **Percentage of population aged 18-22* entering tertiary education**

Country	1970	1975	1980	1985	1990	1995
Belgium	17	22	26	32	40	56
Denmark	19	30	28	29	36	48
Germany					34	46
Greece	13	18	17	24	36	42
Spain	9	20	23	29	37	48
France	19	25	25	30	40	51
Ireland	12	17	18	22	29	40
Italy	17	26	27	25	32	42
Luxembourg						
Netherlands	20	25	29	32	40	48
Austria	12	18	22	26	35	48
Portugal	7	10	11	12	23	39
Finland	13	28	32	34	49	55
Sweden	22	30	31	31	32	47
United Kingdom	14	19	19	22	30	50
EU-15 (average %)	**15**	**22**	**24**	**25**	**35**	**47**

NB: * Basic group is ages 18-22, but this varies slightly for different countries
Source: Unesco statistical yearbooks

increasing levels of investment over time across all the Member States. These increasing trends are correlated with economic growth statistics. However, the direction of causality remains to be established. Is increased educational investment a prime factor determining growth in GDP per capita or is this observed increase in education a result of continuing economic growth? The literature on economic growth reviewed in Chapter 6 of this paper suggests that there is a growing weight of evidence that it is the former, although there is also important feedback in the other direction.

3.4. Educational qualifications of the workforce

The OECD has adopted the international standard classification of education (ISCED) system to facilitate comparisons of educational attain-

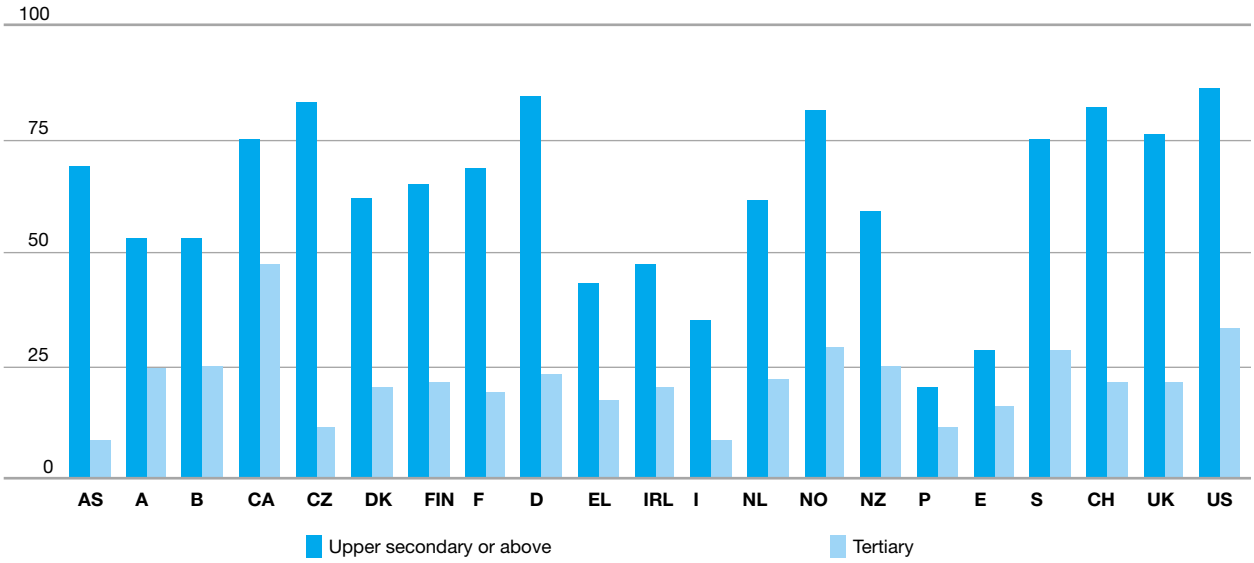
Table 6: **Educational attainment of the adult population.**

	Highest completed level of education		Average years of schooling
	Upper secondary or above (%)	Tertiary (%)	
Australia	53	24	11.9
Austria	69	8	11.9
Belgium	53	25	11.7
Canada	75	47	13.2
Czech Republic	83	11	12.4
Denmark	62	20	12.4
Finland	65	21	11.6
France	68	19	11.2
Germany	84	23	13.4
Greece	43	17	10.9
Ireland	47	20	10.8
Italy	35	8	10.0
Netherlands	61	22	12.7
New Zealand	59	25	11.4
Norway	81	29	12.4
Portugal	20	11	10.0
Spain	28	16	11.2
Sweden	75	28	12.1
Switzerland	82	21	12.6
United Kingdom	76	21	12.1
United States	86	33	13.5
OECD average	**62**	**21**	**11.9**

NB: The estimates of average years of schooling relate to total cumulative time spent in formal education over all ISCED levels from the beginning of primary level (ISCED 1) to tertiary level. These estimates are obtained by using data on educational attainment of each age group from the labour force survey and applying an estimated average cumulative duration for each level of education. Where there are programmes of different duration at the same ISCED level, a weighted average is taken based on weights corresponding to the number of persons in each broad educational programme.
Source: Education at a glance – OECD indicators (OECD, 2001a), indicator A2.1, p. 38 (using data on educational attainment of individuals from labour force survey sources, or in the case of Denmark, the register of educational attainment of the population).

ment between countries ([2]). ISCED was originally designed to serve as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally. The ISCED typology is described in further detail in Annex 1. This classification system forms the basis for much of the comparative evidence emanating from the OECD on education systems (e.g. OECD, 2001a; Steedman and McIntosh, 2001). International comparisons

Figure 2: **Highest educational attainment of the adult population**



Source: OECD (1998)

Figure 3: **Average years of schooling**

Source: OECD (1998)

([2]) OECD has adopted ISCED, but Unesco remains responsible. Unesco revised ISCED in 1997 with the aim of reflecting evolution in education-training systems and increasing comparability of data. The new ISCED distinguishes between programme orientation (general education, pre- and vocational education and training) and programme destination (further studies, labour market). This means that there exist consistent and comparable data on education and training (but the potential of new ISCED is still unexplored).

Table 7: **Average schooling and no schooling rates 1970-2000**

	Mean school years				% with no education (age 15+)			
	1970	1980	1990	2000	1970	1980	1990	2000
Middle East/North Africa	2.07	3.29	4.38	5.44	69.8	55.5	42.8	32.0
South Asia	2.05	2.97	3.85	4.57	69.3	66.9	55.2	45.2
Sub-Saharan Africa	2.07	2.39	3.14	3.52	63.8	56.8	45.9	42.8
East Asia and Pacific	3.80	5.10	5.84	6.71	35.4	22.6	26.4	19.8
Latin American and Caribbean	3.82	4.43	5.32	6.06	31.2	23.8	17.2	14.6
Advanced countries	7.56	8.86	9.19	9.76	5.1	4.8	4.5	3.7
Transitional	8.47	8.90	9.97	9.68	3.1	2.8	1.7	2.2
World	5.16	5.92	6.43	6.66	31.4	29.5	26.4	24.2

Source: Barro and Lee (2001)

of education are typically based on years of schooling, and/or the highest educational level achieved.

A comparison between OECD countries of educational attainment is provided in Table 6 and Figures 2 and 3. Two measures are provided – the proportions of the working age population whose highest attainment level is upper-secondary or tertiary (primary level attainment is now almost universal in the OECD) and the average number of years of schooling. As can be seen, there are only relatively small differences between countries in terms of average years of schooling across the OECD.

Recent work by Barro and Lee (1993, 1996, 2001) has also focused on comparisons of educational attainment between countries. However, given the wider set of countries they consider – including many developing and transition countries – and the paucity of detailed data (such as household surveys), especially for their historical series, they simply focus on average years of schooling and a broad measure of education level attained. Table 7 and Figures 4 and 5 provide some details for a range of country groups.

In general, there have been increasing average levels of participation in education over the last three decades, in all regions, but growth has been particularly strong in the Middle East and North Africa. Mean school years have increased in developed countries too, with the net result that there has been a substantial increase in the world stock of educated people, although little convergence between regions. South Asia and Sub-Saharan Africa still have substantial proportions of their populations with very little or no education.

A simple comparison of these data with those on economic growth rates does not reveal any obvious and immediate links. Teasing out the causal links between the two is a complex problem, as the discussion in subsequent sections makes clear.

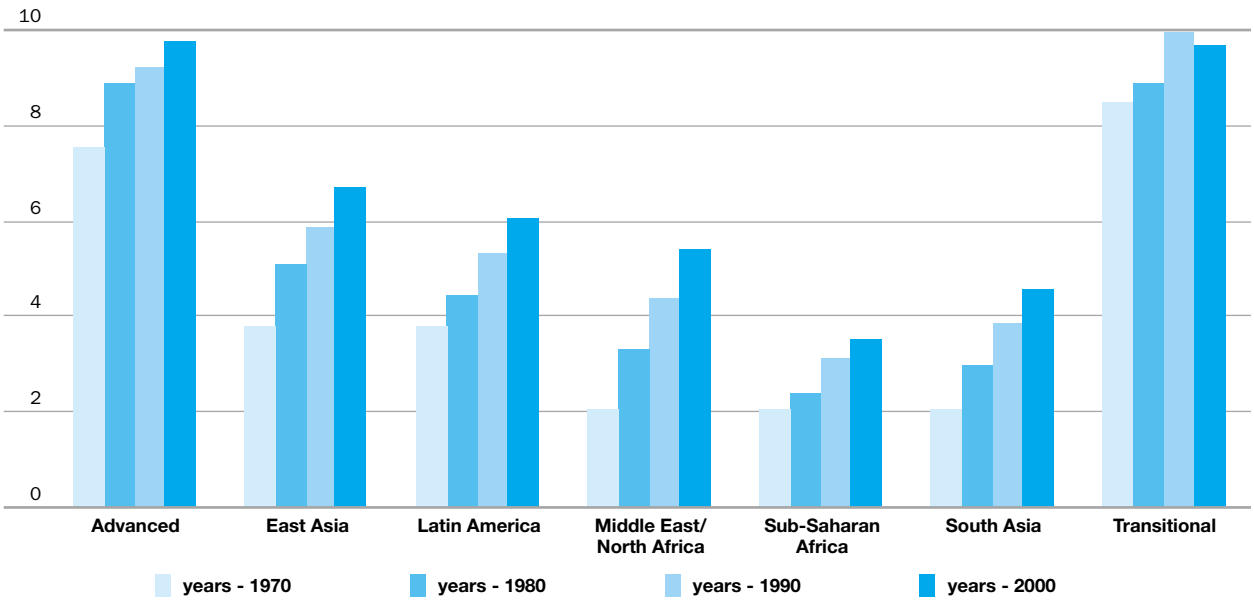
3.5. Vocational training

Consistent statistics detailing trends in vocational training across EU countries are often more difficult to obtain, although more recent OECD statistics and European labour force surveys (ELFS) provide much useful comparable information in this area. Table 8 shows some comparative data for selected Member States for one particular survey period. While consistent definitions were agreed for the ELFS, exactly what sorts of training are included and which are excluded by the survey questions is not at all obvious. McIntosh (1999) has detailed a whole range of difficulties in trying to use these data to draw quantitative comparisons about levels of vocational training across the EU. Questionnaires used to collect this information are often revised and modified between successive surveys, so that discontinuities in the data sets over time are commonplace.

Table 8 appears to show some marked discrepancies across countries between the percentages of individuals receiving training in the month prior

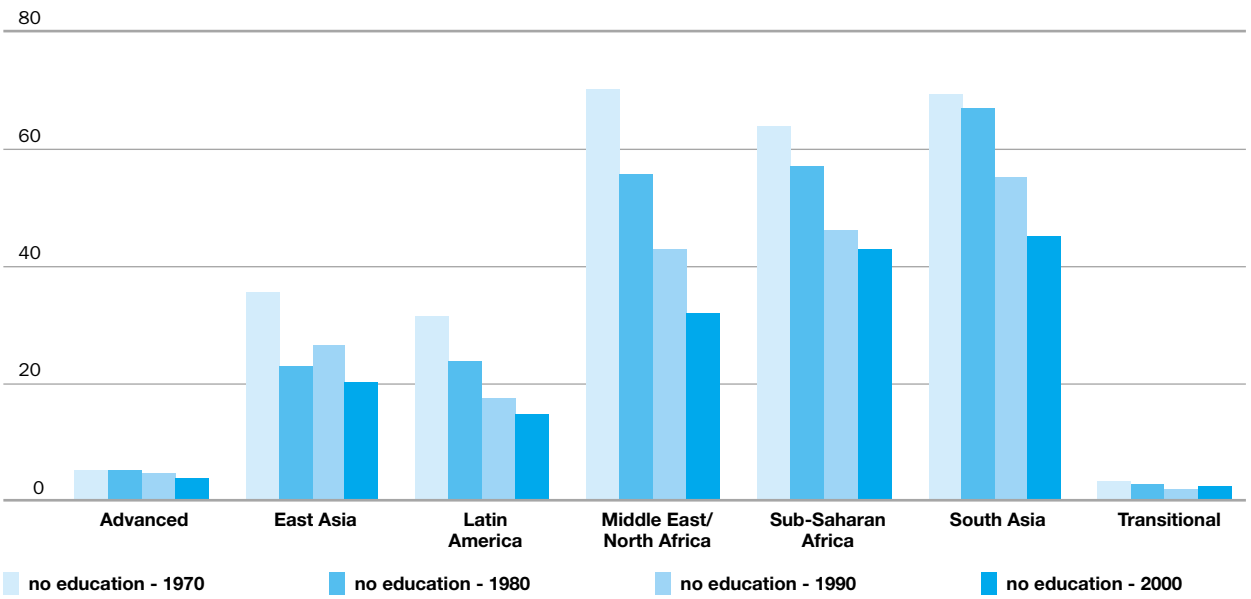
to the survey; while Sweden has just over 10 %, France and Portugal have less than 1 %. However, much of this variation is explainable in terms of how the training question is interpreted in different countries, rather than real observable differences. Much of Table 8 is concerned with how the incidence of training is distributed across the characteristics of individuals, their job tenures and their places of work. In most Member States, training is concentrated on those in the younger

Figure 4: **Schooling attainment 1970-2000: average years of schooling**



Source: Barro and Lee (2001)

Figure 5: **Schooling attainment 1970-2000: percentage of population 15+ with no schooling**



Source: Barro and Lee (2001)

age groups, although Sweden is a significant exception. While in the Sweden and the UK vocational training is aimed more towards those employees with higher prior education levels (ISCEDs), in Germany the opposite is the case, with the least qualified employees being those most likely to receive training. Workers who have been in the job for the shortest period of time receive more training in France and the UK than longer-term employees, whereas in Sweden the pattern is reversed with training increasing with length of job tenure. Table 8 also shows how in Germany, France and the UK training incidence is highest in smaller enterprises that employ fewer workers, while in the Netherlands training is highest in the largest enterprises.

It is clear that these training statistics are complex and difficult to interpret, given the significant differences that underlie the national vocational training systems. There is good reason to suppose that vocational training, like its educational counterpart, has been on an increasing trend in all Member States over recent decades. However, measurement problems mean that vocational training data are unlikely to be suitable for inclusion in models of the kind described later in this study. In an earlier Cedefop report, Luttringer (1998) has detailed some of the difficulties in defining precisely investment in continuing vocational training and also in relating it to productivity gains, both at the micro and macro levels.

A proxy measure of skill levels in populations is provided by the OECD's international adult literacy survey (IALS). However this survey only covers a limited number of EU countries over the period 1994 to 1998. It is very likely that increases in adult literacy are associated with economic growth.

Table 8: **Comparisons of vocational training based on European labour force survey**

Category	Germany	France	Netherlands	Portugal	Sweden	UK
All employees	4.9	0.5	5.3	0.1	10.5	7.3
Females	4.8	0.3	4.4	0.1	10.8	6.7
Males	5.0	0.6	5.8	0.1	10.2	7.8
Age 15-20	65.1	26.5	8.0	0.2	3.4	25.6
Age 21-30	3.5	0.5	6.7	0.1	9.0	6.6
Age 31-40	0.8	0.1	5.4	0.1	12.1	6.2
ISCED high	1.0	0.2	3.7	0.3	14.7	10.5
ISCED medium	1.9	0.2	5.8	0.2	10.1	6.0
ISCED low	24.6	1.1	5.1	0.1	6.0	6.5
Tenure +6 years	0.5	0.1	4.6	0.2	11.7	5.6
Tenure 1-5 years	9.8	0.1	8.5	0.1	10.0	6.7
Tenure <1 year	6.2	2.5	3.4	0.1	7.7	8.1
< 11 employees	5.5	1.4	3.5	0.1	-	9.3
11-19 employees	5.5	1.3	4.4	0.2	-	6.6
20-49 employees	4.4	0	3.9	0	-	6.9
50 > employees	3.4	0	5.9	0.4	-	7.0

4. Rates of return on education and training

4.1. General literature strands

There is extensive and detailed literature on rates of return on education and training, based on human capital theory. Much of this literature relates to the rates of return for the individual and society in general of investment in human capital, in the form of education and training. Most of this microeconomic research draws on work by Becker (1964), Mincer (1974) and many others. Measuring the benefits of education and training is complex and can be considered at various levels and from differing perspectives:

(a) at an individual level, examining the impact of education or training on the chances of being employed or unemployed or, most commonly, earnings;
(b) from an organisational perspective, examining the impact of education and training on organisational performance. The extent to which employers engage in training their staff and provide employees with transferable skills in the labour market is critical (Stevens, 1999);
(c) at a macro level, examining the role of education and training, typically using qualifications as a measure of activity, and their impact on productivity, output growth and employment.

The discussion in this section briefly focuses on certain aspects of the first of these, while the second and third form the subject matter of Chapter 5 and 6 respectively.

4.2. Rates of return on investment in human capital

A number of reviews on the rates of return on general education and training have been undertaken; most recently both Harmon and Walker (2001) and Blundell et al. (2001). A review of the most significant literature on rates of return on continuous vocational training in companies has been carried out by Barrett (2001), in an earlier Cedefop report. Sianesi and Van Reenen (2000) have carried out a review of the macroeconomic returns on education, but this largely deals with research considered in subsequent sections of the present document.

General literature on the subject demonstrates most directly the links between education and training and performance at an individual level. However, it is important to appreciate how some of the microeconomic theory and analysis carries implications for the macroeconomic level which, (subject to certain concerns about the extent to which qualifications act as a signalling device rather than actually enhancing productivity), can be regarded as the sum of the individual parts. While much of the evidence relates to the benefits to the individual, it is clear that this has direct implications at a more macro level.

The main emphasis of most of this research is on the returns on higher education (e.g. a first degree), although there is fairly extensive literature on the returns on training, particularly in the US. The prime focus of most of this literature is also upon the benefit to individuals, although some explicit efforts have also been made to assess wider benefits to society as a whole that effectively represents a macro effect, which is the principle concern of this study.

The key concept here is the notion of the rate of return on the investment in human capital that education and training represents. Rates of return are typically estimated in two ways:

(a) early studies used a discounted cash flow, accounting framework;
(b) more recently researchers have adopted an earnings function approach.

The effects on employment, productivity and earnings can be expressed in terms of the rate of return on education and training.

Typically, rates of return are computed for various qualifications or for the length of time spent in education or on training courses. The rate of return expresses the value of an additional year of education (or the value of a particular qualification) in terms of the associated increase in earnings or income. The issues addressed in the wide variety of studies that have estimated

rates of return on education and training include variations in rates of return according to type of qualification, gender, age and ability; the screening impact of additional education to filter individuals into well-paid jobs; the effects of over-education and the direct impact of education and training (including government training schemes) on the probability of employment.

The discounted cash flow accounting approach compares income or earnings streams of individuals with and without the education or training programme (i.e. they compare graduate income streams with those whose highest qualification is A level ([3])). The calculation generates an internal rate of return on the investment that can be compared to the going rate of interest. It is possible to distinguish between two substrands: *ex post* rates of return (which generally compare actual incomes of individuals of different ages, with and without the education or training) and *ex ante* rates of return (which generally compare an individual's perceptions of future income streams over future years with and without the education or training).

The earnings function approach, involves estimating an earnings function based on data on the earnings of large samples of individual workers, together with information about their personal and other characteristics, including their investments in education and training. Estimates of rates of return on years of schooling or on individual qualifications can be obtained from such an analysis using a method pioneered by Mincer (1974). Although it has been refined in various respects, this basic approach has become the accepted standard, allowing for problems of endogeneity and spurious correlation to be directly addressed. Although the discounted cash flow approach still has some adherents and is still useful in situations where the large cross-Sectional data sets on individual earnings are not available, the earnings function model is now by far the most popular.

In effect, both approaches attribute the difference in income between individuals or groups of individuals to the education or training programme. This is only true if the individuals being compared (i.e. those with and without the education or training) are identical in every important respect. Finally, this approach makes no allowance for selection biases (i.e. that the individuals most likely to benefit select themselves/ are selected onto the programme). Some researchers have tried to address the issue of selection as well as testing the biases resulting from ability. Their results suggest that the major part of the benefits that accrue to individuals as a result of investment in education or training reflect enhanced productivity. Hujer et al. (2003), in an associated study, discuss some of the methods and limitations of evaluation and impact research.

Despite this, there have been continuing concerns about over-education, qualification inflation and graduate unemployment, see for example, Büchel (2001). In the UK, two papers by Brynin, (2002a and b) focus on these concerns. They examine first, the impact of graduate densities on wages, and second, the impact of over qualification on returns on first and second jobs. Graduate density is defined as the proportion of graduates in employment defined by both occupation and industry. Together with other variables, including average education, these measures are then used as potential explanations of wage outcomes.

The results suggest some evidence of graduate overcrowding but also gender-based job segregation that appears to operate in favour of women. For men, there are diminishing returns from expansion in graduate numbers overall. Brynin also examines the extent and impact of over qualification for a job. Normally this is assessed by asking about the level of education required for the job and comparing this to actual qualifications. This often indicates that a large proportion of people have some excess education, although typically they earn more compared to other people doing the same kind of work. Normally such individuals earn less than those doing the kind of job for which they consider they are appropriately educated. The results indicate that for younger cohorts, having excess education brings diminishing returns in their first job, but this does not apply to the older cohorts. These points were originally raised in the Cedefop second research report, Part 4.

Brynin reports that, as average qualification levels have increased over time (as measured by

([3]) The General Certificate of Education (GCE) Advanced (A) level is normally taken at the end of secondary school in the UK. A levels are the main standard for entrance to higher education.

average O-level/GCSE ([4]) results), the status of second as well as first jobs (as measured by the 'Hope-Goldthorpe scale' of occupational status) has been declining. This does not necessarily imply the need to put the brakes on the expansion of education but does demonstrate that not everyone will benefit uniformly from further expansion of education.

4.3. Private versus social rates of return

An important feature of this micro literature, carrying implications for macro studies, is the key distinction between private and social rates of return. In effect, the private rates relate only to the costs and benefits experienced by the individual undertaking the education or training. In particular, the costs of education would only involve those elements paid for by the individual (i.e. they would not include fees if these were paid by the government) and higher future incomes would be assessed net of tax. The social rate of return, on the other hand, takes into account all costs and benefits. Private and social returns are generally always different for the types of reasons set out above. An Austrian empirical study by Fersterer and Winter-Ebmer (1999) demonstrates some of the differences in the rates of return on various levels of education for Austria.

In addition, there is the issue of spill-over effects and externalities from education and training, which may also have a distinct spatial aspect. An example relates to poaching. If, for example, few firms train, then the trained workers can be offered higher salaries by firms that do not undertake training. The firms which train lose in this process and the firms that do not train benefit, although, increasingly, firms ask for a repayment of training costs if workers leave a firm. This undermines the incentive to train. If, however, all firms train (to the same standard), then, ignoring differences in types of skills, there is no incentive to poach and, when individuals do move, those lost can be replaced by others of equal skill level. There are other aspects of social returns, however, linked to new growth theories, which are developed in Chapter 9 below. In particular, the bridging concept is that education spills-over from the educated to the non-educated group. The original idea was proposed many years ago by Blaug (1972).

Mingat and Tan (1996) produced estimates of social returns on education, to incorporate externalities and non-economic effects, for a wide range of countries over the period 1960-85. They used the overall economic performance of the various countries to capture these externalities. Their results confirm the social profitability of investing in education, but they suggest that the results are sensitive to the stage of economic development achieved by the individual country. The best returns for low-income countries came from investing in primary education, in secondary education for middle-income countries, and for the highest-income countries the optimal social return was from higher education. Despite this, there is evidence from some countries, including the UK, that there are still significant benefits to be obtained by investing in basic literacy and numeracy among those segments of the population that have, for one reason or another, missed out on education, Dearden et al. (2002)

Harmon and Walker (2001), in their recent review of evidence and issues relating to the returns on an individual's education, indicate a considerable degree of consensus on estimates of the rate of return for an additional year's education. Basic specifications suggest a return for a year of schooling of between 7 and 9 %. Most studies suggest that women gain more from additional education than men, that those in the top part of the income distribution gain higher returns per year of education than those in the bottom part , and that the effect of underlying ability on earnings is small compared with the effect of education. The impact of such education on overall national output and productivity is not considered by such studies.

Much of the analytical debate regarding the need for greater public investment in education and training has rested on the social rate of return relative to the private one. Evidence on social rates

([4]) The Ordinary (O) level is the main examination taken by secondary school pupils in the UK leading to the General Certificate of Secondary Education (GCSE). They are usually taken after four or five years of secondary schooling and can lead to more advanced education and training.

of return looks at the benefits to the economy from increased years of education, typically by calculating the costs of education/schooling compared to pre-tax earnings. From a methodological perspective this is contentious due to the need to make many assumptions, but available evidence indicates returns are around 6-12 % (Chevalier et al., 2001) (Steel and Sausmann, 1997). A new study by Trostel et al. (2002), uses broadly comparable data covering a number of countries to show that recent rates of return on schooling vary significantly across the 28 countries in the sample set but are still generally positive and large.

The present study is as much concerned with vocational training as with general education. The most obvious and direct effect of training by employers is to provide additional skills and to raise productivity. This is the central notion of the human capital model of training. Barrett (2001) reviewed a number of empirical studies across several countries, examining the links between returns on continuing vocational training and company performance. The main results suggest that strict rates of return, equivalent to those used in the higher education studies, have rarely been used in the evaluation of continuing vocational training. Such training is usually found to have a positive effect on both productivity and wages, but there have been few attempts to demonstrate whether these are sufficient to guarantee a good rate of return. Specific training has the greatest impact by raising the productivity of the employee within the firm providing the training. General training, which can be used by all companies, is still beneficial, but it tends to have less impact on company performance, although it may have important benefits for the individual and for society at large. There remain important differences in the perception of the value of training between the individual, the company investing in the training and society as a whole. These issues are more fully investigated in the associated study by Hansson et al. (2003).

5. Human resources and performance

5.1. Links between human resources and performance at company level

Most of the studies on rates of return discussed in the previous section are concerned with issues of appropriate measurement and analysis of the factors that lead to variation in the measured rates for the individual. Generally, there is no attempt to relate such rates of return specifically to more general corporate performance. It can be assumed from human capital literature that greater education leads, *ceteris paribus,* to higher productivity, which will be reflected in economic growth or other kinds of improved performance for the individual company or organisation.

Outside mainstream economic literature, studies in the management of human resources report a range of results concerning the impact of human capital on firm and industry performance. Such literature bridges the gap between rate of return analysis and macro level studies. It suggests that companies employing managers, professional and other staff with higher qualifications can expect to achieve better commercial performance. This literature is briefly reviewed here.

There has long existed a widely held belief that people are a key source of an organisation's competitive advantage (Prahalad, 1983) (Pfeffer, 1994) (Wright et al., 1994). By implication, it may be argued that it is the quality of the management of human resources that determines organisational performance (Adler, 1988) (Reich, 1991) (Youndt et al., 1996). There appear to be a number of different emphases in this literature, including the role played by managers, as well as the extent and nature of human resources themselves.

5.2. Management skills and organisational performance

A key theme in the economics and broader management literature has been the important role that managers (and administrators) play in determining organisational performance. Amongst trading companies, for example, it has generally been assumed that the capacity of the chief executive officer (CEO) or the management team forms the ultimate limit to the rate of sustainable growth (Bosworth and Jacobs, 1989).

The way in which this line of thinking developed was to look at the goals of the large owner-managed firms and the manner in which these impacted upon company behaviour. The empirical counterpart to this was structure-conduct-performance literature, where firm size and market power were key components. This section focuses on more recent literature concerned with the level and discipline of qualifications of the workforce and, in particular, the CEO or management team. (Bosworth, 1999).

There is no real underpinning theoretical literature, although there are clearly links with the theories relating to individual rate of return, human capital and the value of intangible assets. Empirical modelling usually attempts to relate P, some measure of company performance to Q, a vector of qualification and skill-related variables, and X, a vector of other variables influencing company performance.

A further issue is the use of qualifications as a measure of the quality of workers or managers. Certainly education and training impart a variety of knowledge and skills that may raise the productivity of the individual in the job in which they are employed. However, these are input and not output measures. There is no indication as to how good or relevant the education or training is or, indeed, the capacity of the individual to absorb the knowledge. In some ways this can be seen as an empirical issue. It is possible simply to estimate an equation where P is determined by Q and X, to see whether qualifications are significant or not, in the presence of other determinants. It should be noted that measurable qualifications are not the same as actual skills or quality of competence.

The role of leadership has been defined in several ways. The first is 'stewardship', which is typically represented as a dummy variable for a

specific CEO in a particular company (Lieberson and O'Connor, 1972) (Weiner and Mahoney, 1981). A dummy variable is defined D_{ijt} as taking a value of 1 when the ith CEO is heading company j at time t. An alternative way is to attempt to quantify CEO 'strategy' by observing key variables over which the individual has control, such as capital structure and retained earnings (i.e. two financial strategy variables). It can be seen that the first variable is a crude proxy, and the second echoes the Tobin's Q type specifications discussed in Chapter 7 below.

HRM literature is mixed in its views about the impact of leadership. One strand argues that the evolution of formal and informal organisational structures in large corporations means that they largely run themselves, so effectively limiting the influence of any single individual, even the CEO. Hall (1977) argues that leadership is important in times of growth, development and crisis, but not in times when the organisation is roughly maintaining a *status quo*. Weiner and Mahoney (1981) point out that while the presence of a leader remains essential, the particular leader that is chosen may be of little importance. Lieberson and O'Connor (1972) found that situational and organisational factors were of greater importance than leadership.

5.3. Empirical studies at company level

Issues of HRM at company level were discussed earlier in Cedefop's second research report, Part 3 and they are also reviewed in the parallel study by Hansson et al. (2003). A key theme of HRM literature is the link between HRM strategy employed by the organisation and performance. Youndt et al. (1996), for example, distinguish between universal and contingency strategies ([5]). The authors report that their empirical study largely supports the contingency approach. More importantly, from the perspective of the present study, the authors conclude that HRM systems, which focus on human capital enhancement, are directly related to multiple dimensions of organisational performance, in particular to employee productivity, machine efficiency, and consumer alignment. However, in line with their conclusions about the contingency approach, Youndt et al. report that fuller analysis reveals that enhanced performance is predominantly the result of linking human-capital-enhancing HRM systems with quality manufacturing strategies. There is a link between HRM strategy and the quality of management decisions.

An earlier survey of over 700 UK production companies revealed the relatively low levels of qualifications of both the boards of directors and their CEOs (Bosworth et al., 1992). However there was strong confirmation of a link between the existence of a R&D culture and the ability and willingness to innovate, particularly when graduates were employed to carry out R&D. Regression analysis of the extent of the introduction of new technologies by companies in the sample (a performance indicator) revealed a positive correlation between the probability of innovation and the presence of graduates in the workforce. Firms that utilised these advanced technologies tended to outperform non-users in a number of respects. In particular they worked closer to full capacity and had higher growth in turnover and market share. However, one consequence of working closer to full capacity and being more dynamic was that such companies tended to experience more acute skill shortages. The study reported both direct and indirect (i.e. *via* innovation) links between qualifications and performance. Two of the main conclusions drawn from the study, were '[…] the presence of graduates […] improves general economic performance' and '[…] the differential impact of graduates (generally) on company performance […] is much more clear-cut than the differential performance that could be attributed to the employment of professional scientists and engineers *vis-à-vis* graduates from other discipline areas.'

Barry et al. (1997) update and extend the earlier results of Bosworth et al. (1992) and compare them with a study by Wood (1992), who linked a profit-based measure of performance to qualifications. Wood found that manufacturing companies run by CEOs possessing any kind of degree/profes-

([5]) 'The universal, or "best practices" perspective implies a direct relationship between particular approaches to human resources and performance, and the contingency perspective posits that an organisation's strategic posture either augments or diminishes the impact of HR practice on performance.' (*op cit*. p. 837).

sional qualifications were more likely to achieve superior levels of profitability. However, there was no evidence that the precise type of degree/professional qualification held by the CEO made a great deal of difference to the level of profitability.

The Barry et al. (1997) study focused more simply on the top executives of the companies, rather than the earlier approach that had incorporated both non-executive and executive directors. A key conclusion on the role of qualifications was that companies headed by qualified top executives tended to outperform those with unqualified top executives and many of the latter companies exhibited significant under-performance in the market-place. A further conclusion concerned the contribution of the discipline background of the top executive, whereby companies headed by top executives with non-technical qualifications – particularly accounting – outperformed companies with top executives who were qualified engineers or scientists.

A key question relates to what the measure of company performance should be. Earlier conceptual literature suggested that growth might be a key performance indicator, but there is little in empirical literature that has tested such a relationship. There are some models in structure-conduct-performance literature that have explored the influences on growth, but these have not usually incorporated the human capital variables. There are, however, some studies that test alternative goals, such as profits. Here, however, it is not possible to use, for example, private rates of return theory as an underpinning, as this is based upon the idea that individuals are paid the value of their marginal product (or some equivalent dynamic concept). However, it is fairly easy to think of a rationale from the more institutional/contracting literature that suggests, for example, more qualified individuals are offered contracts that induce them to generate a surplus. This surplus is then shared between shareholders and qualified workers in the form of both higher profits and higher wages.

A study by Ballot et al. (2001) examined the impact of human and technological capital on productivity in a panel sample of large French and Swedish firms. Specifically, measures of a firm's human capital stock were constructed on the basis of past and present training expenditures. The results confirm that such firm-sponsored training, together with R&D, are key inputs to the market performance of firms in both countries. Another study by Blechinger and Pfeiffer (1998) used survey data for the German manufacturing sector to explore the links between employment growth, technological change and labour force skill structures. Innovative firms experienced the highest growth rates and such firms tended to employ more highly skilled workers. An HRM study by Papalexandris and Nikandrou (2000) into Greek firms found that, where training was treated as a continuous, lifelong learning process, it had considerable impact on the growth of firms.

5.4. Empirical studies at the industry and sector level

A different approach to exploring the links between investment in human resources and productivity in organisations is that developed over the last 20 years by researchers at the national institute of economic and social research (NIESR) in the UK. Much of this work is summarised in Prais (1995) and all the relevant papers have been published in full in various editions of the *National Institute Economic Review*. The research approach consists of carrying out empirical international comparisons of productivity and associated schooling and vocational training investments between Germany, France, the Netherlands, the UK and other selected countries. Often matched samples of plants and firms from specific industrial sectors have been used to explore the productivity and human capital relationship.

It should be noted that this body of research draws on statistics and information from several EU countries. Moreover, this research is noteworthy in utilising vocational training data, as well as the more commonly adopted years of schooling measures. The concern is not so much with the statistical impact of an extra year of training or schooling on productivity, but rather with the results of different kinds and qualities of human resource investment.

Prais (1995) summarises broad statistical estimates from various national labour force surveys carried out in the period 1988 to 1991. This data shows marked differences in intermediate vocational training qualifications between selected EU countries. While in the UK only 25 % of all

economically active persons achieved such qualifications, the comparable figure for France was 40 % and for Germany it was 63 %. The main difference was found in craft training rather than technician training. Conversely, some 64 % of the UK workforce were found to have no vocational qualifications of any sort, whereas the comparable figure for France was 53 % and for Germany only 26 %. Prais concluded that the UK was anomalous in the relatively low proportion of its workforce that has received systematically organised vocational preparation and attained formally examined vocational qualifications. During the ensuing decade, investments in vocational training across the Member States have changed these percentages but the differentials between countries still persist and this has implications for comparative productivity.

Various studies carried out by researchers at the NIESR have sought to demonstrate the link between a better educated and better trained workforce and realised higher output per worker. Investigations were made into manufacturing plants in the UK and their counterparts in other EU countries. The studies looked into the metalworking, woodworking, clothing and food manufacturing industries, as well as selected service sector trades. It was found that across all these industries the acquisition of skills amongst the workforce was a critical factor in raising productivity, as measured by output per worker. Recent studies of this kind have been carried out by Mason et al. (1999) into banking services and by Jarvis et al. (2002) into the ceramic tableware industries. Commonly, plants in Germany, France and the Netherlands, where the percentage of vocational qualifications was much higher, return significantly higher output per worker than their UK counterparts.

Steedman (2001) has recently compared systems of apprenticeship training across various European countries (from a UK perspective) and drawn implications for productivity. This study identified significant shortcomings in the UK approach that have resulted in an inferior quality of vocational training for young workers.

Another study by O'Mahony and de Boer (2002) confirms that the UK continues to lag behind both Germany and France in terms of labour productivity, and this gap is primarily explained by differential rates of investment in both human and physical capital. This predominantly statistical study compared labour productivity not only across the aggregate economy but also over some 10 broad industrial sectors. It applied education and training statistics, divided into higher, intermediate and lower level qualifications, to quantify comparative workforce skills in the different countries. It identified a significant association between labour productivity and measured workforce skills across the different industrial sectors of the comparator countries.

6. The role of education and training in economic growth

6.1. General literature strands

Over the last three decades a large body of literature has been produced examining the role of human capital in determining the level and growth of GDP per capita. Much of the earlier work is mainly theoretical and deals with different growth model specifications and their associated economic properties; for a summary, see Aghion and Howitt (1998). More recent work seeks to test empirically the different model specifications, most commonly using cross sectional data for a large number of countries. Some researchers have attempted time series analyses for smaller groups of countries, such as those in the OECD area, where the quality of educational data are both more frequent and perceived to be more reliable. A few studies have combined cross sectional data with time series information to produce panel data sets in which allowances can be made for country-specific effects. Two recent papers by Sianesi and Van Reenen (2000) and Temple (2000) provide useful overviews of the various empirical studies. The former paper looks at the links between formal education and economic growth across all countries, while the latter is concerned with the impact on growth in OECD countries of both education and more widely defined social capital. The present paper draws on both these studies.

From a comparative international perspective, attempts to identify the extent to which education and qualifications affect relative economic performance, including employment levels, have begun to reveal the importance of human capital. Macroeconomic models incorporate human capital into growth specifications either through extensions of the Solow neoclassical growth model (Solow, 1957) or through endogenous growth equations, as developed by Romer (1986), Lucas (1988) and others. A current application of such a model is shown in the associated study by Izushi and Huggins (2003). Fundamentally, neoclassical models imply that a one-off increase in the stock of human capital leads to an associated one-off increase in productivity growth, whereas endogenous growth models suggest that the same one-off increase in human capital can lead to a permanent increase in productivity growth. In the short term, both models produce broadly similar results, each dependent on the precise specification, but, over the longer term, the newer growth models imply significantly higher returns on investments in human capital.

Regardless of the precise model that is adopted, there is strong evidence that higher educational inputs increase productivity and so produce higher levels of national growth. After surveying the empirical results from a wide range of model specifications, Sianesi and Van Reenen (2000) concluded that an overall 1 % increase in school enrolment rates leads to an increase in GDP per capita growth of between 1 and 3 %. An additional year of secondary education which increases the stock of human capital, rather than just the flow into education, leads to more than a 1 % increase in economic growth each year. The results vary dependent on the model specifications and the data sets in use. Sylwester (2000) has suggested that current educational expenditure leads to future economic growth, so there is a significant time lag in the causal relationship.

Aside from concerns relating to the preferred model specification, other methodological issues concentrate on the most appropriate variables for inclusion and their methods of measurement. A very important strand in the literature concerns the definition of human capital and how far human capital can be practically measured. This issue was originally addressed in an earlier Cedefop report (Westphalen, 2001), where human capital was widely defined to include knowledge, skills, competences and similar attributes. For the most part, empirical growth models adopt a much narrower interpretation of human capital and usually some measure of flow or stock of secondary education is used to proxy human capital. Typically, no attempt is made to incorpo-

rate vocational training data into growth models. Koch and Reuling (1998) pointed out some of the difficulties of measuring training investments with any degree of consistency across different countries. Recently, other authors have suggested that it is social capital as well as human capital which contributes significantly to growth (Woolcock, 2000), but given the measurement difficulties, social capital type variables have not, to date, been much used in growth models.

Another strand in the literature is concerned with the selection of appropriate data for measuring economic growth across countries and through time, on a consistent basis. A majority of studies make use of the Penn World Table series produced by Summers and Heston (1991) and this comprehensive data set has been updated and extended by Barro and Lee (1996). Some authors, such as Osberg and Sharpe (2000), have argued that GDP per capita is an inadequate indicator of the overall economic well-being of a nation and they maintain that the link between human or social capital and economic well-being is much stronger than is often implied when simple GDP measures are used in growth models. Such analyses lead towards the literature that links investments in human capital, and education in particular, to externalities in economic growth. Higher levels of education are typically associated with better environment, higher levels of public health and greater social cohesion, all of which would be expected to feed back into faster economic growth measured in the wider sense. This strand of literature has recently been surveyed in OECD (1998).

Most of the literature produced on this topic has appeared in English language publications. A majority of the studies are by UK and US authors; European authors have produced some of the OECD publications. However, the empirical studies use international data sets and EU and OECD countries are widely analysed within much of the published research.

6.2. Growth accounting literature

Growth accounting literature is deemed to be sufficiently well known to warrant only brief treatment here. Griliches (1997) has provided a useful survey of literature on applied growth accounting exercises. This has much in common with general rates of return on education and training, although it focuses much more explicitly on macroeconomic issues with the measured effects of education and training in the form of higher output or sales rather than earnings. Growth accounting literature has a long pedigree, which can be traced back to Solow (1957). In essence, this assumes a Cobb-Douglas production function:

$$Y_t = A_t K_t^a L_t^b M_t^c \quad (1)$$

Where Y is gross output (e.g. sales turnover), K is physical capital, L is labour stock (employment) and M is materials and intermediate inputs. A_t reflects efficiency, so that the higher A_t, for any given values of the inputs, the higher is output. The units of measurement of the inputs affect the level of A_t. This can be avoided by writing the equation in growth form (i.e. differentiating with respect to time),

$$\Delta Y_t = \Delta A_t + a\,\Delta K_t + b\,\Delta L_t + c\Delta\, M_t \quad (2)$$

where the Δ associated with each variable reflects the rate of growth. It can be seen, by rearranging equation (2), that ΔA_t is the rate of change in total factor productivity.

$$\Delta A_t = \Delta Y_t - a\,\Delta K_t - b\,\Delta L_t - c\Delta\, M_t \quad (3)$$

In other words, it represents the output growth that cannot be explained by changes in the growth of physical inputs. Hence A_t was christened the 'residual factor'. In the original Solow study this residual component accounted for some 85 % of output growth. A follow-up study by Jorgenson and Griliches (1967) attempted to explain this residual factor.

Further extensions of the framework to allow explicitly for quality change and control over input and output prices are reported in Bosworth and Gharneh (1996), using a pure accounting tautology in a dynamic context. This literature is shown to have evolved through many phases, which can be categorised as three different generations. First generation models are of the form described in equation (1), using highly aggregate measures of the inputs (i.e. all physical capital, all employees and the total real expenditure on materials and intermediate inputs). Second gener-

ation models are basically the same functional form, but utilise a much more disaggregated set of variables, many different types of capital and a large variety of different types of hours worked. Third generation models not only disaggregate the inputs in detail, but also begin to disaggregate the sectors of the economy, separately distinguishing between the production sectors of the economy and the educational sector.

Jorgenson and Fraumeni (1992) use growth accounting methodology in a third generation framework to demonstrate that investment in human and physical capital accounts for a very high proportion of growth in both the education and production sectors of the US economy over the post-war period. Specifically, growth in labour input is held to account for just over 60 % of overall economic growth and increases in labour quality (education and training) explain some 42 % of this labour contribution. As usual in the growth accounting approach, the contributions of the various inputs to output growth are obtained by weighting the input growth rates by their shares in the sector's value added. The contributions of capital and labour inputs are then decomposed into separate components of capital stock and quality, and of hours worked and labour quality.

Hall and Jones (1999) adopt a growth accounting framework to explore differences in output per worker across different countries. They use the Summers and Heston (1991) database, augmented by educational attainment statistics as produced by Barro and Lee (1996). Their findings suggest that differences in physical capital and educational attainment explain only a small amount of the differences in output per worker. International output differences are predominantly accounted for by differences in productivity and differences in growth rates derive almost entirely from differences in the growth of A in equation (2). This result is at odds with the results of Jorgenson and Fraumeni (1992).

It is important not to read too much into the empirical estimates based upon the growth accounting type of model because this approach entails imposing many assumptions rather than testing them empirically. The methodology typically involves constructing the estimates using an accounting tautology. The rate of change of each input is weighted by the share of that input within the total. The validity of this depends crucially on the assumption that each factor is paid the value of its marginal physical product. The growth accounting approach only reveals the sources of economic growth, if, amongst other things, there are competitive factor markets. The apportionment of output growth to measured and residual inputs provides no real insight into the process that determines such contributions. While human capital has a significant role to play in explaining output growth in this type of model, the measurement of this human capital is usually a complex mix of educational, demographic and labour market variables.

6.3. Neoclassical growth models

Although growth accounting exercises are useful for exploring the links between human capital and economic growth, they are limited by their basic assumptions. As Griliches (1997) recognised in his survey, the true test of the importance of education to growth is to include such a variable in an estimated production function. The starting point for such an approach is the Solow (1957) or neoclassical model. This growth model has previously been described in detail in an earlier Cedefop report (Barrett, 2001), so only an outline is provided here.

The production function can be written in the form where some measure of output is related to the relevant inputs (as in equation (1) above) ([6]). Using the Cobb-Douglas form:

$$Y_t = A\, e^{gt}\, K_t^a\, L_t^b\, M_t^c \qquad (4)$$

where Y is gross output or sales, K is the physical capital stock, L denotes labour and M is the materials and intermediate input variable (all variables are in real or volume measures) ([7]). This is supposedly a technical relationship between inputs and outputs. The link with the growth accounting approach is obvious, as (4) is almost

([6]) Gross output is preferred. This is related to capital, labour, materials and fuels (often called the KLEM models). Net output (or value added) is sometimes used, which is related only to capital and labour.

([7]) The A term is now a constant.

identical to (1). There are two main differences. First there is an extra term, e^{gt}, which attempts to pick up the effects of technological change (i.e. an exponential time trend in times series estimation). Second, the function is now estimated directly using regression techniques, rather than imposing accounting values. The parameters a, b and c are still interpreted as factor shares.

This basic model can be augmented, in approximation to second generation growth accounting models, by the inclusion of different types (or vintages) of capital, K_{1t}^{a1} … K_{nt}^{an}, and similarly, different types of labour (i.e. different lengths of schooling, qualifications, occupations, etc.). Assuming that the homogeneous nature of the variables, as in equation (4) is maintained, but representing their changing quality by some measure or vector of measures, H, a model is derived:

$$Y_t = A\, K_t^a\, L_t^b\, M_t^c\, H_t^d \qquad (5)$$

where H is an indicator of the changing quality of inputs and represents some weighted average of education or qualifications ([8]).

It is now fairly easy to develop a link to the literature of knowledge production functions. The basic idea of this approach is to regress some measure of output, preferably gross output, on tangible and intangible inputs. Thus:

$$Y_t = A\, K_t^a\, L_t^b\, M_t^c\, R_t^d \ldots R_{t-n}^e \qquad (6)$$

where the R variables denote current and past investments in knowledge and are virtually identical to H in equation (5). One way of looking at this relationship is that current and past knowledge generates current output (or sales), holding tangible inputs constant. An alternative interpretation is to note that $\{Y_t/AK_t^aL_t^bM_t^c\}$ is a measure of total factor productivity, and that current and past knowledge is driving total factor productivity.

Although their endogenous counterparts have, to some extent, superseded these neoclassical models, they continue to be empirically tested and Sianesi and Van Reenen (2000) were led to conclude that the neoclassical approach produces results that are more consistent with the established microeconomic evidence. One of the better known and most influential contributions to growth literature is the study by Mankiw et al. (1992), who use an augmented Solow model to explain cross country differences in income levels from 1960 to 1985. This model of equation type (5), but without the materials input variable, explains over 70 % of the variation in income per capita across a large sample of countries. Human capital, as proxied by secondary school enrolment ratios, accounts for almost half the difference in per capita incomes. For non-oil countries, a 1 % increase in the average percentage of the working-age population in secondary school is estimated to lead to a 0.66 % increase in long-term income per capita.

Koman and Marin (1999) applied an augmented Solow model, in a time series framework, to explain recent economic growth trends in Germany and Austria. The results obtained did not support this type of specification and the incorporation of a variable measuring the accumulation of broadly-defined human capital led to insignificant estimates. Temple (1998) has shown that the estimated parameters and convergence rates in this type of model are highly sensitive to measurement errors, and the obtained results are not always statistically robust.

Neoclassical models remain restricted by their underlying assumptions of perfect competition and constant returns to scale. A critical property of the basic production function, equation (4), is that there are diminishing returns on the accumulation of capital. In the absence of any technological change, diminishing returns will eventually choke off any economic growth. The inclusion of human capital accumulation in the model, equation (5), increases the impact of physical investment on the steady state level of output and it can then account for a very slow rate of convergence in income levels across countries. However the problem of exogenous technological change remains and Romer (1994), amongst others, has stressed the need to make technological advances explainable within the model framework.

6.4. Endogenous growth models

In contrast to neoclassical models, endogenous growth models explicitly incorporate technology

([8]) Some models use stock or levels of education and training, while others use flow or accumulation of the same variable. The preferred specification is usually empirically determined.

(the A term in equations (4) through (6)) and attempt to recognise that technological change depends on economic decisions in the same way as capital accumulation. In particular, technological change is most commonly related to the stock of human capital, which is explicitly modelled in terms of educational investments in these endogenous specifications ([9]). The inclusion of technological change and knowledge dissemination into the neoclassical framework is rendered difficult because of the underlying competitive assumptions, which do not allow for the possibility of increasing returns to scale. In the endogenous models, economic growth can continue indefinitely because the returns on investment in a broad class of both physical and human capital goods do not necessarily diminish through time. Spill-overs of knowledge across producers and external benefits from improvements in human capital are part of this process because they offset tendencies to diminishing returns. Growth frameworks have also incorporated R&D concepts, as well as imperfect competition (Romer, 1986) (Barro and Sala-I-Martin, 1995).

A large number of endogenous growth specifications have been put forward. A typical specification for analysing growth across several countries follows Barro (1997):

$$\Delta y = f (y, y^*) \quad (7a)$$

$$y^* = f (Z) \quad (7b)$$

where Δy is the growth rate of per capita output, y is the current level of per capita output and y* is the long-term or steady state level of per capita output. For a given value of y, the growth rate rises with y*, which is determined by a wide set of economic, policy and environmental variables. These variables differ between studies, but typically Z in equation (7b) contains variables measuring population (fertility and life expectancy), labour supply, government expenditure and investment, terms of trade, inflation and, most significant for present purposes, educational variables. Measurement issues associated with the educational variables are discussed below.

Barro (2000) maintains that in this model any increase in the steady-state level y* will raise the per capita growth rate, y, over a transition interval. So if, for example, government improves the business climate by increasing its expenditure or if they decide to increase their investment in education by increasing enrolment rates in secondary education, this will increase the target level y* and raise Δy. As actual per capita output increases, diminishing returns will eventually restore the growth rate to a level determined by the long-term rate of technological progress. In the very long term, the impact of improved policy is on the level of per capita output rather than just its growth rate. However, transitions to the long term tend to be lengthy and the growth effects from shifts in government policy tend to persist for a significantly long period.

6.5. Empirical growth regressions

Following the early work of Barro and his collaborators (Barro, 1991) (Barro and Sala-I-Martin, 1995) (Barro and Lee, 1996), a large number of growth regressions containing human capital variables in the set of regressors have appeared. Temple (2000) has distinguished two main groups of model specification, those that link output growth to some initial level or stock of educational attainment, such as secondary school enrolment rates, and those that relate growth to the flow of educational attainment rather than its level. The first group assume that the stock of human capital is the engine of economic growth whereas the second group attribute such growth to the accumulation of education and training in a given period. This distinction is more fully developed in the associated paper by Izushi and Huggins (2003), where empirical tests are carried out on both model forms.

Most empirical models combine data from a large group of countries, both developed and developing, often using dummy variables to distinguish geographical or economic groupings of countries. The aim of these studies is to identify statistically significant and robust relationships between the various factors (the Z variables in equation (7a) above) and economic growth

([9]) Applied examples of such models are provided in Sections 6.5 and 6.6 below. The methods of incorporating technological change and human resource investments into the models are discussed in these parts of the paper.

across the full sample of countries. The estimates seek to determine causal relationships and so establish the sources of economic growth.

Barro's original 1991 study used data for 98 countries from 1960 to 1985 and related the real growth rate of GDP per capita to initial human capital, as proxied by school enrolment rates for 1960, and a large set of other potential determining variables. It found that output growth was significantly positively determined by both primary and secondary school enrolment, in the presence of other determinants. A one percentage point increase in primary school enrolment was associated with a 2.5 % increase in GDP growth and a similar increase in secondary school enrolment produced 3 % growth. When attempts were made to control for measurement error, the results became weaker in magnitude but still significant. When 1950 school enrolment rates were added to the model they become insignificant, as became a variable measuring the student-teacher ratio. This study also revealed how human capital variables were significantly correlated with lower levels of net fertility and larger levels of physical capital investment.

There followed several papers in the Barro tradition; see Sianesi and Van Reenen (2000) for a more complete overview. Different data sets and measured variables were applied in an attempt to replicate and establish the robustness of the Barro results. Englander and Gurney (1994) re-estimated some of the early growth regressions using only OECD data, which are regarded as a more homogeneous and superior quality data set. Secondary school enrolment rates were confirmed as one of only three significant determinants of labour productivity growth, alongside growth in the labour force and increases in the capital to labour ratio. However, this study found that these significant regressors provided much less explanatory power when estimated for the narrower group of OECD countries than for the original wide sample. Englander and Gurney acknowledged difficulties with the education proxy variables, measurement reliability issues and problems in ensuring strict international comparability: all these issues cast doubt on the robustness of the results.

Gemmell (1996) also worked on OECD data sets and his original contribution involved the construction of some alternative measures of human capital based on both stocks and annual average growth rates at primary, secondary and tertiary education levels. He found that a 1 % increase in initial tertiary human stock was associated with a 1.1 % increase in per capita GDP growth, while a 1 % increase in subsequent growth in tertiary education (flow) was associated with almost 6 % output growth. While the direct growth effects come through tertiary education, secondary education was found to have an indirect impact through its positive significant association with physical investment. When these OECD results were compared to a wider sample of countries, it was found that primary human capital had the most impact in the poorest group of the less developed countries and secondary human capital was the most significant variable for the intermediate group of less developed countries.

Benhabib and Spiegel (1994) use a new set of country comparative data on human capital stock initially to test the augmented neoclassical model, given as equation (5) above and later to modify the specification to allow human capital to enter directly into productivity in an endogenous growth specification. The neoclassical model yields insignificant and generally negative coefficients on the human capital stock variables, a result which holds when other regressors are added into the model and alternative proxies for human capital are applied. In contrast, the endogenous specification produces human capital levels that are positive, but not always significant, determinants of per capita income growth. These results suggest a distinct role for human capital in enabling foreign technology in developing countries and the creation of new domestic technologies in more highly developed countries, rather than entering the model on its own as a conventional factor of production.

Barro and Lee (1993) add comprehensive new educational data sets to the Summers and Heston data and test endogenous specifications of equation type (7) using a much wider set of potential regressors. In particular, the average years of secondary schooling of the adult population at the beginning of the data period are introduced as a key explanatory variable. Barro and Lee's results suggest that an extra year of male secondary schooling is associated with a 1.4 % increase in GDP growth per worker. In comparison, an addi-

tional year of female schooling seemingly has a negative impact on a country's growth rate. Female education is significant in reducing national fertility and hence population growth. Barro (1997), using modified data in panel format and applying more sophisticated estimating techniques, produces a similar set of findings to the earlier paper. An extra year of male upper-level schooling is associated with a 1.2 % increase in per capita GDP growth rate. Male primary schooling is found to have no significant impact on growth and, again, female schooling at various levels have negative but insignificant coefficients in the various equations that are reported.

Krueger and Lindahl (1998) criticise the findings of both Benhabib and Spiegel (1994) and Barro (1997). In particular, they focus on the results which identify only the initial level or stock of educational attainment as the determinant of GDP growth and the failure to find growth in such attainment (the flow of educational investment) as a key determinant. Krueger and Lindahl show the spurious results of the earlier two papers to be attributable to the extremely high and unaccountable measurement error in first-differenced country comparative education data. In a simplified version of equation (7), with only levels of schooling and changes in schooling variables on the right hand side ([10]), the increase in education as the key determining variable of GDP growth is shown. The initial level of education is not positively related to future economic growth for the average country when assumptions on linearity and homogeneity of parameters for education are relaxed. Unfortunately, the estimates of the impact of changes in educational attainment on income growth turn out to be implausibly large when set against findings from microeconomic studies into private returns and the authors identify endogeneity bias (richer countries tend to expand their educational infrastructure) as the likely cause of the problem.

A study by Judson (1998) attempts not only to substantiate the role of increasing investment in education in promoting growth, but also to examine the importance of the allocation of this investment in the growth context. In addition to the familiar Summers and Heston data, and the Barro and Lee human capital stock statistics, Judson uses Unesco data on educational enrolments and spending to estimate the efficiency of existing educational allocations within countries. Overall, a 1 % increase in human capital growth is found to be associated with an 11 % increase in GDP growth rate ([11]). Judson applies a country comparative growth decomposition regression to show that the correlation of human capital accumulation is not significant in countries with poor allocations but it is strongly significant and positive in countries with better allocations (predominantly richer countries). This finding that the contribution to growth of human capital depends on the efficiency with which it is accumulated has important policy implications in terms of the exact allocation of educational and training resources.

Graff (1995) examined the role of human capital in explaining economic growth in some 114 countries from 1965 to 1985. Generally, the results showed the accumulation of human capital, physical capital and technological progress all to be significant determinants of the growth process. In a related study, Graff (1996) investigated the importance of higher levels of education for a subset of poorer countries. This variable was found to be important for growth, so long as the investment in higher education did not lead to imbalances elsewhere in education provision, especially to the detriment of elementary levels of education.

While most empirical growth studies use country comparative data, either averaged across a sample of years or taken over several years in panel data format, a few studies attempt time series analysis within an individual country. The major problem with the time series approach is obtaining adequately long series on consistent bases; this is a particular problem for education and training variables. One example of the time series approach is provided by Jenkins (1995) for the UK. This paper uses annual data from 1971 to 1992 and it proxies the stock of human capital by three series measuring workforce qualifications. These series are used as key determinants of

([10]) Some of these variables are lagged and both time and geographic-regional dummies are also included.

([11]) This implausibly large elasticity impact is a common finding in studies of this kind and it has led Sianesi and Van Reenen (2000) to conclude that the effect is seriously overstated due to a number of methodological problems.

aggregate output, alongside physical capital, total workforce, capacity utilisation and a time trend. The overall result confirms the finding that investment in human capital increases productivity. Highly-qualified workers are found to contribute almost twice as much to productive efficiency as those with no qualifications at all. The relatively small number of observations ([12]) mean that the unrestricted estimates are imprecisely determined and such results cannot be regarded as robust.

Another example of time series modelling is Asteriou and Agiomirgianakis (2001), who use cointegrated regressions to explore the long-term relationship between formal education and GDP in the Greek economy. This study finds a significant relationship between primary, secondary and higher education enrolments and GDP per capita. The main direction of causality runs through the education variables to economic growth, but in the case of higher education, there exists reverse causality. This problem is more fully discussed in Section 6.10 below.

6.6. A recent example of growth modelling

One of the more recent papers in the Barro tradition reports empirical results for the country comparative data set updated to 1995 (Barro, 2000). The paper shows the results of using panel data for more than 80 countries over 3 decades; the sample is disaggregated into three 10-year time periods and the countries are grouped according to various development criteria. The growth rate of real per capita GDP is regressed against a large group of potential determinants, as outlined in equation (7) above. Several of these determining variables are only available, at best, at five-year intervals and some less frequently, so either average values are used for each decade or, in the case of the key education variables, their level at the beginning of each period is applied. The main education variable is one favoured by Barro from earlier empirical exercises. It measures the average years of school attainment at the upper (secondary and tertiary) levels for males aged 25 and over. Subsequent analysis introduces several alternative educational measures into the model: primary school attainment, attainment by females and results on internationally comparable examinations. It should be noted that due to lack of data availability at the country comparative level, no measures of growth in education (flows) are incorporated, only stock levels at the beginning of each period.

The model is estimated by three-stage least squares, using instrumental variables. Some basic results are reproduced as Table 9. In the overall sample, the education variable turns out significantly positive, in the presence of many other policy variables. The estimated coefficient implies that an additional year of schooling raises the growth rate on impact by 0.44 % per year. Barro maintains that a possible interpretation of this effect is that a work force educated at secondary and tertiary levels facilitates the absorption of technologies from more advanced countries. In this model, the effect from an additional year of schooling impacts on the growth rate of GDP and only feeds back onto the level of GDP slowly over time (higher levels of GDP have a negative impact on the growth rate). Using further assumptions on national convergence rates and the average costs of providing an additional year of schooling, Barro suggests that the coefficient value of 0.0044 implies a real social rate of return on schooling of the order of 7 % per year; a figure within the range of typical microeconomic estimates of returns on education.

Column 2 in Table 9 shows how results change, using a slightly more restricted version of the model, when the sample is based only on OECD countries. The result for this group of countries is much less satisfactory in terms of the significance of the regressors, very few of which are significant. In particular, the key education variable takes a value of zero. When other wealthier, non-OECD, countries are added to the OECD set to form the rich country sample (column 4), there is some improvement in the results and the additional year of schooling impact is now significant, but its effect on economic growth is only about half as strong as was the case for the full sample. Results for the poor country sample are better in terms of significant regressors, although the

([12]) This is the main restraint on time series analysis in growth studies.

overall coefficients of determination are relatively much lower for this group (below 50 %). The impact of the additional year of schooling on growth turns out to be almost four times greater for the poor countries compared to the rich group.

Barro (2000) considers additional dimensions to the years of schooling, beyond those reported in Table 9. Female attainment in secondary and higher levels of education become insignificant when added to the basic model for the overall sample. The same insignificant results apply to variables measuring average years of primary schooling for males and females separately, although it is clear that primary schooling is critical as a prerequisite for secondary education. Problems of colinearity are present between some education variables and other potential growth determinants; most obviously between female education and fertility rates.

Barro also attempts within the model framework to introduce measures of quality of education as represented by international examination scores, where available. Such indicators of the quality of schooling capital have been claimed by Hanushek and Kimko (2000) to be more important for subsequent economic growth than years of educational attainment. Predominantly, data are only available for richer countries and only for recent years. Results suggest that science scores (as a measure of quality of education) are significantly positive for growth, mathematics scores are also positive, but of less significant impact than science, while reading scores apparently have no significant impact. Given the dubious quality of some of these data, it would be wrong to read very much into the results.

It is clear that modelling exercises in the Barro tradition do not produce results that can be regarded as robust. Modifications in specifications and changes in data sets can lead to large differences in estimated coefficient values, as exemplified in Table 9. It might have been expected that the superior quality data available for the more homogeneous group of countries within the OECD would have yielded better results than those for the full sample, but this was not the case. Such findings have prompted some researchers to carry out tests of robustness on the model results (Temple, 1998). Others have introduced more complex model specifications to accommodate full sets of panel data (Islam,

Table 9: **Barro growth regressions**

Independent variable	Overall sample	OECD sample	Rich-country sample	Poor-country sample
Log GDP	0.107*	-0.034*	-0.0343*	-0.0190*
Log (GDP)squared	-0.0084*			
Years of upper school for males over 25	0.0044*	0.000	0.0023*	0.0084*
Govt consumption/GDP	-0.157*	0.015	-0.014	-0.167*
Rule of law index	0.0138*	0.0115	0.0116*	0.0196*
Exports + imports/GDP (Openness ratio)	0.0133*	0.0148*	0.0112*	0.0361*
(Openness ratio)* Log GDP	-0.0142*			
Inflation rate	-0.0137*	-0.0228	-0.0051	0.0033
Log fertility rate	-0.0275*	-0.0209*	-0.0174*	-0.0212*
Investment/GDP	0.033	0.045*	0.029	0.053
Growth rate terms of trade	0.110	-0.010	-0.008	0.0134*
Observations & R squared				
1965-75	81, 0.62	23, 0.85	32, 0.77	49, 0.48
1975-85	84, 0.50	23, 0.65	32, 0.62	52, 0.39
1985-95	81, 0.47	23, 0.50	31, 0.52	50, 0.44

NB: * indicates coefficient is statistically significant at 5 % level
Source: Adapted from Barro (2000, Table 1, p. 19)

1995), while a further group have explored the differences that data quality makes to the results (De La Fuente and Doménech, 2000). Some of the results obtained from growth modelling imply some improbably large impacts of initial human stock (education) on growth and these results are sometimes at odds with findings from microeconomic studies (Topel, 1999). One of the issues which has not been resolved is the extent to which some of the results based on the broader groups of countries reflect greater variability in the data (which helps to establish the parameters of the relationships being tested) or whether it is a consequence of including extreme outlier observations, which bias the outcomes and cause spurious results based on poor quality data.

6.7. The influence of data quality on results

The issue of data quality is a common theme in many of the studies reported above; both Sianesi and Reenen (2000) and Temple (2000) raise problems with data quality and suggest that empirical relationships between human capital and growth may be compromised by measurement errors. De La Fuente and Doménech (2000) suggest that some of the insignificant relationships are attributable to some of the educational data that are commonly used in growth regressions. Results that rely on time series variation in the data are especially prone to error. When data adjustments are applied in a preferred growth specification, a much more significant relationship between educational attainment and economic growth is identified.

De La Fuente and Doménech review the various data sets on educational attainment that have been constructed on the basis of Unesco enrolment statistics; the best known of these is the Barro and Lee (1996) series. Enrolment data are transformed into attainment stock figures through a perpetual inventory method and interpolations between census observations. The various authors apply different assumptions and estimating procedures to produce series that exhibit inconsistencies, one to another, across countries. Beyond this problem, there remain accuracy and consistency concerns about the base Unesco enrolment data. Some schooling levels reported for some countries do not appear to be very plausible, while others display extremely large changes in attainment levels over short time periods or extremely unlikely trends; see the discussion in Behrman and Rosenzweig (1994).

While De La Fuente and Doménech (2000) conclude that the Barro and Lee series are probably the most accurate source of data on human capital stocks, these data still contain a large amount of noise that can be traced largely to inconsistencies in the underlying primary statistics. De La Fuente and Doménech revise the educational attainment data for 21 OECD countries during the period 1960-90, using detailed statistics from national sources within each country. In general, the resulting series are held to be much smoother through time and, as a result, much more plausible. The new data are then compared to the original in various growth specifications (variants of equation (5)), using average years of schooling of the adult population as the measure of human capital stock. The size and significance of the coefficient on this newly constructed human capital variable shows an appreciable improvement over the original Barro and Lee variable. When the estimates are repeated with data in first differences, the gain is even more noticeable and only the revised data produce a significant coefficient. Further tests using other growth specifications confirm this result and the equations with the revised data meet the appropriate tests for robustness.

Bassanini and Scarpetta (2001) apply the De La Fuente and Doménech human capital series in panel regressions over the period 1971-98. This study follows Islam (1995) in making full use of both the time series and cross-sectional dimensions of the data. Country comparative studies that fail to use the time dimension produce results which are an average for heterogeneous countries and therefore hard to interpret in the context of a single country policy (Lee et al., 1997). The estimation method used by Bassanini and Scarpetta employs pooled mean group techniques that allow short-term coefficients, speed of adjustment and error variances to differ across countries, but imposes homogeneity on long-term coefficients. Various specifications are estimated, but the empirical results favour an endogenous growth model with broad constant returns on human and physical capital. The results indicate a significant and posi-

tive impact of human capital accumulation on per capita output growth. One additional year of education produces 6 % growth in output in the long term, a result held to be consistent with microeconomic evidence. The findings survived a number of checks for robustness using modified specifications and country comparative samples. The empirical results were sensitive to the use of more reliable data and the choice of estimating approach.

6.8. Human capital externalities

It has long been recognised that the benefits of investing in human capital are not restricted to the direct recipient but spill over to others in society. A better-educated and trained workforce may well improve the productivity of their less educated work colleagues. Acemoglu (1996) argues that an increase in the average level of human capital will often cause firms to anticipate growth and make greater investments in physical capital and research and development. Given an imperfect matching process, firms that invest more will not necessarily be associated with the workers who have invested more in education. However, other workers will benefit, as firms using more physical capital than before employ them. Increases in the average level of human capital clearly create external benefits, but growth models may not be capable of capturing all these external effects.

McMahon (2000) has argued that the direct effect of education on economic growth is separable from the indirect effect or externalities. Of these externalities, probably about 75 % are non-market outcomes which feed back into economic growth, but are not readily measurable in the same way as GNP. The main non-market externalities are: health, including longevity, infant mortality and fertility; environmental impact, including various forms of pollution and deforestation; crime, including rule of law, crimes against the person as well as property crime; better income distribution and the issue of poverty; and democratisation, including human rights and political stability. These issues are dealt with more fully in Chapter 9 of this paper and in the fuller treatment in the associated paper by Green et al. (2003). It will be recalled how Barro regressions, such as those in Table 9, attempt to capture some of these impacts on growth, but measurement limitations prevent models capturing most of these influences. There is also likely to be much interaction between the different non-market social outcomes.

It is clear that human capital externalities are much more than just a spill-over effect from education in the economy. They are a whole series of net outcomes, most of which are only partially realised after initial impact and many take full effect over a very long time span. These externalities, along with investment in human capital, are important in offsetting diminishing returns on physical capital and so determining positive future per capita growth rates. Investment in education and training is important, not only for its direct contribution to growth but also for the indirect externalities that it creates, as these eventually feed back into the growth process.

6.9. Social capital and economic growth

Most of the literature reviewed in this section is concerned with the link between human capital and measured per capita output or productivity growth. As such, human capital is narrowly defined to be some measure of education, usually average years of schooling at primary, secondary or tertiary levels. Temple (2000) recognises that the failure to incorporate measures of vocational training is a serious omission from the definition of human capital. Broadberry and Wagner (1996) have shown that vocational training is closely connected with corporate production strategies and also national output growth. However, the extreme variability in vocational training approaches across countries makes it difficult to measure and quantify to facilitate inclusion in country comparative growth modelling. McIntosh (1999) demonstrates some of the problems involved in making comparisons of vocational training between six EU countries. A wide spectrum of training exists in most countries and often a large amount of training is informal, on-the-job training that may not be recorded and so cannot be systematically measured. It is unlikely in the near future that country comparative growth models, which constitute the core of this growth literature, will be able to incorporate measured training variables.

Despite measurement difficulties, a number of research papers have recently appeared linking economic growth to social capital (e.g. Temple, 2000; Osberg and Sharpe, 2000; Woolcock, 2000 and the literature reviews in these papers). Social capital is a difficult concept to define precisely, but, most simply, it refers to the social norms and networks that facilitate collective action. It embraces the nature of social ties within communities, the relationship between civil society and the state and the quality of governing institutions. The development of social capital is likely to prove highly significant for improvements in economic well-being; a wider concept than simply growth in per capita GDP.

While literature on social capital lies mostly outside mainstream economics, there has, in recent years, been an increasing body of material on social capital published by organisations such as OECD. The majority of this literature is still to be found predominantly in social science and political publications. Two studies have attempted to construct quantitative indicators of social capital and relate them to other economic variables, including productivity. La Porta et al. (1997), Knack and Keefer (1997) and, most recently, Green et al. (2003) used an index of trust, derived from a *World values survey*, carried out across some 28 market economies. La Porta et al. found the trust index to be weakly associated with country comparative growth from 1970 to 1993, but the explanatory power was low and measurement concerns serve to limit the usefulness of these findings. Knack and Keefer report a strong correlation between trust and average years of schooling. Education is argued as strengthening trust and civic norms, thus producing another external effect from investment in human capital. Literature on social capital and growth remains at a relatively early stage and until better methods of measuring the social variables can be devised, social capital, together with vocational training variables, are likely to have a only marginal role in quantitative growth analyses.

6.10. Possible endogeneity and simultaneity bias

Sianesi and Van Reenen (2000) have identified possible problems of reverse causality (i.e. growth stimulates education and training) in the links between investment in human capital and economic growth. As per capita income increases, so educational inputs, both in terms of quantity and quality, also grow, but it is not obvious that this economic growth is caused by the rising educational standards. Income growth is likely to induce a higher demand for education and training and much of this demand will be income elastic. In countries experiencing significant economic growth, governments are more able to increase public spending on education and training, and to ensure better access to such education for more of the population.

A review of international literature on the demand for higher education shows that one of the key determinants is real income per capita (Briscoe and Wilson, 1998). In an empirical study of entrants into UK higher educational institutions, real income was identified as one of the more consistently significant determinants, drawn from a wide list of potential explanatory variables. Literature on education also suggests a similar link between demand for both primary and secondary education and the level of, or growth in, national income.

For the growth models discussed in the present paper, the issue is whether growth in the economy is brought about by the accumulation of human capital or whether the stimulus of growth induces the workforce to seek after higher educational and training standards. Bils and Klenow (2000) have challenged the findings of Barro and others (Section 6.6) on the grounds of reverse causality, whereby it is shown that faster economic growth induces greater schooling opportunities by raising private returns.

Sianesi and Van Reenen (2000) maintain that the most plausible answer to the causality problem is that both processes are at work simultaneously, so that there is a bi-directional causality between investment in human capital and economic growth. Such considerations suggest that growth models ideally should recognise the endogenous nature of human capital and control for the simultaneity bias. Unfortunately, endogeneity problems apply to other right-hand side variables in the growth equations, such as physical capital accumulation. There would seem to be a shortage of plausible instruments to ensure robust empirical estimating.

Aghion and Howitt (1998) have pointed out some of the potential difficulties in relating economic growth to the initial value of an

explanatory variable, such as school enrolments at the start of the data period (Section 6.5 above). There exists the possibility that both the growth and the enrolment variable are jointly determined by some external factor, such as the prevailing political regime, that plays no specific part in the model. There is also a strong likelihood that expectations of future economic growth may spur many workers to invest in education and training now, in anticipation of future economic opportunities. Where time series data are available on a sufficiently long basis, lagged values of these endogenous variables may be used as instruments in the estimating equations. However, even then, the exogeneity of such lagged estimators may be questioned for, as Temple (1999) has shown, there may be long and delayed impacts of human capital accumulation on growth.

7. Market value and related literature

7.1. Literature strands

Market valuation literature has much in common with the production function approach on which the growth models discussed above are based. However, much of it is concerned with individual companies, although their effects can have important macroeconomic consequences. There are two main market valuation literature substrands. The archetypal market value models examine the role of the stocks of intangible assets, including human capital investments, in determining market value ([13]). The estimated coefficients effectively provide a measure of the market's valuation of these intangibles. A second substrand examines the different impacts of the expected and unexpected changes in intangible assets, for example, an unanticipated increase in the company's R&D expenditure or a new invention that is reflected in a patent grant. A further emerging theme concerns the distribution of values of intangibles, for example, linked to the risky nature of R&D investment.

The market value of a company is taken to be a measure of the firm's (potential) dynamic performance. In essence, the rationale for the model is that the market value of the firm is higher the greater the future profit flows of the firm and, thereby, the higher the future dividend payment to shareholders. On the assumption that intangible assets are the main source of abnormal profits, then market values will reflect the perceived returns on R&D and other intangible capital, such as goodwill built up through advertising. Market value is, therefore, a forward-looking indicator of company performance, in other words, it is a dynamic measure of performance. In the long run, the market value is equal to the discounted sum of expected profits (although it may be higher than this, given that the holding of any share is an option).

The so-called Tobin's Q form of this relationship is set out in a number of places (e.g. Hall, 1999), which also describes the potential bias of the linear approximation that is usually adopted prior to estimating. This can be written as,

$$\log MV = \log Q + a \log K + a \log (1 + c \{R/K\}) \quad (8)$$

where K denotes (the replacement value of) tangible assets and R refers to intangible assets; MV/Q is analogous to Tobin's Q (and identical to Tobin's Q where a=1 and there is only one type of asset, a tangible asset, K); the coefficient 'a' describes the overall scale effect and should be equal to unity under constant returns to scale. The specification may disaggregate K and/or R into various components.

The link to the models outlined in Section 6.3 is fairly easy to establish. Clearly, the higher the contribution of current and past R&D to future total factor productivity, other things being equal, the higher profits and growth are likely to be. It has been demonstrated elsewhere that the market value approach and the production function when applied to individual companies are broadly consistent from a theoretical perspective. Under (fairly heroic) assumptions regarding perfect information and efficient operation of capital markets, in principle, they will yield identical results (Bosworth and Gharneh, 1996). Certainly, the empirical results from the two approaches available for the US look broadly consistent. A key distinctive feature of market valuation literature is that it has, to date, only been investigated for quoted companies, using financial accounting and stock market price data.

7.2. Some empirical results on market value models

This work has recently been reviewed by Toivanen et al. (1998) and others. Studies are usually based on large-scale panel data sets of individual companies. Most of the literature focuses on the role of R&D, rather than human capital *per se,* and

([13]) A minor offshoot of this literature is the work that attempts to look at the explanation of share prices. For the purposes of the present paper, we treat these as broadly equivalent approaches.

the principal result is that the R&D has a significant positive effect on market value. In general, it makes little difference whether the R&D flow or stock is used, as the flow is relatively constant for each company. However, in those studies which distinguish between R&D anticipated, e.g. by investors, and unanticipated R&D, it is normally the latter that plays a significant role.

The second variable that has been extensively investigated is the number of patents, although there is a small amount of work emerging now on the quality of patents as measured by citation counts. Market valuation literature suggests a strong positive relationship between patents and market value, especially when patents are used in place of R&D.

Patents represent an outcome of the R&D process. Carrying out R&D and obtaining patents requires the deployment of high level skills. However, such activity involves a certain level of risk, so for any particular project there is no definite link between employment of skilled labour and such outcomes. Nevertheless, the evidence suggests that, on average, they are important. When the two variables are entered together, they tend to do broadly the same job, although patents are somewhat more noisy and the R&D variable tends to dominate. Patents also have the disadvantage that they are less relevant outside of certain key manufacturing sectors, and also in the case of small companies. New intellectual property variables have recently been tested, including trademark data. Anecdotal evidence suggests that, on average, trademarks are at least as valuable as patents.

7.3. Knowledge, intellectual capital and intangible asset literature

The growing interest in knowledge and intellectual capital forms one of the most exciting developments in recent economics and management studies. It builds upon a number of the earlier discussions described above, including the role of R&D knowledge, intellectual property and intangible assets. However, it should be noted that work in this area, particularly empirical testing of the emerging models, is in its infancy and research seeking to identify various indicators or proxies is somewhat speculative.

The literature points to important distinctions between information, knowledge, intellectual capital and the broader range of intangible assets (Nonaka and Takeuchi, 1995). These distinctions are important insofar as information and knowledge are only inputs into the production of intellectual capital, where the latter can be defined as all of the knowledge that has produced or is capable of producing value for the company. In other words, intellectual capital is intellectual material that has been formalised, captured and leveraged to produce a higher value asset. The principal focus is the efficiency with which companies access information and transform it into intellectual capital and other valuable intangible assets, thereby determining competitive advantage and improvements in performance.

The growth in the importance of intellectual capital is a result of the shift towards knowledge-based, rather than manufacturing-based production, with the implications that this has for the focus on intangible rather than tangible assets. Lynn (1998) has claimed that there has been a metamorphosis from a resource and manufacturing-based economy to one in which knowledge and services are the key drivers of economic growth. Evidence of the importance of the broader range of intangible assets abounds. For example, a number of pharmaceutical companies are sold at many times the book value of their tangible assets. Similarly, the market valuation of many companies is significantly higher than their balance sheet valuations. In addition, it is argued that organisations have restructured in order to cope, increasing their agility, by eliminating hierarchies and decentralising, in some cases creating ‘spider web’ or ‘fish net’ organisations (Bartlett and Ghoshal, 1993) (Hedlund, 1994).

Applying a process perspective, it is possible to distinguish at least eight categories of knowledge focused activities:

(a) generating new knowledge;
(b) accessing valuable knowledge from outside sources;
(c) using accessible knowledge in decision making;
(d) embedding knowledge in processes, products and services;
(e) representing knowledge in documents, databases and software;

(f) facilitating knowledge growth through culture and incentives;
(g) transferring existing knowledge into other parts of the organisation;
(h) measuring the value of knowledge assets and/or impact of knowledge management (Ruggles, 1998).

Much of this knowledge is created through investment in human capital, with high levels of education and training inputs.

The importance of the management of intellectual capital has been pointed out by a number of commentators. For example, it has been argued that intellectual capital is the invisible skeleton of the corporation; that it is, in fact, an economic operating system, widely viewed as the company's single most valuable asset (Darling, 1996). It is only by formal systems of human capital reporting that intellectual capital can be made visible; see the discussion in Cedefop second research report, Part 3. At the present time, the management of intellectual capital is still an experimental exercise for most organisations, although a number of key companies (e.g. Hewlett-Packard and Dow Chemicals) are recognised to be leading the process. The Society of Management Accountants of Canada is at the forefront of the promotion of measurement and reporting of intellectual capital. Currently, no company is likely to have a comprehensive intellectual capital management system in place; many will actively manage parts of their intellectual capital, such as their patent portfolios or brands, or parts of their human capital through their HRM systems. There is a strong link here to the discussion in Chapter 5.

8. Further links between education and training and company performance

8.1. Literature strands

This section draws together a number of more disparate areas of literature that have some bearing on the links between education, training, skills and economic performance. The concern here is mainly with company performance because, when companies are aggregated together, the macroeconomy emerges. The key issues are to do with company size, including the problems of small firms, and with work on structure conduct and performance. These are considered in turn. As with some of the other areas of research previously discussed, the importance of the links between investments in human capital (in various forms) and economic success are highlighted.

8.2. Company size and the problems of small firms

There is a significant amount of literature on various aspects of company size and aspects of performance, such as growth, with important links to the structure-conduct-performance hypotheses. The material can be traced back at least to Gibrat's law of proportionate effect. However, this literature has become increasingly less mechanistic and more behavioural as it has evolved over time, branching off in many directions, some of which have already been discussed in other sections of this report. In this section, the focus is wholly on the rather mechanistic Gibrat's law. Structure-conduct-performance and the small firm elements are examined in the following subsection.

In essence, Gibrat's law is concerned with whether company growth is related to size. Thus, if the following relationship is estimated:

$$(S_{t+1}/S_t) = aS_t^{b-1} \quad (9)$$

using data on firm size, S (where t denotes the year), it is possible to test whether large firms grow faster than small firms (b>1) or whether small firms grow faster than large firms (b<1). Simple tests of the law involve no other variables, but more recent tests have included a variety of other right-hand side variables to control for other influences on growth, including human capital.

There are a number of reviews reporting estimates of Gibrat's relationship (Hay and Morris, 1979). The results indicate that the simple formulation of Gibrat's law does not generally hold, although it is accepted that there are some industries in which company growth is significantly related to size (both positively and negatively). A general finding is that variance in growth rate is negatively related to size; in other words, there is a greater diversity of performance among small firms. For example, in the small firm sector in the UK, approximately half the growth in the sector comes from a very small percentage of firms. One early, yet still valid observation, from Singh and Whittington (1968) was that of the serial correlation of growth rates; in other words, firms that tended to grow fast over one period would grow faster in other periods. This links to the company-fixed effects literature to be found, for example, in the market value based studies of performance.

A recent paper in this tradition, but focusing on growth in company size in the service sector, is Johnson et al. (1999). It estimates an equation on growth in employment, using existing size as one of the explanatory variables. It finds a non-linear relationship between growth and size, with growth decreasing with size up to five employees, then rising with size from five to 15 employees, before falling again. They note that the higher profit maximising scale of around 17 employees is in the middle of the range at which salaried managerial appointments tend to be made by small firms. The other variables included, however, give counterintuitive results, with both the education level of the owner and the number of professionals employed having a negative impact on growth rates. There are clearly important differences between small and large firms in a number of respects.

8.3. Small and medium size enterprises and the qualifications of managers

Bosworth (1999) has shown how there has been a major growth in interest in the performance of small and medium sized enterprises in recent years. Interest arises for a number of reasons, including the large proportion of total employment accounted for by the small firms' sector and also the high failure rate among small firms, particularly those that are newly established. Two potentially relevant areas of analysis are identifiable in literature on small firms', the role of qualifications and the quality of management within small firms. This has tended to be a more qualitative literature, often descriptive or case study in nature.

There are several important problems in coming to any firm conclusions about small businesses, including the general paucity of the data, and, in particular, the coverage of the very smallest, often owner-managed firms (i.e. micro-firms). A second problem is that both the data and case study evidence indicate the extreme heterogeneity of firms in the small business group.

While there is little dispute about the hypothesis that small firms would perform better if management quality were to be increased, it is clear that this may not carry the same implications for the role of qualifications leading to improved performance. It appears to be the case that the distinction between qualifications and skills/quality is the greatest for small firms. Small firms have quite different management needs and, with the exception of certain professional and related services, qualifications *per se* are not seen as important, at least for the owner-manager. Qualifications may be more important for non-owner managers and other employees of small firms, in order to gain flexibility in the job market.

Studies suggests that a number of qualifications available in the UK, such as MBAs, do not appear to be at all relevant to the small firm. Even those which are potentially relevant, such as NVQs and GVNQs, do not appear to be wholly useful for many small firms. Other countries' experiences suggest that one possible way forward is to link the training provided to the development of the business, for example, to provide training implicitly or explicitly when providing help to the business to overcome problems. Demonstrating the usefulness of training to the development of the business can encourage small firms to take further education and training subsequently. This is often best taken forward on a regional or local basis ([14]).

8.4. Structure-conduct-performance models

The bulk of structure-conduct-performance literature is now somewhat dated, although there continue to be articles published in this area. An overview of this literature suggests that there are essentially two main strands of investigation:

(a) static models, which focus on the impact of company size and market power on profits (or other current performance measures);
(b) dynamic models, which focus on the impact of company size and market power on invention and innovation and, thereby, by implication, on company growth and performance.

The key importance of the dynamic models is the role that they ascribe to managers (including their skills and qualifications) and the importance they attach to intangible assets (including knowledge and skills) in determining company performance.

Managerial theories, first seen in the 1960s and 1970s, were primarily concerned with company goals in large, professionally managed companies, as opposed to the small owner-managed companies. In general, the former were argued to be sales revenue, utility or growth maximisers and the latter were depicted as profit maximisers. This strand of the literature involves some form of optimisation and the rationale for this literature was that professional managers would act in their own best interests. The main theoretical predictions are that, in the main, managerial models suggest higher levels of labour demand than the profit maximising case. In addition, a number of these models suggest a skewing of demand towards higher-level skills and occupations.

([14]) The examples of Emilia Romagna in Italy and the small firm hubs in India and Pakistan, in particular, are examples of local small firm synergies.

Behavioural theories, which developed a few years after their managerial counterparts, discussed firms as 'satisfiers', rather than optimising units, operating under uncertainty and imperfect information. These behavioural theories said little about labour demands *per se*, but suggest that all firms operate with some degree of inefficiency (i.e. X-inefficiency), only part of which it is economic to remove.

In practice, most empirical literature is based upon fairly *ad hoc* tests of relationships between performance, company size and market structure. Bosworth (1983) has argued that there are various categories of model that are potentially relevant. In those which have the longest pedigree, causality runs from company size to performance:

$$P = f(S, C, X) \quad (10)$$

where P is a measure of performance, such as profitability or sales growth, S refers to size, C denotes the degree of concentration in the market and X is a vector of other explanatory variables, which often have included factors such as advertising expenditure. This is of some interest, as size is purported to affect performance, and size is almost certainly a proxy for other things such as skills, knowledge and R&D.

If different sizes of companies had different goals, this would have direct implications for their performance and for their labour demands, including the demand for skills.

In the case of dynamic structure-conduct-performance models, while it is true to say that increases in size give rise to greater R&D, it is less clear whether the increase in R&D is just proportionate, more than proportionate or less than proportionate with size. In addition, the finding that formal R&D only begins above a certain size threshold is muddied by the fact that small firms may still undertake R&D, but this is not a separate function and tends to be more informal in nature than in larger firms. This is made even less clear by the fact that there is fairly strong evidence that many major inventions have been made by individuals rather than by large corporations. In addition, as noted above, changes in R&D expenditure (an input measure of invention and innovation) with company size says nothing about the relationship between R&D outputs and size. This issue does not appear to have been resolved. However, the empirical evidence seems to support the hypothesis that larger firms are better innovators than small ones, and that R&D expenditures and associated investments in human capital help in the scale and success of innovation activities.

The stylised views of management behaviour set out in managerial and behavioural theories have proved to be far too simplistic. While profit maximisation seems a reasonable first approximation of the likely goal of an owner-manager, in practice, even here there appears to be a much more complex picture. Bosworth and Jacobs (1989) reviewed the various literatures about management goals and behaviour. They found a wide range of goals, including the maximisation of profits. Equally, however, they included the maximisation of the owner's utility (which was influenced by time spent working, by the rewards gained from extra work and by the status and power conferred by self-employment and the control of others). Other managers purported to minimise their risk, growth often being associated not only with high risk, but also with personal and social (family) costs.

There were some characteristics that helped to determine which goal would be set. It was often the older small business, rather than the newer, that tended to adopt more conservative and less dynamic goals. Owner-managers themselves tended to be divided between the artisan and the entrepreneurial, an almost cultural difference between individuals. In addition, psychological make-up of the individual was also important; often the individual's need to maintain control constrained the willingness to grow. Where control was important, the manager often exhibited a reluctance to employ more highly qualified individuals, as the latter might deploy reasoning and knowledge that the managers would not understand, thereby leading to a loss of control.

9. Spill-over effects and externalities

9.1. Literature strands

Evidence of the positive influence of education, training and skills on performance is most apparent at the level of the individual. Comment has a tendency to focus on private rather than social performance. Some, although by no means all, of these benefits can also be expected to accrue at a macro level. Some of the benefits may, of course, be dissipated in competition between individuals or companies, with no overall social gain.

Several literature strands indicate that there may be important additional spill-over effects and externalities. Spill-overs include technological, spatial and environmental aspects. Some references have already been made to externalities in Section 6.8 above.

9.2. Technological spill-overs

It is neither necessary nor appropriate to dwell on technological spill-overs, as they are a natural extension of both endogenous growth theories (Chapter 6) and the market valuation approach, in which the performance of a particular company is influenced by the R&D or patents of other companies (Chapter 7). In the case of patents, for example, the publication of the patent specification discloses information that may be of use to competitors or to companies in other product areas which use (or might use) related technologies. In practice, many of the market value studies that have investigated the role of spill-overs have found that they appear to be statistically more important than the firm's own R&D or patents. There are a number of existing reviews (Griliches, 1981 and 1992). The key variables are R&D and/or patent flows and/or stocks, although, in this case, the focus is on the general pool of intellectual property generated by other companies. There are clearly potentially important links with the knowledge management area, including the sources and management of information, and the most appropriate organisational structure to maximise the benefits to the company of the intellectual capital pool.

9.3. Spatial and city dynamics

Spatial literature considers the synergies that stem from a particular location. One particular theme has been the dynamics of small firm clusters, stimulated originally by the dynamics of small firms in the Emilia Romagna region of Italy (Goodman and Bamford, 1989). However, there has been similar work in developing countries, including India and Pakistan (Nadvi, 1998). In the case of the small firm surgical instruments cluster in Sialkot, Pakistan, for example, 'Clustering has allowed small businesses to become highly specialised, and to benefit from external economies and joint action.' The evidence suggests that such clusters benefit from both vertical and horizontal synergies, from cooperation and other forms of spill-overs, as well as from intense competition between rivals. Such clusters also benefit from the presence of external institutions, such as the Metal Industries Development Centre, in Pakistan, which is widely used by local small and medium size enterprises. External agents form the principal sources of information and technical know-how.

Spatial literature resides primarily with economic geographers and a comprehensive survey of UK urban labour markets was carried out by Turok (1999). Some 20 cities with a population size above 250 000 are identifiable from the 1991 census and of these, 8 are deemed to be conurbations, while 12 are free-standing. These 20 cities accounted for more than 40 % of all national jobs and so they exhibit a high concentration of both skills and companies.

During the 1980s and 1990s these cities continued to suffer from a relative decline in job availability, especially for full-time males in the local population. In consequence, there was a slow outward migration of skills from the urban centres and reduction in male activity rates

(Turok, 1999). The long-term trend out of manufacturing and into service sector activity continued and its impact was most strongly felt in the cities. Although government provided a range of training schemes for the unemployed, some key skills were eroded, as the jobs were lost, especially in the recession of the early 1990s. When the economy began to recover later in the decade, companies found problems with skill shortages and deficiencies in the cities.

For the highly qualified workforce, the city has increasingly become a magnet for job opportunities. Warf (1995) has noted the geographic repercussions of the growth of telecommunications on the development of world cities, of which London is one of the foremost. There has been an agglomeration of professional jobs on offer as telecommunications offices have mushroomed across the city. Graham (1999) has noted how 'a host of value-added and consultancy firms are also concentrated in the city, supporting state-of-the-art innovation, financial telecoms services and corporate telematics applications'. It is clear that synergies of all kinds stem from city location.

As the knowledge economy gathers strength, so cities become ever more important. It has been claimed that trends towards decentralisation, which were observable from 1960 to 1980, are now in the process of being reversed (Amin and Graham, 1997), although in some parts of the EU there remains statistical evidence of withdrawal of firms and people from large agglomerations to rural areas. Large cities at the end of the twentieth century have become the national economic motor, acting as powerhouses for the personal interaction which drives the teamwork and creativity that is essential for good corporate performance. Skill training which concentrates on city professional workers is likely to produce the highest social benefits, even where labour turnover is significantly high for individual companies. A key feature of much of the literature in this area is the emphasis on professionalisation of employment in many cities and at the same time the polarisation of employment structure with many low skilled and low paying jobs being created (e.g. Hamnett,1996).

A recent study by OECD (2001b) provides evidence of links between skills acquisition and economic growth in 180 regions across 15 Member States. Correlations were made between primary, secondary and tertiary education levels and regional GDP per capita. Whilst tertiary education was important, the strongest significant association was with secondary education. The former level of education is critical for R&D and related innovations, but it is secondary education that provides the intermediate skills that are critical to industrial know-how and learning-by-doing. Correlations at the regional level are blurred by the mobility of labour between regions.

Moretti (1999) used US census data to try to estimate the external returns on education by comparing wages for otherwise similar individuals who work in cities with differential levels of education. Estimating problems arose in trying to isolate the causal impact on individual wages of the average level of city-specific education. The main finding was that a one-year increase in higher education in a city raised average wages by between 8 and 15 %, after controlling for the private return on education. However, this result does not necessarily point to an external effect, as it may simply be caused by complementarities between well and poorly educated workers. There are significant econometric difficulties in achieving robust results in this type of study.

9.4. Environmental externalities

Investment in education produces environmental spill-overs in many different ways. One obvious area is through health and life-expectancy. Higher levels of investment in human capital create greater awareness of the potential causes of illness and promote increasingly healthier life-styles. A more highly educated workforce choose safer occupations and societies with higher relative education bring in health and safety laws to protect the employees. Grossman and Kaestner (1997), after controlling for per capita income, found that people with more education simply live longer. One particular manifestation of the external impact of education on health is in the reduction in infant mortality rates in developing countries. Women with higher levels of education are more aware of the dangers to their children's health and they are more likely to take the steps that lead to lower infant mortality. Wolfe and Zuvekas (1997)

demonstrate that better education also prompts lower fertility rates and smaller family sizes give the children better health and survival prospects.

McMahon (2000) has argued that higher levels of education will lead to the creation of more sustainable environments, as greater awareness of physical environmental damage becomes apparent. Initially, faster economic growth is associated with global warming, deforestation and many forms of pollution, but education enables populations to take steps to rectify some of this damage without sacrificing the growth gains. Most developed societies, with relatively higher human capital investments, have environmental protection laws. The spill-over of education on the physical environment is an expanding area of specialist study that lies beyond the reaches of the present paper.

10. Conclusions

This section contains an overview of the key findings in the paper. It also attempts to draw together the implications for policy and to identify possible directions for future research.

Some of the material presented in this section also appears in the executive summary.

10.1. Summary of key points

This paper has presented an extensive international review into the various strands of literature that bear on the links between investment in education, training and skills and economic performance at the level of the macroeconomy. Where training and education conducted by firms and industries was identified as contributing to overall economic growth, this was also reviewed. It was not possible to segregate macro from micro studies, as the amount of overlap was found to be considerable.

An initial examination of recent EU statistics measuring GNP, employment, unemployment and various educational and vocational training investments suggested that economic growth across the 15 Member States is associated with increases in both education and training. However, a fuller appraisal of the data revealed the difficulties in demonstrating significant causal links between growth and investment in human resources. The amount of literature in this area underscored the complexity of this relationship.

Studies on the general rate of return were found to demonstrate strong links between education and training and economic performance, not only for the individual, but for society as a whole. Evidence on social rates of return has concentrated on the benefits to the economy arising from increased education, calculating all the costs of schooling and education compared to the relative pre-tax earnings of individuals in receipt of such education. Many qualifying assumptions needed to be made in arriving at a quantifiable estimate, but several studies have suggested a social rate of return in the range 6 to 12 %. Comparable studies to establish the social rate of return for vocational training proved hard to find, although there was some evidence that such training has a significant positive impact on productivity.

Literature on the management of human resources at both company and industry level exists in both micro and macro level studies. This research stresses the belief that individual workers are a key source of an organisation's competitive advantage. It is the quality of these human resources that determines organisational performance. There appeared to be a number of different emphases, including the role played by HRM in promoting such resources, and the role of management itself, particularly top managers. One important theme was the role of leadership. Another theme stressed the importance of workforce skill qualifications in contributing to higher levels of productivity across different industrial sectors. This literature emphasised the importance of education and training in often very complex industrial processes.

Economic growth models directly explore the quantitative relationship between investments in education and training and the level and growth of per capita GDP at national level. This covers a large number of studies, beginning with the growth accounting models, through to the endogenous growth models that are widely applied in many recent empirical studies. Both data sets and econometric modelling techniques have developed extensively over recent years and many different model specifications have been proposed and empirically tested. Typically, these models use data drawn from a cross-section of different countries, sometimes only for developed countries but often for a wider set of nations. Data difficulties commonly mean that consistent series of educational variables are hard to obtain over sufficiently long time periods to facilitate econometric time series analyses. For developed countries over more recent years, cross-sectional and time series data have been combined into panel sets to enable a more comprehensive testing of the relationship between human resources and economic growth.

Overall, these growth models demonstrate that higher educational investments have had a significant impact on national economic growth. Broadly, the weight of evidence suggests that a 1 % increase in school enrolment rates has lead to an increase in GDP per capita growth of between 1 and 3 %. An additional year of secondary education, which increases the stock of human capital, rather than simply the flow into education, has lead to a more than 1 % increase in economic growth each year. The results vary considerably, depending upon details of model specification and the precise data sets in use. Issues dealing with the robustness of such results are widely discussed. Almost all these growth models use only a limited set of educational variables to proxy human resource input and they do not incorporate any vocational training or social capital variables.

Market valuation literature is an area concerned with the factors that determine the growth of individual companies and so, indirectly, the overall economy. Research studies in this area are concerned with how intangible assets, such as technical knowledge, influence potential performance and net worth. These are intimately tied to investment in education and training, as well as skills, which may often be a necessary, if not sufficient, condition for improving such intangible assets. Research and development, patents and intellectual capital are key determinants of corporate market value.

Further studies relate to the links between education, training, skills and economic performance. This is concerned with company size and the structure, conduct and performance. Many studies have emphasised the role of the small firm in economic growth. Such small firms are an extremely heterogeneous group that have markedly different training needs from those of their larger counterparts. There is often far less emphasis on educational and training qualifications in small firm environments. Empirical research studies suggest that conventional theories of company behaviour ware far too simplistic for explaining the goals and aspirations of these smaller organisations.

The final strand of literature deals with some of the indirect effects of investment in human resources that are not normally captured in measured national economic growth. Such spill-overs and externalities can be technological, spatial or environmental. Each can contribute significant social gain. Many of these effects are found to be related to other areas covered in this review. The spatial externalities, that embrace city dynamics, demonstrate how geographical clustering of businesses employing highly qualified workers can produce high productivity and strong local economic growth. Environmental spill-overs are often related to health and life expectancy, which typically increase in consequence of higher levels of education.

10.2. Some policy implications

The overall conclusion from this body of work is that the impact of investment in education and training on national economic growth is positive and significant. However, its total effect is difficult to measure with any precision, as many of the influencing mechanisms are indirect and complex. Education is certainly a key determinant of economic growth for both developed and developing countries: its impact is probably more marked in developing nations. The link between vocational training and economic growth is more difficult to demonstrate at the macro level, mainly because of measurement difficulties associated with training investments. It is easier to see a positive impact from vocational training at company and industry levels, although again these are difficult to quantify precisely.

Despite the qualifying assumptions and computational difficulties, evidence suggests a very significant return for both the individual and society as a whole from investments in higher education in developed countries. Computed social rates of return vary between countries and over different time periods, but most are positive and they provide justification for government continuing investment in higher education. However, there are emerging concerns of graduate overcrowding, as the percentage of graduates in the labour market continues to increase, and this trend needs careful monitoring to ensure that social returns are not diminished through overqualification.

The computation of social rates of return on vocational training, equivalent to that for higher education, is very difficult to achieve because of the inconsistent data usually available on such training

investments. Research supports the claim that vocational training improves the performance of the individual in the workplace and so raises the productivity of the employing organisation. Studies on HRM argue that the skill of the individual worker is often a critical factor in an organisation's competitive advantage. Comparative international studies emphasise the key importance of skills training in raising productivity. Despite this, employers in many countries have a rather negative attitude towards investment in skills and training. Unless the institutional and legal infrastructure encourages employers to invest (as in Germany) there is a tendency to rely on others to carry out the investment (as is often the case in the UK). It seems clear that governments should provide every incentive to companies, either through tax allowances or direct grants, as well as through reforms to institutional structures, etc., to encourage them to increase their investment in training. Such training can provide strong spill-over effects for the whole of society.

The weight of research evidence suggests that where governments manage to increase the stock of the educated workforce, through additional years of secondary or tertiary education, rather than simply enhancing the flow into education in any given year, the impact on economic growth is more significant. Such a finding directs government policy towards changes to improve the quality of education rather than just the numbers passing through the system in the short term. For most Member States the emphasis is on access to tertiary education and the quality of the graduates produced by universities. For less developed countries the critical factor is secondary school enrolment rates and the need to extend the number of years in such education. It is difficult to measure the relative quality of education in different countries, but this would appear to be a key issue for governments to address if educational quality is to be significantly improved.

The role of R&D in the growth of firms is strongly underlined in various studies and it is clear that successful R&D depends on skilled human resources. Governments need to provide incentives to firms to continue to make investments in the education and training that enhances their innovative capabilities. In particular, attention needs to be paid to the role of the small firm in contributing to R&D and so to overall economic growth. Often small firms may not have sufficient resources to invest in training their workforce, but they can be expected to benefit from training carried out by larger firms when the trained workers subsequently move to new jobs in the small firm sector.

There is no guarantee that any investment in human capital will result in a positive return, whether it be investment in training, deployment of highly skilled labour, R&D or in some other form. There will always be some risk and uncertainty. In general, the evidence suggests that such investments pay off but each case needs to be considered on its merits.

10.3. Possible areas of future research

This review has drawn attention to difficulties with published data related to the measurement of education and training provision. Many of the growth model studies raised problems with data quality. In particular, consistent time series of educational statistics were often lacking or the time-span coverage was too short for meaningful analysis. Empirical results often proved sensitive to the exact data set in use. The compilation of accurate educational statistics measuring both quantity and quality of provision is an important area of research. Information on the quality of teaching was frequently unavailable to researchers and this undoubtedly limited the rigour of the analysis.

Most of the reviewed research studies were concerned only with educational variables and did not extend to vocational training. This limitation arises from the restricted availability of suitable data on training provision at industry or the economy level. Individual companies often produce such data but they are less frequently available at higher levels of aggregation. There is a strong need to continue to produce consistent statistics on all types of training provision and to ensure that these statistics are broadly comparable across EU countries.

This paper touched upon insights into links between skills, education and training and productivity growth at corporate level. However, given that the prime emphasis was the link to macroeconomic growth, it was not possible here to explore this area fully. Specifically, research studies in HRM and the market valuation of

companies could be examined in greater depth to reveal the mechanisms by which education and training investments lead to improved corporate performance.

Relatively recent studies on social capital and its contribution to economic growth was only touched upon in this paper but it would certainly warrant a much fuller exploration. Several papers have now been published on social capital but its role as a determinant of economic growth needs to be tested empirically. Again, some important data difficulties will first need to be overcome.

List of abbreviations

CEO	Chief executive officer
ELFS	European labour force surveys
EU	European Union
GDP	Gross domestic product
GNP	Gross national product
HRM	Human resources management
IALS	International adult literacy survey
ISCED	International standard classification of education
NIESR	National institute of economic and social research
R&D	Research and development

Annex

International standard classification of education (ISCED)

Educational level	Details/age range	Common terminology	Classification
Early childhood education	Introduction of pre-school children to a school-type environment, from age 3	Pre-primary, nursery, kindergarten, pre-school	ISCED 0
Primary education	First stage of basic schooling, up to age 11 or 12	Elementary school	ISCED 1
Lower secondary education	Second stage of basic schooling, up to age 14 or 15	Junior high school	ISCED 2
Upper secondary education	Stage leading to final secondary qualification, typically age 18 or 19	Senior high school, Lycee, Gymnasium, Sixth form, Further education	ISCED 3 ISCED 4
Tertiary education	Programmes significantly more advanced than upper secondary studies	Higher education, College education	ISCED 5A ISCED 5B ISCED 6
University level education	Studies leading to a first degree, at least bachelor's level or equivalent		ISCED 5A ISCED 6

Source: OECD (2001a).

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