

**The Economic Impact of Large-Scale  
Investments in Physical and Intellectual  
Infrastructure**

**A Review of International Evidence**

**Contract Number 103/2006**

**A Final Report for**

**Welsh Assembly Government**



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## **LE Wales**

LE Wales is an economics and policy consultancy based in Wales and is a part of the Indecon - London Economics Consulting Group. The Group also has offices in London, Dublin and Brussels, and associated offices in Budapest, Paris and Valletta.

Based on a thorough understanding of the economic forces driving markets and their interactions with public policy and the legal and regulatory environments, LE Wales brings the powerful tools of microeconomics to bear on problems faced by companies, regulators and policy-makers.

We have strong capabilities in public policy development and evaluation including the analysis and design of economic incentives, the ex ante appraisal of policies and projects, ex post policy and programme evaluation and regulatory impact assessment.

We are able to use a wide variety of analytical techniques to assist our work, including cost-benefit analysis, multi-criteria analysis, policy simulation, scenario building, statistical analysis and mathematical modelling. We are also experienced in using a wide range of data collection techniques including literature reviews, survey questionnaires, interviews and focus groups.

## **Acknowledgements**

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## **Executive Summary**

### **Introduction**

This is the final report for a study undertaken by LE Wales for the Economic Research Unit of the Welsh Assembly Government. The overall aim of this assignment is to undertake a review of the international evidence on the economic impact of large-scale investments in physical and intellectual infrastructure.

In Phase 1, initial literature reviews were undertaken in a range of areas.<sup>1</sup> Following Phase 1, a decision was undertaken to proceed to Phase 2 and to undertake a review of economic development initiatives and more detailed reviews in the areas of ICT and renewable energy. For Phase 2, a particular focus on any evidence of the ability of large scale investments in these areas to deliver step changes in economic performance was also requested.

The material in this report, covering both the Phase 1 and Phase 2 reviews, covers a very wide area of economic research. As such it cannot provide a very extensive coverage of each individual area. What we hope it does do is to provide a sufficiently detailed coverage that enables an understanding of the key research that links investment in physical and intellectual capital with economic performance in each topic area.

In this Executive Summary we discuss, in turn, the main drivers of economic growth, evidence relating to the effects of investment scale, lessons for the Welsh context and research priorities for the future.

### **Drivers of economic growth**

Even though the literature on economic growth has seen a resurgence in the past 20 years, and some of its findings seem promising, it is still in the stage where more work is needed in order to provide robust answers to the two

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<sup>1</sup> These reviews were not fully comprehensive. The aim was to provide enough material about the general nature of the literature available to allow an informed decision about Phase 2. The Phase 1 reviews were completed in January 2007.

main questions<sup>2</sup> of the field and to provide clear-cut guidelines to policy makers about what to do to spur growth.

It is important to note that empirical findings in this area need to be treated with caution since there are a number of generic problems in estimating these relationships including the difficulty of measuring some important variables and difficulties in determining the direction of causal effect.

Nevertheless, theoretical and empirical research has identified the following as factors that generally appear to have a positive impact on growth:

- support for R&D;
- investment in human capital;
- open economies;
- active financial markets;
- public investment in infrastructure (transport and ICT in particular);
- enforcement of property rights with no or limited expropriation;
- no or limited corruption; and
- political stability.

The evidence for the growth impacts of investment appears stronger for those areas related to knowledge and innovation, in particular the development of human capital and ICT networks. Whilst there is good evidence that transport investment is associated with economic growth in developing countries today, and in the past in those countries which we now regard as developed, it is less clear that there is a strong national impact now in countries where transport networks are already well developed. The potential role of transport networks, both positive and negative, that is outlined in the regional growth models (discussed below) means that it may still be an important factor in the Welsh context.

### **The importance of investment scale**

Most of the theoretical models of economic growth assume either that there are diminishing returns to scale from aggregate investment in physical capital or that returns to scale are constant when returns to scale in physical and human capital are considered together. There appears to be relatively little research, particularly empirical research, that considers non-linearities and

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<sup>2</sup> What are the main determinants of a country's long-term economic growth? Do different economies converge in terms of well-being?

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threshold effects in the relationship between investment and economic growth.

Nevertheless, new theories of regional growth introduced models that suggested the possibility of significant threshold effects when considering the relationship between investment and economic growth. These models describe the interplay between forces that tend towards spatial concentration of economic activity (agglomeration forces) and forces that lead to the dispersion of economic activity (dispersion forces). In these models trade costs, often treated synonymously with transport costs, and knowledge spillovers play a key role in determining the location of economic activity. The models suggest that changes in trade costs and the extent of knowledge spillovers can lead to step changes in the location of economic activity between “core” regions and “periphery” regions. These lead to step changes in economic growth in each region.

The existence of threshold effects means that it is possible for increases in investment to have little effect on growth unless investment is increased beyond the threshold level. In other words, this points to the persistence of spatial concentration outcomes in the face of regional policies, unless thresholds are overcome. The models also suggest that investment aimed at reducing trade costs (e.g. investment in improved transport links) may, depending on the policy objective, have undesirable effects. They predict, for example, that improving transport links between the core region and the periphery region will increase economic growth across the two regions, but will shift economic activity to the core region, thus increasing regional disparities. Increasing the scope of knowledge spillovers may play an important role in both increasing growth overall and reducing regional disparities.

These models are analytically complex and so direct empirical testing is difficult. There is some more indirect evidence in the literature that seems consistent with the ideas developed in these models, though it certainly does not “prove” them in any way.

There may also be a non-linear relationship between some types of ICT investment and growth, though the evidence for this is limited. The network characteristics of telecoms and internet services and some types of computer software suggest the possibility of discontinuities or thresholds in relation to network size. One of the key characteristics of a network is that the benefit to one user of the network changes when the number of other users changes.

This is known as a “network effect” and gives rise to the possibility of threshold effects in network expansion.

The existence of “critical mass” has been described as a central feature of network industries. There is some empirical evidence that network effects drove the rapid expansion of the US fax market during the 1980s. There is also evidence from one study of a link between telecoms infrastructure and a non-linear impact on economic growth, though the estimate of critical mass for fixed line telephone penetration was significantly below the level already achieved on average across the UK.

### **Key lessons for the Welsh context**

#### *Large investments are not enough on their own*

It is clear from the evidence that there are no easy generic answers to the problem of low economic growth. Many successful investment responses depend on specific economic circumstances.

The potential for threshold effects suggests that some investments will never lead to any significant impact on growth because they do not enable critical mass to be achieved. There is also clear evidence that many types of investment need to be accompanied by complementary investments in order to make significant impacts on economic growth. In ICT, for example there is a body of evidence that suggests that investments need to be accompanied by changes in business processes and improvements in employee skill levels for the full economic benefits to be realised. This has been suggested as a possible explanation for why some European countries appear to have benefited less from ICT investment than the USA.

Sheer size of an investment does not guarantee larger impacts on economic growth. In our case studies we provide some examples of very large scale investments which seem to have had little strong impact on economic growth. These include the European Union’s structural funds programmes.

This evidence suggests that, for the full economic growth benefits of future large scale investment in Wales to be realised,<sup>3</sup> very careful consideration may need to be given to whether, and if so how, they can make significant net

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<sup>3</sup> The Severn barrage and the proposed defence training academy at St Athan are topical examples of such investments.

contributions to growth in the Welsh economy. What additional measures need to be put in place to ensure that growth impacts are captured in Wales?

*The complex impacts of spatial factors and agglomeration effects*

The new regional growth models emphasise the importance of transport links and knowledge spillovers in determining the spatial development of economic activity in “core” regions and “peripheral” regions. These models seem to have a particular resonance for the Welsh economy, both in its relationship with neighbouring economies and in the relationships between regions within Wales. The relationship between East Wales and West Wales & the Valleys, for example, or the relationships between the “core” regions of the North East and South East of Wales with their respective “peripheral” hinterlands. They may also be very relevant at a more local scale – in relation to specific small and medium-sized towns and their hinterlands.

Given the potential for non-linear responses to policy interventions that is described in these models – and these may be negative impacts for “peripheral regions” – care needs to be taken in policy development, particularly transport policy. Some of the literature suggests the possibility that whilst improving transport links between a core and a periphery region might stimulate economic growth across the two regions as a whole, this could be at the expense of the periphery region. Nevertheless transport investment may still enable better advantage to be taken of agglomeration economies – it has been suggested that the limited levels of agglomeration in Wales is a particular problem relative to other parts of Great Britain.

*The key role of knowledge and skills*

In contrast to investment in transport links, the literature on agglomeration and spatial effects suggests that investment in knowledge spillovers may play an important role in both increasing growth overall and reducing regional disparities.

The particular importance of knowledge and skills for economic growth is also clear from the range of other evidence we review in this study. The material re-emphasises the importance for the Welsh economy of policies in relation to education, training, research and development and the diffusion of knowledge.

ICT networks play an important role in knowledge development and diffusion and it is clear from the evidence that the Welsh policy focus in this area of rapidly developing technology needs to be maintained.

### **Research priorities**

Since ICT investment and agglomeration effects are the two areas most likely to be associated with non-linearities in the relationship between investment and economic growth, we suggest that research priorities lie in better understanding of the significance of these two factors in the Welsh context.

Further work to understand the extent to which the regional growth models are relevant for Wales and to understand the policy implications for Wales should be beneficial. These models also point to the potentially positive impacts of increasing knowledge spillovers, at least in some circumstances. A more in depth understanding of the policy implications of research in this area would be beneficial.

In the context of the potential link between ICT investment and economic growth we have highlighted evidence that suggests that the penetration of some telecommunications services (mobile phones, personal computers, narrowband internet use, broadband internet use) for SMEs in Wales is low compared to other parts of the UK. It would be useful to understand further why this is the case, whether any measures to reduce barriers to take up can be introduced and whether this is likely to have important economic impacts.

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## 1 Introduction

This is the final report for a study undertaken by LE Wales for the Economic Research Unit of the Welsh Assembly Government, under contract 103/2006. It reports on both the Phase 1 and Phase 2 literature reviews for this assignment.

The overall aim of this assignment is to undertake a detailed and comprehensive review of the international evidence on the economic impact of large-scale investments in physical and intellectual infrastructure.

In Phase 1, initial literature reviews were undertaken in a range of areas.<sup>4</sup> Following Phase 1, a decision was undertaken to proceed to Phase 2 and to undertake a review of economic development initiatives and more detailed reviews in the areas of ICT and renewable energy. For Phase 2, a particular focus on the ability of large scale investments in these areas to deliver step changes in economic performance was also requested.

The material in this report, covering both the Phase 1 and Phase 2 reviews, covers a very wide area of economic research. As such it cannot provide a very extensive coverage of each individual area. What we hope it does do is to provide a sufficiently detailed coverage that enables an understanding of the key research that links investment in physical and intellectual capital with economic performance in each topic area.

Given the huge range of research reviewed, it had not been possible to comment on the robustness of each study that we have reviewed. Throughout the text we have indicated where it is clear that some strands of the research provide more robust evidence than others. It is important to understand that there are many generic methodological and empirical problems faced by studies that attempt to show a cause and effect link between investment and growth.

In our discussion of economic growth in Chapter 7 we refer to the problems faced by researchers in matching statistical specifications to theoretical models and to the problem of isolating the impacts on growth of specific factors when there are so many variables that affect growth. Many empirical

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<sup>4</sup> These reviews were not fully comprehensive. The aim was to provide enough material about the general nature of the literature available to allow an informed decision about Phase 2. The Phase 1 reviews were completed in January 2007.

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studies also fail to adequately address the issue of the direction in which causality runs, preferring to focus on evidence of a statistical link only. In our discussion of the transport sector in Chapter 8 for example, we refer to the possibility of economic growth driving the level of investment in transport infrastructure, as well as the possibility of investment in transport infrastructure influencing economic growth levels.

Some of the studies we refer to in this report seek to provide evidence on the regional and local economic impacts of various categories of investment. Studies of this type often have an advocacy role – they are seeking to justify (ex ante or ex post) a particular investment. – and need to be seen in that light. It is also important to recognise that positive local impacts may be offset by negative impacts elsewhere. An infrastructure investment with positive employment and output effects in Gwynedd, for example, may not have a significant net effect on output and employment at the Wales level because employment and output is being displaced from elsewhere in Wales.

Some of the studies we refer to are based on cost-benefit analysis. There are many issues in developing robust analyses of this kind, but one important issue to consider is that benefits, where they are not market-based benefits, are often very hard to measure. In addition, positive net benefits from a specific investment, do not necessarily translate into GDP growth impacts.

In Part 1 of this report we provide an overview of the main findings:

- we discuss the relationship between investment and growth and the importance of scale and threshold effects in Chapter 2;
- in Chapter 3 we summarise the findings of the sector-specific literature reviews of both Phases;
- Chapter 4 reviews the case study material on economic development initiatives;
- Chapter 5 discusses the implications for policy and further research;
- Chapter 6 provides the references made in Part 1.

In Part 2 of this report we provide the Phase 1 literature reviews (Chapters 7 to 10 and Annex 1).

In Part 3 we provide our Phase 2 literature reviews, covering ICT (Chapter 11), renewable energy (Chapter 12) and economic development initiatives (Chapter 13).

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## 2 Investment and Growth – Does Scale Matter?

### 2.1 Concepts

One of the requirements for Phase 2 of this study was to consider in particular the nature of evidence in respect of the ability of large scale investments to deliver step changes in economic performance, rather than providing incremental improvements. In order to contribute to this it was suggested that the study consider threshold effects and non-linearities in the impacts of large scale investments.

We discuss this evidence in the remainder of this Chapter, alongside evidence relating to economies of scale effects more generally.

Figure 2.1 illustrates the differences between constant returns to scale (CRS), increasing returns to scale (IRS) and decreasing returns to scale (DRS) in respect of the impact of investment on output. The dashed CRS line is at 45° to the origin and shows output rising at the same rate as investment - if investment doubles, for example, output also doubles. The IRS line shows output rising at a faster rate than investment - if investment doubles, for example, output more than doubles. The DRS line shows output rising at a slower rate than investment - if investment doubles, for example, output less than doubles.

Figure 2.2 illustrates a discontinuity, or threshold effect, in the TH line. As investment reaches the level  $I_1$ , output increases rapidly from  $O_1$  to  $O_2$ . The implication of this is that if a policy maker understands this relationship they are able to ensure that investment is made at a level  $I_1$  or higher. Much lower levels of output would be achieved if investment was made at a level just below  $I_1$ .

Figure 2.1: Illustration of Returns to Scale

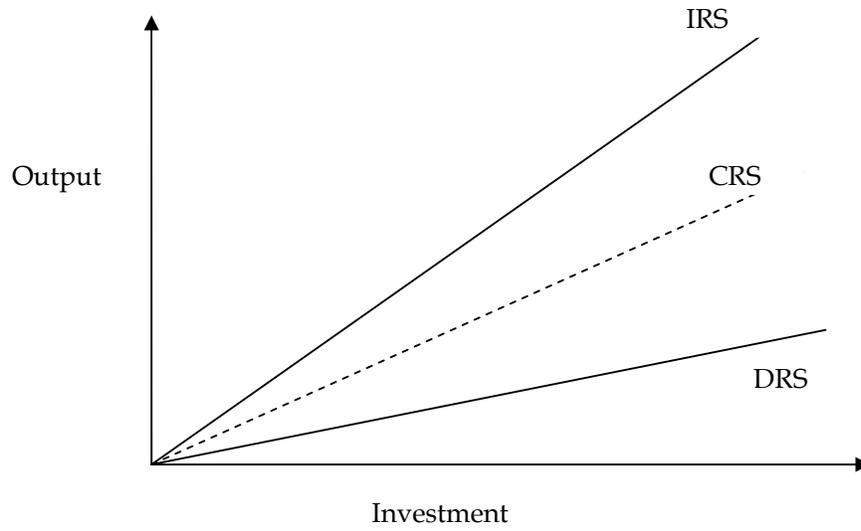
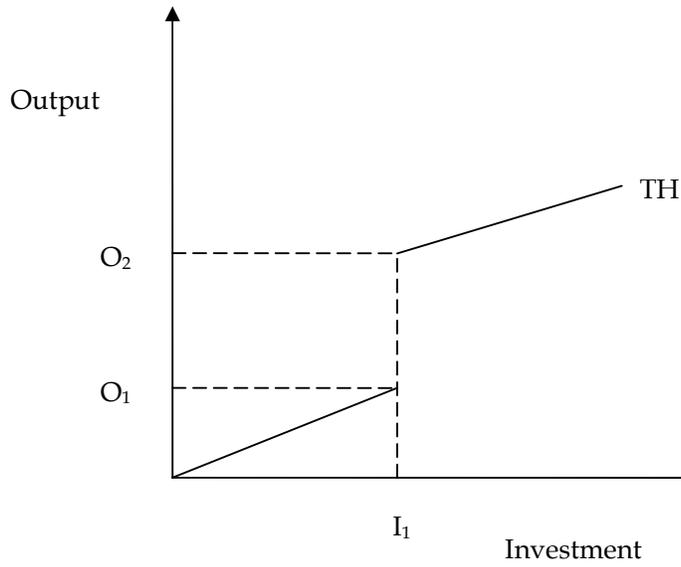


Figure 2.2: Illustration of Threshold Effects



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## 2.2 Theories

Much of the literature that we have reviewed for this study provides evidence in relation to the economic impact of specific investments. In other words it provides evidence about specific points on the curves illustrated above and so cannot provide an indication of the overall shape of the curves and the extent of threshold effects. Nevertheless there are some indications in the literature about the extent to which increasing returns to scale and/or threshold effects may be present.

The literature on economic growth (discussed in Chapter 7) makes assumptions about the extent to which there are returns to scale from investment in physical and human capital at an aggregate level.

Neo classical growth models assume that at an aggregate level there are diminishing returns to scale from physical capital alone. In other words an increase in physical capital alone will result in a less than proportionate increase in output.<sup>5</sup> However, the endogenous growth models also assume that if both human capital (knowledge and skills) and physical capital increase together, then there can be constant returns to scale from this combined increase.<sup>6</sup>

Theories of regional growth introduced models that suggested the possibility of significant threshold effects when considering the relationship between investment and economic growth. These models are discussed in Chapter 13. They describe the interplay between forces that tend towards spatial concentration of economic activity (agglomeration forces) and forces that lead to the dispersion of economic activity (dispersion forces). In these models trade costs, often treated synonymously with transport costs, and knowledge spillovers play a key role in determining the location of economic activity. The models suggest that changes in trade costs and the extent of knowledge spillovers<sup>7</sup> can lead to step changes in the location of economic activity

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<sup>5</sup> There is also some empirical evidence to support this proposition.

<sup>6</sup> In other words, in order to take greater advantage of the output possibilities of increased physical capital, more labour is also needed. For example, it may not be possible to fully utilise an additional machine in a production process unless there is an additional employee to operate that machine.

<sup>7</sup> The concept of knowledge spillovers (or technological spillovers) is based on the assumption that the marginal cost of creating an idea declines as the total stock of ideas increases (i.e. with knowledge accumulation). In spillover models, this is viewed as a technological externality, or spillover – innovators today benefit from previous innovation.

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between “core” regions and “periphery” regions. These lead to step changes in economic growth in each region.

The existence of threshold effects means that it is possible for increases in investment to have little effect on growth unless investment is increased beyond the threshold level. In other words, this points to the persistence of spatial concentration outcomes in the face of regional policies, unless thresholds are overcome. The models also suggest that investment aimed at reducing trade costs (e.g. investment in improved transport links) may, depending on the policy objective, have undesirable effects. They predict, for example, that improving transport links between the core region and the periphery region will increase economic growth across the two regions, but will shift economic activity to the core region, thus increasing regional disparities. Increasing the scope of knowledge spillovers may play an important role in both increasing growth overall and reducing regional disparities.

These models are analytically complex and so direct empirical testing is difficult. There is some more indirect evidence in the literature that seems consistent with the ideas developed in these models, though it certainly does not “prove” them in any way. Some examples include:

- the persistence of regional disparities;<sup>8</sup>
- the possibility of negative regional impacts from transport investments in some cases;<sup>9</sup>
- the attribution of funding limitations as an explanation for the “failure” of convergence policies;<sup>10</sup>

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<sup>8</sup> Reference is made to evidence of this in the UK and in the EU in Chapter 13.

<sup>9</sup> In one study of the impact of EU structural funds on regional development, for example, the authors made the following comment in respect of infrastructure investment: “a strategy strongly skewed towards the development of infrastructure in regions with relatively vulnerable local production structures, weak entrepreneurship levels and technological base, may solve an important development bottleneck and reduce the infrastructural gap with the rest of the EU, but may leave these regions more exposed to competition from stronger and more technologically advanced firms from core areas. Spain provides an example of where this mechanism may already be at work. The strong recent investment on transport infrastructure in Spanish Objective 1 regions – which to a large extent has been devoted to the construction of road and high speed rail links between the periphery of the country and Madrid – has probably helped to boost the phenomenal growth rates that Madrid has experienced in the second half of the 1990s, but has left many of the Objective 1 regions, whose economic prospects the new roads and rail-links were supposed to increase, struggling to catch up.” (Rodriguez-Pose et al, 2004).

<sup>10</sup> See Rodriguez-Pose et al (2004) and Gripaos (2002).

- cases where even very large investments appear to have had limited impact on growth;<sup>11</sup>
- the generally more positive role attributed to investment in human capital, knowledge and ICT in the empirical literature.<sup>12</sup>

We also found some additional discussion of threshold issues in our reviews of sector-specific material for ICT and for Transport.<sup>13</sup> This is outlined below.

## 2.3 ICT<sup>14</sup>

There appears to be little evidence that explicitly explores the link between the scale of ICT investments and economic growth impacts.<sup>15</sup> Nevertheless, it is widely recognised that in a network industry like telecoms, positive externalities, called network externalities, exist.

The network characteristics of telecoms and internet services and some types of computer software suggest the possibility of discontinuities or thresholds in relation to network size. One of the key characteristics of a network is that the benefit to one user of the network changes when the number of other users changes. In a telecoms network, for example, the benefits to a customer of being a part of the network increase when the number of other telephone users increases because there are more people with whom it is possible to have a phone conversation. This is known as a “network effect”.<sup>16</sup> This network effect gives rise to the possibility of threshold effects in network expansion.

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<sup>11</sup> See the case studies in Chapter 13.

<sup>12</sup> See Chapters 11, 7 and 10.

<sup>13</sup> In addition, one study suggested that the concept of thresholds was not useful for analysing the impacts of renewable energy production on rural economies. The study argued that renewable energy schemes are “inherently small-scale and generate community benefits rather than substantive employment or income generation”.

<sup>14</sup> See Chapter 11 for more details.

<sup>15</sup> See Chapter 11 for a reference to one study that does examine a threshold effect in this relationship.

<sup>16</sup> This effect is also known as a network externality where the effect is not internalised in decision-making about the size of the network.

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The existence of “critical mass” in network industries has been described as a central feature of network industries. The critical mass is the network size below which a network is not viable because the value of the network to users is below the cost of the network. As the network size increases the average cost per customer typically reduces (because of economies of scale) and the value per customer using the network increases (because of the network effect). These characteristics suggest that particular networks will either not exist or they will exist at a size at or above critical mass, except for a period in which they are rapidly expanding to critical mass. There is some empirical evidence that network effects drove the rapid expansion of the US fax market during the 1980s.

By implication, if there is a critical mass for ICT networks and if ICT networks do influence economic growth, then investments in ICT that contribute to the achievement of critical mass - resulting in a step change in network size - could be associated with larger impacts on economic growth. This does not necessarily imply step changes in economic growth however - the impact on growth of having a particular network as opposed to not having it may only feed through over a long period of time. There is some evidence that there may be lengthy time lags between ICT investment and impacts on productivity.

## 2.4 Transport

As discussed above, transport plays an important role in the regional growth models that suggest the possibility of threshold effects. In this section we discuss additional evidence of the relationship between transport investments and thresholds that is linked to the publication of the report of the Eddington Review in December 2006.<sup>17</sup>

The Eddington Review considered the long term links between transport improvements and the UK’s productivity and growth performance. A number of research papers were published alongside the main report. One of those papers (Mann, 2006) considered the potential for step change transport improvements to generate wider economic benefits.

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<sup>17</sup> This evidence was not discussed in our Phase 1 review of the transport literature – presented in Chapter 8.

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The main focus of the Mann paper was the consideration of whether there were benefits from step change transport improvements that were not captured in current transport appraisal methodologies and, in particular, whether this might change the case for a major high speed rail investment in the UK, such as a north-south link.

The paper reviews some relevant literature, including a number of papers that raise the issue of which region benefits when two regions are linked by improved transport infrastructure. Some point to the possibility of core regions, such as London, benefiting more than peripheral regions, though Mann concludes that the evidence on this point is conflicting.

Overall, Mann concludes that transformational economic benefits are unlikely to arise from a north-south high speed line because UK cities are already well-connected and because agglomeration benefits typically extend only to 45-60 minute door to door travel times. Schemes that reduce congestion and commuter times are more likely to lead to increased agglomeration benefits – through widening the effective labour catchment area.

## **3 Investment Impacts by Sector**

### **3.1 Transport**

There is a longstanding debate on the role of transport infrastructure in economic growth. While there is broad agreement that adequate transport connections are a necessary precondition for economic development, a sophisticated transport network alone is not sufficient to bring it about. Although many studies have reported a link between growth and transport investment, the causal connection between the two remains a matter of debate.

Still, there are robust predictions regarding the effects of investment in transport infrastructure. Better transport links can increase business efficiency by lowering the direct cost of transport, increasing the potential for economies of scale, and expanding competition by increasing the size of geographical markets. In addition, transport links are essential for the creation and maintenance of industrial clusters and agglomerations. Thereby they contribute to the efficient division of labour and facilitate the emergence of network and spillover effects.

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Efficiency and effectiveness of transport infrastructure projects depend crucially on pre-existing conditions. It is clear that the lower the existing stock of infrastructure, the higher the potential benefits of more investment. In addition, the success of transport investments depends to a great extent on a region's specific economic structure.

We examined a number of case studies. These are drawn from various international sources, including academic papers as well as evaluation studies by funding bodies, pressure groups, and consultants. The bulk of evidence relates to road, rail, and air transport from developed economies, mainly in Europe (i.e. Austria, Germany, France, Ireland, Norway, Portugal, Spain, and the United Kingdom; additional evidence is drawn from Australia, Canada and the United States).

Many studies find high returns to infrastructure investment, often as high as several multiples of the initial investment cost. However, many studies are vulnerable to criticism, especially as regards their methodology and quality of data. Moreover, the variation in outcomes is large. Some regions benefited considerably as a result of new transport connections, while others did not experience any significant impact. Positive impact is more likely in areas that are already experiencing economic progress. This suggests that transport is but one ingredient in a successful regional development strategy.

## 3.2 Renewable Energy

The evidence on the economic impacts of renewable energy that has been reviewed has been less comprehensive than the evidence reviewed for many of the other sectors. Nevertheless there are some relevant themes that emerge from the literature that we have reviewed.

There is often not a strong commercial case for investment in renewables in the absence of public sector intervention. Nevertheless, there is public sector intervention in this area, through the Renewables Obligations. The main justification has been the gains from reducing contributions to greenhouse gas emissions, but more recently energy security has also been a factor in the debate. Even in the presence of public sector intervention it can sometimes be difficult to make a strong case for investment in renewables as there are a number of barriers. These include the risks inherent in investing in what are often emerging technologies; the intermittent nature of the energy supplied from most renewable resources; and the costs of investment and connection to the national grid.

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There are a number of wider economic benefits from investment in renewables in addition to those derived from reducing greenhouse gas emissions and increasing energy security. They include reductions in local air pollution in comparison to generation from fossil fuels and increases in employment in the industry as renewable generation is generally more labour intensive. There are also some wider economic costs relating mainly to impacts on the landscape (e.g. wind farms) and on wildlife (e.g. tidal barrages).

Finally, a number of studies suggest a differential impact between rural and urban areas, noting that many renewable energy schemes are located in rural areas, whilst many conventional power generation sources are in more urban areas. Where this is the case, the suggestion is that much of the direct employment generated can be expected to be in rural areas, subject to the local availability of relevant skills.

### 3.3 ICT

Over the last ten years a large volume of literature has developed which examines the links between the ICT sector and the economy. Much of this literature suggests that there is a strong link between ICT and positive economic impacts.

There is a range of evidence that suggests that ICT investment is generally beneficial to the performance of firms. A further important insight of these studies is that there are a number of complementary factors that can significantly enhance the impact of ICT investment on productivity and growth. These factors include human capital, a firm's experience in innovation, its use of advanced business practices and the intensity of organisational restructuring.

ICT investment can also make a significant contribution to GDP growth. A number of studies estimate the impacts in the USA where the highest effects are usually found. There is also evidence of significant, though smaller, impacts in many other OECD countries, including the UK. Evidence of the link between ICT investment and productivity is generally weaker, though positive effects are found in many cases.

A number of studies also examine the impacts of broadband investment and roll out on local and regional economies. Several North American studies suggest that there can be significant local benefits from investment in municipal fibre optic networks. One Australian study found that those

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sectors that experience the biggest increases in output as a result of widespread broadband adoption are sectors such as construction, mining and trade (retail, accommodation and food and beverages). These sectors don't necessarily experience large direct productivity gains from their own broadband use, but derive indirect benefits through cheaper production inputs from improved productivity elsewhere (e.g. transport) and from increased demand for their products deriving from higher private consumption. Two UK studies, in Scotland and Wales, predict significant future benefits from further broadband adoption.

In our review of the demand and supply of telephone and internet services in Wales we found that whilst the availability of services (fixed and mobile telephony as well as narrowband and broadband internet access) was strong in Wales, competition in the provision of those services was weaker in Wales than in England. Whilst satisfaction levels for existing customers were generally similar in Wales to the UK average, with some exceptions, take up levels in Wales were lower – particularly for mobile telephony services and for broadband services. In principle, lower levels of competition might reduce the extent to which the ICT infrastructure can contribute to economic growth, though there is little direct evidence of this.

### 3.4 Early Years

There is a wide range of literature linking early years provision and economic impacts, though the very large part of this literature is US based. A very extensive literature has built up around three longitudinal childcare studies undertaken in the US. The three studies are well known and the results of the studies often quoted in the wider literature on childcare impacts. Estimated benefit cost ratios are very high – in the range 3:1 to 9:1. In addition to the direct benefits to the participants in terms of their improved human capital, wider benefits from investment in quality early years programmes are also noted in the literature. These include reductions in crime, higher future incomes and less need for social welfare payments. Recent UK based research, however, has questioned the validity of drawing conclusions for UK policy-making based on the findings of these three US studies, since the context of the studies is very different from the modern UK context.

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There is limited UK material relating to the impacts of early years interventions. The main UK scheme at present is Sure Start. Sure Start programmes first started in the UK in 1999 – 2000 and so it is still early to draw conclusions about their long term impacts. Initial evaluations suggest mixed impacts. One study also suggests that there could be net positive GDP impacts from a move to more universal provision of early education and care in the UK, though the evidence is far from conclusive.

There have been a large number of US studies that estimate the economic impacts of the childcare industry either at the State level or at county or City level. One extensive study of the US childcare industry found that there were positive short term regional economic impacts and long term benefits deriving from the improvement of human capital.

Some researchers argue that the returns to investment in early years education for disadvantaged children are higher than returns to education later in life because early years education may have a dynamic effect and impact on educational performance in later years as well.

### 3.5 Higher Education

We have undertaken a comprehensive review of the literature relating to the economic returns to the individual, the state and the wider economic and non economic impacts associated with higher education qualification attainment. Trading off the financial costs and benefits associated with obtaining higher education qualifications; there are large positive economic returns to the individual and the state from investing in higher education.

Much of the research to date estimating the economic impact of specific higher education institutions has considered only the static effect of higher education (as if a HEI was any large employer). Looking at the dynamic human capital impact of HEIs through the production of more highly trained and productive employees, the dynamic economic effect of HEIs is substantially greater than was previously estimate to be the case. In the case of one recent study, it was found that the human capital impact of the university (through the production of graduates) exceeded the direct and indirect economic impact of the institution.

HEIs themselves have large positive spillover effects on the local, regional and national economies. Although labour mobility reduces the dynamic impact of HEIs on their local environment, it is clear that the availability of a highly skilled graduates as well as highly qualified researchers undertaking

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academically robust research does attract some firms in certain industries to locate close to HEIs. In addition, there is evidence to suggest that an increase in the proportion of graduates in a local economy has a wage impact on non graduates.

The evidence for university research activity acting as a prime driver of firm location is not overwhelming. One particular study from the US suggests “70 per cent of the links between biotechnology companies and the university-based scientists are non-local”. In addition to this, the knowledge transfer activities between research institutions and businesses do not simply comprise of a range of informal networks but are carefully planned and often contractually based. It is not simply the case that a new research department will suddenly generate a cluster of (high-tech) companies operating in the locality feeding off the human capital of researchers and highly qualified graduates

Finally, there are positive non monetary outcomes associated with higher education qualification attainment. These relate to health and vulnerability (e.g. general health; psychological state); parenting (e.g. number of books owned by children), civic participation (e.g. voting; membership of voluntary organisations) and attitudes. There is a developing economic literature now considering the intergenerational transmission of skills and social mobility. The evidence suggests that parental educational attainment is becoming increasingly an important determinant of children’s future outcomes.

### **3.6 Other Infrastructure**

We provide a very brief overview of the evidence on economic impacts from other types of physical and intellectual infrastructure: tourism and events; housing; healthcare; and primary and secondary education. There is a literature on economic impacts in each of these areas.

The evidence for significant long run impacts is clearer for primary and secondary education than it is for the other areas. The material here is linked to the wider evidence of the link between human capital and economic growth that is discussed in our review of the economic growth literature.

Health has also been shown to be linked to economic performance, though the evidence is clearer for developing countries where health levels are much lower than they are in developed countries. There is some evidence that there can also be a link with growth in developed countries.

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The housing market can certainly have an influence on short run macroeconomic performance, but it can also have longer term effects through its influence on labour mobility and the consequences that restrictions in labour mobility can have for regional development. Investment in housing may also have important local regenerational effects.

There have been many studies of the economic impacts of tourism and cultural and sporting events that suggest their importance for local economies, but there has also been much scepticism about the level of these reported impacts, particularly for large sporting events, and the extent to which they can have significant long run impacts.

## **4 Economic development initiatives**

The relationships that determine the spatial distribution of economic activity are complex. Regional economic theories suggest that the natural endowments of an area and the interaction between transport costs, knowledge spillovers, and economies/diseconomies of agglomeration determine the path of regional economic development.

It has also been argued that cities can be a driving force of regional change. Successful urban regeneration projects can impact positively on the performance of regional and national economies. The examples of development initiatives in Bilbao, Barcelona and London show that renewal initiatives are able to respond to a legacy of de-industrialisation and can help to achieve new periods of economic growth.

However, there is no single regeneration policy suitable for every region. Effective regeneration schemes have to be tailored to local conditions and region-specific characteristics. Imitating successful solutions from other regions does not guarantee that similar effects will take place in the designated area.

Nevertheless, there are a number of lessons that can be drawn from the literature. The most important are the following.

Regeneration projects need to identify clear long-term goals and need to be based upon a detailed analysis and understanding of the area being developed. Consideration needs to be given to the additionality of benefits and the potential for displacement of economic activity from other regions. Recognition of the scope for benefit leakage to other regions is also needed.

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One way in which a regeneration project may increase economic activity is through first providing a distinct improvement in the quality of the physical and natural environment. This could stimulate an increase in growth through the attraction of inward investors, the inward migration of skilled workers, and limited outward flows of skilled workers. In this respect, it is important for urban regeneration initiatives to make “places where people want to live”.

Regeneration projects cannot operate successfully as single elements (e.g. new housing) in isolation. The case studies reviewed in Chapter 13 all involve a range of coordinated activities that aim to complement and support each other.

Participation of a broad range of partners, including local communities, entrepreneurs, professional bodies, business associations and non-Governmental organizations, is essential in ensuring the success of complex regeneration projects.

Specialisation can be a source of competitive advantage for regional economies – it is also one of the factors contributing to theories about the benefits of agglomeration. Concentration of industrial production in relatively small geographical areas can stimulate accumulation of sector-specific expertise, which in turn can lead to growth in the knowledge base and product innovation. On the other hand, highly specialised urban economies can face a greater risk of becoming over-reliant on a particular sector and are more vulnerable to external shocks (shifts in competition, trade and technology). The North East Coal Mining Project, discussed as one of our case studies later in Chapter 13, provides a good example of the dangers of over-reliance on one sector. It has been argued that the most successful city regions appear to be those characterised by what might be termed “clustered diversity”, i.e. the presence of several specialised clusters of activity.

Recently, the concept of “creative city” has emerged in the theory of urban regeneration. The term is used to describe a city that can stimulate creative activity and innovation. Creative cities play an important role in enhancing the dynamism, resilience and overall competitiveness of the economy. They offer opportunities for cross-disciplinary learning, and promote innovation in a wide array of occupations and industries. The soft infrastructure factors are important in attracting and retaining human intellectual capital. In order to develop economically and socially, cities have to create a favourable environment, where well-educated, creative people will want to work, live and play.

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## 5 Policy and Research Implications

There is scope to review further research material in each of the topic areas we have reviewed for this study. This is particularly the case for the material that was only reviewed in Phase 1. However, we set out here what we see as the priorities, given the potential implications for the Welsh economy of the various areas of research.

One developing area of theoretical work and to a lesser extent, empirical work, in recent years has been the development of economic models that seek to explain the regional differences in economic performance using ideas about the importance of agglomeration for economic activity and the relationship between agglomeration forces and dispersion forces. These models emphasise the importance of transport links and knowledge spillovers in determining the spatial development of economic activity in “core” regions and “peripheral” regions.

These models seem to have a particular resonance for the Welsh economy, both in its relationship with neighbouring economies and in the relationships between regions within Wales. The relationship between East Wales and West Wales & the Valleys, for example, or the relationships between the “core” regions of the North East and South East of Wales with their respective “peripheral” hinterlands. They may also be very relevant at a more local scale – in relation to specific small and medium-sized towns and their hinterlands.

Further work to understand the extent to which these models are relevant for Wales and to understand the policy implications for Wales should be beneficial. Given the potential for non-linear responses to policy interventions that is described in these models – and these may be negative impacts for “peripheral regions” – care needs to be taken in policy development, particularly transport policy. Some of the literature suggests the possibility that whilst improving transport links between a core and a periphery region might stimulate economic growth across the two regions as a whole, this could be at the expense of the periphery region. Nevertheless transport investment may still enable better advantage to be taken of agglomeration economies – it has been suggested that the limited levels of agglomeration in Wales is a particular problem relative to other parts of Great Britain.

These models also point to the potentially positive impacts of increasing knowledge spillovers, at least in some circumstances. A more in depth understanding of the policy implications of research in this area would be beneficial.

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The particular importance of knowledge and skills for economic growth is also clear from the range of other evidence we review in this study.<sup>18</sup> The material re-emphasises the importance for the Welsh economy of policies in relation to education, training, research and development and the diffusion of knowledge.

## 6 References

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<sup>18</sup> See the Chapters on ICT, early years and higher education.

## **Part Two: Phase 1 Reviews**

<b>7</b>	<b>Economic Growth</b>	<b>21</b>
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## 7 Economic Growth

The economic growth literature investigates the long-run performance of the economy. In particular, it addresses the following two questions:

1. What are the main determinants of a country's long-term economic growth?
2. Do different economies converge in terms of well-being?

In this section we review the main strands in economic growth theory as well as the related empirical work.

### 7.1 Theories of Economic Growth

In this section we provide a brief overview of growth theory. Newer theories about the geographical pattern of economic development are discussed in 13.2 below. The basic model for economic growth is the neoclassical growth model by Solow (1956) also known as the Solow growth model. We first present this model and discuss its shortcomings. Then we turn our attention to more recent growth theories aiming to address these shortcomings.

#### 7.1.1 The Solow Model

The Solow model is a neoclassical growth model developed in the 50s and the 60s and it is the benchmark model of economic growth.<sup>19</sup> It has the following two building blocks: (i) the output of the economy can be consumed or used as capital in the production process and (ii) it is produced by the following aggregate production function:

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha}, \quad 0 < \alpha < 1 \quad (1)$$

where  $Y$ ,  $K$ ,  $L$  and  $A$  denote output, capital, labour and "effectiveness of labour" or "knowledge" in period  $t$  respectively. Condition  $\alpha < 1$  implies that, keeping everything else fixed, there are decreasing returns on capital.<sup>20</sup> Note, however, that there are constant returns to scale for capital and labour, i.e. if both of them double, the amount produced also doubles.

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<sup>19</sup> The most important references for neoclassical growth theory are Solow (1956), Swan (1956), Cass (1965) and Koopmans (1965).

<sup>20</sup> Decreasing (increasing) returns on capital means that doubling the amount of capital leads to less (more) than double amount of output.

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In this aggregate production function, labour  $L$  and the productivity of labour (or knowledge)  $A$  are assumed to grow at an exogenous rate of  $n$  and  $g$  respectively. Finally, the increase in the stock of capital is financed by the savings of the economy as follows:

$$K_{t+1} - K_t = sY_t - \delta K_t \quad (2)$$

where  $s$  is the saving rate, whereas  $\delta$  is the depreciation rate of physical capital in the economy.<sup>21</sup>

The Solow model implies that, as long as  $\alpha < 1$ , regardless of its starting point, the economy converges to a balanced growth path – the steady state growth path – where output and capital are growing at the same constant rate  $n + g$ . Accordingly, output per worker is growing by the rate  $g$  of growth of technological progress.

With respect to the variation in output per worker over time or across countries the Solow model identifies two possible sources: differences in physical capital per worker and differences in the effectiveness of labour. Regarding physical capital per worker, empirical research assuming that capital's contribution to output is roughly reflected by its private returns shows modest effects of the differences in the stock of physical capital per worker on the differences in output per worker.<sup>22</sup>

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<sup>21</sup> In some models  $\delta$  is taken to be zero for simplicity.

<sup>22</sup> The condition that capital's contribution to output is roughly reflected by its private returns assumes that there are no externalities from investing in capital accumulation. This may be a strong assumption under several circumstances – for theoretical growth models exploring capital-related externalities, see Romer (1986), Lucas (1988), Rebelo (1991) and Basu and Weil (1999). Regarding empirical evidence, the work by DeLong and Summers (1991, 1992) and Bils and Klenow (2000) suggests that capital-related externalities do not seem overly important for explaining cross-country differences in output. However, the views on the importance of capital-related (also including human capital) externalities for world-wide growth are less pessimistic.

As a result, one needs to look at differences in the effectiveness of labour over time or across countries. It must be noted, however, that the Solow model is fairly imprecise about this concept. In principle, one could argue that the effectiveness of labour corresponds to some measure of abstract knowledge. Alternatively, it can be argued that by broadening the scope of capital, including human capital in the analysis, at least part of the effectiveness of labour variable can be explained. Finally, one may consider a list of other variables, like the education and skills of the labour force, the strength of property rights, the quality of infrastructure, cultural attitudes toward entrepreneurship and work, etc., to expand the concept of effectiveness of labour. The new growth theory surveyed in the next section focuses exactly on these issues.

### 7.1.2 New Growth Theory

The main feature of the new growth theory models is that they try to model the evolution of the effectiveness of labour variable, which is taken to follow an exogenous path in the Solow model. No unified way to model this variable has been established yet and existing models mostly succeed in addressing just one of the two main questions of economic growth.

In this section, we first present a model that takes knowledge or technological progress to be the main determinant of the effectiveness of labour. The model shows that research and development (R&D) is of crucial importance for understanding world-wide growth but is probably not central to cross-country differences.

Second, in order to address cross-country differences, we broaden the scope of capital and present a model that includes human capital in the analysis. The main insight of this model is that variations in human capital – along with variations in physical capital – are non-negligible determinants of cross-country income differences.

However, the real drivers of these differences are the factors determining the variations in output for any given stock of physical and human capital. We discuss these variables in the closing part of this section. Due to the abundance of possible candidates, and the controversies regarding their relative importance, we opt for an informal discussion of these factors.

### A Model of Knowledge Accumulation (R&D)

In this subsection we present a model that takes knowledge accumulation or technological progress as the main determinant of the effectiveness of labour and models its evolution explicitly. As a result, the evolution of technological progress is no longer exogenous and the models endogenizing it are called endogenous growth models.

With knowledge accumulation being modelled explicitly, the economy becomes a two-sector economy producing physical output and knowledge. The production of knowledge is also referred to as an R&D process. Clearly, capital and labour need to be shared between these two sectors. In particular, a share of  $a_K$  of capital and a share  $a_L$  of labour is used in the production of knowledge and a share of  $1 - a_K$  of capital and a share of  $1 - a_L$  of labour is used in output production. Therefore, the output production function in (1) has to be modified as follows:

$$Y_t = [(1 - a_K)K_t]^\alpha [A_t(1 - a_L)L_t]^{1-\alpha}, \quad 0 < \alpha < 1 \quad (1')$$

The production of knowledge (R&D) also depends on the quantities of capital and labour employed as well as on the amount of current knowledge in the economy. Therefore, a possible formulation of the production of knowledge is the following:

$$A_{t+1} - A_t = B[a_K K_t]^\beta [a_L L_t]^\gamma A_t^\theta, \quad B > 0, \quad \beta \geq 0, \quad \gamma \geq 0 \quad (3)$$

where  $A_t$  denotes the stock of knowledge in the economy in period  $t$ , while  $B$  is a shift parameter.

The following two observations are in place with respect to the R&D function. First, unlike in the case of output production function, constant return to scale to capital and labour is not required. In particular, doubling both capital and labour may repeat the existing knowledge production process leading to the same discoveries and not doubling knowledge as a result. In this case there are decreasing returns to capital and labour. Alternatively, due to the fixed setup costs and interaction among researchers, doubling both capital and labour may result in more than double knowledge, which is a case of increasing returns to capital and labour.

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The second observation related to equation (3) is that parameter  $\theta$  can be interpreted as the effect of existing stock of knowledge on the success of R&D. In particular, past discoveries may ease the way for new discoveries, and as a result, the existing stock of knowledge can exert a positive externality on the R&D process.<sup>23</sup> Alternatively, as the easiest discoveries are made first, the existing stock of knowledge can exert a negative externality on the R&D process.

The insights of the model presented above depends on whether  $\beta + \theta$  is smaller or larger than 1.<sup>24</sup> In particular, if  $\beta + \theta < 1$ , the growth rate of knowledge and capital converges to a steady state value and the economy converges to a balanced growth path.<sup>25</sup> If  $\beta + \theta > 1$ , the economy exhibits ever-increasing (explosive) growth rather than convergence to a balanced growth path.<sup>26</sup>

The case of  $\beta + \theta = 1$  is more ambiguous. If the growth rate of population is positive ( $n > 0$ ), the economy exhibits the same qualitative results as in the case of  $\beta + \theta > 1$ . However, if the growth rate of population is zero ( $n = 0$ ), the economy converges to a balanced growth path.<sup>27</sup> In particular, the growth rate along this path is an increasing function of the saving rate and of the size of the population.

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<sup>23</sup> A positive (negative) externality occurs when an economic decision causes benefits (costs) to third parties. In this case, the participants deciding about a certain transaction do not reap all the benefits (incur all the costs) of that particular transaction.

<sup>24</sup> The reason for this is the following. The output production function in (1) exhibits constant returns to scale in the two produced factor, knowledge and capital. As in our formulation of capital accumulation in Footnote 21 the production of capital also exhibits constant returns to scale, whether there are increasing, decreasing or constant returns to scale to the produced factors depends on their returns to scale in the production function of knowledge, which in turn depends on how  $\beta + \theta$  compares to 1.

<sup>25</sup> Note that even though this result seems similar to the one at the Solow model, growth is endogenous in this model. As in the case of the Solow model, steady state growth rate is unaffected by the saving rate.

<sup>26</sup> Intuitively, knowledge is so productive in this case that each marginal increase in its levels leads to so much more knowledge that the growth rate of the economy raises rather than falls.

<sup>27</sup> With some modifications of the model, convergence to the balanced growth path can be achieved even with rising population. See Peretto (1998), Dinopoulos and Thomson (1998) and Howitt (1999) for further details.

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It must be noted at this point that in their intentions to explain variations in long-run growth, new growth models have been focusing on non-decreasing returns to production factors.<sup>28</sup> However, as it can be seen from our presentation, non-explosive growth can only result under very strong conditions if non-decreasing returns to production factors are to be assumed.

After discussing the role of the main factors (capital, labour and knowledge) in the model let us turn our attention to allocation rule of resources to output production and R&D.

### *Incentives for Knowledge Accumulation*

One crucial point of the knowledge accumulation model presented above is that production factors (capital and labour) need to be allocated between the production of output and the production of knowledge. Clearly, this allocation is governed by the costs and benefits of each choice, which in turn are affected by the characteristics of output and knowledge respectively. While most of the produced output would qualify as a good with standard features being sold on more or less competitive markets, knowledge is a more specific good, and leaving its production to market forces alone might not be best from the society's point of view.

In particular, knowledge has two main features. First, it is non-rival, which means that the use of a certain item of knowledge does not exclude that someone else uses the same item of knowledge. With non-rivalry, the marginal cost of producing one more unit of a certain item of knowledge is zero. As a result, marginal cost pricing - zero price - is not possible as then the costs of R&D are not covered. Therefore, some departure from the competitive model is needed.

Second, knowledge is heterogeneous regarding excludability, which means that it is not always possible to prevent someone from using a certain item of knowledge. In particular, when knowledge is excludable, a properly designed patent system can provide the right incentives for R&D. However, if knowledge is non-excludable, a patent system is not implementable, and therefore, there are no private gains from R&D.

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<sup>28</sup> For a reconciliation of the assumptions of decreasing returns with empirical evidence, see Jones (1995) and Jones (2002).

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This implies that the incentives to allocate resources to R&D are often non-trivial. However, economic research has managed to identify some factors that may have an impact on the allocation of resources to the development of knowledge.

First, take basic scientific knowledge. As it is generally freely available, R&D in this area cannot be motivated by private returns. In addition, even if it is available for free it is useful in production, giving rise to positive externalities. This calls for a subsidization of it.

Second, due to the presence of many types of externalities, very often the market does not provide the optimal amount of incentives to invest in R&D and subsidies or taxes may be required to achieve the socially optimal level of R&D.<sup>29</sup>

Third, it can be observed that major innovations are often a result of the work of extremely talented individuals, who in turn have other choices of activity, e.g. rent-seeking. As a result, the forces influencing these individuals to pursue activities that are socially productive become of crucial importance. In particular, the size of the relevant market, low transportation costs, the absence of barriers to trade and the ability to keep the returns from one's activities increase talented individuals' returns from innovation.<sup>30</sup>

Finally, it is often the case that R&D occurs in part not as a result of deliberate efforts, but as a side effect of another, conventional economic activity, including goods production or capital accumulation. This is the case of learning-by-doing and the incentives to invest are not solely linked to the costs and benefits of the R&D resulting as a side effect of the conventional economic activity.

Our brief discussion above suggests that the market is not expected to provide optimal incentives for R&D and appropriate policy intervention can increase efficiency. However, there is no general rule for the optimal intervention and a case-by-case analysis is needed for accurate insights.

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<sup>29</sup> See Reinganum (1989), Romer (1990), Grossman-Helpman (1991) and Aghion and Howitt (1992).

<sup>30</sup> See Murphy, Shleifer and Vishny ((1991) for more details of the argument.

By evaluating the knowledge accumulation model in a broader perspective, it can be said – and empirical investigations support this view – that knowledge accumulation is central to worldwide growth but probably not to cross-country differences. In particular, existing cross-country income variations would be only consistent with unreasonably slow knowledge transfers.

In fact, under the assumptions of the model presented above, the non-rival nature of technology should imply a fast (almost instant) knowledge transfer from richer to poorer countries. However, this is not what we observe in practice, as poor countries often lack the ability to adapt the advanced technology. Note that the inability to adapt the latest technology is not necessarily linked to the R&D process itself.

As a result, to address the causes of cross-country variation in income levels, one needs to extend the Solow model (or the endogenous growth model presented above) in additional ways. One standard way is to broaden the scope of capital by introducing human capital into the model.

### A Model of Human Capital

In this subsection we broaden the scope of capital in growth models by extending the Solow framework to incorporate human capital. In this new model the output production function (1) needs to be rewritten as follows:

$$Y_t = K_t^\alpha (A_t H_t)^{1-\alpha}, \quad 0 < \alpha < 1 \quad (1'')$$

where  $H$  is the total amount of productive services provided by workers. By this definition,  $H$  denotes the contribution of workers of different skill levels to production, including contributions in both raw labour and in human capital.

The accumulation process of  $K$  and  $A$  is the same as in the Solow model. The main contribution comes through the explicit modelling of the accumulation of human capital. The simplest approach for this is to assume that the amount of human capital of each worker depends on the number of years spent in education. By assuming that each worker receives the same amount of education  $E$  and that this value stays constant over time, workers' contribution  $H_t$  to output production in period  $t$  can be written as:

$$H_t = L_t \times G(E) \quad (4)$$

where  $G(\bullet)$  is an increasing function describing the amount of human capital per worker as a function of years of education.

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This model exhibits similar features to the Solow model as the economy converges to a balanced growth path where output per worker is growing by the exogenous rate  $g$  of growth of technological progress.

However, the explicit modelling of schooling provides additional insights with respect to the Solow model. In particular, an increase in  $E$  has at least two effects. First, even though a rise in  $E$  does not have affect the growth rate of output per worker, it increases output per worker on the balanced growth path by the same proportion as it increases  $G(E)$ . Second, as a rise in  $E$  is an increase in the number of years spent in education, it decreases the number of active workers in the economy. This identifies a negative impact on the value of output per person (rather than worker) in the economy. The net effect on output per person is a priori ambiguous and depends on additional assumptions to be made.

Regarding the importance of human capital in explaining cross-country variation in output per worker, empirical research finds that differences in schooling count for about a quarter (23%) of the gap between countries. As the physical capital counts for another one sixth (17%) of this difference, it turns out that other determinants of output for given stock of physical and human capital count for 60% of the income gap between countries.<sup>31</sup> We are looking at these other factors in the next subsection.

### Other Factors

In this subsection we briefly discuss a set of other variables that have been thought as possibly having a strong impact on the variation of cross-country outcome levels. Due to their larger number as well as the controversies regarding their relative importance, we opt for an informal discussion of these factors.

Note that the model presented in the previous subsection makes the stock of human capital depend on the years of education only. However, other factors that vary across countries, like school quality, on-the-job training, informal human capital acquisition, child-rearing, and prenatal care also have an impact on the quality of human capital, and on the output in turn. Taking this into consideration, the contribution of human capital to the output gap

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<sup>31</sup> See Hall and Jones (1999) and Klenow and Rodriguez-Clare (1997).

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between countries raises to one third (33%), leaving non-capital determinants of output to count for 50% of the income gap between countries.<sup>32</sup>

However, these estimates assume that capital's contribution to output is measured by their market earnings (or marginal products), which is taken to be about 1/3 across countries. One can object both assumptions. First, if there are externalities from physical or human capital, their marginal products will differ from their earnings, and therefore, cross-country accounting procedures will misestimate their contribution to cross-country income differences.<sup>33</sup> Second, market earnings for capital may also vary across countries due to differences in taxation, government expropriation, litigation, theft and extortion, bribe-taking of officials or collective actions taken by workers. As a result, the marginal product of workers supplying a given amount of labour is higher in richer countries.

The group of factors affecting market earnings for capital are often referred to as social infrastructure. For example, Hall and Jones (1999) define social infrastructure as all the institutions that encourage investment and production over consumption and diversion. The distinction between investment and consumption is important because future output is only increased by the use of resources to create physical or human capital, whereas the distinction between production and diversion is important because only production activities increase the economy's total output at any point in time. Regarding this last point, it seems plausible that the fraction of resources devoted to rent-seeking are higher in less developed countries. If this is correct, differences in rent-seeking activities may be an important factor of cross-country income differences.

In fact, there are many aspects of social infrastructure. Romer (2001) classifies them into three groups. The first group consists of the government's fiscal policy. Clearly, the tax rate on investment or the government's allocation of resources between investments and other type of spending affect the society's resource allocation between investment and consumption.

The second group of institutions and policies determining the social infrastructure include the factors determining the environment where private

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<sup>32</sup> See again Klenow and Rodriguez-Clare (1997). If physical capital affects human capital quality, the increment in the share of human capital explaining cross-country income differences needs to be split between physical and human capital.

<sup>33</sup> Note that the empirical relevance of this observation is questionable, as we discussed in Footnote 22.

decisions are made. In particular, business contracts not being enforced, or the courts' related performance being unpredictable have a negative impact on long-term investments.

The final component of the social infrastructure is the government's own rent-seeking activity. In particular, expropriation and bribe-taking by government officials hinders long-term investments.

This completes our discussion of the possible impact of non-production factor variables on economic growth and also our brief overview of economic growth theory. In the next section we turn our attention to the empirical evidence connected to the theoretical considerations discussed above.

## 7.2 Empirical evidence on economic growth

In this section we present the main findings of empirical research on economic growth. We will dedicate special attention to the two main questions of the economic growth literature, namely (i) what are the main determinants of a economic growth over time; and (ii) what are the determinants of the cross-country variation of output growth.

Empirical models of growth can be classified into three categories: historical studies, growth accounting models and cross-country growth regressions.

Historical studies make the least use of any economic theory. However, their importance lies in the fact that they can bring a much deeper conception of the social, political, institutional and technological sources of growth than rigorous economists can incorporate in their formal models. Therefore, even though they should not be used for systematic analysis of economic growth, they can be of great use in pointing to particular factors that others are likely to miss.

Growth accounting models look at the various versions of the aggregate production functions presented in the previous section and try to estimate the relative contribution of inputs, mainly capital, and of efficiency to cross-country differences in income.<sup>34</sup> As we briefly mentioned in the previous section, recent growth accounting work estimates the share of physical and human capital in explaining cross-country income variations to be slightly

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<sup>34</sup> Labour should also considered as an input, however, growth accounting methods often look at variations of output per worker across countries and in this case capital per worker is considered to be an explanatory input.

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below one half.<sup>35</sup> Accordingly, the rest of the variation, slightly more than one half, can be attributed to efficiency, or in terms of the general model, to factors other than capital.

The main benefit of the growth accounting literature is that it drives attention on the crucial importance of efficiency and invites research to explain its drivers. However, it does not offer any guidance for what the determinants of this important residual factor are. This is the point where cross-country regressions come into the picture.

### 7.2.1 Cross-country growth regressions

In this subsection we present the main findings of empirical work on economic growth using cross-country growth regressions. The main advantage of this approach is that unlike growth accounting, it aims to identify the main drivers of the differences in productivity growth across countries.

Cross-country growth regression equations can generally be derived from different versions of the aggregate production function specified in (1''). One particular useful form of the aggregate production function is the following:

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta}, \quad 0 < \alpha, \beta < 1, \quad 0 < \alpha + \beta < 1 \quad (1''')$$

where all the variables are the same as defined before, with  $A$  being an index of technical efficiency.

As  $\alpha + \beta < 1$  in this model the economy converges to a balanced growth path. By approximating the actual performance of the economy along this steady state path, growth in this model can be written as

$$\ln \frac{Y_t}{L_t} - \ln \frac{Y_0}{L_0} = -\theta \ln \frac{Y_0}{L_0} + \phi \ln s_k + \varphi \ln s_h - \gamma \ln(n + g + \delta) + \phi \ln A_0 + gt + \varepsilon \quad (5)$$

where  $n$  and  $g$  denotes the growth rate of labour ( $L$ ) and technological progress ( $A$ ),  $s_k$  and  $s_h$  denote the investment rates in the two types of capital, while  $\varepsilon$  is an error term. The two types of capital are assumed to depreciate at the same rate  $\delta$ .<sup>36</sup>

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<sup>35</sup> See Hall and Jones (1999) and Klenow and Rodriguez-Clare (1997).

<sup>36</sup> This theoretical framework for growth regression was derived by Mankiw, Romer and Weil (1992).

In the regression above the coefficient  $\theta$  of the initial income  $Y_0/L_0$  is of crucial importance. In particular, for countries with the other parameters identical, a positive estimated coefficient  $\theta$  of initial income means that a country with lower initial income, i.e. a poorer country, will grow more quickly for a transitional period.<sup>37</sup> This means that countries converge to their balanced growth path determined by the variables ( $n$ ,  $g$ ,  $\delta$ ,  $s_k$  and  $s_h$ ) of the model, or equivalently, the levels of output per capita in countries with the same balanced growth path converge to each other.<sup>38</sup>

Note that the regression equation in (5) can also be used to explain variation of income rather than variation of growth rates across countries, which very often is a more natural research question and occasionally of potentially more use for policymakers.

Even though the approach presented above provides a simple theoretical framework for growth regressions, many empirical researchers opt for the simpler way of estimating regressions of the following type:

$$\ln \frac{Y_t}{L_t} - \ln \frac{Y_0}{L_0} = \beta X_t + \omega_t$$

where  $X_{it}$  is a vector of variables that have been identified in the theoretical literature as possible drivers of long-term growth, while  $\omega_{it}$  is the error term.<sup>39</sup>

Clearly, both approaches are ridden by plenty of econometric problems. Overall, many surveys conclude that empirical evidence on economic growth is highly inconclusive.<sup>40</sup> However, we briefly review below some of the findings that are relatively less often questioned.

### Empirical findings

In presenting our findings, we rely on the formulation of the aggregate production function, according to which aggregate output is determined by

<sup>37</sup> The reason for this is that poorer countries have a lower stock of capital, which in turn commands a higher return to it and a higher investment rate, leading to faster growth.

<sup>38</sup> This corresponds to the concept of conditional convergence, as opposed to absolute convergence, when all the countries converge to the same balanced growth path, or  $\sigma$ -convergence, when the level of inequality across countries is supposed to stay constant over time. See Barro and Sala-i-Martin (1992) and Sala-i-Martin (2001) for more details.

<sup>39</sup> These regressions are sometimes called “Barro regressions” after the influential work of Barro (1991).

<sup>40</sup> See Temple (1999), Pritchett (2006) and Zaghera, Nankani and Gill (2006) among others.

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for R&D, macroeconomic evidence only finds modest effects of R&D on growth.<sup>48,49</sup> Nevertheless, there is another finding that R&D can have large level effects, i.e. it can lead to a large one-off increase in output, and this by itself is sufficient for an interest in the policy effects of research incentives.

After discussing evidence on the importance of the main factor inputs of the aggregate production function we briefly review empirical findings related to factors thought to influence cross-country income variation through the “effectiveness of labour” variable.

One factor which is linked to the R&D process and is important for cross-country income variation is technological transfer. Empirical research provides evidence for such spillovers as it finds that foreign R&D can have large effects on domestic total factor productivity.<sup>50</sup> This is important as it provides some support for endogenous growth theories. The technological spillovers can only make an impact if the country is open to accept them. More generally, empirical research has found a positive impact of openness on growth.

Another factor that proved to have an impact on growth is the activity of the stock market. In particular, empirical evidence suggests that active stock markets play a role in subsequent growth.<sup>51</sup>

As long-term growth emerges as the sum of short-run performances, one needs to investigate the effect of short-run macroeconomic indicators on growth. In particular, one could examine among others the impact of budget deficits, inflation and real exchange rate stability on growth. Plenty of regressions result in coefficients of the expected sign. However, it has proved difficult to isolate specific policy variables and demonstrate which ones have a robust correlation with growth.

Empirical researchers have also looked at the impact of government on economic growth. Even though basic intuition would suggest a negative correlation between the size of the government, i.e. the public

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<sup>48</sup> Note that this finding questions the validity of research-driven growth models.

<sup>49</sup> See Jones (1995).

<sup>50</sup> See Coe and Helpman (1992).

<sup>51</sup> See Levine and Zervos (1997).

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expenditure/GDP ratio, and growth, empirical evidence only offers weak support for this view.<sup>52</sup>

However, evidence on the impact on economic growth of public spending on infrastructure development is more positive. In particular, empirical investigation finds that public investment in transport and communication is positively correlated with growth.<sup>53,54</sup> The positive impact of investments in information and communication technology (ICT) is particularly accentuated as investments of this type increase productivity.<sup>55</sup> More generally, infrastructure spending appears to make a significant contribution to economic growth, and even more so, when it is accompanied by insitutional reforms that lend credibility and effectiveness to government policy.<sup>56</sup>

Finally, researchers also looked at some social and political factors that might have had an impact on growth. In particular, economic freedom seems to be more strongly connected to growth than political rights - contract enforcement and the risk of expropriation being of special importance. Regarding the political factors, political instability is found to have a strong negative effect on growth, while the level of democracy does not seem to be a decisive factor.

Even though the empirical evidence discussed above tends to look at the impact of certain variables on the variation of output across countries, the variation in income across the regions of a country can be of equally important concern. It turns out that most of the results of the cross-country investigation continue to hold for cross-regional variations. In particular, the investments in transport infrastructure and ICT are of special importance.<sup>57</sup> In

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<sup>52</sup> See Levine and Renelt (1992) and Hall and Jones (1997).

<sup>53</sup> In particular, a better transport and communication system reduces transaction costs and, therefore, can increase the relevant geographical market, assuring higher possible returns for various investment activities, including R&D, and fostering economic growth.

<sup>54</sup> See Easterly and Rebelo (1993) and Démurger (2001). The latter paper is of special interest as, by looking at Chinese provinces, it compares regions inside of a country when providing evidence of positive impact on growth of public investment in transport and telecommunication.

<sup>55</sup> See Roller and Waverman (2001) as well as Milana and Zeli (2002) and Oulton and Srinivasan (2005). Note that the positive impact on growth of ICT investments can be identified even at the regional level.

<sup>56</sup> See Esfahani and Ramirez (2003) who look at the impact of public investments in telecom and power on economic growth.

<sup>57</sup> See, among others, Démurger (2001) and Ford and Koutsky (2005).

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addition, empirical research also shows economic convergence across regions.<sup>58</sup>

### 7.3 Conclusion

Even though the literature on economic growth has been revived in the past 20 years, and some of its findings seem promising, it is still in the stage where more work is needed in order to provide robust answers to the two main questions<sup>59</sup> of the field and to provide clear-cut guidelines to policy makers about what to do to spur growth.

Existing empirical findings need to be treated with caution for three reasons.

1. The econometric specification of empirical models does not always link very well with some of the underlying theory, and so any intuition behind such evidence can tend to be a little spurious.
2. The measurement of some variables is often not straightforward. For example, human capital can be measured in many ways, by different levels of education or school enrolment.
3. Researchers often find it hard to address properly the two main econometric problems inherent in the empirical research on economic growth: endogeneity and causality.<sup>60</sup>

Nevertheless, theoretical and empirical research has identified the following as factors that may have a positive impact on growth:

- support for R&D;
- investment in human capital;
- open economies;
- active financial markets;
- public investment in infrastructure (transport and communication in particular);
- enforcement of property rights with no or limited expropriation;

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<sup>58</sup> See Sala-i-Martin (1996).

<sup>59</sup> What are the main determinants of a country's long-term economic growth? Do different economies converge in terms of well-being?

<sup>60</sup> Endogeneity refers to the fact that an independent variable included in the model is potentially a choice variable, correlated with unobservables relegated to the error term. Causality becomes a concern when two variables evolve together in time and it is not properly determined which one of them is the cause in a relationship and which one is the effect.

- no or limited corruption; and
- political stability.

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## 8 Transport

### 8.1 Introduction

The links between transport investment and the economy have been investigated for many years and there has been much debate on the role that transport investment plays in contributing to economic growth at both the national and the regional level.

In this Chapter we first review research that seeks to link transport investment and overall economic growth. We then review material that examines local and regional economic impacts. This includes reviews of material that examines the impacts of specific transport investments across a range of transport modes – road, rail and air.

### 8.2 Transport Investment and Economic Growth

A number of studies have examined the relationship between transport investments and economic growth. It is clear that in the past innovations in transport provision have had significant impacts on economic growth. The development of canal networks and then rail networks in the UK in the eighteenth and nineteenth centuries are closely associated with the development of the industrial revolution.<sup>61</sup>

In modern developed economies, however, it is less clear that there is a strong link between additional investment in transport infrastructure and economic growth. The Eddington report (Eddington, 2006) reviews evidence in this area and finds a number of studies that show a link between transport investment and GDP growth.<sup>62</sup> It is also noted however that there is uncertainty about the causality inherent in these relationships – is transport investment driving growth, is growth driving transport investment, or is there some more complex interaction between the two?<sup>63</sup> Eddington suggests that it is most likely to be an interaction between the two factors.

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<sup>61</sup> See Crafts & Leunig (2005).

<sup>62</sup> Banister and Berechmann (2000) also review the evidence in this area.

<sup>63</sup> Others also make this point about causality. See OECD (2003) and SACTRA (1999).

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In addition to the problem of causality, there are also problems in isolating the impacts of individual factors on GDP because there are so many factors that affect GDP.<sup>64</sup> One study concluded that there was no definitive estimate of the effects of infrastructure, and transport infrastructure specifically, on GDP.<sup>65</sup>

Even if one accepts that transport infrastructure was an important determinant of economic growth in the past, there is no reason to believe that it will still be linked to GDP in the future. Production and distribution processes could become less or more transport intensive in the future. This means that less infrastructure could be required to achieve similar levels of economic growth.<sup>66</sup>

### 8.3 Local & Regional Economic Impacts

There is a substantial literature both with respect to the impact of public transport and private transport-oriented interventions.<sup>67</sup> This section focuses on studies which analyse the economic impacts of specific transport developments at the local or regional level.

#### 8.3.1 Evaluation framework

The most commonly used evaluation framework is cost benefit analysis. In this respect, the OECD has provided guidelines on how to identify regional impacts of transport infrastructure investment and how to include them in appraisal methodologies. The main impacts have been identified as (OECD, 2002):

- Direct user benefits: travel time, vehicle operating costs and safety.
- Accessibility: improvement in accessibility will increase the market size

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<sup>64</sup> See OECD (2003).

<sup>65</sup> Eberts (1999) as quoted in Eddington (2006).

<sup>66</sup> To a great extent, this is already taking place. The technological revolution in information and communications technologies (ICT) are facilitating that exchanges are made increasingly using ICT platforms. For example, nowadays many of the exchange of information can be done over the internet or fax when it required physical transport of mail in the past.

<sup>67</sup> For example, ODPM/RICS (2003) identified 150 references on the topic of land value and public transport, with 18 key references examined. Their conclusion was that “the expected effect on both the residential and commercial property markets is positive but the range of impacts is very variable”.

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for manufacturing, tourism and/or labour, leading to increased competition and/or centralisation. On the other hand, the impact for the region concerned could be both positive and negative, depending on its initial level of competitiveness.

- Employment: the impacts of construction, operation and maintenance of transport infrastructure on employment include both newly created and relocated jobs.
- Efficiency: time and cost savings as well as gains in accessibility and reliability would allow productivity gains to be achieved by firms by improving their production and distribution.
- Social inclusion: transport infrastructure projects could either result in further exclusion of communities or could contribute to addressing the problem of social exclusion by improving accessibility and mobility.
- Environment: including air and water quality, noise, regional impacts and use of natural resources.

Alternative methodologies are sometimes also used. One of the most commonly used approaches to assessing the economic impact of potential road improvements are survey-based studies. The usual approach is to survey businesses which are thought likely to have been affected by the proposed development, generally firms located in areas served by the infrastructure (see Pineda, 2004).

### 8.3.2 Key issues

The most fundamental outcome of investment in transport infrastructure is the a lower cost of accessibility to various locations, for households, retailers and industrial firms. In the short to medium term, the effect would be observed on travel variables, such as travel volumes or choice of routes. In the longer term, impacts will be reflected in the location decisions of households and firms and in changes to land and property prices.

#### *Wider impacts of transport links*

The Eddington Transport Study (2006) distinguishes the following important linkages between transport and other markets.<sup>68</sup>

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<sup>68</sup> The range of benefits accruing from transport infrastructure has been considered by the Standing Advisory Committee on Trunk Road Assessment (SACTRA, 1999), DfT (2005), the Eddington Transport Study (2006), and various academic studies.

- **Business Efficiency:** Transport improvements can deliver efficiency in delivery time, cost and journey reliability. This can contribute to GDP through an increase in overall cost savings for business. This is especially true where such transport improvements are targeted at congested routes, predominantly used by business and freight.
- **Business investment and innovation:** Direct savings from transport could lead to a higher rate of business investment and productivity benefits. At the same time, cheaper transport could also allow business to benefit from economies of scale.
- **Clusters and agglomerations:** Transport could facilitate concentration in clusters or agglomerations of firms and workers. In such environments, interactions between firms and individuals allow the sharing of knowledge, development of new ideas, and a greater choice of jobs which can generate productivity benefits.
- **The labour market:** Transport policy is fundamental to the operation of the labour market as it influences people's decisions to work, where to do so and how far to travel. However, there is very little evidence on the precise contribution that transport makes in supporting labour markets.
- **Competition:** Transport improvements can have a similar effect on the economy as a reduction in trade barriers and deliver growth benefits by exposing firms to greater competition.
- **Domestic and international trade:** Transport can help reduce costs and therefore barriers to trade. Increase in trade means a greater volume and choice of imports of manufactured goods and raw materials.
- **Globally mobile activity:** Good transport links, both internationally and domestically, can be important in attracting, retaining and expanding businesses, capital investment and labour in a globally mobile environment.

### *Regional development*

There have been arguments for regional and urban investment policies stating that regional development policy strengthens integration and cohesion of countries while reducing the disadvantages in peripheral or poorly connected locations.

Even here there are many unresolved questions (see Banister and Berechman, 2000).

- It is not clear whether such a policy actually provides the greatest benefit to these peripheral regions. Little empirical evidence is available on whether transport infrastructure investment in the

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periphery actually strengthens these areas, as it extends the market area and permits migration of labour to the centre where opportunities are perceived to be greater.

- It is unclear whether the local economy in the peripheral region benefits over the longer term. It has been argued that infrastructure investment should take place in those locations where the greatest return is expected (this is likely to be in the regions with the most buoyant economic conditions or where relevant factors of production are available, such as natural resources or skills).

The degree to which infrastructure improvements will affect economic development is not independent of the existing level and performance of the stock of capital infrastructure. In areas where the stock of the transport infrastructure is already highly developed, even a sizeable infrastructure investment is unlikely to significantly affect travel behaviour, markets, and economic development.<sup>69</sup>

Some have argued that a lack of investment in infrastructure of all types (e.g. schools, water and public buildings) has had an adverse effect on efficiency and productivity. But there are claims that there is a difference between the implications of *not investing* in the infrastructure and identifying the impacts of *additional* investment.<sup>70</sup> Proponents of this line of argumentation have viewed the transport system as a constraint on the attainment of economic opportunities. Any additional investment can lessen this constraint and so enable the attainment of higher economic development. If a region has all the other economic factors present for growth, then its full potential may not be realized without further transport investment (Hirschman, 1958; Hansen, 1965).

The conclusion has been that transport is a second order consideration for location or relocation decisions, provided that there is a good quality road network available. In other words, the argument on the development effects of infrastructure is now seen as being “necessary” but not “sufficient” for economic development (Huddleston and Pangotra, 1990).

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<sup>69</sup> This means that, in general, one can expect a declining marginal economic development effect from additional infrastructure investment.

<sup>70</sup> This debate concerns much of the recent research in the US and elsewhere (Aschauer, 1989; Munnell, 1990; Berechman, 1995; Helling, 1997).

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### 8.3.3 Roads

Investment in the road infrastructure of an economy is believed to bring about significant economic and regional development benefits to an economy, under certain qualifying assumptions. These assumptions include that the economy is classed as a developed economy with different centres of economic activity that currently do not have good transport links. One caveat for this type of investment is that simply linking any two cities will not stimulate economic activity. Road investment should be seen as a *facilitator* for further economic development and not a *creator* of economic activity.

#### *The orbital motorway around Amsterdam*

The orbital motorway around Amsterdam (the Netherlands) was completed in 1990. It was suggested that this project would have a major impact on office location and commercial development in the region. The evaluations made ex-post seem to contradict this original assumption.

A study by Bruinsma et al., (1996), found no significant impact on office rents and locations. In fact, factors like building amenities had greater impact on office location decisions than improved accessibility had.

Kroes et al. (2004) present the results of a major before-and-after study carried out to establish the short term effects of the removal of a severe bottleneck in the road network around Amsterdam. The results of the study indicated that, in the short run, there was little or no change in mode choice, nor was there significant emergence of new induced trips.

#### *Review of some UK evidence*

A economic impacts assessment studies of specific road projects was undertaken by Piedad (2004) on behalf of the National Assembly for Wales. The routes for which case studies were reported are:

- M4/Severn Bridge/Second Severn Bridge;
- A55 North Wales Expressway;
- M62 Liverpool to Hull;
- M25 Orbital Road;
- M40 London to Birmingham;
- Skye Bridge;
- Road improvements around Merthyr;

- 
- Fixed Road Connection to Kristiansund; and
  - French A71.

The study provides several findings on the economic impacts of road improvements and it summarises some of the case studies.

- The study of the Severn Bridge found that firms which already drew supplies from across the estuary increased their sourcing from these suppliers, as a result to more competition which led to lower prices. Another study estimated that as a result of the construction of the Severn Bridge with its links to the M4, South Wales had attracted between 9,000 and 12,000 jobs in firms not previously located in the region. The same study concluded that 1,500 new manufacturing jobs were attracted to sites along the M62 over a ten-year period.
- The potential impact of the Second Severn Crossing was found to be positive for companies in South Wales with 52% (59%) of companies responding believing access to suppliers (customers) would be improved.
- Almost 30% of businesses surveyed felt that the A55 road improvements had reduced their production costs either through reducing the delivery charge or by new suppliers entering the local market which in turn forced local suppliers to reduce prices. In addition, the study estimated the road improvements would generate an additional 350 jobs.
- There is evidence from the survey of businesses likely to be affected by the completion of the M4 that the road improvements would improve access to their existing markets and provide opportunities for exploiting new markets which in turn would increase business activity.
- A study for the M62 estimated that there would be almost 3,700 additional jobs in indigenous manufacturing in the study area as a result of the construction of the motorway.
- A study of the impact of constructing a fixed road link from Kristiansund to mainland Norway found that commuting increased following the road improvements, and as a result there was considerable centralisation of activity with a number of businesses moving their activity from the island to the mainland. In the short term, Kristiansund lost jobs.
- The study which analysed the socio-economic impact of the Skye Bridge found that competition increased in the local construction market as a result of the bridge. Businesses in the construction sector working in the local market confirmed that the opening of the Bridge had made it easier for companies based elsewhere in Scotland to access their markets in Skye. These companies assessed the effect on their business performance as negative, but consumers of

construction services in Skye should have benefited from the increased competition.

- The study of road improvements around Merthyr (Cardiff Business School, 1997) found some evidence that that the most recent inward investors to Merthyr might not have considered the area if the improvement of the A470 had not been completed. In addition, a total gain of 1,695 direct jobs (in the inward investing companies) and 1,182 indirect jobs (throughout the rest of the economy) were estimated.
- Another study examined the impact of the French A71 motorway linking the cities of Orleans and Clermont Ferrand via Bourges and found that land values rose as a result of the road.

The Pidea (2004) report provides two key conclusions. First, the existing body of evidence is more compatible with the view that transport investments can affect the *distribution* of economic activity than with the claim that transport investment materially affects *growth* at the UK level. Second, the evidence on regional and local impacts is poorly developed. Whilst individual studies have produced reasonably convincing evidence on the effects of particular projects, it is difficult to draw very general conclusions from the evidence. Moreover, there is little consistency in methodologies used or the quality of the evidence assessed.

### *OECD analysis of ex-post studies*

The OECD used an evaluation framework to analyse existing ex-post evaluation studies. The variables that were common to most case studies included: travel time, vehicle operating costs, accessibility and safety, and employment and business impacts (i.e. created or destroyed).

There were other variables that were often stated as important to policy objectives, but not always taken into account. These included: environment impact variables, relationship to other developments, social cohesion, quality and level of service, reliability and regional redistribution.

The number of ex-post studies analysed were the following:

- Australia: Berrima and Mittagong Bypass highway system case studies;
- France: Seven motorway projects;
- Norway: Kristiansund road tunnels and bridges system project;
- United Kingdom: Severn Bridge (opened in 1966); Humber Bridge (opened in 1981); M62 (opened in 1966 and 1976); M40 Motorway; A55 North Wales Expressway;

- United States: “Appalachian Development Highways Economic Impact Study” (system made of different highway corridors from Mississippi to New York).

The basic conclusion reached by the OECD Working Group is that there is a lack of information derived from ex-post studies which could provide a firm, quantitative basis for claims about the impact of infrastructure investment on regional economies and regeneration. As a result, the ability of the Working Group to provide guidance on improving project appraisal methodology was limited.

### *The contribution of road projects in the EU*

A European Investment Bank (1998) study covers a sample of 16 large-scale road projects and 7 major rail projects financed by the European Investment Bank (EIB) in 5 European Union (EU) countries between 1982 and 1991, and measures their contribution to regional development.

The success of the projects was examined by comparing the forecasts made at the appraisal stage with the operational results. The study concluded that all projects proved a success technically, financially and economically.

In terms of the contribution to regional development, the success of the operations is less clear. The evaluation concluded that in the case of 2 roads and 2 railway lines the projects had a positive effect on regional development; that 1 road had a negative impact; and that in the other 9 cases, the analysis was inconclusive.

Overall it is recognised that success of the project is a necessary but not sufficient criterion and if the local network is inadequate and/or there are deficiencies in other sectors related to the project, the operation must be combined with parallel accompanying measures, in order to contribute effectively to regional development.

The Vasco da Gama bridge over the Tagus Estuary was one of the most polemic projects ever built in Portugal and indeed in the European Union. Benefiting from significant funding from the Cohesion Fund, the project failed to meet its main declared objectives (decongesting the old bridge and providing a north-south link around Lisbon), and its location was the worst of three alternatives in terms of land management, nature conservation, transportation system and cost (Melo, 2000; Departamento de Prospectiva e Planeamento, 1998; CET, 2001).

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A comparative ex-post impact assessment of “brick and mortar” and “soft” large investments in the Oise valley in France (Ministère de l’équipement, du logement et des transports, 1997) found that traditional infrastructure investments in transport and water/sewage have a greater economic impact (measured as labour and capital productivity) than large scale investments in education, health and culture.<sup>71</sup> Moreover, the magnitude of the effect depends on the population density of the area. Finally, spillovers need to be estimated over a relatively large area as induced private investments are not always located in the immediate neighborhood of the public sector investment.

### *The US experience*

Rephann (1993) comes to five conclusions on empirical evidence of roads from the US (as cited in Banister and Berechman, 2000):

- Road investment appears to have a greater effect on economic activity in the less industrialized regions such as the Sunbelt
- Extremely underdeveloped regions are less promising candidates for road development than regions in an intermediate stage of development which are experiencing low growth.
- The effects are positively correlated with urbanization levels and metropolitan proximity.
- Other types of infrastructure (e.g. airports) may contribute to the effectiveness of highway investments.
- Additional roads may result in diminishing marginal returns.

### *Experience in Germany and Austria*

Germany has been a testing ground for the effects of large-scale infrastructure investment on regional development. In the years following the country’s unification, substantial investments have been made, above all in a multi-modal transport network, but also in other areas. There have been some studies conducted over recent years that evaluate the effects of roads.

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<sup>71</sup> In France, all large investments projects are by law (Loi d’orientation sur les transports intérieurs, 1982, art. 14) to be subjected to ex-post economic and social evaluations 5 years after the completion of the project. So far, very few such evaluations have been undertaken and many of these are not publicly available.

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Gather et al. (2003) find that large-scale investment in road building in the East German state of Thüringen did not lead to any appreciable effects in terms of growth and employment. Instead, comparative analysis of different regions suggests that physical proximity to regional population centres determines the development performance of lagging regions, rather than the existence of a dense network of motorways. Moreover, they find that good transport links might even impact negatively on regional economies, for example by facilitating the movement of workers to more developed regions further away.

A study by Schröder (2006) surveys the recent quantitative literature on the economic impact of road-building in East Germany (focusing on the state of Saxony). The author's own empirical analysis provides support for the conclusions found in Gather et al. (2003). This is the proximity of motorway connections is neutral with respect to indicators such as unemployment and business investment. Motorways do, however, seem to have an impact of regional demographics: Schröder's study shows that population decline tends to be faster, the greater a region's distance from a motorway connection.<sup>72</sup>

In an econometric study which relates regional investment volumes to the average drive-time to the nearest motorway, Komar (2000) finds that a 1% reduction in drive-time leads to an increase in investment of 0.25%. Similar results are reported by Ragnitz et al (2001), who use the same methodology.

Federer and Schuh (2005) discuss the theoretical effects of infrastructure investments and try to quantify these effects for the Austrian economy by using a simulation model. Assuming an increase in the investment in the country's transport infrastructure from 0.9% in 2005 to 1.25% in 2009, they estimate GDP growth to accelerate by an additional €4 billion by 2009. They also expect that investment in transport infrastructure will create an increasing number of jobs, rising to 50,000 per year in 2009.

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<sup>72</sup> However, the study also mentions the fact that even in Germany's rural regions, the average drive-time to the nearest motorway is just 23 minutes.

The German Federal Ministry of Transport, Construction and Housing commissioned a detailed evaluation of the investments in the German transport infrastructure between 2000 and 2006. The 2003 interim report by the consulting firm GEFRA contains the results of cost-benefit analyses for 4 railway projects, 5 road-building projects, and a qualitative discussion of investments in flood-defences in 8 locations. The report found substantial net benefits in all cases. In railway projects, estimated benefits ranged from 1.5 to 10.7 times the initial investment cost, while in road-building projects, the benefits ranged from 3.9 to 18.6.

An overview of further evidence linking road infrastructure investment and local economic development is provided in Table 1.

**Table 1: Summary of studies examining links between road infrastructure and local economic development**

Author	Geographical Scale	Infrastructure	Conclusions
Botham (1980)	28 Zones (UK)	Changes in national highway stock	Small centralising effect on employment
Briggs (1981)	Non-metropolitan counties (US)	Presence of inter- state highway	Presence of interstate highway is no guarantee of county development
Bruinsma et al. (1996)	Orbital corridor (NL)	New urban motorway	No clear impact on office rents. Some increase in productivity and employment
Cleary & Thomas (1973)	Regional level (UK)	New estuarial crossing	Little relocation but changes in firm's operations
Dabinett et al (1999)	Metropolitan area (UK)	New local roads	Substantial increase in planning applications
Dodgson (1974)	Zones in North (UK)	New motorway	Some relationship between transport costs and employment growth
Eagle and Stephanedes (1987)	87 counties (US State)	County highway expenditure	No relationship with employment growth
Headicar (1996)	Regional corridor (UK)	New motorway	Substantial development
Judge (1983)	Regional level (UK)	New motorway	Very limited economic impact
Langley (1981)	Highway corridor (US)	Highway	Devalued property area
Linneker and Spence (1996)	South East (129 zones) Rest of GB (50 zones)	Orbital motorway (M25)	Employment growth in areas of accessibility growth (decentralising)
Mackie and Simon (1986)	Regional level (UK)	New estuarial crossing	Small overall effect - some reorganisation of operations
Mills (1981)	Metropolitan areas (US)	Presence of orbital highways	No significant effect on location patterns
Mills and Carlino (1989)	Counties (US)	Interstate highways	Significant effect on population and employment
Moon (1986)	Metropolitan areas (US)	Highway interchanges	Existence of inter- change villages identified
Orus (1997)	Urban and rural areas (FR)	Access to national network	Employment growth concentrated in urban areas with good access
Rienstra et al. (1998)	National study (NL)	Motorways	No clear impact on employment
Stephanedes (1990)	87 counties (US State)	Highway investment	Could affect economic development - depends on county's economy
Stephanedes and Eagle (1986)	87 counties (US State)	County highway expenditure	Some positive association with employment levels
Welsh Economy Research Unit (1996)	Regional corridor (UK)	Trunk road improvements	Small increase in employment
Wilson et al (1982)	Regional level (CA)	Highway investment	Some regional economic develop- ment identified
Zembri-Mary (1996)	Regional corridor (FR)	New Motorway	Large increase in land values

Source: *Holvad and Preston (2005)*.

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### 8.3.4 Rail

Investment in rail systems has often been justified not only on the basis of strict cost benefit analysis, but also the broader employment and development benefits. The empirical evidence, however, does not always corroborate this view.

#### *Factors affecting the success of urban rail systems*

Babalik (2000) developed a planning framework to predict the success of new urban rail systems. The framework was developed on 8 urban rail systems from the US, Canada and Britain:

The study included the following systems from the following countries.

- US: Miami Metrorail, St Louis MetroLink, San Diego Trolley, and Sacramento Light Rail.
- Canada: Vancouver SkyTrain.
- Britain: Tyne and Wear Metro, Manchester Metrolink, and Sheffield Supertram.

The results were validated against 9 systems from the US, Canada and France, and further 3 from Turkey.<sup>73</sup>

It is important to note that the study defines *success* in its own special way. It has been defined as the fulfilment of the expectations of the project. These are: to attain a high patronage; to be cost-effective in terms of building and operating the system; to increase public transport usage; to prevent or solve the problems of traffic congestion and environmental pollution; and to improve the land-use and urban growth patterns.

The framework developed by Babalik predicts the success of urban rail systems according to the following suitable factors and policies (Table 2). The more factors and policies apply to a case, the more successful that urban rail system is likely to be.

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<sup>73</sup> Previous research that has also looked at the selected systems includes Fullerton and Openshaw, 1985; Gomez-Ibanez, 1985; Johnston et al, 1988; Pickrell, 1990, 1992; Walmsley and Perrett, 1992; Davoudi et al, 1993; Heseltine and Mulley, 1993; Rowley, 1995; Warren, 1995; Knowles, 1994, 1996; TRB, 1996a; Haywood, 1998a, 1998b, 1999; Senior, 1999.

**Table 2: Factors and policies contributing to success of urban rail systems**

<b>Factors</b>	<b>Main characteristics</b>
<b>Urban factors</b>	The city centre is economically vital Residential density in the city is medium to high The city had developed along radial corridors with the system located along one of them.
<b>Socio-economic factors</b>	The project has high local support Public transport modes are considered safe and transport usage is high The system is located along a corridor with high demand for public transport (if the system serves medium and high income areas) Bus fares can be controlled (if the system serves low-income areas).
<b>Planning factors</b>	Urban rail system planning has been done in conjunction with regional/metropolitan plans and in integration with other urban projects (regeneration, renewal) The location of urban rail stations is well integrated with existing activity centres The system creates a significant improvement in accessibility The system is located along a developed corridor The corridor does not serve declining areas The corridor is compatible with growth trends.
<b>Cost factor</b>	The system is inexpensive or it is expensive but the area is very suitable for rail investment (i.e. urban and socio-economic factors all or mostly apply).
<b>Operating policies</b>	The urban rail service is very frequent. There is provision of <i>travelcards</i> that allow unlimited journeys free transfers between buses and the rail system allowed offers for free travel for some times of the day (off-peak) Effective marketing of the system Security staff on board, at stations, and at park and ride areas.
<b>Transport planning policies</b>	Bus services are reorganised and integrated into the rail system Car parking facilities are provided at stations to be used for free by the system riders Car parking in the city centre is restricted.

Source: Babalik (2000).

This research shows that there are certain conditions that “would support an urban rail investment as well policies that would help increase its success”.

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### ***Light Rail Rapid Transit system in Buffalo, New York***

Construction of the Light Rail Rapid Transit (LRRT) system in Buffalo, New York commenced in 1979. The project was located within a declining central city area and represented a large public investment (\$520mn, in 1982 prices). Economic and land development and the creation of jobs were the major factors in the funding decision, rather than transportation benefits. The growth objectives were to be obtained by providing adequate capacity to transfer fast and conveniently a large number of passengers from the city edge to the heart of the downtown.

Berechman and Paaswell (1983) studied this project and drew the following main lessons.

- Attractiveness of an area is determined by a range of features in addition to accessibility.<sup>74</sup> The lack of regional or citywide support policies was probably the most serious threat to the revitalization of the Buffalo downtown (conflicting highway, parking, transit and zoning policies are examples of this problem).
- Improved rail transit accessibility is neither a necessary nor a sufficient condition for revitalizing the Central Business District.

### ***The French high-speed rail system (TGV)***

In France, the high speed rail system (Train à Grande Vitesse, TGV) has been in operation since 1981 (when the Paris-Lyon line was opened). Since then, connection to the TGV network has often been seen as a boost to the local economy. Banister and Berechman (2000) have surveyed the main impacts of the TGV.

- Although the new Paris-Lyon TGV route had three new stations: “Le Creusot”, “Mâcon”, and “Lyon Part-Dieu”, it was only in Lyon that significant growth took place around the station. The explanation was that the new station had good local access (as well as being two hours from Paris). However, other factors were also important: the little available space in central Lyon also made relocation around the station more attractive for high tech service industries needing good access to Paris. These sort of local advantages were not available in Le Creusot and Mâcon.

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<sup>74</sup> Personal safety and comfort, upgrading of existing facilities, variety and quality of activities, and competition from other accessible and attractive areas in the region.

- As the TGV network expanded, the impacts in other locations were of a diverse nature. Substantial growth took place in Le Mans, Nantes and Vendôme where local conditions were buoyant.
- However, growth has not been homogeneous across all stations and the level of development has depended on the overall economic strength of the local economy and the presence of service sector firms requiring access to Paris.

The main lessons of the Lyon (and also Lille) success can be summarised in the following points (Greengauge21, 2006)<sup>75</sup>:

- Economic and land-use trends are relevant to development, and in particular if service-sector activities are present in the city.
- The selection of the location for the high-speed line station is critical and it must be developed in line with a masterplan.
- Effective regional and local transport is crucial to tying together the various elements.

### 8.3.5 Airports

Aviation infrastructure is often quoted as attracting investment from overseas and in high technology industries.<sup>76</sup> Thus, through this medium investment in aviation infrastructure may promote growth as an *indirect creator* of economic activity rather than just a *facilitator*.

Many studies have discussed the impact of airports on economic activity through a similar set of factors. The factors vary in the extent that they are a direct or indirect impact of the airport, and in how they can be measured. The impacts on employment, income and output are often considered under following headings:

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<sup>75</sup> The lessons from the French TGV can also be identified in a number of other cities. Greengauge21 (2006) provides a summary of additional examples. In Spain, Zaragoza lies in the middle of the future Madrid-Barcelona high-speed train (AVE). Zaragoza has already developed a strong service sector economy and the city has been developing the area around the station. A second station in Köln in Germany (Köln Deutz) has been developed as part of a major redevelopment of the area around the Fair. In Cordoba, on Spain's first high-speed (AVE) line between Madrid and Seville, the redeveloped station became the centre for regional and local rail and other public transport as well as for AVE services. In Turin (Italy) the major terminal is being replaced by a new station able to take high speed trains. Around the station, major redevelopment is being carried out. In Belgium redevelopment has taken place at the three main city stations, with considerable redevelopment around the station.

<sup>76</sup> See the below discussion of the attraction of industry to the Paris CDG area and the area around Cork Airport.

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- **Direct impact:** is wholly or largely related to the operations of the airport itself, for example those employed in catering or engineering at the airport;
  - **Indirect impact:** is generated through off-site activities by organisations and companies in the chain of supply of goods and services to the airport. These may be locally based or more remote from the airport depending on the nature of the supply chain;
  - **Induced impact:** is generated as a result of the spending of wages and salaries earned by employees in direct and indirect employment. Affluence created by the operations of the airport itself is likely to increase demand at local amenities for example;
  - **Catalytic impact:** is generated by the wider role of the airport in promoting business activities, encouraging inward investment and inbound tourism. Good air links may provide access to export markets or lower firms transport costs raising competitiveness. These strategic advantages are in turn attractive to investors.

In addition, more recently environmental costs have been cited as an important consideration.

We describe a selection of the main airport impact studies found in the literature.

### ***Bristol International Airport***

In 2005, Bristol International Airport (BIA) was the tenth largest airport in the UK. A study on the economic impact of BIA (Tym et al., 2005) assesses the employment impacts of the current operations and computes the direct, indirect and induced-employment estimates.

In terms of direct employment the study reports considerable growth as a result of the airport's current operations (particularly since 2003<sup>77</sup>). The figures for indirect employment are estimated at 1,306 jobs, of which at least 65 jobs (only 5% of the total) can be attributed to the local region.<sup>78</sup> The study finds that 978 jobs are generated in induced employment as a result of spending habits of both direct and indirect employment.

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<sup>77</sup> The report quotes headcount employment figures of 2,160, 2,577 and 2,653 for 2003, 2004 and 2005 respectively.

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The report also forecasts the impacts of BIA's proposed expansion.<sup>79</sup> The report states that the plans are estimated to generate a substantial rise in employment in the region. Two sets of employment (including direct, indirect and induced) estimates are produced based on growth in passenger numbers (2,222 and 2,758 FTE jobs up to 2015 and 2030, respectively) and air traffic movements (1,981 and 2,276 FTE jobs up to 2015 and 2030, respectively). The report also discusses the catalytic impacts. It is estimated that BIA's current operations are associated with 1,097 FTE tourism-related jobs in the region.

Whitelegg (2005) argues that claims of job creation for BIA are not supported by the evidence. The author suggests that the resources employed as a result of the airport would have found other uses without it. He also highlights that tourism is a net drain on the South West and UK economy, as those travelling abroad spend far more than those visiting.<sup>80</sup> Finally, after observing that outward is higher than inward investment he argues that if there is a link between enhanced accessibility provided by international air services then this works to the disadvantage of the UK.

Whitelegg also criticises the theory underlying the idea of job creation in other sectors as jobs created indirectly will not necessarily be located in the region of the airport since this will depend on the nature of the supply chain.<sup>81</sup>

Finally, Whitelegg argues that airports increase congestion in local areas.<sup>82</sup> Therefore, an airport development may simply shift the constraint on activity to another part of the overall transport network. This is consistent with the findings from other authors reported earlier.

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<sup>78</sup> Although the study states that this is a conservative estimate, this reflects the low levels of local sourcing.

<sup>79</sup> Proposals are contained in its Master Plan Study Stage One Report 2005.

<sup>80</sup> Whitelegg (2005) states that "in 2004, UK residents on visits overseas spent £30 billion whereas visitors to the UK spent £13 billion, giving a deficit of £17 billion

<sup>81</sup> He argues that the application of "generic multipliers" drawn from previous studies to calculate the number of additional jobs is invalid and unjustified.

<sup>82</sup> He cites £15 billion pa as a frequently used estimate of economic loss from traffic congestion. The study suggests that BIA will account for 30% of traffic on the A38 by 2015 and 40% by 2030.

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### *Review of the impact of airports in Europe*

A study of the social and economic impact of airports in Europe was carried out by York Aviation (2004) for the Airports Council International Europe (ACI Europe). The impact is considered in terms of direct, indirect, induced, and catalytic impacts.<sup>83</sup>

The report makes an assessment of the direct, indirect and induced impacts on employment. Evidence from 59 airports suggests that on average European airports support 950 on-site jobs per million passengers. The study estimates that when direct, indirect and induced jobs are included the average airport supports around 2,950 jobs nationally, 2,000 regionally or 1,425 jobs sub-regionally.

In addition catalytic impacts are also assessed through a number of surveys. The main conclusions were that airports are “national and regional economic motors”, enhancing business efficiency and productivity by providing easy access to suppliers and customers. In addition, the study stresses the importance that businesses place on accessibility to air travel in their location decisions. Airports are described as giving a “strategic advantage” which “enables them to act as attractors of a broad range of economic activity”.<sup>84</sup>

Oxford Economic Forecasting’s (1999) estimate that the impact of aviation growth on the output of the UK economy was of the order of £550 million per year.

Finally, the study also addresses how much the aviation industry contributes to the tourism industry. The conclusions are that tourism is a growth industry in Europe and that a high proportion of tourist visits use air travel. Increased tourist spending in Europe is described as “another powerful catalytic impact”. However, the report acknowledges that some countries have a negative balance of payments in tourism, of which the UK is one.

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<sup>83</sup> Since catalytic impacts can be hard to quantify these impacts are assessed through a number of surveys.

<sup>84</sup> The study cites examples such as Munich and Paris CDG as airports identified by company surveys as important for location decisions. These include global headquarters and innovative high-tech firms supporting the idea of inward investment as an impact of airports.

### ***Frankfurt Airport***

A detailed study of Frankfurt Airport by the Institute for Traffic Science University of Cologne<sup>85</sup> focussed on the consequences of restricting development in the context of the construction of a fourth runway. This study quantified the direct and indirect employment effects and also the economic impact on the local area (Hesse). This was done through detailed examination of the input-output tables showing expenditure on air transport by businesses in the region. The effect of restricted availability of air service connections was evaluated through consideration of the effect on the productivity of businesses in the region, and the overall implications for regional employment and income. Failure to construct the runway was estimated to result in a 2.6% reduction in total jobs and a 3% reduction in 'total gross value creation' (for the alternative scenario where construction took place but where restrictions were applied to air traffic, the same figures were 1.5% and 1.2%, respectively).

### ***Bradley International Airport***

The Connecticut Department of Transport committed \$235.6 million to major improvements at Bradley International Airport (Connecticut, US). Spending consisted of the construction of a new terminal, parking garage, renovation of existing terminals, and maintenance and updating of existing capital. The Connecticut Centre for Economic Analysis made an analysis of the likely economic consequences of the developments (Carstensen and Lot, 2001).

The results indicated that the investment will have a positive impact on the economy of the state. Employment, gross state product and personal income will grow as a result of the investment under both the conservative and optimistic estimates. The State of Connecticut will gain in gross and net state tax revenue.

### ***The contribution of regional airports in Ireland***

AerRianta (2001) analyses the regional contribution of airports in Ireland by collecting the findings of impact studies for three airports: Cork, Shannon and Dublin. These studies measure the overall impact of each airport as the sum of direct, indirect and induced impacts in terms of income, output and

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<sup>85</sup> "Role of the Airport Frankfurt/Main as a Location Factor for the Regional Economy – A study for the Mediation Group", Institute for Traffic Science University of Cologne (cited in York Aviation, 2004).

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employment. Unlike some studies, in which the future effects are forecasted, these studies only assess the impacts in a static framework and so do not illustrate the role played in the dynamic development of the regions.

Cork airport has played an important role in the development of the regional economy since 1961, contributing to “attracting international high technology investment and the promotion of an export-oriented indigenous sector”. The impacts of the air port in terms of employment, income and output created in the region are estimated through the input-output method (see Moloney et al., 1997) and show that the presence of the airport provides a boost for regional employment and income. The results are in line with other case studies.

In AerRianta (2001), Shannon airport is described as acting as a “gateway for the West of Ireland”, facilitating economic growth of the area. The study also reports that the airport has contributed to attracting foreign investment to the region and provided access for local indigenous firms seeking to export. In this case, the airport might be seen as an important facilitator of growth. This is because it relaxes the significant constraint on economic activity due to the regions geographic inaccessibility.

The study presents estimates from Tucker (1997) on jobs generated as a result of the operations of the airport itself, the airports contribution to the region’s industrial sector, and the importance of the airport to the tourism industry. The findings highlight the importance of Shannon Airport as a business and employer itself, and as a provider of critical support to industry and employment in the Western region.

Finally, a similar analysis of the employment and income generated by Dublin Airport is presented using the results from Meyler (1995). This study also estimated direct, indirect and induced employment and income effects of the airport. The findings show that the airport is a significant employer in the Dublin region, and generates large amounts of income for both households and governments.

### *Other European examples*

Thießen (2006) considers the relative performance of smaller regional airports compared to large international hubs. The main finding is that for a host of performance indicators, small regional airports, such as Leipzig airport, are good substitutes for large international airports, such as Frankfurt. In

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addition, the author notes that there are diminishing returns to airport expansion with respect to employment and regional GDP.

Thomson et al. (2005) conducted an evaluation of 32 large-scale investment projects in the area of airports and air traffic management facilities, mostly in Europe. They find only one case in which the contractor had conducted an *a priori* assessment of the cost-effectiveness of the investment. In their own assessment, the authors find mostly positive financial returns to the investments (up to 30% in one case). However, the authors are cautious about the accuracy of their calculations, which suffer from a lack of adequate data.

## 8.4 Conclusions

The key messages emerging from this review are summarised in the following points:

- ❑ There is no clear consensus that transport infrastructure investment always brings significant economic and regional development benefits.
- ❑ At the macro level, early studies showing a positive link between infrastructure and growth have been criticised for the methodology. Subsequent studies have showed a weaker relationship.
- ❑ Investment in transport infrastructure is appropriate if the benefits outweigh the costs. The general approach for evaluation of transport investment is cost benefit analysis which compares the cost of the infrastructure with the direct benefits for users: travel time, increased accessibility, employment, efficiency, social inclusion and environmental benefits.
- ❑ The evidence yields no clear overall picture of success. Some regions benefited considerably as a result of new transport connections. However, the number of projects that did not experience any significant impact is extensive.
- ❑ The evidence also suggests that transport projects are more likely to be successful in areas with already buoyant economic conditions. In this respect, infrastructure is seen as a “necessary” but not “sufficient” condition for economic development.
- ❑ Transport investment is likely to have diminishing returns in economies with well-developed infrastructure. In these economies, projects designed to tackle congestion problems and transport bottlenecks are likely to offer larger economic benefits than those targeted at creating new opportunities where demand does not exist.
- ❑ In this respect, in economies with a developed transport network, investments to improve the already-existing commuter services might be an efficient way of increasing economic growth. This includes efficient

management, efficient pricing and promoting competition in the sector.

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## 9 Early Years

### 9.1 Introduction

There is a wide range of literature linking early years provision and economic impacts, though the very large part of this literature is US based. There have been a number of useful studies providing an overview of the main issues and research in the USA (Stoney, 2004; Friedman, 2004; Lynch, 2004).

For this review, we have grouped the main research in to two main areas: cost-benefit analysis, rates of return and policy evaluations; and wider economic impacts. Much of the research on costs, benefits and rates of return is based on three US longitudinal studies that have an extensive literature associated with them. The material on policy evaluations relates to evaluations of other specific policies such as the Sure Start programme in the UK. The research in the area of wider economic impacts is largely US-based and examines the size of the early years/childcare industry and its contribution to local and regional economies, including the impacts on GDP and employment.

### 9.2 Cost benefit analysis, rates of return and policy evaluations

#### US Longitudinal Studies

A very extensive literature has built up around three longitudinal childcare studies undertaken in the US. The three studies are well known and the results of the studies often quoted in the wider literature on childcare impacts. The three studies are:

- **Perry High/Scope Study.** Initiated in the 1960s and based in Michigan. A group of 128 low income African-American children assessed as being at high risk of school failure form the basis of the study. 58 of them attended a high quality two-year pre-school programme for 2 and 3 year olds; the remainder did not attend a pre-school programme.
- **Carolina Abecedarian Study.** Initiated in 1972 with 112 mostly African-American children assessed as being at risk of poor intellectual and social development. The children were allocated to two groups - those attending a high quality pre-school programme and those not attending a pre-school programme.

- **Chicago Child-Parent Centre (CPC) Study.** Initiated in the 1980s and based on 1,539 low income mainly African-American children. The sample was split between those who had already attended Child-Parent Centres and those who had not.

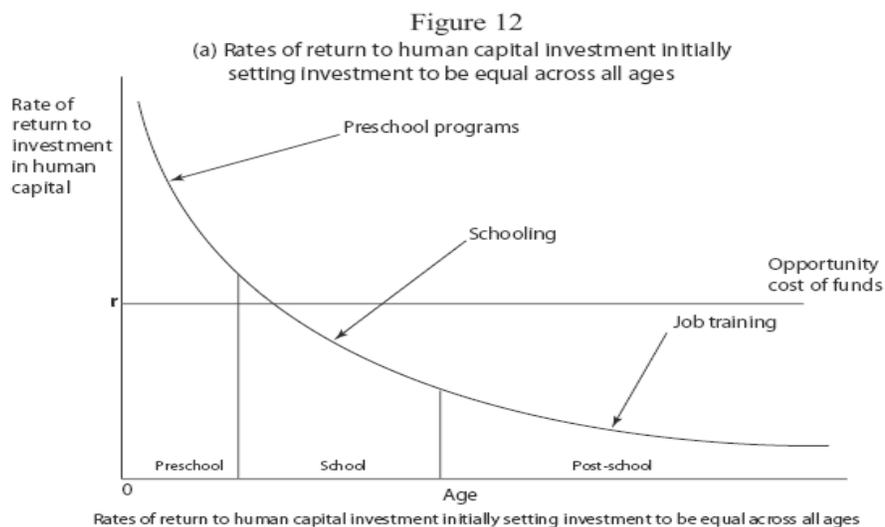
Research in the childcare area often refers to the rates of return to childcare (or benefit cost ratios) that have been estimated based on these three studies. One study (Lynch, 2004) for example, notes that across the four longitudinal studies the aggregate benefits to cost ratios are in the range 3.78:1 to 8.74:1.<sup>86</sup> This study also refers to estimates of a 12% annual real rate of return for non-participants in the Perry High/Scope study and a 4% annual real rate of return for participants, giving a 16% return overall. Another study (Friedman, 2004) refers to research indicating that the Perry High/Scope project suggests that for every dollar invested over \$7 in benefits was returned to participants and to society more widely. Similarly, research linked to the Abecedarian project suggested a benefit of \$3.78 for every dollar invested.

One study (Lynch, 2004) draws on these studies and describes some of the wider economic benefits (in a US context) of investment in early years programmes. He points to reductions in crime, higher future incomes, less need for social welfare payments; and notes that increased future incomes for participants also means that their children are less likely to grow up in poverty.

Heckman and Masterov (2004) make similar arguments, and argue, in particular that the returns to investment in early years education for disadvantaged children may be higher than returns to education later in life because early years education may have a dynamic effect and impact on educational performance in later years as well. Standard economic theory would suggest that there are diminishing returns to education and that preventative measures undertaken early in the lifecycle would be more economically worthwhile than palliative interventions later in life. They illustrate this view in a diagram that is reproduced overleaf.

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<sup>86</sup> The fourth study is the "Pre-Natal/Early Infancy Project" initiated in the late 1970s and based in New York State. 400 mothers were involved in this study. See Karoly et al, 1998 for more details.



Source: Heckman and Masterov, 2004.

Recent UK based research has questioned the validity of drawing conclusions for UK policy-making based on the findings of these three US studies. Penn *et al* (2006) undertook a review of literature associated with the long term economic outcomes of centre-based early childhood interventions. The only three relevant studies they found were the three US studies discussed above. Penn *et al* review the extensive research literature directly associated with these three studies and raise doubts about whether the widespread use of the results of these studies is justified:

“Although there seems to be a general indication from these three studies, and others such as Head Start, that early childhood interventions may make a long-term difference ..... and save money, the processes involved are relatively unclear..... On the basis of this review, the widespread, international use of the most favourable headline findings, and in particular of the Perry High/Scope study, is unjustified. Apart from the variation within and between studies, and problems of interpretation of the results, especially crime figures, there is also a problem about the context in which these studies were carried out. The targeting of low-income African-American children in ghettoised neighbourhoods, in a period of considerable racial tension, leads to considerable doubts about the generalisability of these interventions outside their original context.” (Penn *et al*, 2006)

### UK Longitudinal Study

There is one longitudinal study in the UK<sup>87</sup> that seeks to test the impacts of early years childcare. The Effective Provision of Pre-School Education (EPPE) Project is longitudinal study, undertaken between 1997 and 2003, of the cognitive and non-cognitive development of 3,000 children in various types of pre-school education. The study was intended to assess the impacts of different kinds of early years provision and to assess progress up until the end of Key Stage 1. The primary aim of the evaluation was to identify the aspects of pre-school provision which have a positive impact on children's attainment, progress and development. The study (Sylva *et al*, 2004) concludes that high quality pre-school care does have a positive impact on child development. It notes that the quality of the pre-school care as well as the quantity (more months but not necessarily more hours/day) are both influential<sup>88</sup>.

We are aware of one study that draws on the EPPE results in order to assess the costs and benefits of early years interventions. A study for the Daycare Trust and the Social Market Foundation (PricewaterhouseCoopers, 2004) estimated the costs and benefits of a "vision" for universal early education and care in 2020. The vision involved a number of elements, including:

- 12 months paid parental leave: 6 weeks at 90% of earnings and the rest at national minimum wage levels;
- a home care allowance paid to parents who choose to stay at home to look after children aged 12-24 months;
- some free education and care for 2, 3 and 4 year olds.

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<sup>87</sup> We have seen it referred to as the only similar longitudinal study in Europe.

<sup>88</sup> The importance of the quality of the childcare used as a substitute to maternal care is reiterated in the Gregg *et al* (2005) work. This study focused on the impact on cognitive and non cognitive development of children following the return to work of their mother. The authors found that the cognitive development of children is affected if maternal care is substituted with informal care but there is no adverse effect on cognitive development if the child is placed in high quality childcare settings.

PwC estimate that current total spending in the UK on early years education and care is around 0.8% of GDP and that the Daycare Trust/SMF vision would cost a further 1.8% of GDP, giving total expenditure of 2.6% of GDP. By comparison, they estimate that Sweden and Denmark currently spend around 2.0 – 2.5% of GDP on early years education and care. PwC estimate incremental benefits in the range 1% to 2% of GDP – roughly similar to the estimate of 1.8% of GDP for incremental costs, though the uncertainty around the benefits estimates is higher.<sup>89</sup> PwC argue, however, that there are further benefits that they have not been able to include in their benefit estimates. These include reducing future spending on remedial education, healthcare and criminal justice costs through giving children from disadvantaged backgrounds a better start in life.

### **Other Early Years Policy Evaluations**

There are also a number of other studies that evaluate the performance of early years interventions with respect to their objectives. In general these do not examine the direct economic impacts of these interventions, they focus instead on the educational and social impacts. There are a number of studies that examine the UK Sure Start programme (Institute for the Study of Children, Families & Social Issues, 2005 and 2006; Lewis and Archer, 2002; Meadows, 2001; and National Audit Office, 2006) and a major study that assessed a similar programme in the US – the Early Head Start Programme (Department of Health and Human Services, 2002).

Sure Start programmes first started in the UK in 1999 – 2000 and so it is still early to draw conclusions about their long term impacts. Initial evaluations suggest mixed impacts. The study by the Institute for the Study of Children, Families & Social Issues (2005) suggested, for example, that parents/families with greater human capital were better able to take advantage of Sure Start than those with less human capital (i.e. teen parents, lone parents, workless households).

The evaluation of the US Early Head Start programme ((Department of Health and Human Services, 2002) found that results were generally positive with a number of benefits being achieved (e.g. on the children’s cognitive, language and emotional development, and on parenting). It noted, however,

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<sup>89</sup> Benefits include increased parental employment and increased future productivity for the children as adults.

that the magnitude of benefits was generally modest and that, given the timing of the research, it was not possible to judge whether these benefits would last beyond the short term.

### 9.3 Wider economic impacts

There have been a large number of analyses undertaken of the economic impacts of childcare in the US in the last 5-10 years. One of the reasons for this has been the need to support arguments for maintaining public financial support for childcare in an era of declining State budgets (Stoney, 2004). There has also been an extensive programme of research in this area, the Linking Economic Development and Child Care Research Project, based at Cornell University, following the award of a US Government research grant in 2002.

The US literature in this area focuses on estimating the contributions of the childcare industry to GDP and employment, including the estimation of multipliers, and the impact on public finances. It also examines the childcare industry from the perspective of the contribution it can make to economic development.

One study (Liu, Ribeiro and Warner, 2004) constructs input-output models for each of the 50 states of the USA and uses these models to estimate childcare output multipliers and childcare employment multipliers. These multipliers measure the extent to which childcare expenditures stimulate economic activity (output or employment) in other sectors of the economy.

The study found wide variation in both Type I and Type II output multipliers by State - ranging from 1.32 to 1.60 for Type I multipliers and from 1.64 to 2.17 for Type II multipliers.<sup>90</sup> Type II output multipliers tend to be smaller for States with smaller more rural economies. A more open economy is also likely to reduce the multiplier effect. Type I employment multipliers range between 1.17 and 1.34 and Type II employment multipliers range between 1.32 and 1.62.<sup>91</sup>

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<sup>90</sup> Type I multipliers include direct and indirect effects, whilst Type II multipliers include direct, indirect and induced effects. Type II multipliers are always greater than Type I multipliers.

<sup>91</sup> An employment multiplier of 1.62 suggests that for every job in the childcare industry in that State 0.62 of a job is generated in other industries in that State.

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In a comparison of childcare multipliers with multipliers for all other industries the Liu *et al* study found that childcare output multipliers were relatively high (top quartile) indicating that the childcare industry, and its employees, make more local purchases than most other industries. The childcare output multipliers were similar to the multipliers for other social infrastructure sectors such as schools, colleges and hospitals and higher than the multipliers for physical infrastructure sectors such as water and passenger transport. Childcare employment multipliers were relatively low, however, reflecting the labour intensive nature of the industry relative to other sectors.

The Liu *et al* study concludes – “This analysis shows that child care is a good investment for economic developers – for its short term regional economic linkage as well as its long term investment in human capital development for the next generation of workers”.

There have been a large number of US studies that estimate the economic impacts of the childcare industry either at the State level or at county or City level. Calman and Tarr-Whelan (Calmand and Tarr-Whelan, 2005) list 64 such economic impact studies across the US.

For illustration, we have included references in this report to a relatively small number of US economic impact studies, not all of which are included in Calman and Tarr-Whelan:

- Alaska (McDowell Group, 2006);
- New York (Warner *et al*, 2004);
- Illinois (Cahn *et al*, 2005);
- Kansas (Stoney *et al*, 2003);
- Massachusetts (Traill and Wohl, 2004)
- Vermont (Windham Childcare Association, 2002).

The results of the Kansas study are particularly interesting because it has a similar population to Wales.<sup>92</sup> Direct expenditure by Kansas families on childcare was around \$430m in 2001, with additional spending of around \$90m coming from Government sources. Around 14,400 staff worked in the regulated childcare sector at this time. The study estimates a Type II output multiplier of 1.98 and an employment multiplier of 1.55. These multipliers do

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<sup>92</sup> The population of Kansas in 2005 was around 2.7 million. Source: US Bureau of Census. Naturally, there are many other factors which make Kansas very different from Wales.

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not include all economic benefits such as the freeing up of the parents to go to work. Parents who join the labour force as a result of childcare subsidies earn around \$110m. The study also emphasises the importance of childcare subsidies for low income parents.

There is also a US literature on the impact of childcare on businesses and the productivity of their employees (see Shellenback (2004) for an overview of some of the key issues). Shellenback argues that there are benefits to companies from the availability of quality childcare resulting mainly from reduced employee absenteeism and the consequent increase in productivity. Reference is also made to reductions in employee turnover. A figure of \$3bn is provided as an estimate of the cost to US businesses of absenteeism as a result of problems with childcare, though this appears to be based on research that is now 20 years old.

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## 10 Higher Education

### 10.1 Economic returns to the individual (from provision of teaching)

The academic evidence on the economic returns to human capital accumulation has focused on three specific areas. The first (most basic) has considered the economic returns to additional years of post compulsory schooling (degree level or otherwise); the second (most numerous) considers the economic returns to higher education qualifications in terms of the percentage change in earnings or the increased likelihood of being employed and the third (most recent) considers both the augmented earnings and employment outcomes of individuals and translates these percentages into lifetime monetary values.

In this section, we do not consider the first category of findings as these have been superseded by more recent and relevant research work.

The benefits associated with education attainment are many, though the majority of the studies to date have focussed on either the enhanced earnings or the improved labour market participation of those individuals with higher levels of qualification.

The academic literature has become more sophisticated and increasingly differentiates between the economic returns achieved by an individual with a qualification and the economic returns attributable to the qualification itself. Specifically, it is incorrect to compare the earnings associated with average degree holder with the earnings achieved by individuals with lower qualification levels and simply attribute the earnings difference to any difference in qualification attainment. It is entirely plausible that there are different personal characteristics associated with degree holders compared to non-degree holders, and it is these differences in personal characteristics that drive earnings gaps between the two groups.

It is for this reason that the majority of the recent studies have focused on the raw earnings benefit associated with obtaining degree level qualifications compared to those individuals in possession of university entry level qualifications but who do not go on to complete higher education. This has traditionally been seen as a more appropriate comparison of like for like, and in this way, the economic benefit associated with the qualification is

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estimated rather than the return to the innate ability or personal motivation of the individual.

In a study representative of the wider economic literature, Blundell et al (2003)<sup>93</sup> estimated that the earnings premium associated with obtaining a higher education qualification is approximately 23.5 percent compared to possession of 2 or more 'A' levels when personal, family and ability characteristics are built into the model<sup>94</sup>.

There is substantial variation in the undergraduate degree earnings premium depending on the subject, as well as the level of study, the individual's gender, and the level of prior attainment.

### Individual returns by Subject

One of the first analyses considering the economic benefits of higher education subjects<sup>95</sup> found that men in possession of an undergraduate degree achieved an earnings premium of approximately 15% over individuals in possession of A-levels. The corresponding estimate for women was 19%. However, men in possession of mathematics degrees achieved a 25.7% earnings premium over those with A-levels as their highest qualification, while corresponding women achieved a 38.6% earnings premium. In contrast, men in possession of undergraduate degrees in the Arts registered a 4% penalty relative to those individuals with A-levels, whilst women achieved a 17% premium.

The financial benefit of completing a degree is much greater for women than for men, but this may be due to the relatively low earnings of non-graduate women. This gender differential is reiterated in the work of Dearden, McGranahan and Sianesi (2005) using the 1970 British Cohort Study, which consisted of a panel of data on a group of individuals born in a week in 1970 who were followed during the course of their lives.

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<sup>93</sup> Blundell, R., L. Dearden and B. Sianesi (2003) *Estimating the Returns to Education: Models, Methods and Results*, IFS Working Paper No. WP03/20.

<sup>94</sup> This result is characteristic of the types of studies that have been undertaken and reiterates the findings of Dearden (1999), Dearden *et al* (2000), Harkness and Machin (1999), Chevalier and Walker (2001), McIntosh (2004) and Conlon (2005). For a full review of the literature, refer to Chevalier *et al* (2002).

<sup>95</sup> Walker and Zhu (2001)

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**Individual returns by socio economic class**

A second finding of the Dearden et al (2005) analysis relates to the variation in economic returns according to the social class and family income of individuals. The authors find that whilst the average earnings premium associated with higher education qualifications for all men is approximately 15%, the earning premium for men from lower socio-economic groups was approximately 19-20% (compared to 9-14% for men from higher socio-economic groups). This differential did not exist for women. Women with higher education qualifications appeared to earn the same premium irrespective of family income and socio-economic grouping

**Financial benefits of higher education qualifications**

The general result suggests that there is a significant earnings premium associated with additional qualification attainment as well as an increase in the probability of being employed. Translated into monetary terms, the most recent estimate of the discounted additional lifetime earnings (net) associated with degree level attainment approximates £120,000<sup>96</sup>. In other words, the present value over a lifetime of undertaking and completing a degree level qualification is £120,000 compared to those with 'A' levels as their highest qualification

As part of the PwC report (2006), an analysis of the economic returns associated with different types of higher education qualification was undertaken at an aggregated level within one institution<sup>97</sup>. The analysis found that the additional gross lifetime benefit resulting from possession of an undergraduate degree was approximately £185,000. The corresponding estimates associated with a postgraduate degree was £70,000-£80,000; £30,000- £40,000 for a postgraduate certificate (compared to an undergraduate degree). The analysis also showed an additional lifetime benefit of £35,000-£40,000 for a HNC/HND and £5,000-£15,000 for a diploma in higher education, compared to A-level attainment.

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<sup>96</sup> Hansard written answer provided by Alan Johnson, Secretary of State for Higher Education 8<sup>th</sup> December 2003.

<sup>97</sup> The analysis was not disaggregated by subject of qualification due to the limited sample sizes.

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## 10.2 Economic Returns to the State (from provision of teaching)

There has been one recent study that has considered the economic returns to both the individual and the state. The PricewaterhouseCoopers LLP report (2005) for the Royal Society of Chemistry and the Institute of Physics assessed both the economic benefits to the individual through enhanced earnings and employment outcomes as well as the direct and indirect costs associated with qualification attainment. The analysis also considered the investment in higher education for the state.

The report indicates that during the period of study itself, there are significant costs borne by the state. It costs the state approximately £21,000 to provide education to degree level for the average graduate. This estimate includes the direct funding through HEFCE, as well as the foregone taxation revenue while the individual is in university, the interest rate subsidy on student loans; and the potential cost of loan write off.

However, there are also substantial tax benefits accruing to the Exchequer, particularly later in a graduate's working life, as earnings and related taxation payments increase.

Trading off the costs and benefits to the state, the analysis illustrates that the rate of return to higher education qualifications is in the region of 12.1% though is likely to decrease (to approximately 11.0%) following the introduction of differential top up fees.

## 10.3 Individual Institutional level impacts

This section reviews studies of recent economic impacts of Higher Education Institutions (both individually and as a group) together with the most recent economic impact study of the HEI sector as a whole completed by researchers from Strathclyde University on behalf of by Universities UK (2006).

In many of the analyses of the direct impact of higher education institutions, the key variable estimated is the multiplier which provides a relationship between the expenditure of a university and the eventual economic impact of that expenditure as it churns repeatedly throughout the economy.

The Keynesian multiplier model is a method that is used frequently to estimate the impact of higher education institutions upon regional and local economies (for example, HERDA-SW (2002) and Nottingham Research

Observatory (2004)). The models estimate three aspects of university economic impact: spending by staff, spending by students and spending by the university. Each type of spending has a direct and indirect impact on the local economy. The direct impact is the value of spending directly by staff, students and the university. The indirect impact is the 'knock on' effect of direct spending that gets recycled in to the local economy through spending on local goods and services. Sometimes these analyses are known as Type I input output models. All of the studies considered here except Harris (1997) and the University of Wales, Bangor report (1997) have used the Keynesian multiplier approach.

The fundamental feature of this methodology is the use of a multiplier which models the amount of economic impact due to knock-on effects. The value of the multiplier will be low for areas where there is substantial leakage of spending to areas outside the local economy. The value of the multiplier will be high for areas that are more self-sufficient and retain a greater proportion of spending within the local economy.

The most recent analysis undertaken to assess the economic impact of a specific institution that goes beyond the traditional input-output type analyses was undertaken by PricewaterhouseCoopers LLP (2006) when considering the local, regional and national impact of London South Bank University. This analysis used an econometric approach to assess the lifetime earnings premia associated with different levels and types of qualification relative to the average level of student qualification on entry.

### Overview of Economic Impact Assessments

The primary studies we considered as part of this analysis are as follows:

<b>Institution</b>	<b>Research undertaken by</b>	<b>Year</b>
London South Bank University	PricewaterhouseCoopers LLP	2006
University of Plymouth	Social Research and Regeneration Unit	2005
Nottingham Trent University	Nottingham Research Observatory	2004
University of Bristol	Chatterton	1997
University of Hertfordshire	PACEC	2004
University of Portsmouth	Harris	1997
University of Wales, Bangor	University of Wales	1997
South West HEIs	Herda-SW	2002

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PricewaterhouseCoopers LLP (2006) undertook an analysis of the human capital impact of London South Bank University in addition to standard direct and indirect spending effects. The analysis considers the lifetime economic impact of LSBU specific degree level qualifications relative to the qualifications students are in possession of on entry to the university.

The Social Research and Regeneration Unit, 2005 provides an assessment of the University of Plymouth's Exmouth campus economic impact upon the town of Exmouth. The report uses the Devon local GVA model and the Keynesian multiplier model.

The Nottingham Research Observatory uses a regional multiplier analysis to look at the impact of both employment and expenditure by Nottingham Trent University.

Chatterton (1997) looks at the local and regional impact of the University of Bristol and also uses a typical traditional Keynesian multiplier approach.

The University of Hertfordshire report (2004) looks at the economic impact of the University in terms of jobs supported as a result of spending associated with university activities.

Harris (1997) measures the local impact of spending by the University of Portsmouth<sup>98</sup>.

The University of Wales, Bangor (1997) report quantifies the impact of the University of Wales, Bangor on the North Wales economy<sup>99</sup>.

HERDA-SW (2002) considers the economic impact of the South-West region's HEIs on the regional economy for 1999-2000.

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<sup>98</sup> Unlike other economic impact assessments Harris uses various detailed databases which allow more accurate measurement of university impact. In this study, an input-output table was constructed in order to assess the total (i.e. direct, indirect **and induced**) effects of direct University spending. This table contains direct information on sales, imports and exports which were collected through survey work. This approach allows separate estimation of supplier and induced-income effects which is not possible with the Keynesian approach. This inclusion of induced effects in the analysis results in a Type II multiplier being estimated.

<sup>99</sup> The report looks at the impact of UWB's spending and receipts, including spending on (and then by) staff; and the impact of expenditure by students attracted into Bangor by the University. The UWB report also used a specifically formulated input-output model. This was applied to the North Wales economy to estimate the local economic significance of the University.

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### **Expenditure multipliers**

While there is some variation in the methodological approach and the multipliers estimated in each of the analyses, there does appear to be some overall consistency in the indirect impact of university expenditure. In addition, each of the analyses attempts to assess what proportion of university expenditure remains in the local community.

The Nottingham Trent study estimated that spending on local goods and services accounted for 38.1% of total spending by Nottingham Trent University, the remaining expenditure 'leaking out' in taxes, 'imports' and surpluses. Similarly, Chatterton (1997) reported that just over 50% of the University of Bristol's purchases remained inside the South West region. The UWB analysis demonstrates that out of total operating spend (including manufactured items, maintenance, business services etc), 35% of spending was retained within North Wales, whilst for capital (construction) spending over 53% was local. In the case of expenditure on labour, 95% of labour costs for UWB staff were assumed to be local.

The Social Research and Regeneration Unit estimated a multiplier for indirect spending of 1.3 for University of Plymouth Exmouth Campus following initial expenditure by the university. The expenditure multipliers for the University of Bristol used were 1.2 for the Bristol area, and between 1.23 and 1.30 for the South West region. Using various databases in Harris' (1997) report, the University of Portsmouth's direct expenditure was estimated to result in an output multiplier effect of between 1.24 and 1.73. There was some additional analysis undertaken to estimate multipliers associated with different types of expenditure. The multiplier effect of University on Portsmouth's non-wage expenditure on the local economy was calculated between 1.15 and 1.86. The short course and consultancy services of University of Portsmouth Enterprise Limited on the local economy resulted in an income multiplier effect between 1.08 and 1.40. The North Wales output multiplier (direct and indirect) resulting from UWB expenditure was calculated as 1.38.

### **Employment Multipliers**

Again there were slightly different approaches to the employment effects associated with each of the universities. The University of Plymouth report only considered the additional impact on employment arising from the expenditure of the permanent and fixed term staff. The Nottingham Research Laboratory report attempted to calculate the number of jobs created, arising

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from the expenditures by staff, students and as a result of the university central spending. In the case of Nottingham Trent University, the total indirect and direct employment effect of the university was calculated as 4,012 FTE jobs. The total direct employment effect was in the region of 3,000 while the indirect effect was in the region of 1,000 implying an employment multiplier of 1.3<sup>100</sup>.

Chatterton (1997) estimates an employment impact multiplier of 1.7, which is relatively high compared to other studies.

The University of Hertfordshire report (2004) identifies the number of jobs supported directly by the University such as jobs for academic and non-academic staff as well as the 'knock-on' jobs supported indirectly in companies supplying the University with goods and services (supply chain jobs) and jobs arising from spending out of wages (induced jobs). The report also provides an assessment of the spending and jobs that stay within, Hatfield, Welwyn Hatfield and Hertfordshire. The report identifies that 610 jobs supported by spending in Hertfordshire; 60 jobs supported by subsequent spending. Given that there were approximately 2,500 individual directly employed by the university, the local employment multiplier stands at approximately 1.27.

Harris (1997) identifies that the employment multiplier effect of the university sector is between 1.55 and 1.79. These multipliers are larger than the output multipliers, indicating that the University of Portsmouth has a greater impact in terms of jobs on employment intensive service-sector industries.

### **Universities UK report**

The recent UUK report is the third UK-wide study of the impact of the higher education sector on the national economy published by Universities UK. Compiled by researchers at the University of Strathclyde, this report updates earlier studies published in 1997 and 2002. The report focuses on 171 higher education institutions (HEIs) for whom data is collected by HESA for the academic and financial year 2003/4.

The analysis considers the university sector as a conventional industry, highlighting the major economic characteristics of higher education institutions including their sources of revenue, employment created, output

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<sup>100</sup> Theoretically, it might be expected that employment multipliers are slightly less than expenditure multipliers.

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generated and export earnings attracted. In this study the “higher education sector” impact is defined to be that of HEIs together with that of international students and visitors to the HEIs.

The report is based on data from the Department for Education and Skills commissioned Student Income and Expenditure Survey, HESA published data, Labour Force Survey data, previous HEI studies and the ONS Travel Trends survey.

### *Economic modelling*

The researchers estimate the economic activity generated in other sectors of the economy through the secondary or ‘knock-on’ multiplier effects of the expenditure of the higher education institutions, their staff and that of international students and visitors attracted to the UK by the higher education institutions. This includes the impact of off-campus expenditure of international students (i.e. all non-UK domiciled students) studying at the UK HEIs. The off-campus expenditure of UK domiciled students was excluded as this may not be regarded as additional to the UK economy as a whole.

### *Type-II input-output model<sup>101</sup>*

The model used was a purpose designed and specially constructed ‘type-II’ input-output model based on actual UK data derived from the 2001 ONS input-output tables together with Labour Force Survey data. In addition 12 regional extensions to the model were developed covering every part of the UK to adjust for regional factors.

The major components of HEI expenditure were used to provide an initial estimate of direct expenditure were taken from HESA. Detailed estimates of HEI expenditure types were taken from a range of sources; these included data from a UK-wide survey conducted for previous studies, together with observations of detailed patterns of expenditure from a number of individual HEIs case studies, and information obtained from sector purchasing consortia. This enabled the construction of a disaggregated HEI expenditure matrix for incorporation into the model.

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<sup>101</sup> An input-output (I-O) model is a predictive economic model. In this case, they are used to estimate the direct, indirect and induced economic effects of university expenditure and predict changes in overall economic activity as a result of a change in the local economy. Type I models include direct and indirect effects, and Type II multipliers include direct, indirect and induced effects and this incorporate the knock on spending effect of wages and salaries of employees of HEIs. The multipliers associated with Type II models are in all cases greater than those estimated in Type I models.

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**Main Results**

The ratio of total output to direct output - the sectoral gross output multiplier - has been estimated as 2.52 for HEIs. The implication of this findings is that the purchasing 'linkages' of the HEIs with the rest of the economy were somewhat higher than the average for other sectors of the economy. In other words, the expenditure of higher education institutions remains in the domestic economy to a greater extent than expenditure in other industry sectors. The report found that although the institutions themselves had a very high propensity to purchase UK goods and services (including labour services), the overall impact was moderated by the fact that significant fractions of labour payments were 'leaked' from the economy in the form of import purchases and tax payments.

The University UK report estimates the employment multiplier for HEIs estimated to be 1.99. Higher Education Institutions appear to have a higher employment multiplier than most of the other service industry employment multipliers recorded within the report. The report states that this is because the knock-on effects of HEIs are relatively concentrated in sectors which are also labour-intensive (such as distributive trades and business services).

In other words, for every £1 of university expenditure, an additional £1.52 of expenditure is generated throughout the economy. In terms of employment, for every job directly created by the university, there is approximately another job generated elsewhere in the economy.

**Incorporating Human Capital Impact - London South Bank University**

The income of London South Bank University was approximately £106 million in 2004/05. Applying the methodology from the recent Universities UK report, the direct and indirect impact of the university as a result of primary expenditure is approximately £244 million per annum. In other words, the expenditure of the university has a multiplicative effect and generates income, expenditure and employment elsewhere in the economy.

Approximately 52% of direct university expenditure takes place in the London region as a whole with 7% taking place in South East London.

Undertaking an econometric analysis of the relative earnings associated with degree level qualifications and students' entry level qualifications, PwC (2006) estimated the value added generated by the university through its teaching activities and the provision of higher education qualifications.

The report estimated that the average economic value of an average LSBU undergraduate degree is £180,000 in today's money terms. Taking into account the entry level qualifications of LSBU students suggests that there is an additional £5,600 per student value added associated with LSBU undergraduate degrees. Combining these results, the average LSBU undergraduate degree is worth approximately £185,600 per student in today's money terms.

It was also found that the economic value added associated with a postgraduate degree is approximately £73,000 in today's money terms; £34,815 for a postgraduate certificate, £38,853 for a HNC/HND and £5,242 for a Diploma in Higher Education.

The total gross domestic economic impact of LSBU stands at approximately £655 million per annum. The income of the university stands at £106 million per annum.

## 10.4 Business Impact

Most economic research in this area has concentrated on the effects of training on firm profitability, sales and innovation success. However, as with much of the analytical work relating to the impact of education on economic growth at an economy wide level or the early work on the impact of education on individual earnings and employment outcomes, higher education qualifications (or the proximity of institutions and their links with local or regional enterprises) is rarely included as a specific input.

As Blundell et al (1999) point out, there are several problems in measuring any type of return to qualifications to firms because of the lack of adequate data on firm productivity, competitiveness and profitability. Even under the assumption that such data has been properly measured, it is extremely difficult to establish any type of causal relationship between higher education and firm profitability as it is not clear whether it is firms with a better endowment of human capital that perform better or if it is actually the case that firms performing better are led to choose a more skilled workforce.

In the relatively limited evidence that does exist, using French and British establishment level data, Caroli and Van Reenen (1999) show that the proportion of skilled workers (defined as being those workers in possession of post compulsory education) has a positive effect on the incidence of organisational change taking place though this is clearly a 'soft' outcome and of limited use.

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Bishop (1994) finds that more educated workers tend to make more suggestions about work processes and be more innovative on the job in general. Duguet and Greenen (1997) find that a larger proportion of skilled labour leads to a higher probability of innovation taking place in French firms, even after controlling for the possible endogeneity of skill composition.

Using French data, Goux and Maurin (1999) argue that after controlling for the selectivity of firms' training practices, the estimated impact of post school training on wages becomes negligible. However, they also find that training is mainly beneficial to employers, partially by reducing the probability that employees switch firms.

The statistical associations between education and profitability are also studied by Leiponen (2000). Using a panel of Finnish manufacturing firms it is found that innovation is correlated with measures of education. This correlation appears to depend on the presence of a sufficient proportion of employees with general skills acquired in higher education, which is consistent with the view that these skills enable workers to adapt faster and better to a firm's needs to become more competitive. This study, however, does not clearly establish a sound causal relationship between education and firm performance.

According to Green (1999), most UK employers believe that training (unspecified) is beneficial to their firms and that training creates a more productive work force. However, this measure of training is not particularly detailed or elaborated upon so it is not possible to identify the role played by higher education in increasing productivity.

The work that has investigated the link between training and firm performance has generally looked at the impact of training on intermediate indicators such as labour productivity, employment growth and labour turnover rather than overall firm profitability (Green, 1997). This does not apply to all the existing literature, however, as Ashton and Green (1996) find a positive correlation between workforce skills and productivity.

Dearden, Reed and Van Reenen (2000) have constructed industry-level data on training and productivity levels and found significant correlations between productivity and higher industry level rates of training. The overall effect of training on productivity is around twice as high as the wage effect. The authors clearly recognise the problem of potential endogeneity of training. The benefits of training to firms that have actually undertaken the training of their own workers may not be a lesson that can be transferred to representative firms in the economy.

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The evidence for the US is mixed. Black and Lynch (1995) use firm level data to show that the equivalent of an extra year of educational attainment amongst workers raised productivity by a figure between 5 and 12 percent. Their results were however mixed when they investigated the impact of different training measures on firm productivity.

## 10.5 Regional Impact

There are a number of ways in which the benefits of Higher Education Institutes may be geographically localised. Firstly, in their role as educators, HEIs increase the knowledge and skills of participants. This potentially increases the pool of skilled labour available to local businesses, though the willingness of graduates to migrate diminishes the extent to which this benefit disproportionately affects the region where higher education is obtained. Secondly, as originators of research, HEIs may be the source of new job creation and income growth within regions, to the extent that knowledge spillovers depend on the proximity of academic researchers to industrial users of this research.

In the US, the observation that rapid growth of high-tech industries has occurred in areas that have top research universities has motivated research in this area (Beeson and Montgomery, 1993). In general this research seems to emphasise that proximity to knowledge creation activities rather than proximity to a skilled labour force appears to drive economic growth, though in practice it might be difficult to separate the two. Employment of graduates from 'good' research departments may be one of the mechanisms through which new ideas are communicated to industry. Thirdly, as with any type of institution, HEIs will have direct employment effects (i.e. staff recruitment) and may benefit the local economy through their spending patterns. This is the most commonly examined impact of universities on the local economy, though these effects are independent of the teaching and research role of HEIs. Hence they might be similar for any large employer.

As we have considered some of the direct and indirect economic impact analyses in a previous section, we focus on the recent literature in the US, which investigates the extent to which higher education (research and teaching) outputs are captured locally through job creation and measures of innovative activity.

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### **Employment effects**

There is increasing evidence that the overall skill level of an area's workforce has fundamental effects on the local economy. For example, the macroeconomic literature (Glaeser et al. (1995) and Glendon (1998)) finds that cities with well-educated workforces tend to grow faster than cities with less well-educated workforces. Audretsch and Felman (1996) find 'skilled workers' to be one of several 'knowledge' variables having an impact on the propensity for innovative activity to cluster spatially. However, this does not mean that graduates necessarily choose to stay in the local labour market, thereby benefiting the local economy.

Bound et al. (2001) investigate whether the production of higher education in US states affects the local stock of human capital in that state. They suggest that the relationship may not be strong given the mobility of college graduates (Long, 1988; Bound and Holzer, 2000). A central finding is that the relative flow of degrees conferred within a state only has a modest effect on the relative stock of university-educated workers within the state and, as such, states have only a limited capacity to influence human capital levels in their workforces by investing in higher education degree outputs.

Results by Beeson and Montgomery (1993) also imply that university graduates do not have a high probability of retention within regional labour markets (i.e. US Standard Metropolitan Statistical Areas). They show that gross migration flows, both into and out of a region, are higher in areas with universities that have large amounts of R&D funding, indicating active labour markets with a high turnover. On the other hand, they find regional employment growth rates to be positively associated with changes in university R&D funding, as well as to the number of nationally rated science and engineering programs at local universities. They also show a positive relationship between the percentage of the workforce employed as scientists and engineers and variables measuring university R&D funding and the proportion of undergraduate degrees awarded in science and engineering at local universities. However, showing that measures of economic performance (e.g. employment growth) are positively associated with university characteristics does not necessarily mean that firms are locating near universities specifically to take advantage of a skilled labour force.

The motivation for firms to locate near higher education institutions might be to take advantage of research conducted at universities. If knowledge transfer depends on proximity (whether the transfer mechanism is recruitment of graduates or other links to universities) and this leads to higher productivity,

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then one would expect to see a positive relationship between variables such as employment growth and university characteristics (e.g. R&D funding). The available evidence does not clearly indicate that employment of graduates is the mechanism through which firms benefit from locating near universities.

### **Firm opening and survival rates**

Bania et al. (1993) investigate whether the opening rate of manufacturing firms within US regions is influenced by university characteristics: total university research; the number of research universities and the percentage of employees who are scientists and engineers. The only consistent evidence concerning the effect of university research on new business start-ups was found for 18 prominent high-technology industries in Electrical and Electronic equipment. The authors suggest that this is consistent with the view that universities have been particularly important in the development of the microelectronics industry. However, they could show no evidence that a more technical workforce (i.e. a higher percentage of scientists and engineers) increased business start-up rate.

Chen and Williams (1999) provide evidence that is consistent with Bania et al. (1993) when they show significant effects of university R&D funds (measured in per capita terms) on the survival rates of some industries. However, the relevant industries in this case are Chemicals, Transportation Equipment and Food. They interpret their findings as consistent with the view that university research and development activity has spillover effects to the region through technical innovation processes. For example, small firms can lower the cost of production by adopting any new processes or products and enhance their survival once they obtain 'the spillover knowledge'.

Finally, Zucker et al. (1998) examine start-up of US biotechnology firms. Adoption of biotechnology has increased rapidly in the last two decades, transforming the nature of the pharmaceutical industry and significantly influencing other industries such as food processing, brewing and agriculture. They present strong evidence that the timing and location of initial usage of the biotechnology is primarily explained by the presence at a particular time and place of scientists who are actively contributing to basic science as represented by publications reporting genetic-sequence discoveries in academic journals. They also quantify separable (and positive) effects of US federal research support at major universities. They state that at least for this high-tech industry, the growth and location of intellectual human capital was

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the principal determinant of the growth and location of the industry itself and is testament to the value of basic research.

### **Creation of ‘innovative activity’**

A number of studies investigate the extent to which university research ‘spills over’ into the generation of inventions and innovations by private firms. Using surveys of research managers, Nelson (1986) finds university research to be an important source of innovation in some industries, particularly for those relating to the biological sciences. Jaffe (1989) develops a ‘knowledge production function’ framework where corporate patents are used as a proxy for economically useful knowledge. In an analysis of state-level corporate patent activity, he provides some evidence of the importance of geographically mediated commercial spillovers from university research, especially in Drugs, Chemicals and Electronics. However, as discussed by Acs et al. (1992), results concerning the role of geographic proximity in spillovers from university research are clouded by the lack of evidence that geographic proximity matters within states. They cite literature enumerating the weaknesses of using patented inventions as a measure of innovative output.

For example, Pakes and Griliches (1980) argue that ‘patents are a flawed measure (of innovation output); particularly since not all new innovations are patented and since patents differ greatly in their economic impact’. Acs et al. (1992) use another measure of innovative activity: the number of innovations recorded in 1982 by the US Small Business Administration from the leading technology, engineering and trade journals in each manufacturing industry. Using this measure of innovation, they show a more important impact of university spillovers and provide stronger evidence of the importance of spillovers arising from geographic proximity. Thus, spillovers are facilitated by the geographic coincidence of universities and research labs within the state.

Using more disaggregated data (i.e. US Standard Metropolitan Statistical Areas), Jaffe et al. (1993) use patent citations to provide evidence on the importance of the localisation of knowledge spillovers. The general idea is that if regional localisation of spillovers is important, patent citations should come disproportionately from the same state or metropolitan area as the originating patent. They attempt to control for the preexisting pattern of geographic concentration of technologically related activities. Their results suggest that geographic localisation effects are large and statistically significant. However, they also find evidence that geographic localisation

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weakens over time. Furthermore, they acknowledge that ex post, the vast majority of patents are seen to generate negligible private and social returns. They suggest that case studies of a small number of highly cited patents could prove informative about the mechanisms of knowledge transfer and the extent to which citations correspond to externalities in an economic sense.

Audretsch and Feldman (1996) provide further evidence of the importance of higher education as a determinant of regional concentration of innovative activity. They construct a measure of the spatial distribution of innovative activity (using the same data source as Acs et al. 1992) and regress this on various 'knowledge measures' (i.e. industry R&D, skilled labour and university research) while controlling for the degree of concentration of production across states. They show that innovative activity is more likely to occur within close geographic proximity to the source of that knowledge, be it a university research laboratory, the R&D department of a corporation or exposure to the knowledge embodied in a skilled worker.

### **Why and when is geographic proximity important?**

Although there is evidence suggesting the benefits of geographic proximity between universities and firms, there is less information about why exactly this is important and in what context. Zucker et al. (1994) note that the standard notion of geographically localised knowledge spillovers is based on the idea that university scientists are pursuing basic research, the results of which can be most quickly put to commercial use by those enterprises located nearby who can most readily learn novel results from social ties between employees and university scientists or by attending informal seminars at the university.

However, they show that the process has not worked like that for biotechnology, where all the parties involved (government and other funding agencies, universities, professors and enterprises) are or can be connected by contractual and/or ownership ties in competitive markets. Thus knowledge has not inadvertently 'spilled-over' to the commercial sector but has resulted from scientists entering into contractual arrangements with firms or starting their own firms to extract returns on their intellectual capital. Zucker et al. (1994) believe that this geographically localised impact, like intellectual capital itself, is a transitory phenomenon during the important initial period of industry development resulting from a major, commercially valuable scientific breakthrough.

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Audretsch and Stephan (1996) have investigated the company-scientist locational link for biotechnology in great detail. They use a data set, which includes almost the entire population of biotechnology firms that prepared an initial public offering in the early 1990s to examine the extent to which firms and the university-based scientists involved with those firms are located in the same region. They show that while a substantial number of university-based scientists participate in networks that are geographically bounded, approximately 70 per cent of the links between biotechnology companies and the university-based scientists are non-local. They conclude that 'while proximity matters in establishing formal ties between university based scientists and companies, its influence is anything but over-whelming'.

However, they also show the context in which proximity is relatively more important for these companies. For example, proximity matters more in the case of founders than for members of scientific advisory boards, presumably reflecting the qualitative difference in the services provided by the scientist. They argue that while geographic proximity matters when knowledge spillovers are informal, it is not so important when knowledge is transmitted through formal ties between researchers and firms since face-to-face contact does not occur by chance but instead is carefully planned.

Whether university-based research affects regional economic or innovative activity through market channels (e.g. formal contacts between academic scientists and firms) or 'knowledge spillovers' (i.e. positive externalities from university research that affect the performance of nearby firms) is the subject of on-going research. For example, Mowery and Ziedonis (2001) attempt to look at this using university patent citations. As they state, their study highlights the importance of additional research on how firms manage the acquisition of technologies through contractual agreements and spillovers. Knowledge flows embodied in patent licenses and citations co-exist within a broader environment of technology outflows from universities and through other channels that include the dissemination of research finding through publications and conferences, sponsorship of research, employment of university graduates and faculty consulting.

## 10.6 Social Returns

In this section, we review economic research on the wider benefits of higher education to the individual (i.e. non-monetary benefits), and to society (both economic and non-economic). The focus of attention among labour economists has traditionally been on estimating private returns to schooling.

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However, there is a large literature addressing non-monetary and social benefits of schooling, though there are much fewer studies focusing specifically on the benefits of higher education. We consider categories of relevant literature under four main headings: the 'social rates of return' approach; wages in cities; macro approaches; and non-monetary outcomes.

### **Social rates of return: an accounting framework**

There is limited literature that attempts to estimate the social returns to education using an accounting framework. The main concept is to calculate the internal rate of return to education. This involves evaluating the profitability of any given investment by calculating its (discounted) flow of benefits and costs. The internal rate of return is the discount rate for which the present value of benefits less costs equals zero. It can then be compared to the reference discount rate for the decision-maker.

Compared to the computation of private rates of return, social rates of return take account of all the direct costs of schooling (not just those borne by the individual) and use pre-tax (instead of post-tax) earnings. Thus, all the costs of education are included while many of the potential benefits are excluded (e.g. externalities in the form of macroeconomic and social gains, and the lower risk of unemployment faced by individuals with more education).

Implementation of the methodology generally involves use of survey data where earnings of graduates and non-graduates can be compared. For example, Steel and Sausman (1997) use the General Household Survey (averaging over 1989-95 data) to measure the flow of benefits to the economy by looking at how much more employers are willing to pay for graduate level skills in comparison to someone with two or more A-levels. The graduate earnings premium is assumed to mainly reflect productivity differences between the two types of workers. However, to account for other determining factors (such as innate ability or motivation) the estimate is scaled down according to an 'alpha' factor. Following the work of Denison (1964), in many studies the alpha-coefficient is taken to be 0.66 (i.e. this is the proportion of the earnings premium attributed to education). However, this has been the cause of some controversy among researchers in this field (see discussion in Hough, 1994). For example, Psacharopoulos (1975) suggests that a figure of 0.7 or 0.8 may be more appropriate, while the Dearing Review adopted a range of alpha factors (0.6, 0.8 and 1.0)

### **Social rate of return estimates**

Steel and Sausman (1997) calculate the social rate of return for graduates in the UK from the General Household Survey. The comparison group is employees with two or more A- levels. The results indicate that the social rate of return to a full time undergraduate degree (across the entire age spectrum) is in the region of 7-9% (compared to an 11-14% private rate of return). The Department for Education and Skills' estimates indicate that the social rate of return for UK graduates is in the region of 8-11%.

The PricewaterhouseCoopers LLP (2005) report for the Royal Society of Chemistry presented rates of return to the individual and the state. As part of the analysis, social rates of return were also computed (though remained unpublished). The methodological approach was not the accounting method scaled by some alpha factor discussed above but based on standard wage equations. The results indicate that the social rate of return is significantly higher than those estimates indicated above - standing at 17.0% to the average degree holder.

It is interesting to observe the difference between some of these findings and those reported in the growth literature (see below). In contrast to the accountancy 'social rate of return approach' (especially as reported by Steel and Sausman, 1997), studies based on the macro approach find high 'social returns' (i.e. in terms of economic growth/productivity) to measures of engineering and science graduates but a negative return to legal studies.

Birdsall (1996) argues that graduate training in science is partially a public good in that successful graduates tend to enter teaching or research and receive less in salaries than the full value of their marginal social value. This shows how the definition of 'social returns' and the methodology applied can dramatically change results and potential policy implications.

### **Wages in cities: measuring externalities**

#### ***Theoretical issues***

This strand of the literature focuses explicitly on the positive externalities that may arise from education. The recent literature in this area draws attention to several mechanisms through which human capital externalities may be generated. For example, Acemoglu (1996) develops a theory in which externalities from education arise if human and physical capital are complementary factors of production and firms and workers are imperfectly

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matched. The idea is as follows: firms' choice of jobs and physical capital depend on the education and skills of the workforce. Firms expecting to hire more educated workers will invest more in physical capital. Some workers who have not increased their human capital nonetheless obtain jobs in these firms and end up working with more physical capital, thus earning a higher rate of return on their existing human capital. It has been argued that such human capital externalities should be stronger at the city level rather than for countries or regions (Ciccone and Peri, 2000; Lucas, 1988; Glaeser et al., 1992).

However, Sianesi and Van Reenen (2000) point out that positive spillover effects may accrue at a higher (national) or lower (firm) level of aggregation. Most empirical work in this area has attempted to identify human capital externalities through estimation of a wage equation that includes average schooling levels in cities (as well as individual schooling) as a variable. There is only one study in this literature, Moretti (1998), where human capital externalities from higher education are specifically investigated.

### ***Empirical studies***

Rauch (1993) is the first empirical study attempting to measure human capital externalities by estimating wage equations. He uses US Census data on wages and human capital of individuals in 237 cities in 1980. He includes 'average schooling' as a variable and assumes that this reflects the effect of human capital externalities. He estimates a premium for the latter of about 4 per cent. However, as noted by Moretti (1998), Rauch's assumption that city average education is historically predetermined is problematic if better-educated workers tend to move to cities with higher wages.

Moretti (1998) deals with this problem by treating 'average education' as an endogenous variable. The demographic structure of different cities in 1970 is used as an instrument for changes in education over the 1980s. Using data for the US 1980 and 1990 Census, Moretti (1998) uses the variation in average education across 282 metropolitan areas to measure the external effect of wages on education, after controlling for private returns. He finds that a one-year increase in average education in a city raises average wages by 8 to 15 per cent. However, Moretti (1998) raises the issue later developed by Ciccone and Perri (2000) that this result does not necessarily point to an externality effect, since it may be due to complementarity between high and low educated workers. Moretti (1998) is the only study in this literature that considers the potential influence of externalities arising from higher education specifically. His findings are that a one per cent increase in the

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labour force share of college graduates increases the wages of high-school drop-outs and of high-school graduates by 1.3 and 1.2 per cent respectively. For a one-year increase in city average education, the corresponding figures are 22.2 and 11.7 per cent.

Acemolgu and Angrist (1999) also use US Census data (mainly 1960-80) to look at this issue. They make use of compulsory schooling laws across states to instrument average schooling. With regard to individual schooling, the instrument chosen is an individual's quarter of birth. While OLS estimates show a strong positive relationship between average education and individual wages, no significant relationship is found using the instrumental variables approach. Whereas OLS results indicate that a one-year increase in average schooling is associated with a 7 per cent increase in individual wages (which is similar to the estimated private return), IV results show statistically insignificant effects of average education on wages, ranging from between -1 to +2 per cent. In their comment on the study, Sianesi and Van Reenen (2000) provide a number of reasons for why human capital externalities might be underestimated in this approach. In particular, with regard to this particular study, estimates are only derived for secondary education.

As discussed above, Ciccone and Peri (2000; 2001) imply that none of these papers really identify the effect of human capital externalities on individual wages because all theories implicitly or explicitly assume that workers with different levels of education are perfectly substitutable.

## 10.7 Non-monetary outcomes

### Some empirical findings

There is a long list of potential non-monetary benefits that may accrue to the individual as a result of education and training. Haveman and Wolfe (1984) and McMahon (1998) review the potential outcomes and the many studies investigating these issues. Duncan's (1976) study considers the importance of years of schooling in determining a variety of non-pecuniary benefits. He categorises such benefits as fringe benefits (e.g. medical insurance; pension plans), general working conditions (e.g. health and safety characteristics) and consumption benefits. He finds that years of schooling are significant predictors for most of the non-pecuniary variables. Furthermore, when he combines pecuniary and non-pecuniary benefits into a single composite earnings measure, the estimated coefficient on education is considerably

higher. There are fewer studies that consider the specific impact of higher education on non-monetary outcomes.

Bynner and Egerton (2000) provide some more recent evidence for the UK of the influence of higher education on a range of outcomes, controlling for lower levels of educational attainment (among many other relevant variables). They use the National Child Development Study, which is a panel study of all the children born in the first week of March 1958. Outcome variables include employment; skills improvement; health and vulnerability (e.g. general health; psychological state); parenting (e.g. number of books owned by children), civic participation (e.g. voting; membership of voluntary organisation) and attitudes. Using multi-variate analysis, they find distinctive social benefits of higher education over and above those based on family and earlier education experience. With regard to health, Bynner and Egerton (2000) find that compared with individuals in possession of A-levels as their highest qualification, graduates are more likely to perceive themselves in 'excellent' physical health and less likely to show depression. However, there are some difficulties in the interpretation of such findings. As the authors acknowledge, some of this association could be attributed to 'selection effects' whereby people who are entering higher education are already more healthy than those who do not enter higher education.

Even if the association were to be interpreted as causal, since the authors do not control for income, it isn't clear to what extent the effect of higher education is entirely attributable to its effect on raising respondents' incomes (enabling them to purchase better health care). Hartog and Oosterbeek (1998) use Dutch data to look at the impact of higher education on health, wealth and happiness. Although there is a positive association between higher education and all these outcomes, individuals stating their highest level of education to be 'higher secondary education of a general, non-vocational nature' do best in all these respects. Again the interpretation of 'education' effects is problematic since the explanatory variables may be endogenous to the outcome variables and income is not controlled for.

There are a number of studies investigating the influence of parents' educational attainment on their children's attainment. Bynner and Egerton (2000) find that graduate families appear to have significant educational benefits for children in so far as absence of educational problems and evidence of children's reading is concerned. They suggest that part of the association is due to higher education experience, which lays the foundations for educationally effective parenting. However, again they do not control for

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income, so the extent to which higher education is really picking up an income effect is unclear.

Rudd (1987) investigates the impact of graduate parental education on their children's entry to university and finds that this has a significant influence that is net of parental social class. However, he does not have information on more general measures of parental education. Burnhill et al. (1990) re-examine this issue and find that all levels of parental schooling beyond the minimum school leaving age increases the probability that the child would qualify for higher education. They suggest that most of this effect comes from parental education up to 16 years, rather than whether the parents have a higher education qualification.

There is no doubt that many non-monetary outcomes benefit members of society other than the direct recipients. As McMahon (1998) states, the net benefits of average education levels in the community are usually positive, as suggested by their net effects on poverty, lower average crime rates after controlling for other factors. However, what is in question is how much such social outcomes arise from higher education specifically and how much benefits arise from changes at the lower levels of education. For example, Birdsall (1996) states that positive externalities of higher education are less likely to arise directly from the existence of more people in a society with higher education than is the case with primary education.

The type of 'higher education' externalities emphasised by Birdsall (1996) include those arising from basic research; training in fields such as science where social returns may exceed private returns; and service activities that have social returns (e.g. demonstration projects in education). Although high private returns have been found to basic research undertaken by firms in the US (Mansfield, 1980; Griliches, 1986), Birdsall (1996) is unable to identify a study where social returns to basic research have been estimated.

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## 11 ICT

### 11.1 Introduction

Over the last ten years a large volume of literature has developed which examines the links between the ICT sector and the economy. Much of this literature finds that ICT has made strong contributions to economic growth.

This Chapter is divided into four sections.

First, we summarise some of the key points arising in the literature which assesses the contribution of ICT to national GDP and productivity growth.

Second, we review the literature that has developed on the link between broadband services and local and regional economic growth.

Third, we provide an overview of a range of material that examines other links between ICT and the economy.

Finally, we review the availability of telecoms services in Wales, and the extent to which there is competition in the provision of those services, compared to the rest of the UK. We also consider the extent to which these telecoms services meet customer needs and review the implications of these findings for economic growth.

### 11.2 Contribution of ICT to GDP and Productivity Growth

There is a wide-ranging literature in the OECD countries that links the ICT sector and national GDP and productivity levels.

Before discussing the literature, it is helpful to clarify the terminology. The output of an economy (as measured by GDP, for example) is determined by the level of inputs – usually characterised as being capital and labour, or physical and human capital – and the efficiency with which those inputs are transformed into outputs, or productivity. Two types of productivity are usually discussed – labour productivity and total factor productivity (TFP):

- labour productivity is a measure of output per hour worked;
- in principle, TFP is a measure of the combined productivity of labour and capital inputs. In practice it is essentially a residual, sometimes known as the Solow residual, from an estimate of output growth based on estimates of the growth in inputs, assuming constant returns

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to scale. It captures a range of effects, including those which influence productivity, such as changes in technology and institutional changes, and unrealistic assumptions in the underlying model.<sup>102</sup>

A recent OECD study (OECD, 2004) undertook an in depth review of the economic impacts of the ICT sector. The OECD study notes three mechanisms through which investment in ICT can impact on productivity and economic growth.

- First, investment in the ICT sector contributes to overall capital deepening and so contributes to raising labour productivity;
- Second, rapid technological advances in the production of ICT goods and services contributes to faster growth in total factor productivity in the ICT sector;
- Third, greater use of ICT, including in non-ICT sectors, contributes to increasing firm level efficiency and so contributes to increases in total factor productivity.

In relation to the first factor, the OECD study comments on the data problems inherent in analyses in this area. Data on ICT investment is not always available, and often is not consistent across countries. Data on investment in software is particularly problematic. Nevertheless, estimates provided in the report suggest that ICT investment typically accounted for between 0.3 and 0.8 percentage points of growth in GDP and labour productivity over the 1995-2001 period. The highest contribution to growth was in the USA (0.8 percentage points) and the lowest was in France (just over 0.3 percentage points). The figure for the UK was just under 0.6 percentage points. Investment in software accounted for up to a third of the overall contribution of ICT investment.

A study based on the UK economy over the period 1992 - 2000 (London Economics, 2003) found that ICT capital deepening over this period contributed 0.76 percentage points annually to total labour productivity growth (which averaged 1.6% per annum over this period). The same study estimated that the contribution of ICT investment to GDP growth in the UK over the period was 0.8 percentage points - around one quarter of GDP growth over this period. This study found that manufacturing was the sector that gained most (in relative terms) from ICT investment with 43% of output growth attributable to ICT investment. This was followed by the large service

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<sup>102</sup> See Baier et al (2002) for a fuller discussion.

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sectors such as Financial Intermediation (27%) and Transport, Wholesale and Retail Trade (13%).

An influential US paper (Jorgensen & Stiroh, 2000) examined the contribution of ICT to US GDP and productivity growth over the period 1995 – 1998. They found that the ICT producing sector made a contribution of around 1 percentage point to annual US GDP growth, which averaged 4.73% over this period. They also concluded that increased productivity in ICT producing industries and capital deepening in ICT using industries were key factors in the resurgence of US GDP growth over the period. Computers were found to be more important than software and communications equipment. They found little evidence of ICT led total factor productivity growth in non-ICT industries.

In a more recent study Oliner et al. (2007) consider different explanations for the growth performance observed in the US since the mid-1990s. They find that the remarkable growth period between 1995 and 2000 is best explained by investment in ICT.

However, the authors note that levels of ICT investment fell sharply after 2000, but that this has not led to an equally sharp decline in productivity growth. Some of the current productivity growth – which is still high by historic standards – might be explained by the nature of ICT as a ‘general purpose technology’ that spurs innovation and productivity increases throughout the economy (see below). However, Oliner and his co-authors argue that cost-cutting and lay-offs driven by increased competitive pressures might have been primarily responsible.

In relation to the second and third mechanisms listed above, the OECD study also considered whether the relative importance of the ICT producing and ICT using sectors in different countries, and their growth over time, might be one factor that influences the different rates of economic growth across countries. In other words, does rapid technological change and growth in the ICT sector make an important contribution to growth in the economy in general. The study concludes that the United States and Australia are almost the only OECD countries where there is evidence at the sectoral level that ICT use can strengthen both labour productivity and total factor productivity growth in ICT-using industries. In some other countries, including Canada and the United Kingdom, there is evidence that certain ICT-using industries have experienced a pick-up in labour productivity growth, though not in TFP growth. And for many other OECD countries, there is little evidence that ICT-

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using industries are experiencing an improvement in either labour productivity or TFP growth.

In one recent paper,<sup>103</sup> it is argued that one of the main reasons why labour productivity growth in the EU has lagged behind productivity growth in the USA since the early 1990s has been the much higher levels of investment in the ICT sector<sup>104</sup> in the USA. It attributes the more limited levels of ICT investment in Europe to lower returns to ICT investment arising from higher levels of inflexibility in European markets and the dampening effect that this has on innovation. A further paper<sup>105</sup> also highlights the role of ICT investment and regulation in the poor labour productivity performance in the EU compared to the USA in recent years. It suggests that employment protection regulation, the more limited extent of third level education and the high price of ICT capital in Europe limited investment in ICT in the 1980s, with lags meaning that the effects were probably felt in the 1990s rather than the 1980s.

A further simple point is made by Timmer and van Ark (2005): while they agree that differences in ICT investment explain a large part of the EU-US differential in productivity growth (>50%), they find that most of the rest of the difference is due to the relative size of the ICT-producing sector, which is much larger in the US, and where productivity growth is particularly high due to rapid technological advances.

The length of time which it has taken for investments in ICT to be reflected in productivity estimates may be attributable to the need for business and organisational processes to adapt and change in order to take full advantage of the productivity gains that are possible with higher levels of ICT investment. Firm level evidence on the link between ICT investment and performance tends to support the idea that the adoption of new business processes is important for taking full advantage of the potential of ICT investment.<sup>106</sup>

The OECD study also assesses firm level evidence of different aspects of the link between ICT investment and performance across a number of OECD

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<sup>103</sup> Indepen and Ovum (2005).

<sup>104</sup> And in the "knowledge sector" more generally, including higher education and R&D.

<sup>105</sup> Crafts (2003).

<sup>106</sup> For a more cautious view see Oliner et al. (2005).

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countries. Overall it concludes that there are significant impacts in all of the countries considered. The analysis for the UK focuses on the link between online trading and performance and find a positive impact on productivity. However they found that e-buying typically had positive impacts on outputs whilst e-selling had negative impacts, concluding that increased levels of price transparency and competition in online trading meant that it was more likely to be beneficial for the purchaser than for the seller.

An important insight from the firm level evidence is that there are a number of complementary factors that can enhance the impact of ICT investment on productivity and growth. An analysis of Australian evidence shows that complementary factors that have a significant impact include human capital, a firm's experience in innovation, its use of advanced business practices and the intensity of organisational restructuring. Other studies also draw similar conclusions. One study (Brynjolfsson & Hitt, 2000), for example, concludes that "both case studies and econometric work point to organizational complements such as new business processes, new skills and new organizational and industry structures as a major driver of the contribution of IT. These complementary investments, and the resulting assets, may be as much as an order of magnitude larger than the investments in the computer technology itself." A further study (McKinsey, 1997) also suggested that even though the UK had a higher ratio of school computers than almost any other country, including the USA, there was little evidence that there had been any significant impact on educational standards. The study suggested that there had been too much policy focus on the hardware and insufficient consideration given to the most appropriate way to use computers in education and to integrate them into the education process.

Recent empirical work by Corrado et al (2006) and Marrano et al. (2007) suggests that investment in intangibles (software, R&D, design, etc.) raises output growth and gross value added by at least 10%. They also find that higher productivity is not reflected in labour compensation.

The OECD study concludes that firm level analysis suggests that ICT investment is generally beneficial to the performance of firms but that the evidence at the sectoral level and at the level of the economy is less clear. This evidence suggests that ICT investment has contributed to economic growth in most OECD countries and that the ICT sector has contributed to labour productivity growth in some countries. There is little evidence outside the USA and Australia, however, that the sectors that use ICT the most have benefited from higher total factor productivity growth. There are a number of

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factors that might explain this including differences in data collection and measurement; the longer time that ICT investment has been in place in the USA – this may have enabled longer term spillover effects to appear in the data; firm level benefits may be higher in the USA (and Australia) and so more likely to show up in more aggregate data – this could be the case, for example, if the conditions under which ICT is beneficial to firm performance are more prevalent in the USA (and Australia).<sup>107</sup>

### 11.3 Impacts of Broadband on Regional Economies

Broadband services only started to become widely available in the late 1990s and so the scope for economic impact assessment based on historic data is relatively limited. Early studies (e.g. Crandall and Jackson, 2002) relied on forward-looking models of broadband's potential economic impact. Some studies based on actual broadband rollout started to become available around 2003.

A study (Strategic Networks Group, 2003)<sup>108</sup> of the township of South Dundas in Ontario, Canada suggested that an investment of C\$1.3m on a fibre network, that went into service in 2001, led to a C\$25m increase in GDP for Dundas County and a circa C\$8m increase for Ontario. There were also increases in employment and in tax revenues.<sup>109</sup>

A frequently quoted US study on the impact of a city-wide fibre optic network (Kelly, 2003) also concluded that there were positive benefits from the investment in the fibre optic network in Cedar Falls, Iowa based on a comparison with a nearby, similar town that had no fibre optic network (though broadband access via cable modems and DSL was available). The conclusions are based on a descriptive analysis of the two towns, noting in particular the higher property values in Cedar Falls and the similarities in other characteristics save for the communications networks. No evidence of any statistical links was provided.

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<sup>107</sup> These conditions include sufficient scope for organisational change to take full advantage of the benefits of ICT investments.

<sup>108</sup> This study was commissioned by the Department for Trade and Industry in the UK.

<sup>109</sup> These results were based on a survey of businesses and organisations in South Dundas that asked about impacts attributable to the fibre optic network; and on input-output modelling.

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In 2004 two studies (ACIL Tasman, 2004a and 2004b) were undertaken on the economic impacts of broadband adoption in the State of Victoria in Australia. These studies conclude that the impact of broadband on productivity and on output vary considerably by sector. They find that the service sector (particularly financial and business services) benefits most in terms of productivity gains whereas other sectors such as construction, mining and trade (retail, accommodation, food and beverage sales) benefit most from output gains. These sectors are able to increase output (despite relatively low productivity impacts from broadband adoption) because they derive indirect benefits through cheaper production inputs from improved productivity elsewhere (e.g. transport) and from increased demand for their products deriving from higher private consumption.

At a regional level (within the State of Victoria) these studies find that the areas that experience strongest productivity growth are those that have both broadband availability and a strong presence of companies in the communications, financial and business service sectors. Those that experience the biggest impacts on outputs are areas that include large construction and trade sectors – industrial areas, rapidly expanding residential developments, retail centres, and tourism centres.

A Canadian study (Annis, McNiven and Curri, 2005) examined the economic impacts of broadband in rural Canadian areas in order to further understand issues relating to the “digital divide” with respect to rural and urban areas. They found positive impacts from broadband adoption in two small rural communities in Manitoba and in Nova Scotia. They indicate increases in business revenues from online sales and reductions in travel and postage costs. Another Canadian study (Zilber et al, 2005), which examined two rural communities in British Columbia, found positive impacts from the adoption of broadband. Drawing on a survey of businesses in the two communities, the study concluded that adoption of broadband improved productivity, with many businesses reporting increases in income and reductions in costs.

A study (SQW Limited, 2005) on the use and impacts of ICT and broadband in English rural areas found that higher levels of adoption in rural businesses are linked with higher turnover per employee and higher growth expectations. The more advanced ICT adopters considered that recent developments in ICT made it easier to operate from rural locations, and about

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30% of urban businesses said that they might consider operating from a rural location now that broadband was available.<sup>110</sup>

One US study (Ford & Koutsky, 2005) concluded that the adoption of a fibre optic municipal network in Lake County, Florida has doubled the level of economic activity, measured by per capita sales revenue, in that county relative to ten other similar Florida counties. The analysis was based on the comparison of economic growth across the counties before and after the introduction of the fibre optic network in Lake County in 2001, and involved an econometric modelling process.

A recent US study (Lehr et al, 2006) used State and zipcode level data to examine the economic impacts of broadband across the USA. The study used econometric techniques and found that between 1998 and 2002, after controlling for a number of relevant factors, communities in which mass market broadband services were available by the end of 1999 had more rapid growth in employment and a higher total number of businesses.<sup>111</sup> There was also an impact on higher rentals for residential property. The authors note that there are a number of difficulties associated with causality in this type of analysis. Although they used two approaches to address this issue, they note that they have not proven that broadband causes economic impact, though they believe that the data does show a clear link between broadband and positive economic outcomes.

Recent work in the UK projects positive economic outcomes from the deployment of broadband in the period to 2015. A study of new generation broadband in Scotland (SQW Limited, 2006) concludes that the GVA of Scotland's market sector in 2015 will be £3.4 billion higher due to business take-up of broadband than it would have been otherwise (at 2000 prices).<sup>112</sup> Much of this benefit (77%) derives from the upgrade of dial up connections to first generation broadband services (up to 5Mbit/s). The remainder of the benefits derive from upgrades to second generation (5 – 50Mbit/s) and third generation broadband services (at least 50Mbit/s).

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<sup>110</sup> The data for the study was based on a survey of rural and urban businesses.

<sup>111</sup> The authors were unable to access data on GDP at the community level and so used other variables as proxies.

<sup>112</sup> The range presented around this central projection is of £2 billion to £6 billion.

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Another study (Atkins, 2006) concludes that the present value net benefit of broadband to the Welsh economy over the period 2000 to 2015 will be £1.4 billion. They emphasise that this is a lower bound estimate. An “extreme upper bound” estimate of £28.4 billion is also provided. The estimates are based on an estimate of consumer surplus for the private sector and on “bottom up” measures of net benefits for the public sector, based on a series of case studies.<sup>113</sup>

South Korea and Japan often cited as example of advanced implementation of communications services, particularly broadband services in Korea and mobile phone services in Japan. However, there appears to be little in the literature, certainly in European languages, that makes any attempt to assess the economic impacts of investments in broadband and mobile phone services in Japan or Korea specifically. There is material that examines the link between the ICT sector more widely and GDP and productivity as discussed in the previous section. There is also some literature that discusses the reasons for the advanced development of communications services in these countries,<sup>114</sup> but this does not seem directly relevant for this study.

## 11.4 Other links between ICT and the economy

This section briefly reviews a range of other material that assesses the links between ICT and the economy. Some of the material looks at the impacts of specific elements of the ICT industry on the economy, such as radio spectrum, hardware and software. Other material examines the impact of ICT on specific sectors of the economy, such as education and hospitals.

There are a number of studies that review the links between specific elements of the ICT sector and the economy. One recent study (Europe Economics, 2005) examined the impact of radio spectrum on the UK economy. The study estimated that the net GDP impact from the use of radio spectrum in the UK in the year to 31 March 2006 was £37 billion (about 3% of total UK GDP). The study also estimated net benefits of £42 billion to the UK economy in 2006 of radio spectrum use in terms of consumer and producer surplus. This compares with a net benefit of £28 billion in 2002 (also expressed in 2006

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<sup>113</sup> Note that in their study of the economic impacts of broadband in Scotland, SQW chose to focus on an estimate of GDP impacts rather than consumer surplus impacts because they regarded estimates of consumer surplus to be highly sensitive to assumptions about price elasticities.

<sup>114</sup> See, for example, Kushida and Oh (2006).

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prices). This very large increase is attributed to a number of factors, including increases in the number of mobile phone subscribers, increases in average revenue per user for mobile phone companies, previous underestimates of the value to consumers of broadcast services, and growth in the availability of digital broadcasting services.

A study for the US wireless telephony industry (Entner & Lewin, 2005) found that in 2004 the industry generated revenues of \$118 billion and contributed \$92 billion to US GDP. This made the industry slightly smaller than computers, automobiles, publishing and agriculture.

An Australian study (Access Economics, 2003) has assessed the impacts of rolling out broadband services to hospitals that do not already have broadband access. The study uses a cost benefit analysis framework to analyse the impacts of introducing a broadband network between major healthcare facilities to enable the provision of three relatively well established telehealth applications: telepsychiatry, teleradiology and fetal teleultrasound. These applications make use of the broadband network to enable access to specialists working at other healthcare facilities. The main benefits arise from savings in patient travel time, whilst the main costs relate to broadband access services and equipment, such as videoconferencing facilities. Options for extending the broadband network to different levels of healthcare facility were examined with the largest net benefits being found for providing a network to connect Level 3 hospitals (the largest in a statistical sub-division). These were estimated at AUS\$190 million over ten years.

One study (PricewaterhouseCoopers, 2004) examined the costs and benefits of broadband access across Europe, providing separate cost benefit ratios for urban areas and rural areas. The analysis was undertaken in the context of an examination of the case for public sector intervention (e.g. subsidies) for broadband rollout. The analysis suggested that the benefits per user were similar in rural and urban areas but that the infrastructure costs were much higher in rural areas. The benefit-cost ratio over the first ten years was high in urban areas (1.70:1) but more marginal in rural areas (1.13:1). Extending the period for the NPV calculation improved the benefit-cost ratio for rural areas to 1.32:1 and for urban areas to 1.83:1.

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## 11.5 The impact of scale

Much of the empirical work that seeks to find a link between ICT investment and economic growth utilises growth models that assume constant or diminishing returns to scale from investment (including investment in ICT). As a consequence there appears to be little evidence that explicitly explores the link between the scale of ICT investments and economic growth impacts.

The network characteristics of telecoms and internet services and some types of computer software do however suggest the possibility of discontinuities or thresholds in relation to network size. One of the key characteristics of a network is that the benefit to one user of the network changes when the number of other users changes. In a telecoms network, for example, the benefits to a customer of being a part of the network increase when the number of other telephone users increases because there are more people with whom it is possible to have a phone conversation. This is known as a “network effect”.<sup>115</sup>

In some senses, telephony is a poor example now of network effects because there are so many people already on the telephone network (through fixed lines at home, at work and through mobile phones) that it is hard to imagine that additional users of the network would make much difference to the benefits of being a user. This would have been a better example fifty years ago, when a much larger number of people did not have access to a telephone either at home or at work and the benefits from network effects were correspondingly bigger. However this example does begin to illustrate the potential for threshold effects. In the network literature this concept is generally referred to as the “critical mass” of a network.

The existence of critical mass in network industries has been described as a central feature of network industries.<sup>116</sup> The critical mass is the network size below which a network is not viable because the value of the network to users is below the cost of the network. As the network size increases the average cost per customer typically reduces (because of economies of scale) and the value per customer using the network increases (because of the network effect). These characteristics suggest that particular networks will either not

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<sup>115</sup> This effect is also known as a network externality where the effect is not internalised in decision-making about the size of the network.

<sup>116</sup> See Economides and Himmelberg (1995).

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exist or they will exist at a size at or above critical mass, except for a period in which they are expanding to critical mass. This expansion period can be very rapid. There is some empirical evidence that network effects drove the rapid expansion of the US fax market during the 1980s.<sup>117</sup>

There are many reasons why growth beyond critical mass may slow down and, ultimately, decline. These include increasing costs of network congestion and increasing costs of managing the network. In some cases, as with the fax network, the technology may be overtaken by a superior technology.

By implication, if there is a critical mass for ICT networks and if ICT networks do influence economic growth, then investments in ICT that contribute to the achievement of critical mass - resulting in a step change in network size - could be associated with larger impacts on economic growth. This does not necessarily imply step changes in economic growth however - the impact on growth of having a particular network as opposed to not having it may only feed through over a long period of time. The evidence discussed earlier in this Chapter refers to the potential for lengthy time lags between ICT investment and impacts on productivity.

There is some evidence of a link between telecoms infrastructure and a non-linear impact on economic growth. Using data for a number of developed and developing countries, Röller and Waverman (2001) examined the link between telecoms infrastructure and economic growth. Using data on the number of fixed telephone lines per capita as a proxy for telecoms infrastructure, they concluded that there was a strong relationship with economic growth, but only once a critical mass in terms of the number of telephone lines per capita had been achieved. They estimated that this critical mass was at the level of 24% (fixed lines per capita).<sup>118</sup>

## 11.6 Telecoms services in Wales

In this section we briefly review the availability of telecoms services in Wales, and the extent to which there is competition in the provision of those services, compared to the rest of the UK. We also consider the implications for customers of availability levels and competition and the extent to which telecoms services meet their needs. Finally we examine these supply and

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<sup>117</sup> As above.

<sup>118</sup> In the UK fixed line penetration (fixed lines per capita) was at 56% in 2006 (source: Ofcom 2006).

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demand issues for Wales in the context of what the ICT literature says about how ICT influences economic growth.

In examining the availability of telecoms services in Wales we rely mainly on a report published by Ofcom in May 2007 which collates data about telecoms services in Wales. This report is an update of a previous report published in 2006.<sup>119</sup>

### **Availability and competition in the provision of services**

The Universal Service Obligation on BT means that every household in Wales should have access to a fixed telephone line suitable for voice telephony if they wish. Generally this is available at a standard charge, though in a small number of cases where access is difficult, higher charges may be payable. Since narrowband dial up internet access uses the same technology, availability is the same as for voice telephony.

There are a number of possible technologies for broadband internet access. In the UK, the two principle access technologies are DSL<sup>120</sup> and cable modems, accounting between them for over 99.9% of broadband connections in 2006. For DSL access a household or business premises needs to be connected to a BT telephone exchange that is enabled for DSL only or for LLU<sup>121</sup> and DSL. In the former case only BT can offer DSL services whereas in the latter case, either BT or a competing operator can offer DSL services. Ofcom notes the value of LLU based service for customers as follows:

“Unbundling allows operators to offer voice and DSL services without the constraints of being tied to BT or Kingston Communications wholesale products, giving them control over more of the value chain and allowing greater product differentiation. A customer whose premises are connected to an unbundled local exchange is therefore likely to have access to a wider range of fixed telephony products and services, including DSL broadband packages, than one who is not.” (Ofcom 2007)

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<sup>119</sup> The other data source used is the website [www.samknows.co.uk/broadband](http://www.samknows.co.uk/broadband), from which data on BT exchanges in Wales was downloaded in August 2007

<sup>120</sup> Digital Subscriber Line.

<sup>121</sup> Local Loop Unbundling.

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Nearly all premises in Wales and in the rest of the UK are connected to an exchange that is enabled for DSL.<sup>122</sup> Nevertheless the availability and speed of DSL for individual premises varies according to the distance from the exchange and other factors that affect line quality.

Only 60 (of 434) exchanges in Wales are LLU enabled.<sup>123</sup> Of these 47 are in the counties of South East Wales,<sup>124</sup> with the remainder in Swansea (5), Carmarthenshire (2), Powys (1), Wrexham (2) and Flintshire (3).<sup>125</sup> This equates to 32% of premises in Wales being connected to LLU enabled exchanges, compared to an average of 67% across the UK (Figure 11.1).

Many of those premises in Wales that are connected to LLU enabled exchanges have access to a rather narrow range of alternative service providers - over 60% have access to only one or two alternative providers (see Figure 11.2). Ofcom suggest that customers in some parts of London have access to as many as seven alternative providers.

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<sup>122</sup> In Wales, there are only 241 premises that are not connected to a DSL enabled exchange.

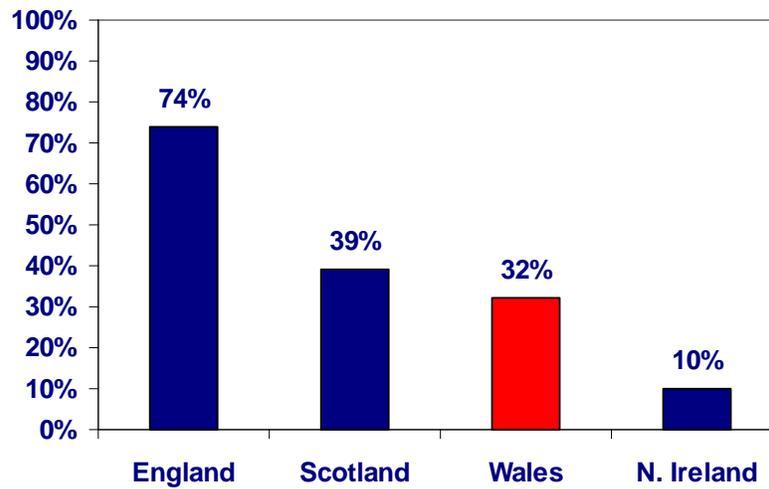
<sup>123</sup> Source: [www.samknows.co.uk/broadband](http://www.samknows.co.uk/broadband) - downloaded August 2007.

<sup>124</sup> Blaenau Gwent, Bridgend, Caerphilly, Cardiff, Merthyr Tydfil, Monmouthshire, Neath Port Talbot, Newport, Rhondda Cynon Taff, Torfaen and Vale of Glamorgan.

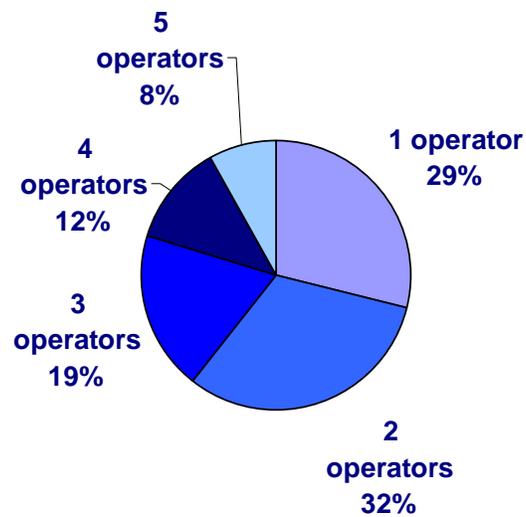
<sup>125</sup> Several Welsh counties have no LLU enabled exchanges - Ceredigion, Conwy, Denbighshire, Gwynedd, Ynys Môn, and Pembrokeshire.

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Figure 11.1: Proportion of premises connected to an LLU-enabled exchange



Source: Ofcom (2007)

Figure 11.2: Proportions of LLU enabled exchanges in Wales by number of competing operators<sup>126</sup>Source: [www.samknows.co.uk/broadband](http://www.samknows.co.uk/broadband)<sup>126</sup> That is, the number of operators in addition to BT.

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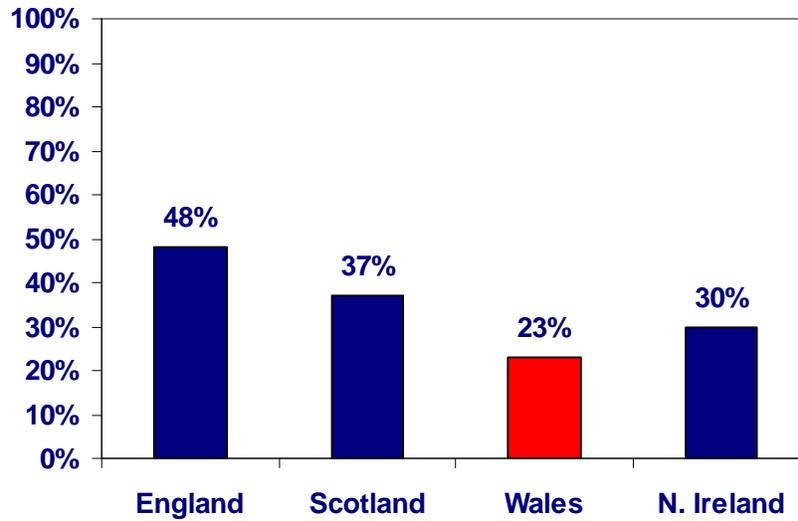
Access to broadband services via the cable network is also limited in Wales compared to other parts of the UK, particularly England. The proportion of Welsh households that are passed by a cable network capable of supplying broadband in December 2006 was 23%. The average for the UK was double that at 46%. These figures, by UK country, are shown in Figure 11.3.

Overall, these figures for LLU-enabled exchanges and for cable networks suggest that access to a range of broadband services and operators appears poor in Wales (as well as Scotland and Northern Ireland) compared to England. Figure 11.4 illustrates average provider penetration across the English regions and Wales, Scotland and Northern Ireland.<sup>127</sup> This suggests a similar pattern of low availability of alternative broadband providers who use alternative infrastructures, as opposed to resellers, in Wales, Scotland and Northern Ireland, compared to England. The breakdown by English region shows the large gap between London and the rest of England. Much of this variation is likely to be driven by population densities.

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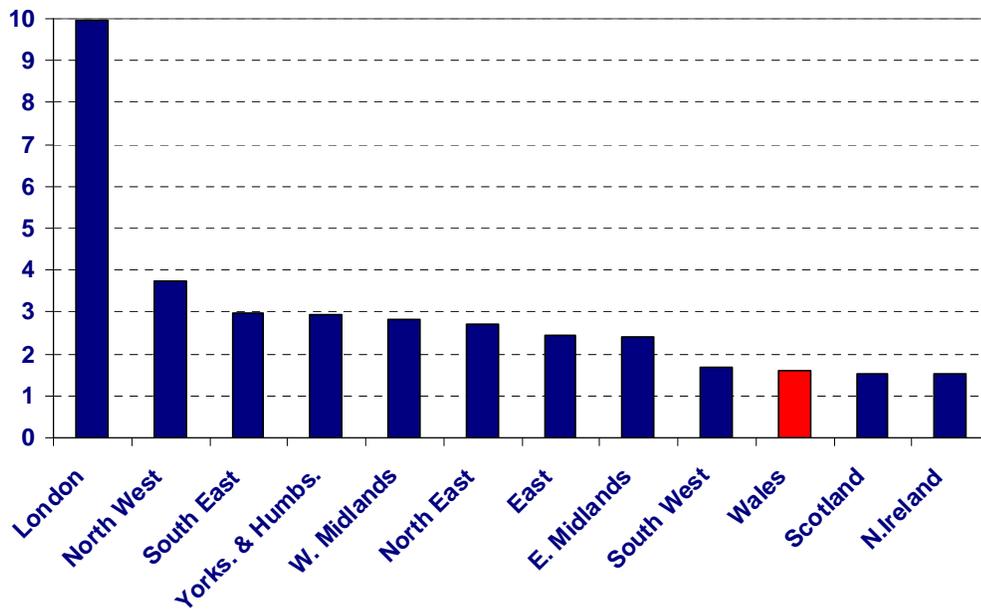
<sup>127</sup> Average provider penetration is defined by [www.samknows.co.uk](http://www.samknows.co.uk) as follows: "The "Average provider penetration" figure is calculated by taking an average of the number of distinct broadband providers operating at each exchange in this region. For the purposes of this calculation, a broadband provider is deemed to be any provider operating their own network or technology (i.e. those providers listed on this website). This includes BT Wholesale ADSL, BT Wholesale SDSL, the cable operators on this website, the wireless operators on this website and the LLU operators on this website. Retail providers who simply resell products are not included. The purpose of this figure is to provide a (crude) comparison of the broadband choices users have between the different regions."

Figure 11.3: Proportion of households passed by Cable Modem (Virgin Media Broadband)



Source: Ofcom (2007)

Figure 11.4: Average Provider Penetration

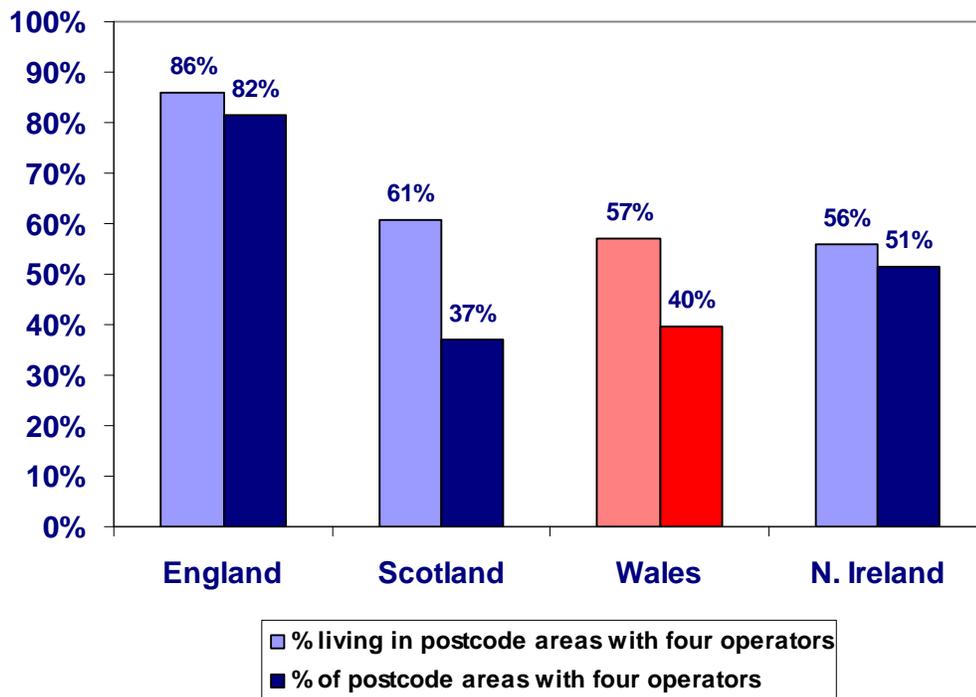


Source: [www.samknows.co.uk/broadband](http://www.samknows.co.uk/broadband)

The picture for mobile voice telephony (2G services) is similar, with customers in Wales, Scotland and Northern Ireland having, on average, access to a lower number of service providers than customers in England. Like the rest of the UK, almost all of the population in Wales (99.8%) live in a postcode district where one or more operators provide at least 95% 2G coverage.

However bigger differences emerge when assessing the choice of operators. On average across the UK in early 2007, 81.6% of the population lived in a postcode district where four operators had at least 95% coverage of the area. In Wales, the equivalent figure was only 57% of the population. Geographic coverage was lower, reflecting the focus of transmission in more densely populated areas. Just under 71% of postcode districts in the UK had four operators with at least 95% coverage. In Wales, the equivalent figure was 40% of postcode districts (see Figure 11.5).

**Figure 11.5 Population & geographic coverage with four 2G operators**



Source: Ofcom (2007)

### Implications for customers

These figures show that in Wales, like the rest of the UK, access to at least some kind of fixed and mobile voice telephony service and to a broadband service is possible for almost everybody. However the choice of alternative service providers, in particular those that make use of their own infrastructure, is significantly more limited in Wales than it is in England.

The lower level of apparent competition in Wales might be expected to manifest itself through some combination of higher prices, poorer service quality and a lower range of services. As tariffs are generally set nationally, then any such effects are most likely to manifest themselves through an impact on service provision and quality.

As part of their study,<sup>128</sup> Ofcom surveyed individuals (aged 15 or over) and SMEs about their satisfaction with telecoms services. The questions were asked to those who were using each of the services in question, for various aspects of quality. In general, satisfaction levels for residential customers were very similar across the four nations of the UK, with differences limited to 3 or 4 percentage points and levels of satisfaction for different services and different quality aspects generally in the range 70% to 90%. For broadband services, however, there was greater divergence in satisfaction levels. These are illustrated in Table 11.1. In Wales, people appear to be much more satisfied with the value for money from their broadband services and a little less satisfied (than customers in England) with the speed of their connection and with the service overall. SMEs in Wales show relatively high levels of satisfaction with all three aspects of their broadband service (see Table 11.2).

**Table 11.1: Satisfaction with broadband service – residential customers**

**%Very satisfied or fairly satisfied**

	England	Scotland	Wales	North. Ireland
Overall satisfaction with broadband service	<b>91%</b>	<b>83%</b>	84%	90%
Value for money of broadband service	76%	<b>66%</b>	<b>82%</b>	75%
Speed of broadband connection	<b>88%</b>	86%	<b>83%</b>	86%

Note: Base is all adults 15+ who have access to broadband at home

Highest level of satisfaction in **bold**; lowest in **red**

Source: Ofcom 2007

<sup>128</sup> Ofcom 2007.

**Table 11.2: Satisfaction with broadband service – SME customers****%Very satisfied or fairly satisfied**

	England	Scotland	Wales	North. Ireland
Overall satisfaction with broadband service	88%	87%	<b>91%</b>	<b>81%</b>
Value for money of broadband service	<b>76%</b>	74%	<b>76%</b>	<b>61%</b>
Speed of broadband connection	<b>86%</b>	<b>78%</b>	85%	<b>78%</b>

Note: Base is all SMEs currently using broadband

Highest level of satisfaction in **bold**; lowest in **red**

Source: Ofcom 2007

This evidence suggests that, in general, customers in Wales are not significantly more dissatisfied with their service levels than customers in England, indeed in some aspects they are more satisfied, despite the apparently lower level of competition in Wales.

These figures only reflect the views of customers who are in receipt of these services. Ofcom also present data on the take up of services. These suggest that, for many services, take up in Wales is lower than it is in England, significantly so in respect of SME take up (see Table 11.3). It is not possible to judge from these data whether take up in Wales is lower because of dissatisfaction with prices and/or service levels, or whether there are other reasons which mean that there is a lower propensity to take up these services in Wales.

Table 11.3: Telecoms &amp; Internet take up – residential and SME customers

	England	Scotland	Wales	North. Ireland
<b>Residential</b>				
Fixed line	<b>90%</b>	<b>85%</b>	89%	<b>90%</b>
Mobile	81%	<b>82%</b>	<b>77%</b>	<b>82%</b>
PC	68%	<b>69%</b>	66%	<b>60%</b>
Total internet	<b>62%</b>	57%	59%	<b>56%</b>
Broadband	<b>45%</b>	<b>42%</b>	<b>42%</b>	<b>42%</b>
<b>SME</b>				
Fixed line	92%	<b>83%</b>	<b>98%</b>	91%
Mobile	55%	<b>57%</b>	<b>46%</b>	54%
PC	84%	<b>88%</b>	<b>76%</b>	<b>76%</b>
Total internet	79%	<b>80%</b>	<b>64%</b>	71%
Broadband	64%	<b>67%</b>	<b>47%</b>	52%

Note: Base is all SMEs

Highest level of take up in **bold**; lowest in **red**

Source: Ofcom 2007

### Implications for growth

In general, competition is believed to contribute to firm level efficiency, and hence labour productivity, as inefficient firms are unable to compete effectively and are forced to improve or to leave the market. Greater competition in the provision of telecoms services could impact positively on economic growth in two ways. First by improving efficiency and raising outputs in the telecoms sector itself and hence raising the direct contribution of the sector to GDP and, second, by reducing input prices (and/or raising service variety and quality) for other firms that use telecoms services and hence increasing their productivity and contribution to GDP.

In relation to the first of these pathways, there is some evidence that competition in the telecoms sector can have a large positive impact on output and productivity in the telecoms sector itself. One statistical analysis<sup>129</sup> based

<sup>129</sup> See Li and Xu (2002).

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on data from the period 1991-98 suggested a strong link between the level of competition (as measured by the number of firms in a market) and both labour productivity and total factor productivity in the telecom sector. The study also found strong complementarities between the effects of privatisation and of competition.

We have not seen any evidence of a direct link between competition in the provision of broadband (and other telecommunications services) and output and productivity levels in other sectors which purchase telecoms services.

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## 12 Renewable Energy

### 12.1 Introduction

Investment in renewable energy (RE) has not been traditionally associated with economic growth. Rather, it has been seen as an environmentally friendly alternative to more conventional energy sources. The higher cost of many RE technologies has meant that public intervention has been necessary to encourage their development and greater use. While environmental benefits and, more recently energy security, provide the main rationale for public support of RE generation, there is a further potential benefit of RE: that it may contribute to the rural community in social and economic terms, more so than conventional energy production.

Within the wider context of UK renewables policy,<sup>130</sup> the Welsh Assembly Government has set a 4TWh per annum renewable electricity production target by 2010 and a 7TWh target by 2020, to facilitate achievement of their objective of 60% carbon savings by 2050. Furthermore, on the basis of numerous studies,<sup>131</sup> the Assembly has concluded that onshore wind will be the main large-scale technology capable of achieving this 2010 target, possibly assisted in the longer term by the Severn Barrage project.<sup>132</sup>

The review of the relevant literature presented here focuses on four main areas: the commercial viability of RE technologies, the economic impacts of the use of RE in general, the different impacts of specific types of RE technologies and the potential for development in Wales.

### 12.2 The Commercial Viability of RE Investments

Since 2002 the Renewables Obligation<sup>133</sup> has supported producers of renewable energy by placing an obligation on electricity suppliers in England

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<sup>130</sup> As set out in the Renewables Obligation Order 2005.

<sup>131</sup> Reports cited in support of this conclusion are: the 2004 DTI Renewables Innovation Review; the Royal Commission on Environmental Pollution report of May 2004 on biomass; and studies undertaken for the DTI 2005 Renewables Obligation review.

<sup>132</sup> Welsh Assembly Government (2005).

<sup>133</sup> The Renewables Obligation replaced the previous Non Fossil Fuel Obligation (NFFO).

and Wales to purchase a percentage of their energy from renewable sources.<sup>134</sup>

Research was recently undertaken for the DTI to assess the scope for commercial viability of renewable energy production (OXERA, 2005). Even though the capital and operating costs of some renewables technologies are expected to fall, and even though the wholesale costs of energy production based on fossil fuels are likely to rise,<sup>135</sup> the study concluded that over the next decade “there appears to be little scope for significant volumes of renewable generation to become commercially viable without continued support from the RO.” Onshore wind and landfill gas developments were identified as the technologies most likely to achieve commercial viability in the next decade, though it was estimated that they would still need some support from the Renewables Obligation. A lower level of support for these technologies than that currently available might be sufficient.

Very recent research (Sustainable Development Commission, 2007) also suggests that the Severn Barrage would not be commercially viable without public sector support.

### 12.2.1 Costs of Renewable Energy

One of the key issues that currently limits the expansion of RE is its high production costs.<sup>136</sup> At the present time, unit costs of RE are high for a number of reasons:

- Large initial investments are often required;
- Supply intermittency and backup requirements;
- Costs of connectivity and transport of electricity;
- Impact on households and community resistance;
- Use of emergent technologies and risks.

We will review each of them in turn.

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<sup>134</sup> For the financial year 2007-08 the figure is 7.9%. This rises annually to 15.4% by 2015-16 and stays at that level until 2026-27.

<sup>135</sup> Following introduction of the EU Emissions Trading Scheme.

<sup>136</sup> Generation costs of onshore wind power have been estimated at around 3.2p/kWh (+/-0.3p/kWh), with offshore at around 5.5p/kWh, compared to a wholesale price for electricity of around 3.0p/kWh. The additional system cost is estimated to be around 0.17p/kWh, when there is 20% wind power on the system (SDC, 2005).

### *Large initial investments*

Developing new renewable resources often requires large initial investments to build infrastructure (e.g. the Severn barrage, off-shore wind farms). Whilst many conventional energy sources also require large up front investments, longer experience with these investments means that there are more established processes and better cost estimates in place. The following are some of the important aspects that need to be considered when making a RE investment (see Powerful Solutions, 1999):

- **Prospecting.** Developers must find publicly acceptable sites with good resources and with access to transmission lines (for example, potential wind sites can require several years of monitoring to determine whether they are suitable).
- **Permitting.** Permitting issues for conventional energy technologies are generally well understood, and the process and standards for review are well defined. In contrast, RE often involve addressing new types of issues and ecosystem impacts.
- **Marketing.** Start-up companies must communicate the benefits of renewables to customers in order to persuade them to switch from traditional sources.
- **Installation, operation, and maintenance.** Workers must be trained to install, operate, and maintain new technologies (and to grow and transport, in the case of biomass fuels). Some renewables need operating experience in regional climate conditions before performance can be optimized.

In addition, to compete against mature fossil fuel and nuclear technologies renewables must overcome the lack of economies of scale. Achievement of economies of scale is likely to lead to cost reductions for wind, fuel cell, and biomass technologies. However, as long as relatively few units are produced, prices will remain high with consequential impacts on demand (Powerful Solutions, 1999).

A reduction in the cost of energy technology by 2025 of 40% over 2005 levels has been estimated for a given level of future demand and mix of technologies (Ecotec 1998). In the future, it is likely that generation costs will decrease as the technology improves and economies of scale become more extensive, but this will be balanced against increased costs for integrating higher levels of wind generation into the system (SDC, 2005).

### *Supply intermittency and backup requirements*

Supply intermittency is one of the main factors that make the business case for RE more difficult. Supply from many of the RE sources (solar, wind, tidal, and run-of-river hydro) relies on weather conditions and as such is highly variable and uncontrollable. This is a significant problem when balancing supply and demand because it means that there must be enough generation capacity from conventional sources (mainly fossil fuels) compensating for times of adverse weather conditions, when RE is not produced. This can add significant cost to RE, as these plants need to be manned and/or maintained, even if they are not in operation.

Some studies have warned that the backup costs of wind energy are very high (PB Power, 2004; Pfaffengerger, 2003). However, some other studies argue that, at current target levels, wind intermittency is not a significant issue for RE development (Mott MacDonald 2003 report commissioned by the DTI and the Carbon Trust for the Renewables Advisory Board). Other studies argue that increasing the proportion of wind power in the electricity system does not require great backup capacity, as is often believed, but recognise that it does slightly increase the cost (SDC, 2005). What seems clear from a number of authors is that the balancing costs for RE become more expensive as the levels of electricity generated through intermittent energy sources increases (Mott MacDonald, 2003).

### *Costs of connectivity and transport*

RE incurs significant costs in connecting energy plants to the national grid for transporting the electricity. This is because renewable plants are usually in rural areas and electricity has to be transported to urban centres, where the energy is demanded.

This problem is likely to be exacerbated in Britain because of the lack of significant interconnections to the European grid and its less modern and developed network, compared to other European countries.

One way to avoid or reduce interconnection problems is to supply RE locally, with any shortage being topped up from the grid. This way, the direct generation of electricity for local needs can be of mutual benefit to both the generator and the consumers.

### ***Impact on households and community resistance***

Although there may be wider acceptance of the need to use more green energy, many local communities are concerned about the negative impacts of having wind farms close to their houses. These may include noise levels, visual impacts on the landscape, and negative impacts on wildlife.

In some cases people have also worried about the impact of wind farms on house prices. The results of a survey carried out among real estate experts in areas near to wind farms shows that 60 % of those questioned reported that windmills negatively affected house prices (Royal Institution of Chartered Surveyors, 2004). According to the study, however, these decreases in house prices were only temporary and property prices came back to their initial levels within two years after the construction of wind farms.

Another study carried out by MORI Scotland (2002) shows that only 7% of people living close to wind farms are of the opinion that wind installations had a negative impact on the area. The number of people who view wind farms as having positive impact is almost three times bigger (20%). However, most of the people questioned (73%) feel that it has had neither a positive nor negative impact or expressed no opinion.

### ***Use of emergent technologies and risks***

The whole RE sector in general is considered to be subject to higher risks than the conventional fuel-based energy sector.

According to a survey carried out among the UK investment community, the main risk is related to political factors (34% of those questioned expressed concerns about the lack of government commitment and possible changes in policy after the next election). Investors were also worried about the short-term character of subsidies available (28% of those surveyed pointed out that there is no evidence of commitment to the subsidies in the long term). Uncertainty about future technology is the next issue highlighted (one in four investors had doubts concerning the technology and its long-term reliability). Finally, 18% of those who took part in the survey were concerned about the operational risks such as wind strength below the viability levels (see Gavin Anderson Company, 2005).

In addition, the high capital intensity of RE makes investment in this sector vulnerable to changes in interest rates. Because production of clean energy does not generally require fossil fuels, the main costs of generation are capital

depreciation and interest costs. As a result, increases in interest rate can significantly affect the profitability of renewable power.

Finally, uncertainty around new advances in energy savings (e.g. building insulation, efficient refrigerators), development of new fuels for the transport sector (ethanol, hydrogen) and new ways of transport with higher energy savings are also viewed as potential risks of this industry.

### 12.2.2 The Need of Subsidies

While there are cases of cost-competitive RE sources, at present, the vast majority of RE is only affordable due to subsidies and there is uncertainty if and/or when RE will become cost-competitive and the subsidies may be removed.

The DTI has put in place a variety of mechanisms to assist technologies at different stages of their development, so that they can mature and be deployed on a scale that will reduce their unit costs. The main mechanism to incentivise the generation of electricity from eligible renewable sources in the United Kingdom is the Renewables Obligation.

While there are many national schemes in place to provide financial support for RE schemes in the UK, the majority of schemes funding is linked to a particular region. The types of financial assistance potentially available for RE projects have been identified as follows (Ecotec, 1998):

- Assistance to projects forming part of an existing programme or strategy;
- Energy-specific assistance programmes;
- Assistance to a specific project as part of regional or national scheme;
- Agriculture or forestry related grants, which are universally available.

Such public subsidies are justified by the contribution of RE to achieving environmental policy objectives. Their presence is also indicative of the need for public subsidy to make RE viable.

The public good nature of the environmental benefits of RE results in underproduction of such energy.<sup>137</sup> At the same time, energy based on fossil

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<sup>137</sup> This is because a customer willing to reduce pollution (through buying more electricity from RE, for example) still has to breathe the same air as the neighbour, who might choose not to pay more. In these circumstances, some customers may decide not to pay for pollution reductions and “free ride” from the contributions of others.

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fuels generates negative effects (externalities) that often are not incorporated into the costs of fossil energy.<sup>138</sup> These special characteristics of RE provide the grounds for Government intervention in the form of provision of subsidies.

One recent study on environmental externalities shows that if damage costs resulting from combustion of fossil fuels were internalised into the price of electricity (via incorporating externalities explicitly into the electricity tariff) a number of renewable technologies could be economically competitive (Owen, 2003).

The need to increase energy security in the light of developments in oil and gas markets provides a further rationale for subsidy.

### 12.3 Economic Impacts of RE technologies

There have been a number of studies analysing the economic impact of the RE industry as a whole. The main findings can be grouped in the following subcategories: environmental effects, impacts on the labour market (job creation and effects on wages), energy security, and rural generation. One final aspect to be also considered is the leakage of the investment to neighbouring regions.

#### *Environmental effects*

Investment in RE as an alternative to conventional generation sources can contribute to reducing greenhouse gas emissions,<sup>139</sup> but it can also reduce other forms of pollution from the use of fossil fuels, including smog, acid rain, and reduce the health effects linked to such pollution.

RE also gives rise to negative environmental impacts which include background noise, landscape effects, and effects on wildlife.

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<sup>138</sup> According to the calculations of the European Commission (2003) the external costs connected with energy production based on fossil fuels range between 1- 15 euro cent/kWh with externality costs for coal being the highest (2-15 euro cent/kWh) and for gas being the lowest (1-4 euro cent/kWh). Costs of energy generated from renewable resources are significantly lower and range between 0-1 cent /kWh for all energy sources (apart from biomass).

<sup>139</sup> Most carbon dioxide is produced by energy use. As distinct from fossil fuels RE generators do not produce CO<sub>2</sub> emission during their operation. In addition, only small amounts of CO<sub>2</sub> are produced during manufacturing and construction of RE installations. According to the calculations of EWEA (2006), wind power installations contributed to the reduction of European CO<sub>2</sub> emission in 2005 in the amount of 67 Million Tones of CO<sub>2</sub> saved.

Wind turbines are generally quiet in operation when compared with noise generated by other activities such as road traffic or trains.<sup>140</sup> However, the fact that wind farms are very often located in the areas of low background noise means that the noise produced by wind turbines is easily detectable.

There is also a visual impact of wind farms on the landscape. Opinions vary as to the extent to which this impact is negative. One advantage of wind farms is that installations can be removed relatively easily and landscape returns very quickly to its previous condition (Wind Energy Fact Sheet 4, 2001).

Finally, wildlife can be affected by wind farms through loss of habitat, collision with wind turbines and disturbance to the breeding areas. A study carried out in Europe and in America shows, however, that wind turbines pose minimal risk to birds. According to monitoring studies of the existing wind farms in the UK, birds live in harmony with wind farms (Wind Energy Fact Sheet 4, 2001).<sup>141</sup>

### ***RE as a source of job creation***

RE is often seen as a source of job creation and regional development. For example, the Renewables Network Impact Study estimated that the UK industry in 2003 sustained around 8,000 jobs and that the market was valued at around £280 million (Mott MacDonald, 2003). They predicted that achievement of the Government's 20% renewable aspiration by 2020, should lead to market growth of £15-£19 billion, supporting between 17,000 and 35,000 jobs (depending on the mix of RE technologies).

Another report (Ecotec, 1998) into the impact of RE in the UK used input-output analysis and found that RE technologies generate more additional employment in the economy than conventional energy technologies. The net employment effect of spending on RE is negative in the short term due to the negative effect of the subsidies on consumer expenditures, whereas the effect is positive in the long run after assuming that RE technology becomes economically viable without the need for a subsidy. According to the report

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<sup>140</sup> According to EWEA (2006) noise level produced by a wind farm at 350 meters is about 35-45 db(A) which is less than road traffic or the same as noise level in a quiet bedroom.

<sup>141</sup> This statement is backed up by the results of the study carried out in the Spanish province Navarra, according to which, the mortality rate of birds caused by collision with wind turbines is only 0.22 per turbine (EWEA, 2006).

this will be the case in the 20-year perspective in the UK, and therefore there will be an overall positive impact on employment in the long-term. It is estimated that the net increase in employment will be 225 jobs per TWh (assuming viability of RE) but there is no evidence in the report showing how this number is calculated.

The employment opportunities created by the RE sector can be of a diverse nature depending on existing local resources. For example, communities in the US Midwestern Corn Belt are seeing a considerable economic boom because of the rapid growth of the biofuel industries.<sup>142</sup> It is also believed that since most of the plants are located in rural areas, they are a significant impetus to rural economic development and economic growth (Urbanchuk, 2007).

A meta-analysis by the Renewable and Appropriate Energy Laboratory examined 13 studies on the economic benefits of RE and found that approximately 240,000 jobs could be created and maintained if the US passed a 20 percent renewable portfolio standard by 2020. Instead, relying solely on fossil fuels, the US would only maintain around 75,000 jobs (see Kammen, Kapadia, Fripp, 2004).

A key result that emerges from this previous work is that, for a range of scenarios, the RE sector generates more jobs per megawatt of power installed, per unit of energy produced, and per dollar of investment, than the fossil fuel-based energy sector. One of the reviewed case studies calculates that over 10 years the solar photovoltaic and wind industry generate 5.7 person-yrs of employment per million dollars in investment. In contrast, every million dollars invested in the coal industry generates only 4.0 person-yrs of employment.

The study also shows that different RE technologies generate more jobs per average megawatt of power in the construction, manufacturing and installation sectors, compared to the coal and natural gas industry (Table 4). However, it should be noted that while the majority of jobs in the fossil fuel industry are in fuel processing, and O&M, the majority of jobs created in the RE industry are in manufacturing and construction (biomass energy is an exception, where the majority of jobs are also in fuel production and processing in agriculture, and O&M).

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<sup>142</sup> A report found that the US ethanol industry created over 163,000 direct and indirect jobs, generated \$4.9 billion in federal, state and local taxes and reduced the federal trade deficit by \$11.2 billion in 2006 (Urbanchuk, 2007).

**Table 4: Average Employment (jobs/MWa\*)**

Energy Technology		Construction, Manufacturing, Installation	O&M and fuel processing	Total Employment
Renewables	Photovoltaic	6.21 - 5.76	1.2 - 4.8	7.41 - 10.56
	Wind	0.43 - 2.51	0.27	0.71 - 2.79
	Biomass	0.4	2.44 - 0.38	2.84 - 0.78
Fossil	Coal	0.27	0.74	1.01
	Gas	0.25	0.7	0.95

Note: \* Average installed megawatts de-rated by the capacity factor of the technology (for a 1 MW solar facility operating on average 21% of the time, the power output would be 0.21 Mwa). Figures collected from different studies.

Source: Kammen, Kapadia, Fripp (2004).

Paying attention to the types of jobs created is especially important for regional and state-level policy. For a particular state or region, even if total person-yrs lost in the fossil fuel energy sector are counterbalanced by total person-yrs gained in the RE industry, the actual shift may be from jobs in O&M to jobs in manufacturing. This could have a significant impact on the length of jobs substituted, as O&M are long term positions whereas manufacturing and construction are cyclical jobs (they last until the construction of the energy plant is finalised).

From a policy point of view, it is also important to understand what type of jobs are being lost, and what type created, and determine what sorts of retraining and retooling programs one would need to make sure that jobs remain in the area.

Making the distinction between different types of jobs is also important because the categories have different scale impacts as the industry expands. For example, an expansion of the photovoltaic industry could also lead to the manufacture of more RE system components for export. This would create additional jobs in manufacturing, but no corresponding jobs in O&M.

The analysis by Kammen, Kapadia, Fripp (2004) does not include jobs that may be generated if the US develops a RE industry for export. In this respect, the authors refer to the study by the Research and Policy Center of

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Environment California that shows that for California alone a RE industry servicing the export market can generate up to 16 times more employment than an industry that only manufactures for domestic consumption. Of course, manufacturing for export means producing at an internationally competitive cost, which can be achieved more easily if the domestic market creates sufficient demand to bring renewables rapidly down the cost curve.

It is important to note that switching from fossil fuels energy production to a relatively more labour intensive approach such as RE is not necessarily a net benefit for the region. Jobs can always be created by substituting labour-intensive activities for more capital-intensive activities, but this does not necessarily create a real benefit itself. More jobs are desirable only when they reflect economic growth or additional income (Weisbrod *et al.*, 1995). In the RE sector, benefits could come from increasing the competitiveness of the local economy (as a result of substituting imported energy, or as a way of increasing security of supply).

The conclusion that RE investments undoubtedly create employment is not unanimous. Hillebrand *et al.* (2005) present a study examining the economic impact of the German government's aim of increasing the share of renewable energies from about 5% to 12% by 2010. They employed an econometric model to estimate the impact, placing special emphasis on employment effects. They found that initially there will be an expansive effect resulting from the investment (bringing approximately 33,000 new jobs), but that this effect will be offset and later dominated by a contractive effect, leading to a slightly negative employment balance by 2010.

The view that investments in renewable resources create employment is also questioned in the study carried out by the Energy Institute in Bremen. The study argues that the net economic effect of switching to renewable resources is negative due to the so called "budget effect" (Pfaffenberg *et al.*, 2003). Since RE is more expensive than the conventional energy produced from fuels, this means that consumers of energy have to pay more for the energy they use. As a result, every person has a limited budget and the more money he/she spends on energy the less money is spent on other goods and services. Lower demand on goods and services leads to the lower production, and thus lower employment. Overall, according to the report, one 1.200 kW windmill leads to the loss of 8 full-time jobs over 20 years. Interestingly, in the short run the effect on employment will be positive, as investment in the infrastructure necessary to produce RE will temporarily stimulate demand.

### ***Additional labour impacts***

A number of studies examine the economic impact of moves toward renewable portfolio standards to promote increased generation of electricity from RE resources.

In a recent study Gittell and Magnusson (2007) concluded that an adoption of 20 percent RE target will not only create 1,100 full-time equivalent jobs in New Hampshire, but also with much higher wages. According to this study, this will generate over \$1 million in state revenue in 2025, and will provide a “newfound opportunity for New Hampshire residents to start businesses”.

The study concluded that the renewable portfolio standard could help diversify New Hampshire and the region’s power-generating capacity (reducing dependency on imported sources) and increase the potential for new RE development within the state and help support the continued operation of existing RE resources.

The authors warn that in addition to benefits there are also costs associated with a renewable portfolio standard but assess that, for New Hampshire, the net economic and environmental effect is expected to be positive.

Not only will new RE facilities have positive economic impacts, but sustaining existing facilities will maintain significant economic benefits. In 2005, the average wage per job in an RE facility in New Hampshire was \$65,979, which was well above the New Hampshire 2005 average wage for job of \$39,794.<sup>143</sup>

Some other studies (Broome, 2002) report benefits coming from different levels of skills, including some lower skilled jobs (for example in wood fuel supply chains, waste processing). Other studies (Scottish Renewables, 2007) point out that investments in renewable resources create new jobs (most of which are highly skilled) and have increased the competitiveness of the Scottish economy through the usage of innovative technologies.

### ***Energy security***

The role of RE in enhancing energy diversity and security is also a topic that has received recent attention (DTI Renewables Advisory Board 2006).

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<sup>143</sup> In 2005, existing RE facilities in New Hampshire employed 194 (paying \$12.8 million in annual wages). The hydroelectric power generation industry employed 52 (\$2.9 million in annual wages). Other renewable facilities, including biomass, employed 142 (\$9.9 million in annual wages).

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The supply of coal, gas and oil can be at risk where there is significant concentration of supplying power (for example, the dominant position of Russia as a gas exporter to the EU places a political risk on gas supplies). Moreover, the prices of fossil fuels are very hard to predict and can be subject to large changes over a short period of time. The best example being the price of gas that increased more than four times during 2005.

Against these threats, RE provides the UK economy with an interdependent and indigenous source of energy that is not affected by the price volatility of fossil fuels or by political developments outside the UK.

Additionally, some RE sources experience low variability (such as biomass) and, in many cases, the degree of predictability of the variability is higher than for conventional fuels. Increased security of supply and better predictability of RE production has a positive impact on backup and reserve capacity. Although backup and reserve capacity is required on all electricity networks, additional RE capacity will make it possible to reduce the amount of conventional capacity required to secure electricity demand.

### ***Rural regeneration***

One of the key features of RE generation instalments is that they tend to be located in rural/remote areas, whereas more traditional energy generation plants are more likely to be located in urban areas, near to ports, gas lines, etc. This switch of employment from urban to rural areas means that investment in RE has significant potential for rural economic development.

The RE sector can contribute towards the sustainable development of rural areas in different ways. Rural areas can benefit from new investment and job creation at various skills levels. RE projects can stimulate local manufacturing and therefore improve the performance of the whole regional economy. In the long run, the locality can benefit from a reliable supply of electricity and diversification of economic activities (Bromme, 2002).

ADAS completed a study on the impact on rural development and sustainability of investing in RE for the UK. The aim of the study was to identify and quantify social and economic benefits from RE and the contribution that RE could make to rural development by 2010 based on meeting the 2010 Government targets. The study considered 12 case studies covering a range of RE technologies and estimated the gross economic impact to be a contribution to output of £743 million into the rural economy and 2,465 full-time jobs (ADAS, 2003).

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In the city of Berlin (New Hampshire) RE has been used as an economic recovery tool after the closure of the paper mill. The mill had been in operation for over 100 years and was vital to the economic stability of the community. With the mill's closure in 2006, hundreds of jobs and tens of thousands of dollars in tax revenue were lost. As part of New Hampshire's renewable portfolio standard it was proposed to turn the Fraser Paper Mill into a 50 megawatt (MW) capacity biomass electrical generation facility that could utilize woodchips. After completion (in 2008) the biomass facility will create approximately 500 indirect and 40 direct jobs in the area.<sup>144</sup>

A study of community benefits from wind power found that developers in the UK offer a range of incentives as part of their development plans (DTI, 2005). These include the use of local contractors and manufactured content, habitat enhancement, contributions to community funds, the provision of tourist facilities, the creation of jobs (in operation and maintenance), and ownership opportunities for local people (either individually or through co-operatives).

These benefits can be fairly sizeable. The developer of the Cefn Croes farm indicated that the £35 million project build cost could have led to £11 million spent in Wales, and £1 million spent locally. At Cefn Croes again, the developer is contributing to a £250,000 land management project. Additionally, in some cases, the creation of community funds (increasingly common in the UK) has provided an opportunity for spending on a wide range of items in local communities.

Elsewhere in Europe, wind farms have shown to be a significant source of local tax revenue in otherwise undeveloped areas. A range of *ad hoc* benefits arising as part of the project (such as transport infrastructure and community facilities) has also been reported (DTI, 2005).

Despite the benefits being offered by developers during the application process, experience has shown that there are often difficulties implementing them in practice and finding appropriate sources of local manufactures. Out of ten case studies reviewed by DTI (2005), none used locally manufactured turbines.<sup>145</sup> This problem is further described below.

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<sup>144</sup> "The Economic Impact of RE", by Stephen Lacey. April 20, 2007. Available at <http://www.renewableenergyaccess.com/rea/news/story?id=48201>.

<sup>145</sup> In some cases, the factories that the developers had anticipated sourcing content from had gone bankrupt or were not ready in time leading to turbines being imported instead.

### *Leakage of Benefits*

In some circumstances it has been reported that the benefits of local investment have largely been realised in other areas, or even abroad.

Often, small communities with few large industries see a great leakage of the invested revenue into nearby towns competing for the supply of some services. As a result, these communities experience less indirect and induced impacts of an RE installation.

In some cases, only a small part of the initial capital injection to build RE installation ends up being spent in the local economies. A report by ADAS analysed 12 case studies and showed that less than 12% of the total expenditure on RE projects was spent locally (5% for wind energy, 12% for hydro plants, and 10% for biomass power plants). The report found that the main part of the construction work was usually undertaken by developers from outside the region and that almost all mechanical equipment was imported from abroad (ADAS, 2003).

Another study on RE developments in Nebraska showed that only 30% of the total construction-related expenditures for building wind facilities had been spent in the State (Clemmer, 2001). This was mainly due to the lack of local manufacturing capacity to build wind turbines or their components. In this case, the main benefits for the local economy came not from stimulating the local manufacturing production but from creating employment connected with construction works and from additional tax revenues. It has been estimated that if half of the turbines had been manufactured in Nebraska, an additional 44 million dollars in gross state product would have been produced each year for 10 years.

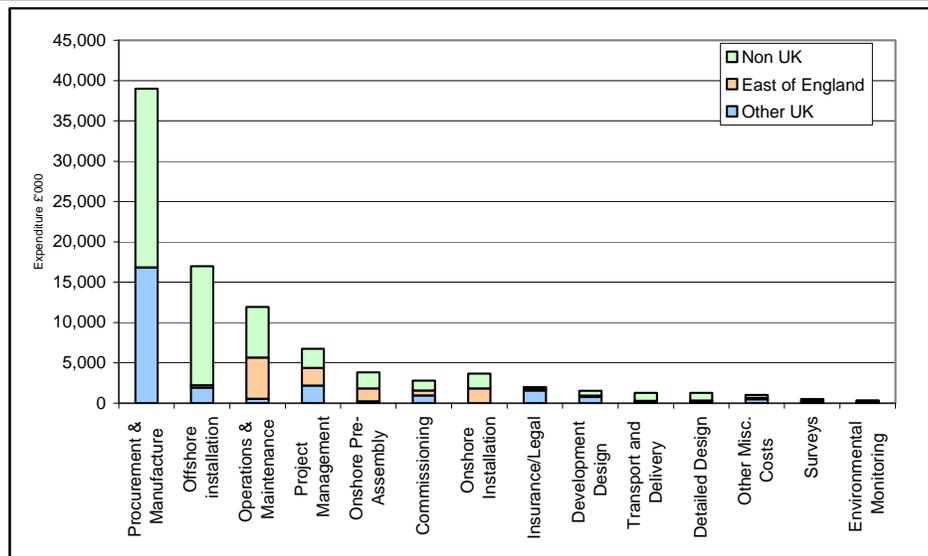
Another analysis of the economic benefits of the wind farm in Scroby Sands (East of England) also shows that the participation of local companies in development of RE installations is limited (Renewables East, 2005). Of the £80 million spent on the project, only £38.8 million were sourced from UK companies (£12.8 million from companies from East of England).

The study shows that the level of the UK and East of England investment content varied heavily depending on the phase of the project development (Figure 6). Foreign companies were able to obtain a high share of a total of £55.7m spent in high-value contracts (they secured 57% of Procurement & Manufacture and 87% of Offshore installation), whereas the majority of UK and local investment took place in the remaining £24.4m spent in low-value

contracts (such as environmental monitoring, survey, insurance/legal and onshore installation works).

The report concludes that if the full capability of the UK and local companies had been used, the size of the contracts awarded to domestic companies could have been significantly higher.

**Figure 6: Scroby Sands - Value by Tier 1 Category (£'000s)**



Source: Renewables East (2005) Scroby Sands- Supply Chain Analysis.

Finally, it is important to note that the extent of capital investment leakages is technology dependent. Hence, investment in specialist goods (e.g. engines or turbines which are in many cases produced by a small number of overseas companies who dominate the market) generally leaks abroad, whereas investment in the less specialised areas of construction and services, on the other hand, generally remains locally, with only a few specialist skills being sources from companies abroad.

## 12.4 The Impact of different RE technologies

There are a number of RE sources that can be used for energy production. In this subsection we review the potential benefits of RE by looking at the environmental and economic impacts.

### 12.4.1 Wind

Wind power is the conversion of wind power energy into electricity. We can distinguish between onshore and offshore wind generators.

#### *Onshore Wind Farms*

The environmental issues of onshore wind farms include: noise generated by wind turbines and their impact on landscape and wildlife.<sup>146</sup> However, in general, all the studies published on wind energy show a low interference between wind farm development and the environment.<sup>147</sup>

Wind farms represent an important source of additional income for local communities. A significant part of benefits for local economy comes from increases in taxes, lease payments to landowners, employment creation, or stimulating the local manufacturing production. The scale of employment creation depends mainly on the capability of the local industry to provide services required by a developer during the construction of a wind farm. In addition, local communities can benefit from the secure electricity supply if electricity is supplied locally.

#### *Offshore Wind Farms*

Environmental issues arising from development of offshore wind farms consider mostly their impacts on marine life. The study of the Centre for Marine Coastal Studies Ltd (2005) shows that there are some fish species present at development sites which can be affected by wind farms. The study concludes that further investigation into the impacts on marine wildlife should be undertaken to measure and assess those effects.

Like onshore, offshore wind farms can also provide extra income for local communities coming from increases in taxes and employment creation.

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<sup>146</sup> A number of studies on impacts of wind farms on local communities show that only a very few people living close to wind farms complain about the increased level of noise or negative visual impact on landscape. A Survey of Local Residents in Scotland (Braunholtz, 2002), for instance, reports that only 4% of those questioned complained about noise or disturbance from traffic during construction.

<sup>147</sup> The noise generated by wind turbines is less than noise levels generated by other industrial activities such as road traffic or trains (EWEA, 2006). As far as the effect on wildlife is concerned, according to the monitoring studies of already existing wind farms in the UK, birds live in harmony with wind farms and cases of birds killed by turning blades are very rare (Wind Energy Fact Sheet 4, 2001). Assessment of the impact on landscape, on the other hand, is very subjective and depends on individual tastes and judgements.

Benefits from construction of offshore wind farms, however, tend to be smaller as these types of projects are usually larger and owned by large developers. However, unlike onshore farms, there are no negative effects related to increased noise or changes to the visual appearance of the countryside (ESD, 2002).

### *Wind in practice*

Wind installations create a direct impact on the economies of rural communities. The case studies reviewed in Pedden (2005) show a positive impact of investment in wind power on rural economies, being reflected by higher employment, income and taxes. The effect on the local economies, however, varies widely depending on the size of the investment and the features of local economy.

In communities in which farming is the only large industry, installation of wind farms creates another industry that becomes a large percentage of the local tax base and contributes to local businesses. In contrast, small communities with few large industries see greater leakage of revenue into nearby towns that provide more services. These small communities experience less indirect and induced impact of a wind installation than a larger community which has the capacity to provide a greater number of services.

The number of jobs created by a wind energy facility depends on the skills available in the community. For example, in Kittitas County (US), 85 local workers and 10 workers from abroad worked in the construction of 260 wind turbines. In addition, 22 employees were hired locally to operate and manage the operation of the wind turbines (Pedden, 2005).

In some cases, a significant part of the benefits for the local community can come from the increases in taxes and lease payments to the land owners. In Vermont (US), for example, the windfarm of 150 M.W. will pay annually 2.7 million dollars to land owners, 2.2 million dollars in property taxes, and 0.7 million dollars in state taxes. In addition, half of 1.3 million dollars required annually for the maintenance materials will be spent in Vermont creating extra 20 jobs in the area and 400,000 dollars in total earnings. It has been estimated that the construction of 260 individual wind turbines in Kittitas County (US) would increase annual property tax revenue by around 2,8 million dollars (see Pedden, 2005).

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Scottish Renewables (2007) review a number of successful projects in the wind RE industry. Livingston Precision Engineering has increased the number of employees working on the domestic wind turbines from 12 to 50 over six months and is planning to create extra 100 jobs due to the rapid demand growth what would bring £2-3m a year to the Scottish economy. Balmoral Group in Aberdeen is experiencing a similar expansion and is going to increase significantly the number of workers.

#### 12.4.2 Biomass and energy from waste

Biomass is produced from organic materials, either directly from plants or indirectly from commercial, domestic, industrial or agriculture products. Energy production from biomass does not require any fossil fuels.

Unlike wind, biomass energy generation involves emission of CO<sub>2</sub> to the atmosphere, but the carbon is part of the current carbon cycle: it was absorbed during the growth of the plant so the sustainable balance between carbon produced and absorbed is maintained. In addition, emission of toxic pollutants can be avoided by installing biomass boilers (ESD, 2002).

As far as energy from municipal or industrial waste is concerned, combustion, gasification and pyrolysis of waste have a number of advantages over waste deposition. First of all, energy is generated from the waste products. Secondly, escape of methane from the landfill sites is avoided. Thirdly, deposition of waste requires a lot of space that can be saved by using the waste for energy production. Finally, it avoids the harmful emissions of waste combustion (ESD, 2002).

Energy generation from biomass benefits local economies mainly in form of additional income to agriculture sector from selling waste products or employment creation. Additionally, using municipal and industrial waste to generate energy, reduces the risks associated with storing this waste, such as risk of leakages of dangerous substances to the local water system (ESD, 2002).

#### ***Biomass in practice***

A report by Arup consultants in association with ESD for the South West of England Regional Development Agency in 2004 estimated (*ex ante*) the economic impact of a 23MW biomass plant proposed for Devon. The consultants use the Biomass Socio-Economic Multiplier (BioSEM) model to quantify the economic impacts of the proposed plant. They estimate that the

plant would bring 263.5 full time equivalent net additional jobs if Miscanthus (a type of grass) was used as feedstock inputs and 171.8 full time equivalent net additional jobs if forestry residues were used instead. They also noted additional positive and negative impacts on other sectors, including agriculture and tourism.

Developments are also taking place in Scotland at the heat and bio fuels sectors. The construction of the UK's largest biomass plant in Lockerbie will create around 340 jobs in the area (Scottish Renewables, 2007).

### 12.4.3 Hydroelectricity

Hydropower is a way of producing electricity from the power produced by water under pressure. There are three types of hydropower facilities: impoundment, diversion, and pumped storage.

Using hydroelectricity power is usually associated with many potential negative environmental effects. Dams may interfere with fish habits by blocking their passages to the ocean. The diversion of water impacts on stream flows and may lead to drying up of some river channels, which, in turn, may result in destruction of some aquatic and streamside habits. Hydroelectric plants can also lower the amount of oxygen in the water, which has an impact on water quality and may lead to the growth of algae and aquatic weeds. Small-scale hydroelectric power production has much lower impact on environment than large dams and reservoirs.

Large-scale hydro projects very often require dislocation of large number of people. Small-scale dams and generators usually do not interfere with people's activities. Regarding benefits, hydro projects can contribute to the local economy mainly through employment creation during construction works (ESD, 2002).

#### *Hydroelectricity in practice*

One of the main conclusions of Scottish Renewables (2007) is that the renewable resources sector is closely linked to other industries. The case study about Glendoe Hydro Power Station, for example, shows that a large number of Scottish firms (mainly from the civil engineering sector) are involved in the process of building the hydro station.

#### 12.4.4 Wave and tidal power

The movement of waves creates a large potential power source. A wave power station converts this energy into electricity. Electricity from tidal power, on the other hand, is generated from tide movements.

Wave power poses a minimal risk to the environment. There is a small hazard that lubricating oil can leak to the ocean but the potential damages are insignificant in practice. In addition, some wave power devices provide coastal protection from floods.

Tidal power generation has a bigger impact on the environment than wave power generation. Construction of barriers across estuaries can affect the quality of water and therefore change local ecosystems, for instance, through reducing mudflats for wading birds (ESD, 2002).

The local economy can benefit from construction works. In the case of tidal power, new developments can also enhance opportunities for water sports (ESD, 2002).

##### *Tidal power in practice*

The proposal for a barrage from the English coast to the Welsh coast over the Severn tidal estuary (the second highest tidal range in the world) has been considered as early as Thomas Fulljames in 1849, though this was more for the transport link than for the electricity generation. However, until as recently as 1989, the project was not considered viable.

In 2002, Sir Robert McAlpine Limited found that the capital cost of the Severn Barrage scheme described in 1989 (estimated to be between £10.3-£14.0 billion, inflated to 2001 prices) had not allowed for improvements in construction methods and productivity since 1988. They also noted that several changes in project finance since 1989 had led to an estimated 40% reduction in the cost of capital for the Project. Based on a "straightforward project financing model" prepared by PricewaterhouseCoopers, generating costs were estimated to be less than £60/MWh (in 2001 terms). Using additional assumptions on market price for base load power and an average selling prices of Barrage power, the study estimated that Barrage electricity could be worth at least £77/MWh. Since the value of the electricity outweighs

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the cost by £17/MWh this suggests that there exists a *prima facie* case for the Barrage.<sup>148</sup>

The recent major investigation into tidal power undertaken by the Sustainable Development Commission re-examined the potential for a Severn Barrage (SDC, 2007). The SDC concluded that there was a strong case for a sustainable Severn Barrage, which could need to be accompanied by a significant compensatory habitats package to counter the possible loss of biodiversity. They noted that a barrage could make an important contribution to UK renewable energy targets and be part of a wider package of measures to reduce greenhouse gas emissions. They also concluded that output variability was unlikely to be a problem in practice and that there would be ancillary flood risk benefits, although they were sceptical about the case for new road and rail links over the barrage.<sup>149</sup>

#### 12.4.5 Solar and Photovoltaic energy

Solar panels work by converting light directly into energy. There are two main types of solar panels: solar water heating collectors using the sun energy to heat water; and photovoltaic (PV) panels which transform the solar radiation directly into an electric current.

Investments in solar panels have a small impact on local employment compared with other RE facilities. The main cost and labour are associated with the production process of solar panels rather than with their installation.

PV modules are very environmentally friendly, make no noise and do not emit any pollutants. In addition, PV modules have very little visual impact. In most cases they can be integrated into the roof structure with little visual impact. There is some negative environmental impact during production of PV cells as it is an energy intensive process.

##### *Solar energy in practice*

Solar energy is still expensive compared with conventional fossil fuels but the costs have decreased significantly over the last years. It is estimated that the

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<sup>148</sup> The consultants noted that the results were sensitive to uncertainty and that a more detailed evaluation was needed.

<sup>149</sup> The need to allow upstream Access for shipping could make this difficult in practice.

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price of PV solar energy in Wales will be competitive beyond 2020 (WOF, 2006)

Similarly to other RE, PV is a rapidly growing industry. In 2005 a total of 1,727 MWp of PV cells were produced. This is an increase of 45% over 2004. The majority of PV installations are located in Germany, Japan and USA (WOF, 2006).

The National Renewable Energy Laboratory estimated that each dollar spent on solar energy power plants in California contributes approximately \$1.40 to California's Gross State Product. According to the report solar energy generates 94 permanent jobs for each 100MW generating capacity, compared to 56 jobs from combined cycle plans. In addition, the 4000 MW solar energy capacity would offset at least 7,6 million tones per year of CO<sub>2</sub> (NREL, 2006).

Solar energy power plants are generally small in size with average capacity between 35 to 80 MW. Currently the biggest solar electric plant is located in Germany in Bavaria but larger projects are currently under construction. For example, Stirling Energy Systems is planning to build a 500 MW plant in the Mojave Desert in California.

## 12.5 Implications for Wales

During the course of this literature review we have not seen any clear evidence of a link between investment in renewable energy production and economic growth, and certainly no evidence linking renewables with step changes in economic growth. This does not necessarily mean that there are no such links.

It may just be that the relevant research has not yet been undertaken. The relatively recent development of renewable energy technologies and the length of time before GDP estimates settle down means that it would be difficult to assess impacts on economic growth. Even if there were such evidence and it suggested no link between renewable energy investments and growth in the past this would not necessarily be a good guide for the future in a sector where the technology is still at a relatively early stage of development.

Nevertheless, according to one study on economic impacts of RE on rural development, the concept of thresholds is not useful for analysing RE impacts on rural economies. The study argues that RE schemes are "inherently small-scale and generate community benefits rather than substantive employment or income generation" (ADAS, 2003).

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The impact of RE in Wales has been described as promising by Broome (2002).<sup>150</sup> Whilst there is the potential for the construction and operation of more renewable plant in Wales to lead to greater levels of employment, particularly in rural areas, the evidence suggests that it is by no means certain that impacts will be significant. There are many examples of benefit leakage, particularly where the manufacture of equipment/plant is not local and where the necessary skills base is not available locally. This does not negate the potential environmental and energy security benefits of investment in renewables production.

### *Potential for First-mover Advantages*

In some cases, investment in emerging technologies can lead to a competitive advantage from being the first entrant in a market. Being a first mover can enable companies to capture scarce resources or valuable assets; make use of experience gained in the initial stages of the project (steep learning curve); and/or gain customer loyalty (Finkelstein, 2002).

Being a first-mover in RE could potentially result in the achievement of a technological leadership essential to stimulate further technological development and being able to export such technologies. Note that this first mover advantage is likely to derive from the research and development and manufacture of renewable energy technology rather than specifically from the use of such technologies in energy production. Though as we noted earlier, local demand may enable more rapid movement down the cost curve and hence better export prospects.

Some authors argue that it is not the first but the second-mover firm who has the advantage as it can learn from the experiences of the first mover and may not face such high research and development costs if they are able to create their own similar product using existing technology. A second-mover firm can also benefit from having an educated public and be able to save in marketing costs for the new project. According to this theory, a fast Second (Geroski and Markides, 2005) lets other companies innovate and experiment to create new markets only to enter the market at the right time to create the dominant design and use its size to capture the market.

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<sup>150</sup> The potential impacts relate to the: providing regional benefits for reaching regional greenhouse gas targets; supporting regional employment at a range of different skills levels; contributing towards sustainable development; supporting the rural economy and help to retain investment within the locality; stimulating local manufacturing; and improving economic performance and exports.

Development of wind energy started more than 20 years ago and there are a number of countries like Denmark or Germany that have been actively supporting the RE sector over the last two decades. Their domestic producers are worldwide leaders in wind technology and account for a big share of the sector's production and expenditures on R&D. Danish Vestas, for instance, is the biggest producer of wind turbines in the world with a market share of around 30%. As a relatively mature sector, opportunities for first movers have long gone, unless there are new opportunities relating to very specific developments in technology.

There may be more scope for first (or second) mover positions in some other renewables energy sectors.

- Wave and tidal energy is still in its early phase of deployment and may present some potential for Welsh companies to become first (or second) movers. The natural conditions in Wales are very good for developing tidal and wave energy. It has been suggested that there is potential for the marine energy industry in the UK to repeat the Danish success with onshore wind turbines (Harrington, 2005).
- Wales also has a developing position in the solar energy industry with a number of companies with development and production facilities, particularly in North East Wales. There is also relevant research capability in the Welsh Higher Education institutions.<sup>151</sup>

### 12.5.1 Potential further research

Whilst research that assesses the impacts of renewable energy production on economic growth does not appear to exist at present, it may well be a number of years before such research could generate useful estimates.

One potential area of further research relevant to the Welsh context could be an examination of the extent to which it is feasible to further encourage/enable the development of those renewables sectors where there is already existing research and development and manufacturing capability in Wales, such as photo-voltaic cells.

A further area of potential research is a review of public sector interventions to encourage the development of research and development and manufacturing in renewables sectors that have been successful in other

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<sup>151</sup> See Welsh Opto-Electronics Forum (2006).

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countries. The manufacture of wind turbines in Denmark and the development of the solar energy sector in Germany and Japan are possible case studies.

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## 13 Economic Development Initiatives

### 13.1 Introduction

In this chapter we review some of the literature that examines the impacts of local and regional economic development initiatives. Much of the literature relates specifically to urban regeneration and the role of cities in driving economic growth.

First we review some of the theoretical developments relating to regional development, focussing in particular on what has become known as the “New Economic Geography”.

Second we draw on the literature to outline some of the key characteristics of successful economic development initiatives.

Finally we present some short case studies that provide a range of evidence in relation to the potential impacts of local and regional economic development initiatives.

### 13.2 Understanding regional development

#### *Policy Issues*

Two of the key issues for the formulation and evaluation of local and regional development initiatives are:

1. the extent to which it is possible, through public sector intervention, to influence the long term economic development of a local area or region; and
2. the extent to which such initiatives can positively influence economic growth at a wider level, often the national level, as well as the targeted local area.

In modern day evaluation parlance, these issues raise questions of “additionality” and “displacement”. Do local economic development initiatives provide local benefits that are additional to those that would have been realised in any case, in the absence of intervention? To what extent do

local economic development initiatives merely displace economic activity, moving it into the target locality from some other locality?<sup>152</sup>

In order to provide a basis for answering questions such as these, economic theories of regional development and urban regeneration have been developing over a long period of time.

It is important to note that this is a case where different theories can lead to stark differences in the analysis of economic developments in any particular location, and also to very different policy prescriptions. An instructive example is given by Barry (2002), who juxtaposes two competing explanations for the 'Celtic Tiger' phenomenon in Ireland. Barry suggests that an interpretation seeing the Irish experience as an instance of 'convergence' in the sense of neo-classical growth theory can lead to a false complacency in policymakers. After all, once convergence has been accomplished, national income moves in line with that of other countries on its steady state path, with no need for policy innovations. If, on the other hand, Ireland's transformation is seen - in the light of economic geography - as a regional boom triggered by specific (tax) policies, much greater emphasis would have to be placed on policies actively promoting foreign direct investment, which has been a cornerstone of the Irish success.

### ***Regional Inequalities***

Much of the focus of the work has been on assessing the extent of regional inequalities and in attempting to explain those inequalities. The key focus of EU regional policy, for example, is on reducing the extent of inequality across European regions - known as convergence.<sup>153</sup>

In the UK, a report by HM Treasury and the DTI noted the size and persistence of regional differences in economic performance. The already large gap between GDP per head in London and the South East and GDP per head in the remainder of the UK increased further over the period 1995-2001.<sup>154</sup> The report attributed these differences in economic performance to

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<sup>152</sup> Displacement is a very similar concept to the idea of additionality at the national level. Additionality is usually used to refer to the additionality of benefits at the local level (ODPM, 2006).

<sup>153</sup> See our discussion of EU policy in this area as one of the case studies later in this chapter. Note that this usage of the term 'convergence' is distinct from its use in the context of growth theory (see Chapter 7).

<sup>154</sup> HM Treasury (2001).

many different factors including skills, the mix of occupations, employment and inactivity rates, and productivity.<sup>155</sup>

### *Spatial Concentration of Economic Activity*

Within the field of regional economics, there has been a traditional interest in understanding the factors that govern the distribution of economic activity over space, and the consequences for individuals and communities as this distribution changes.

Modern regional theories focus on the type of characteristics of different locations (city, region, local area) and how these may contribute to local growth. Among these, a primary role is played by local knowledge, human capital (skills), technology, investment, innovation, enterprise, employment and competition.<sup>156</sup>

Historically, physical attributes of an area such as climate and natural resources were used to explain the location of many kinds of economic activity. According to this argument, regions and cities developed mainly because of the benefits of proximity to natural resources, infrastructure, or to a centre of administration or government. This proximity reduced the costs of bringing together people and goods for the purposes of exchange and production (DCLG, 2006).<sup>157</sup>

The importance of location and proximity to other businesses was recognised in research in the early part of the twentieth century but was not modelled explicitly until the 1960s and 1970s. This recent research demonstrated that factors other than natural resource location play an important role in explaining the spatial pattern of activities. A new wave of studies confirmed the existence of productivity gains arising from economies of scale achieved thanks to spatial concentration and agglomeration (Hoover *et al.*, 1984, provide a review).

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<sup>155</sup> University of the West of England (2005) also records, and seeks to explain, productivity differences between Wales and other GB regions.

<sup>156</sup> For instance, highly skilled workers are able to adapt more quickly to new innovations in the workplace, and therefore can contribute better to improving the productive processes of their firms (Frontier Economics, 2004).

<sup>157</sup> For instance, mining and heavy industry developed in the Ruhr valley in Germany, as coal and iron occurred naturally in this region. New York and New Orleans became great port cities because of the natural water-level route to the interior of the country (Hoover *et al.*, 1984).

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The concentration, or agglomeration, of economic activity is a persistent feature of global economic activity at several levels: towns and cities, industrial regions and the clustering of similar activities within city districts. Much work has been done to explain and categorise a range of economic forces that lead to this tendency towards agglomeration.

A number of different supply-side and demand-side agglomeration forces have been described in the literature.<sup>158</sup> Supply side forces include:

- company level economies of scale - falling unit costs as production scale expands;
- localisation economies or economies of scale at the level of the industry/sector. These include information externalities, access to a wide variety of differentiated intermediate goods and services, labour pooling and greater employment opportunities;
- urbanisation economies or economies of scale at the level of the town/city. These include concentration of different sectors in the same location, cross-product technological externalities, sharing of specialised intermediate inputs and economies of scope in production; and
- dynamic agglomeration - this includes economies that relate to knowledge transfers over time due to the concentrations of firms both within industries and across industries.

The demand effects of agglomeration relate to two main advantages. On the one hand, the average cost of providing local public goods (public infrastructure) declines with increases in the population of a city. On the other, a wider variety of goods in bigger cities increases the consumers' utility and enlarges the scope for product complementarities.

In addition to these economic forces that give rise to a tendency towards agglomeration, it is postulated that there are also counteracting forces that give rise to tendencies for dispersion of economic activity. It is the combination of these opposing forces in different ways and circumstances that lead to the wide variety of degrees of agglomeration that we see in practice (e.g. different town and city sizes). The forces for dispersion, or agglomeration diseconomies, are usually attributed to factors such as

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<sup>158</sup> See, for example, Abdell-Rahman (2000).

congestion, higher prices for land and labour, and more intense competition in output markets.<sup>159</sup>

### *The “New Economic Geography”*

Drawing on ideas and models developed as part of trade theory, the modelling of agglomeration effects has been extended since the early 1990s with more complex models that place a greater emphasis on the role of transport costs and trade in explaining the spatial concentration of activity. Some of the more recent models also emphasize the role of innovation and knowledge spillovers in explaining and determining policy outcomes (ODPM, 2006). These developments are sometimes known as the New Economic Geography (NEG).<sup>160</sup> NEG was pioneered largely by Masahisa Fujita, Paul Krugman and Anthony Venables in order to contribute to the explanation of the formation of a large variety of economic agglomerations in geographical space (McCann, 2005; Fujita, 2005).

The two region core-periphery model provides the basic introductory framework for the NEG (Fujita, 2005). According to this model, the location of business activity is driven by three effects:

- the ‘market access effect’ that describes the tendency of monopolistic firms to locate their production in the big markets and export to small markets.
- the ‘cost of living effect’ that reflects the fact that goods tend to be cheaper in the region with more industrial firms (consumers in the region will import a narrower range of products and thus avoid more of the trade costs).
- the ‘market crowding effect’ that relates to the tendency of firms to locate in regions with few competitors.

The first two effects encourage spatial concentration while the third discourages it. Box 1 provides an indication of how the core-periphery model works in a conceptual sense.<sup>161</sup>

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<sup>159</sup> See Graham (2006).

<sup>160</sup> This term is generally used rather loosely – sometimes it is used to describe all of the modern work that relates to agglomeration and spatial concentration. We follow the approach in ODPM (2006).

<sup>161</sup> The text in the box is taken almost verbatim from Baldwin *et al.* (2004). Some minor amendments to the text have been made for further clarification.

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**Box 1: A Core-Periphery “Thought Experiment” (Baldwin et al, 2004)**

Suppose there are two identical regions – ‘north’ and ‘south’. Now consider a situation where this initial symmetry is broken by a single industrial worker migrating from the south to the north.

Since workers spend their incomes locally, the southern market becomes smaller and the northern market becomes larger.

- Due to the market-access effect, the changing market size tends to encourage some industrial firms to relocate from the south to the north.
- However, this industrial relocation will, via that the cost-of-living effect, make a given northern nominal wage look more attractive than the same wage in the south.

For this reason, the initial migration shock may be self-reinforcing; migration may alter relative real wages in a way that stimulates further migration.

However this is not the only possible outcome.

The south-to-north shifting of firms increases the competition for customers in the north and reduces it in the south. This ‘market crowding effect’ means the northern firms will have to pay a lower nominal wage in order to break even, while the opposite happens in the south. For a given cost of living, this makes location in the north less attractive to workers/migrants.

Plainly, there is a tension between the market-access/cost-of-living effects – what we call agglomeration forces – and the market crowding effect– what we call the dispersion force.

- If agglomeration effects are stronger than the dispersion effect any migration shock will trigger a self-reinforcing cycle of migration that results in all industrial workers, and thus all industry, moving to one region.
- Yet if the dispersion force outweighs the agglomeration forces, the initial symmetric equilibrium is stable in the sense that a migration shock lowers the north’s real wage relative to the south’s and this reverses the initial shock.

Migration shocks, in other words, are self-correcting when the dispersion force dominates but self-reinforcing when agglomeration forces dominate.

### *Non-linearities and threshold effects – the impact of trade costs*

Trade cost, which is often treated synonymously with transport cost, is the key variable in balancing dispersion and agglomeration forces in the core-periphery model. When trade costs are very high the dispersion force is dominant and spatial concentration is limited.<sup>162</sup> When trade costs decline both dispersion and agglomeration forces weaken.<sup>163</sup> However, the nature of the models means that dispersion forces weaken more rapidly than agglomeration forces. This means that there comes a point where agglomeration forces become stronger than dispersion forces. At this point, known as the “break point”, the self-reinforcing nature of agglomeration forces (see Box 1) means that economic activity rapidly shifts to the core region. This process is sometimes called “catastrophic agglomeration”. The non-linear nature of this relationship is a key feature of core-periphery models.<sup>164</sup>

It is also possible to consider the reverse of the process described above. Where trade costs are low and a high degree of agglomeration is present, then increases in trade costs beyond a different threshold, the “sustain point” will lead to dispersion forces outweighing agglomeration forces and to a more symmetric distribution of economic activity between the two regions.

The threshold effects inherent in the presence of a break point and a sustain point mean that the model suggests that if an economy features a core-periphery pattern with the industry concentrated in one area, small policy interventions can be ineffective. In this sense, regeneration projects will have to provide incentives strong enough to compensate for agglomeration rents arising from economies of scale. Only when policy interventions reach a certain threshold level will firms start relocating to the periphery area. This initial relocation of firms will, in the model, reduce the agglomeration even further and will generate a circular cycle that will eventually lead to a massive geographical shift of the industry into the less developed region (Baldwin *et al.*, 2004).

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<sup>162</sup> Companies in each region tend to supply the markets in their own region as the costs of trade between regions outweighs any differences in the cost of production.

<sup>163</sup> This is because greater competition between firms in the two regions means that the differences between the two regions are smaller.

<sup>164</sup> This paragraph and the following paragraph, draw heavily on ODPM (2006).

***Extending the NEG model to include technology spillovers***<sup>165</sup>

A further set of models uses an endogenous growth framework to analyse the effects of technology spillovers on the relationship between spatial concentration and economic growth. Physical capital is generally assumed to exhibit diminishing returns to scale, but other forms of capital such as human capital (knowledge, ideas) can be viewed as exhibiting increasing returns to scale – the marginal cost of creating an idea declines as the total stock of ideas increases (i.e. with knowledge accumulation). In spillover models, this is viewed as a technological externality, or spillover – innovators today benefit from previous innovation.

In “localised spillover” models, the importance of location is introduced by raising the possibility that spillovers could decline with distance. This may arise if proximity, such as face to face interactions, is important for knowledge transmission. In the models it means that innovators benefit more from innovation in their own region than from innovation in another region. This reinforces agglomeration effects as the region with the larger initial endowment of knowledge is able to innovate more rapidly and hence has higher levels of economic growth.

Increasing the degree of knowledge spillover from one region to another acts as a force for dispersion, as innovators in one region are able to learn more from knowledge accumulation in the other region and hence have less reason to migrate.

This is a key difference between this model and the core-periphery model. The latter suggests that further integration between regions, e.g. by reducing trade (transport) costs, always leads to greater agglomeration. In the localised spillover models, however, increased integration can lead to both agglomeration and dispersion effects (depending in the relationship between the size of the spillovers and the size of trade costs). This leaves open the possibility that dispersion effects can dominate agglomeration effects and that stimulating inter-regional diffusion of technology and knowledge can provide a firmer basis for reducing regional inequalities than more traditional policies based on physical infrastructure.

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<sup>165</sup> This section draws mainly from Baldwin et al (2004).

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### *National Impacts of local Initiatives*

Regeneration policies can enhance economic growth at the national level by raising productivity or by activating unemployed or underused resources such as labour, land or capital (WDA, 2002).

However, regional policies can sometimes decrease national output. It has been argued that some regeneration projects do not stimulate expansion of business activity but simply relocate existing employment. This relocation of business can impact negatively firms' productivity (and thus national output) if conditions in the new area are less competitive than in the original one. Furthermore, regeneration can lower national output insofar as the cost of projects places a burden on the public by increasing taxes or reducing spending in other areas (ODPM, 2006).

The NEG models also provide some insights into the potential impact of regional policies on national growth. Baldwin et al (2004) suggest that the main policy implications of the NEG models (where congestion effects are not significant) are as follows:

1. infrastructure policies that facilitate transport between regions will increase both regional inequality and national growth;
2. infrastructure policies that facilitate transport within poor regions will decrease both regional inequality and national growth; and
3. public policies that facilitate the inter-regional diffusion of technology spillovers decrease regional inequality and increase national growth.

Where congestion effects at high levels of spatial concentration are taken into account, the NEG models imply the possibility of multiple outcomes – some of which are "good" and some of which are "bad" from the growth perspective. In particular, they imply that where congestion is a factor, policies that improve infrastructure in the poor region can improve both national growth and reduce regional inequality.<sup>166</sup>

### *Empirical Estimates in Europe*

Empirical work linked to estimating the effects of agglomeration and the NEG models is limited, particularly outside the USA. One of the reasons is that the complexity of the NEG models means that they are analytically

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<sup>166</sup> Baldwin et al (2004).

difficult to use. Nonetheless, several attempts have been made to apply NEG concepts in the European context.

A high level discussion by Venables (2005) looks at broad trends in Europe. National economies have been increasingly integrated into a single European economic area. While this generally suggests that the NEG paradigm should be applicable, the continuing barriers between countries (languages, regulations, etc.) and continent's history as an accumulation of competing independent nation states means that the application is often not straightforward.

Thus, while EU countries become more specialised over time in terms of the location of industries, in line with NEG predictions, specialisation is still low compared with US. Income differences between countries have diminished, although incomes in the periphery are still considerably lower on average than in the centre<sup>167</sup>.

At the same time, differences within countries have remained largely unchanged. Within countries, population density is an important determining factor for per capita income and income growth, and the importance seems to be increasing.

In terms of inter-regional specialisation, path-dependency means that in Europe, where there are many pre-existing clusters, specialisation is imperfect. Moreover, continuing labour immobility across European borders sustains an inefficient dispersion of population across a large number of urban centres. A development towards the US pattern of city size distribution and specialisation would see the smaller cities lose population to large urban centres. However, as in the US, the end point of the developments in progress in Europe are likely to be similar to the outcomes observed in the US, with a small number of diversified large cities and a greater number of specialised small ones.

Midelfart-Knarvik and Overman (2002) analyse the economic policies of the European Commission in the light of NEG. Starting from the premise that EU integration by necessity causes structural changes in Member States' economies, the authors describe the conflict that arises from the Commission's twofold commitment to a) foster integration and b) maintain social cohesion.

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<sup>167</sup> Venables (2005) takes Luxemburg as the centre of Europe and estimates that incomes drop by 15% with each doubling of the distance from that centre.

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A cornerstone of the pro-integration agenda is the fight against market distortions caused by State Aid, while the EU's efforts for greater cohesion are concentrated in the Structural Funds programme, which provides just such aid. Aid can be horizontal (eg for SMEs, R&D, regardless of sector and location); sectoral (primarily shipbuilding, steel); or regional.

Against this backdrop the authors argue that EU countries have become more specialised, but the role of objective factors, such as natural endowments and comparative advantage in this specialisation is unclear. In some cases, EC policy, particularly incentives to locate R&D-intensive industries in structurally weak regions without the necessary endowments, seem to run counter to market-driven specialisation. State aid, on the other hand, does not have a significant effect on the location of firms.

Within countries, patterns of specialisation have not changed, but industrial activity has become more concentrated in the centre. Overall, the authors conclude that state aid does not have significant distorting effects and that, while the availability of structural funds does influence firms' location decisions, it often offsets comparative advantage. They cite the case of Ireland as the only example, where, thanks to pre-existing domestic policies (eg in education) structural funds worked as complements to other factors resulting in agglomeration and regional growth.

There is also some empirical work in the UK, that examines the importance of agglomeration effects. One study reviewed the contribution of various factors, including agglomeration, to regional differences in productivity across the English regions, Wales and Scotland.<sup>168</sup> It concluded that one of the factors determining productivity variations was agglomeration or proximity to "economic mass".<sup>169</sup>

Work by the Welsh Assembly Government drew on this study to conclude that (the lack of) agglomeration effects explain a higher proportion of the low output per head in Wales than for any other country or region of Great Britain.<sup>170</sup> They concluded from this, and other evidence, that investing in enhanced transport links between the South Wales Valleys and Swansea,

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<sup>168</sup> Rice and Venables (2004).

<sup>169</sup> More specifically, proximity to a large population of working age within 80 minutes or less driving time

<sup>170</sup> Reported in Welsh European Funding Office (2007), Annex A.

Newport and Cardiff would have the greatest impacts on productivity in the West Wales and the Valleys area.

Previous research<sup>171</sup> for the Welsh Assembly Government's Economic Research Advisory Panel suggests that travel time to major UK conurbations, and local population density, both contribute to the productivity gap between Wales and the remainder of Great Britain. It concludes that the policy implications are not straightforward, but suggests that one possible policy response could be a continued emphasis on the expansion of the Cardiff region, perhaps followed by an expansion in Swansea.<sup>172</sup>

### 13.3 Characteristics of successful initiatives

There is a wide literature that considers the critical success factors that need to be in place in order to ensure effective economic development and regeneration initiatives.<sup>173</sup> This includes policy guidance documents, evaluations of projects and programmes as well as academic research.

The search for social, economic and political initiatives that can effectively create growth in different regions has been a constant topic of discussion particularly where traditional industries have declined, or in cases where the aim is to give a more prosperous region the stimulus necessary to achieve world-class status (WDA, 2002).

In this context, a number of studies highlight the important role business plays alongside Government and the organisations located within the regions. Naturally, firms need to compete nationally and internationally for their products and services, but to do so they make use of the "urbanisation advantages" that can be found in cities and regions.

The most fundamental advantages include access to factors of production (primary goods, labour, land, buildings), markets (concentrations of suppliers, customers and competitors), and public services (schools, universities, hospitals, cultural and leisure facilities).

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<sup>171</sup> University of the West of England (2005).

<sup>172</sup> The study recognises that this may provide little to meet the needs of much of the rest of Wales.

<sup>173</sup> See, for example, British Urban Regeneration Association (2002); Department for Communities and Local Government (2007); and Department for Transport, Local Government and the Regions (2002).

In modern economies driven by knowledge, successful cities also offer pools of technical and professional labour, finance, training, knowledge and information and specialised knowledge-intensive business services. Other local advantages include specialised knowledge relevant to a sector.

In today's global economy, regions have the need to constantly rebuild their economies if they are to prosper. The pace of technological change and the speed of product development in both manufacturing and service sectors means that enterprises, regions and nations must rethink their strategies and devise creative ways of renewing their competitive advantages so that they can increase prosperity (WDA, 2002).

In this regard, economic initiatives for regeneration of deprived regions or areas with industries in decline must be designed in a context that understands and takes into account the forces leading to economic success.

In simplified terms successful cities are those that, by keeping their enterprises competitive, productive and innovative, lead their regional and national economies. In general, such cities have one special ability which is "to continually upgrade their business environment, skill base, and physical, social and cultural infrastructures, so as to attract and retain high-growth, innovative and profitable firms, and an educated, creative and entrepreneurial workforce, thereby enabling them to achieve a high rate of productivity, high employment rate, high wages, high GDP per capita, and low levels of income inequality and social exclusion" (ODPM, 2006).

In the remainder of this section we draw on the literature to summarise some of the key characteristics of successful economic development initiatives.

### ***Clear objectives, pre-project analysis and on-going monitoring***

Regeneration projects need to identify clear long-term goals. A long-term vision and the long-term allocation of resources are necessary if the regeneration project is going to bring a lasting change (BURA, 2004). At the same time, regeneration schemes have to be flexible. This is necessary to cope with uncertainties and problems that might emerge during project development (RACS, 2004). A 20-year plan that cannot adapt to changing circumstances will very quickly become outmoded and be of little use (BURA, 2002).

Successful projects are usually based upon a detailed analysis and understanding of the area being developed. This analysis should identify weaknesses and strengths of the area, as well as, opportunities for future

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developments, and potential threats to the successful implementation of the regeneration projects. Nevertheless, care needs to be taken in developing the analysis. One of the case studies later in this Chapter provides an example of the potentially damaging impacts of poor analysis.<sup>174</sup>

Ongoing monitoring and evaluation is an essential component of any economic development initiative. It helps assess whether the strategy and objectives of the initiative are still valid, enabling adjustment in response to changing circumstances. It can also show whether the objectives of the regeneration strategy have been achieved. Regular evaluation can also help to determine which groups are benefiting from regeneration projects and which are losing as a result of new developments (RACS, 2004). The Temple Bar and Barcelona case studies later in this chapter give examples of how some groups may lose out.

### *The physical and natural environment*

One way in which a regeneration project may increase economic activity is through first providing a distinct improvement in the quality of the physical and natural environment. This could stimulate an increase in growth through the attraction of inward investors, the inward migration of skilled workers, and limited outward flows of skilled workers. In this respect, it is important for urban regeneration initiatives to make “places where people want to live” (NAO, 2007). Strong neighbourhoods can play a vital role in this process (Department for Communities and Local Government, 2007). Many cities possess specific physical and economic assets and successful development initiatives are often based on developing their potential (DCL, 2006).<sup>175</sup>

### *Joined-up approach to city regeneration*

It is widely recognised that regeneration projects cannot operate successfully as single elements (e.g. new housing) in isolation. The case studies discussed later in this chapter all involve a range of coordinated activities that aim to complement and support each other. For instance, development of a cultural

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<sup>174</sup> The North East Coal Mining Project in Canada.

<sup>175</sup> For example, Boston used its abundance of colleges and universities to develop the high-tech economy. Chicago, on the other hand, took an advantage of its central location in the USA and encouraged many big companies to move there their headquarters.

centre or stadium may often need to be accompanied by the development of other leisure facilities such as shops, restaurants and pubs. In addition, improvements in public transport or road infrastructure may be required in order to ensure an easy access to the area under redevelopment (BURA, 2004).

Economic development initiatives also need to focus on both social and economic development. It has been widely accepted that issues such as social inclusion or reintegration of disadvantaged urban areas should be seen as central to the regeneration agenda (Lang, 2005). Cities should engage in initiatives that would support low- and moderate-income families in their attempts to achieve higher incomes. For example, training programs can help low skilled workers to improve their qualifications and to move to the sectors of the economy with greater opportunities (DCL, 2006).

### *Participation*

It is widely recognized that participation of a broad range of partners, including local communities, entrepreneurs, professional bodies, business associations and non-Governmental organizations, is essential in ensuring the success of complex regeneration projects.

Public private partnerships, for instance, can help to secure realistic sources of funding; be more efficient in certain activities (such as new construction techniques); or may have significant comparative advantages (e.g. in the case of the management of complex programs) (Regional Activity Centre Split, 2004). However, on its own, the involvement of the private sector does not guarantee the success of the project. Evidence from some regeneration schemes shows a number of projects that had substantial private sector involvement but for a range of different reasons (poor management, unrealistic objectives) did not achieve all their potential (Department for Transport Local Government and the Regions, 2002).

The engagement of residents and local communities is crucial for the success of regeneration projects. This requires involvement of local people at an early stage to enable exchange of ideas and to ensure that the proposed schemes are best focused on their needs and priorities (DTLR, 2002). Including community representatives in the decision making process further enables them to play a full and effective role.

The NAO (2007) report highlights that achieving demand (for new jobs and housing) to meet enhanced supply is one of the greatest challenges of a

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regeneration programme, and stresses that pro-active marketing is essential in ensuring that sufficient investment is achieved.

### *Specialisation and Diversification*

There is an unresolved issue as to whether economic specialisation or diversity is most conducive to innovation, entrepreneurship and business dynamism.

On the one hand, specialisation can be a source of competitive advantage for regional economies – it is also one of the factors contributing to theories about the benefits of agglomeration. Concentration of industrial production in relatively small geographical areas can stimulate accumulation of sector-specific expertise, which in turn can lead to growth in the knowledge base and product innovation.

On the other hand, highly specialised urban economies can face a greater risk of becoming over-reliant on a particular sector and are more vulnerable to external shocks (shifts in competition, trade and technology). The North East Coal Mining Project, discussed as one of our case studies later in this chapter, provides a good example of the dangers of over-reliance on one sector.

It has been argued that the most successful city regions appear to be those characterised by what might be termed “clustered diversity”, i.e. the presence of several specialised clusters of activity (DCLG, 2006).

### *The Creative City*

Recently, the concept of “creative city” has emerged in the theory of urban regeneration. The term is used to describe a city that can stimulate creative activity and innovation. The creative city is a place where people want to live and work, a place with vibrant neighbourhoods, relative freedom from social deprivation and access to employment and social services (Gertler, 2004).

Creative cities play an important role in enhancing the dynamism, resilience and overall competitiveness of the economy. They offer opportunities for cross-disciplinary learning, and promote innovation in a wide array of occupations and industries.

Creativity of the city can be enhanced through regeneration projects aimed at developing both its formal and soft infrastructure (Bradford, 2002). Formal (or hard) knowledge infrastructure is made of science and technology resources such as universities, research centers, community colleges and

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technology transfer organizations, as well as the availability of local financing for innovative business.

The soft infrastructure factors are important in attracting the human intellectual capital. In order to develop economically and socially, cities have to create a favourable environment, where well-educated, creative people will want to work, live and play (Gertler, 2004). This includes a rich offer of cultural activities (music, visual and performance arts, theatre, dance, literary events) and a social environment characterized by tolerance of difference and low “barriers to entry” into social networks (Florida, 2002).

## 13.4 Case Studies

For Phase two of this study we were asked to review examples of economic development initiatives. In order to illustrate some of their potential impacts we provide here some short case studies of a number of economic development initiatives. Before we discuss our own case studies we refer to a study undertaken for the Welsh Development Agency and One North East which undertook sixteen case studies relating to regional development.<sup>176</sup>

The WDA/ONE study aimed to review development activities in a number of regions around the world where it was considered that a greater level of success was being achieved and where lessons could be learnt that were relevant to Wales. Twelve of the case studies were based on regions that had had general success and four of them were based on regions providing insights into an activity of particular interest. The case study regions are summarised in Table 13.1.

The main conclusions from the WDA/ONE report were as follows:

“The over-riding objective must be to create competitive advantage for the region and its businesses, so that prosperity rises rapidly. The key twin principles are to give priority to developing local businesses, especially those with growth potential, and to encourage an enterprise culture, with newly designated ‘Entrepreneurial Universities’ (modelled on Darmstadt, Östergötland, Oulu and Twente) at the heart of the effort. The aim is, above all, to increase capability rather than simply to grow capacity. Support to businesses should be oriented to providing

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<sup>176</sup> Welsh Development Agency (2002).

practical help to secure competitive advantage through increasing productivity and sales and developing new and better products and services. Other crucial subsidiary themes should be internationalisation, sectoral specialisation (cluster development) and human resources development.” (WDA, 2002)

**Table 13.1: Case Studies in the WDA/ONE Study**

<b>Region</b>	<b>Country</b>	<b>Criterion for inclusion</b>
Atlanta	USA	General success
Auckland	New Zealand	General success
Cambridgeshire	United Kingdom	General success
Cleveland	USA	General success
Darmstadt	Germany	University involvement & hi-tech clustering
Emilia-Romagna	Italy	General success
Ireland	Ireland	General success
Limburg	Belgium	General success
Limburg	Netherlands	General success
Östergötland	Sweden	General success
Oulu	Finland	University involvement & hi-tech clustering
Overlissel	Netherlands	General success
Pais Vasco	Spain	General success
Quebec	Canada	Public investment in companies
Rhône-Alpes	France	General success
Singapore	Singapore	Changing attitudes to entrepreneurship and creativity

*Source: WDA (2002)*

Our case studies were chosen mainly on the basis of the availability of evidence in the literature of their actual or expected economic impacts. We

also sought to avoid duplicating the WDA/ONE material and other material provided elsewhere in this report. Much of the literature we discuss in the sector-specific chapters of this report relates to the economic impacts of specific initiatives. We were specifically asked to look at “major economic development initiatives from around the world that had been designed to alter the economic fundamentals of a location (e.g. Cardiff Bay).” Whilst we examined available evidence linked to Cardiff Bay and a similar sized scheme in Temple Bar, Ireland, we focussed mainly on much larger scale initiatives. Initiatives such as the North East Coal Mining Project, the Thames Gateway and Emscher Park of involved expenditures of many hundreds of millions of pounds.

In addition to a number of case studies involving specific localities, ranging in size from the Cardiff Bay development to the North East Coal Mining Project in Canada, we review evidence related to the impact of the European Union structural funds on regional development and convergence. The list of case studies is provided in Table 13.2 below.

**Table 13.2: Summary of Economic Development Initiatives: Case Studies**

Location	Country	Main sources
Cardiff Bay	United Kingdom	Cardiff Council (2005) Francis et al (2006)
Thames Gateway	United Kingdom	Dept. for Communities and Local Government (2006) Dept. of the Environment (1995) National Audit Office (2007) Thornton et al (2006)
Barcelona	Spain	Barcelona Field Studies Centre (2007) Brunet (2005)
North East Coal Mining Project	Canada	Gunton (2003)
Temple Bar	Ireland	McCarthy (1998, 2002) Montgomery (1995)
Emscher Park	Germany	Environmental Protection Agency (2007) Guerra (2004) Shaw (2002)
Bilbao	Spain	HDS (2005) Plaza (2006)
EU Regional Policy	European Union	EU (2007) Rodriguez-Pose et al (2004)

Source: *LE Wales*

The relationship between large-scale development initiatives and urban regeneration has had a long history. The 1851 Great Exhibition in London and the 1855 World Fair (Exhibition Universelle) in Paris perhaps provide two examples of such events being used to fundamentally reconstruct a city in order to make it more public and 'on display', through massive investments in architecture, design, transport and communication, whose legacies remain apparent in both cities today (Flew, 2005).

Large-scale events have often focused upon urban regeneration and developing a global profile around major sporting events (e.g. Olympics, World Cups) or trade and technological showcases (Expos, World Fairs).

Recently, arts and cultural activities have also been welcomed as a new way of transformation, regeneration and promotion of cities.<sup>177</sup>

### 13.4.1 Cardiff Bay, United Kingdom

The Cardiff Bay regeneration programme was originated with the mission statement to put Cardiff on the international map as a superlative maritime city, thereby enhancing the image and economic well-being of Cardiff and Wales as a whole.

Over the past 15 years, the old docklands area of Cardiff has been revitalised with new residential, business, retail and leisure developments in what, Cardiff Council claims, is now regarded as one of the most successful regeneration projects in the UK (Cardiff Council, 2005). According to the Cardiff Council the regeneration of Cardiff Bay resulted in:

- The creation of many new jobs (17,000 permanent jobs and 13,000 construction jobs supported by the developments themselves) and completion of many new homes (5,000 new homes by 2005, with a further 5,600 planned).
- A variety of infrastructure developments including offices, Cardiff's first 5 star hotel, an open-air events arena, an international arts centre, the National Assembly of Wales Debating Chamber, and the construction of the Cardiff Bay Barrage, creating a 200 hectare freshwater lake.
- Transport developments including the Butetown Link and tunnel and the Peripheral Distributor Road.

The success of the Cardiff Bay has been questioned by some authors. One study reported that the development of the Cardiff Bay area simply encouraged a large amount of redistribution of economic activity from

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<sup>177</sup> There are many examples of regeneration schemes that successfully applied innovative and creative thinking in resolving urban problems. Some of these examples include a small scale intervention. Valencia, for instance, to avoid flood damage, diverted the river Turia from the city centre and turned the former riverbed into an urban park with leisure facilities. This move, not only solved the problem of flooding, but also gave the city green space and created a quiet zone. Paris, on the other hand, was very successful in coupling contemporary architecture with historical buildings. The glass pyramid in front of Louvre, for example, became one of the city's landmarks and redefined the monumental complex and its relationship to the rest of the capital. Innovative thinking applies also to transport systems. A number of cities have already used artists in the development of transport schemes. Many stations of Stockholm underground system, for instance, have been decorated by artists. As a result the Stockholm metro is an attraction which draws visitors (Landry, 1998).

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elsewhere in Cardiff. The paper examined two projects within the area and estimated that 43% of business movements between premises over time represented displacement of existing business activity rather than new activity. (Francis *et al.*, 2006).

An International Sports Village is currently being developed in the Bay. According to Cardiff Council, the Sports Village is expected to attract 3.5 million visitors with an anticipated spend of £270 million providing up to 5,000 jobs and creating an additional 2,500 jobs within the region.<sup>178</sup>

### 13.4.2 Thames Gateway, United Kingdom

The Thames Gateway Program is currently in progress in the South East of England and is Western Europe's most ambitious regeneration program (according to NAO, 2007). The program was initiated in 1995 when the "Thames Gateway Planning Framework" set out the vision for this sub-region as a high priority growth area (Department of the Environment, 1995).

The Government committed to deliver 160,000 homes in the Thames Gateway between 2001 and 2016, of which 24,000 have been built between 2001 and 2005 (NAO, 2007). Investment in transport facilities is also under way.<sup>179</sup> Other actions have dealt with urban regeneration, higher education infrastructure and the development of a natural reserve.<sup>180</sup>

As a result, employment in the Thames Gateway is growing. The number of employees increased by 6 per cent (34,750 jobs) between 2001 and 2004 compared to an increase of 1.6 per cent for the UK as a whole.

However, according to NAO (2007) transport infrastructure is the main constraint to the development in the Thames Gateway, and particularly local transport. The Gateway programme has been enabled by a number of

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<sup>178</sup> Cardiff Council, [http://www.cardiff.gov.uk/content.asp?Parent\\_Directory\\_id=2865&nav=2866,3386,4858,4860,4863](http://www.cardiff.gov.uk/content.asp?Parent_Directory_id=2865&nav=2866,3386,4858,4860,4863).

<sup>179</sup> So far transport investment has included extensions to the Docklands Light Railway, the first phases of the East London Transit and Greenwich Waterfront Transit, and the Fastrack bus-based transit system in North Kent.

<sup>180</sup> These included a regeneration project linking the commercial centre of the Southend-on Sea with the sea front; investments in higher education infrastructure (including the £54m new building of South East Essex College, the new Southend campus of The University of Essex and new joint campus of the Universities of Greenwich and Kent, Mid-Kent College and Canterbury Christ Church in Medway); and an RSPB nature reserve and the development of the Jeskyns Community Woodland converting 146 acres of intensive agricultural land into open parkland and meadows.

'strategic' transport developments but these need to be linked up to other developments through the local transport network to be really effective. That is where investment is currently lacking.<sup>181</sup>

The Thames Gateway provides a good example of the type of factors required by an area to achieve successful development. It had adequate space for development (3,150 hectares of designated brownfield site, and potential for attractive development along the waterfront of the Thames and the Medway). The investment was easy to complement with other developments (such as new transport infrastructure like the Channel Tunnel Rail Link and new stations at the towns of Stratford and Ebbsfleet). Furthermore, its proximity to London's strong and expanding economy was viewed as an important factor that could help and boost the development in the Gateway (NAO, 2007).

The Thames Gateway will play a major part in the hosting of the London 2012 Olympic Games. The area of East London will host the 2012 Olympic Village and the bulk of the competitions. It has been forecasted that, between now and 2012, the hosting of the Games will provide at least 7,000 jobs and bring some £525 million of additional income to East London alone (DCLG, 2006).

However, some authors have argued (Thornton *et al.*, 2006) that the Games may have a significant positive impact on the East of England region only if there is appropriate intervention in key areas. Without this intervention there is likely to be little or even negative impact on the region. The priority areas in which interventions should be made are the following:

- Actions related to tourism infrastructure improvements, addressing supply side constraints and marketing of the region so that the Games can be used as a catalyst to increase tourism.
- Upgrading skills, improving information networks, contract procurement support for local businesses and generating inward investment by using the event to showcase key industries aimed at capitalising on business opportunities.
- Improving sports participation in the region so that significant health benefits can be achieved.

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<sup>181</sup> Davies *et al.* (2003) also found the local transport network to be critical for getting the most from the major regeneration sites, which perform best as an integrated development. For example, residential developments need to be linked to commercial developments to allow the mobility of the labour force to and from work.

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- Encourage creative businesses to enhance their skills and to raise educational expectations through the Olympic vision.
- Ensure that the event is the catalyst for developing new infrastructure, and that this infrastructure is appropriate to the region.

### 13.4.3 Barcelona, Spain

Barcelona has had a long tradition of using mega-events to transform and promote the city (including two Universal Expositions in 1888 and 1929). However, it was the impressive urban transformation prior to the Olympic Games of 1992 that really changed the city, moving it from a typical industrial city in decay to a flexible and modern one.

The modern transformation of Barcelona began with preparations for the Games. Faced with serious problems of urban decay in both inner and peripheral districts, planners took a holistic approach and used the Games as a vehicle for city-wide reforms over four neglected urban areas.<sup>182</sup> The physical transformation of the city was made to very high standards, inviting famous architects to design some of the new projects.<sup>183</sup> At the same time, a radical transformation of inner city districts began, with a policy of improving the social capital and “mopping-up the marginal inhabitants who had given the city a reputation for serious crime” (Barcelona Field Studies Centre, 2007).

The high level of infrastructure investment that was generated has been accredited as key to the successful legacy of the Barcelona Games (Brunet, 2005). This is because many of the projects undertaken were not directly related to the Games: Barcelona planned the projects strategically so the maximum number of useful investment could be left behind after the Games. Construction of sports facilities accounted for only 9.1% of the total investment; whereas the urban transformation undertaken represented (relative to the levels in 1986) a 15% increase in roads, a 17% increase in sewage systems and a 78% increase in green areas and beaches (Brunet, 2002).

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<sup>182</sup> The Olympic Village, developed on abandoned industrial land close to the coast, is the best known feature of this project. The construction of six artificial beaches either side of the Olympic Port has had the most impact and has transformed the Barcelona seafront.

<sup>183</sup> Calatrava (Montjuic Telecommunications Tower); Gregotti (reconstruction of the Montjuic Stadium); Pei (International Trade Centre at the port); and Isozaki (Palau San Jordi gymnasium).

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In the years following the games, the entire region saw exceptional growth on all indicators including employment, investment and income (Brunet, 2005). It was estimated that investment in Olympic facilities and infrastructure led to the creation of additional 20,019 permanent jobs. Between October 1986 and August 1992, Barcelona's unemployment rate halved from 18.4% to 9.6%, while in Spain these figures were 20.9% and 15.5% respectively. Furthermore, many sectors experienced very high growth rates. Construction industry, for example, increased its consumption of cement 3.5 times between 1986 and 2001 (Brunet, 2002).

The initial high levels of investment provided the trigger for continued investment in the years following the Games, investment which came largely from private funding allowing the continued development of the region.

Barcelona is now engaged in a new wave of transformation. A high technology zone (22@), hyper-community (Diagonal Mar), the Universal Forum of Cultures 2004 and a new container port and logistics park are the key developments, all constructed on coastal brownfield and reclaimed land. Inner city and peripheral reforms are also gaining importance.<sup>184</sup>

Behind the attractive international image, Barcelona has a darker side. The marginal inhabitants are being effectively exported to the periphery. One crime-ridden district (La Mina) has been targeted for reform, but satellite towns as far as sixty kilometres from the city are beginning to experience new social problems. Barcelona is now one of the most compact cities in Europe, an advantage for designing sustainability. However, this has led to serious problems of noise (from both traffic and people), traffic congestion and pollution (Barcelona Field Studies Centre, 2007).

#### 13.4.4 Northeast Coal Mining Project, Canada<sup>185</sup>

The development of the coal mining sector in the Province of British Columbia in Canada was stimulated by the growing demand for coal, especially from the Japanese steel industry. Increases in energy and coal prices in the mid 1970s promised a high rate of return from investment in mining industry. Coalmines in the southeast of British Columbia responded to this situation by expanding their capacity and increasing production

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<sup>184</sup> Attention is being refocused on the Eixample neighbourhood. Many of the residential blocks are seeing a gradual return of communal gardens.

<sup>185</sup> This case study relies heavily on Gunton (2003).

volumes significantly. In the northeast of the Province, the lack of necessary infrastructure made expansion of existing coalmines impossible. Consequently, in 1981 the government decided to start a major regional development project in the northeast of British Columbia - the North East Coal Mining Project (NECP).

The NECP included the building of two new open pit mines, a new town of 4,000 people, a new rail line, a new port and upgrades to existing transportation and power infrastructure. The costs of the project were estimated to be \$Can4.6 billion (of which 43% was spent on mines and 57% on infrastructure).

According to pre-project cost benefit analysis the project was supposed to bring an overall net benefit of Can\$377 - Can\$1,884 million (depending on different scenarios). In addition, it was estimated that the project would create 2,053 jobs in the mines, which would result in an overall regional employment impact of 4,979 jobs. A post-project analysis showed that, contrary to the pre-project forecast of large net benefits, the NECP incurred a net loss of Can\$2.8 billion.

The significant difference between the pre- and post-project evaluation has been attributed to a number of factors:

- over-optimistic forecasts for the price of coal;
- actual output of the mines noticeably lower than predicted;
- higher than expected capital and operating costs;
- over-estimation of employment growth by almost 100% (the error was due to a difference between the actual and the forecast multiplier: 1.8 versus 2.5).

The post-project evaluation study also found that NECP did little to solve the structural problems of the region. Most jobs were taken by in-migrants to the region (85% of the new mining jobs and 32% of the indirect and induced jobs); the average income of local residents showed only little improvement; and the regional unemployment rate almost doubled between 1981 and 1986. Finally, the regional economy was less diversified after the project and more vulnerable to economic cycles.

One of the main failures of the pre-project analysis was attributed to the failure to adequately assess risk. It was argued that the involvement of many parties (there were more than 50 lenders, for example) created an additional pathology where the risk was so widely spread that no one could assess it

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properly. In addition to the potential consequences of poor pre-project appraisal, this case also illustrates the potential for leakage of project benefits to areas outside of the target region.

### 13.4.5 Temple Bar, Ireland

Temple Bar is a 218-acre urban quarter located in the heart of Dublin that, in spite of its central location, suffered urban decay for many years. The regeneration of the area was triggered in the 1980s after the State Bus Company announced it wanted to redevelop Temple Bar as a part of a transportation center. This affected negatively the attractiveness of the quarter and led to a dramatic fall in local property prices, and, in turn, prompted the move of many alternative users into the area, such as artists and small retailers (Montgomery, 1995).

The redevelopment project proposed by the bus company never started. The area was recognized very quickly as a cultural and historic quarter of Dublin and both local authorities and the Irish Government took a serious interest in its regeneration. In 1992 the Temple Bar Development Programme was launched. The Programme anticipated the development of 5 hotels, 200 shops and 40 restaurants and two cultural centres (McCarthy, 1998).

The regeneration initiatives brought about many physical changes. The developments included 133 residential apartments, 108 ground floor retail units and 140 new businesses. In addition, 1,900 permanent jobs in the cultural and service industries were created, together with 3,000 temporary jobs in development and construction. The revitalization of the quarter encouraged tourism and pedestrian activity and within a few years the area became the fourth most popular tourist destination in Dublin (McCarthy, 2002).

However, the regeneration programme has not been free from criticisms. Growing popularity of the area pushed up rents and forced some residents and business to move to cheaper locations (most new flats and houses were highly priced and students or low-income families could not afford them). In addition, many concerns have been expressed that the original cultural objectives have been overshadowed by the development of licensed premises. Montgomery (1995), for example, points out that a lot of the area character was lost due to the development of high street stores. As for transportation, some serious problems with parking space appeared.

### 13.4.6 Emscher Park, Germany

Emscher Park is located in the Ruhr valley of north-western Germany. For many years this region was the heartland of Europe's steel and coal industry. The major restructuring of heavy industries over the last twenty years, however, changed the region's economic landscape and led to the economic and social decline of the area (EPA, 2007).

Faced with widespread economic and environmental impacts of industrial decline, the State Government initiated a regional redevelopment plan. In 1989 the International Building Exhibition was given a ten-year mission to achieve the ecological, economic and urban revitalization of the Ruhr valley.

The regeneration strategy was based on developing a network of regional open space recreational areas. The Emscher Landscape Park was developed around 17 towns in the region and covered an area of 300 square kilometres (Shaw, 2002). Noticeably, the regeneration strategy did not consider only economic and job creation factors, but also criteria such as society, the environment and culture.

Between 1990-2000 more than 120 projects were realised at the total cost of 2.5 billion Euro (one third of this sum came from the private investors). The main developments in the area included creation of 15 technology centres; some 2,500 new and 3,000 refurbished dwellings; and many leisure and cultural facilities (such as museums, exhibition halls, a theatre and a water park). In addition, many employment and training initiatives were established to engage local people in the redevelopment projects (Shaw, 2002; EPA, 2007).

The evidence suggests that the project was only partly successful. Although the initiative put around 1,500 hectares of brown field land back into productive use, some 1,800 hectares of previously occupied land were lost during the course of the project (Shaw, 2002).

Furthermore, the employment creation effect of the project turned out to be very moderate. The direct employment effect<sup>186</sup> in 2004 was estimated to be only around 150 additional jobs in the area (Guerra, 2004).

The reaction to the 16 technology centres has been mixed. There are examples of centres performing well (such as the research park in Gelsenkirchen), but there are also some centres that did not attract too much innovative business (Shaw, 2002).

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<sup>186</sup> Impacts of indirect employment have not been estimated.

Overall, the project helped begin the long process of changing a very negative image of the area. It was calculated that in 2004 the Emscher Park attracted 156,200 visitors who spent in the region almost 3 million Euro (Guerra, 2004).

### 13.4.7 Bilbao, Spain

Bilbao was a traditional industrial metropolis that experienced urban decay in the 1980s, as did many European cities. Faced with growing unemployment and contraction of the industry sector, local authorities decided to launch a revitalization strategy, which aimed to transform the city into a modern metropolis and a centre of tourism and services.

The development strategy included a number of large-scale projects among which the most significant was a modern and contemporary new art museum, the Guggenheim Museum, opened in 1997. The construction of the Museum took 3 years and cost \$93.3 million. According to the pre-project economic evaluation the annual income of the Museum was estimated to be \$14 million. Taking into account multiplier effects this was estimated to raise annual spending in the region by \$35 million and generate an additional \$4 million in taxes (Harvard Design School, 2005).

The observed impact of the Museum on the local economy has been viewed very positively. The Museum has about 83,000 visitors a month, of which 66,000 are from outside the Basque region. It has been estimated that it contributed to a rise of 61,742 overnight stays a month, which now maintain almost 4,550 jobs (Plaza, 2006).

It is important to note that the success of the Museum was supported by other regeneration projects. The expansion of the airport in Bilbao, for example, ensured better accessibility to the city, whereas the Metro system opened in 1995 and new trams made it easier and more pleasant to travel within the metropolitan area.

In addition, the relocation of the old port opened a great deal of real estate on the river, which was used as the site of most of the new buildings. The attractiveness of the city was further enhanced by many other cultural projects such as Esuklalduna Conference, the Maritime Museum of the Bilbao Estuary, and the Zubizuri Bridge.

Museums are only part of the city's attractions. Since the inauguration of the Guggenheim museum, eight new hotels have been opened, reflecting the increasing interest in the city. The city now acts as home for two other

museums: the Fine Arts Museum (recognised as one of Spain's finest art museums) and the Maritime Museum.

The reinvention of the city has been achieved after a complete metamorphosis from its position of industrial decline. Bilbao now presents significant opportunities for tourism-based industries, as well as unique study environments for students of Basque society and culture.

### 13.4.8 EU Regional Policy

Regional policy<sup>187</sup> is a core part of the activities of the European Union. The EU allocates around one third of its budget to help lagging regions to catch up ("convergence"); to restructure declining industrial regions; to diversify the economies of rural areas with declining agriculture; and to revitalise declining neighbourhoods in the cities.

The European Commission recently published its fourth Cohesion Report.<sup>188</sup> This assesses the outlook for economic and social cohesion across the EU and provides a preliminary assessment of the impacts of EU cohesion policy in the 2000-2006 period.

The report suggests that the key factors that influence the effectiveness of cohesion policy are:

- a macroeconomic context that facilitates low interest rates – this stimulates investment, which increases productivity and contributes to innovation;
- the efficiency and effectiveness of public administration; and
- external factors such as globalisation.

Cohesion policy is aimed at supporting three main areas of investment: physical infrastructure (mainly transport and environment); Productive investment (mainly SMEs and R&D); and investment in human capital.

The Fourth Cohesion Report concludes that cohesion policy has contributed to convergence over the period 1994 – 2006 as measured by GDP per capita. Of the four largest beneficiaries over this period (Greece, Spain, Ireland and Portugal) three have either made significant gains or had reached the EU27

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<sup>187</sup> In EU terminology this is now known as cohesion policy.

<sup>188</sup> European Commission (2007).

average GDP per capita by 2005.<sup>189</sup> The fourth, Portugal, had GDP per capita of 74% of the EU27 average by 2005. The Report also concludes that overall EU regions have been converging over the past decade with declines in the number of regions with a GDP per capita below the threshold levels of 50% and 75% of the EU average.<sup>190</sup> Nevertheless, it is recognised that large disparities remain, partly as a result of the enlargement of the EU and partly because growth tends to concentrate in the most dynamic regions.

An earlier study, published in 2004,<sup>191</sup> suggested that cohesion policies had failed, that returns on investments in infrastructure and business support were not significant and that only investment in education and human capital has shown medium term positive and significant returns.

The analysis presented in the study suggests that disparities (measured by standard deviations) in GDP per head at the national level increased between 1989 and 1999. Further analyses reported in the paper supported this conclusion, though one analysis suggested a small degree of convergence between Objective 1 regions. The study also attempts to assess whether cohesion funds have had an impact on economic growth using alternative statistical approaches, noting the inherent difficulties given the wide range of factors that influence GDP growth. One approach suggested a weak, but positive, impact from cohesion funds. An alternative approach suggested no impact.

The study suggests some potential reasons for the apparent poor performance of cohesion funds, including:

- the process of EU economic integration favours the concentration of activity in core areas by enabling the formation of greater agglomeration economies in those areas;
- it may be too soon to assess the impacts of cohesion expenditure during the 1990s, the positive impacts may be longer term;
- the volume of funds available is too limited to have any significant impact;

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<sup>189</sup> Greece increased its GDP from 74% to 88% of the EU average, Spain increased its GDP from 91% to 102% of the EU average and Ireland increased its GDP from 102% to 145% of the EU average.

<sup>190</sup> Between 1995 and 2004, the number of regions with a GDP per head below 75% of the EU average fell from 78 to 70 and the number of those below 50% of EU-27 fell from 39 to 32

<sup>191</sup> Rodriguez-Pose and Frateshi (2004).

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- the distribution of funds across different priorities may reflect short term political concerns rather than longer term development needs.

### 13.5 Potential further research

There is scope to undertake a more in depth analysis of the new economic geography models, including the knowledge spillover models and, in particular, the extent to which there is empirical evidence that supports the conclusions of these models.

Such work could be extended to include consideration of the potential policy implications for Wales both in respect of interactions between the internal regions of Wales and in respect of the interaction of the Welsh economy with other neighbouring economies. Such research could provide particularly useful inputs into the development of policy in the transport and knowledge economy areas.

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## Annex 1 Other Infrastructure

### Introduction

In this Annex we provide a very brief overview of the evidence on economic impacts from other types of physical and intellectual infrastructure: tourism and events; housing; healthcare; and primary and secondary education. These brief overviews were prepared as part of Phase One of this study.

### Tourism and events

There are many estimates of the economic impacts of tourism. Tourism can have substantial impacts on local economies in terms of incomes and employment in tourism related sectors. Tourism can also stimulate infrastructure investment that other sectors can benefit from as well. Nevertheless there are many factors which can undermine the extent to which tourism can benefit an economy.<sup>192</sup> In practice much of the income and expenditure relating to tourist facilities can “leak” out of the region in question.<sup>193</sup> In some cases tourism can cause congestion on bottleneck facilities and can also raise prices for some goods and services. Low pay and the seasonal nature of employment in the industry can also be a problem.

There have been many studies in the UK of the contribution that tourist attractions make to local economies.<sup>194</sup> In Wales, these include Blaenavon, the National Waterfront Museum in Swansea and the Museum of the Welsh Woollen Industry.<sup>195</sup> These studies generally outline the contributions these attractions make to local economies in terms of income, expenditure and employment.

There has also been a developing literature over the last decade or so on the economic impact of major sporting and cultural events. Many of these are undertaken in advance of the event in question and they tend to anticipate large positive impacts. There are a number of studies relating to Olympic

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<sup>192</sup> See UNEP (undated) for a useful discussion of positive and negative impacts.

<sup>193</sup> For example, when businesses are based outside the region and profits are “exported” and when inputs are purchased from outside the region.

<sup>194</sup> The website of the National Museum Directors Conference (NMDC) lists a large number of these - [http://www.nationalmuseums.org.uk/economic\\_impact.html](http://www.nationalmuseums.org.uk/economic_impact.html)

<sup>195</sup> See also Harper (2004).

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Games, for example.<sup>196</sup> Some recent studies have however, raised serious doubts about the extent to which anticipated benefits are realised in practice.<sup>197</sup> The European Tour Operators Association study, for example, refers to exaggerated audience figures and displacement of other tourists.

There is also some research available with respect to the economic impacts of sporting facilities.<sup>198</sup> Nevertheless one Welsh researcher in this area noted in a presentation to a conference on regeneration “No academic study has found any evidence of a beneficial impact on medium or long term economic growth or employment generation as a consequence of stadium construction or hosting of major event” (Jones, 2005). This is partly attributed to the difficulties of estimating impacts when they occur in a relatively small area and the very small contribution that sport makes to the economy at large.

### **Housing**

The literature suggests that the housing market influences the economy in a number of different ways. The Barker Review (Barker, 2004) of housing supply for HM Treasury suggested that there was evidence of a long run under supply of housing in the UK and that this was having macroeconomic impacts. Under supply had contributed to instability in the housing market and to a long period of high real house price increases. This in turn had led to macroeconomic instability and hence a more difficult investment climate for business.

High levels of house prices, and tenure patterns, also have other important impacts. One particular area of research has been the impact on labour mobility.<sup>199</sup> There is evidence that manual workers in the UK are less mobile than similar workers in the USA and it has been suggested that the influence of both housing tenure and house prices may be a contributory factor. High levels of labour mobility tend to be more associated with private rental housing than with other forms of tenure, particularly occupier ownership, which is at high levels in the UK, and local authority tenancy.<sup>200</sup> High house

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<sup>196</sup> See Brunet (2005); State of Utah (2000); and Grant Thornton et al (2006) , for example.

<sup>197</sup> See, for example, PricewaterhouseCoopers (2004); and European Tour Operators Association (undated).

<sup>198</sup> See Cardiff Research Centre (undated).

<sup>199</sup> See DTZ Consulting & Research (2006) for a review of this evidence.

<sup>200</sup> See Hughes & McCormick (2000).

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prices also inhibit labour mobility. Champion et al (1998) suggested that homeowners in regions with low prices cannot afford to move to regions with high prices and that homeowners in regions with high prices are reluctant to move in case they will not be able to afford to move back.

The impact that the housing market has on labour mobility can have consequences for employers as it may lead to skills shortages in some areas together with higher wages. These skills shortages arising from housing market problems tend to be for lower skilled workers as those with higher skills tend to be more mobile and less constrained by the housing market.

Housing investment can also play a role in regeneration and in tackling deprivation and social exclusion. People living in concentrations of deprivation and economic inactivity tend to find it harder to break from this cycle than similar people living in less concentrated areas of deprivation. There is also evidence of impacts on health and educational achievement. One report argues that the investment required (£3bn - £4bn) to meet the Welsh Housing Quality Standard by 2012 has the potential to have a very large regenerative impact.<sup>201</sup>

### Healthcare

Health economics is an extensive area of research. Much of the work in this area examines issues such as the cost-effectiveness of various medical treatments<sup>202</sup> and also the economic impacts of health related problems.<sup>203, 204</sup>

There are also assessments that are more directly related to the link between investment in healthcare facilities and the economy. Much of this material is from the USA. These studies show the importance of healthcare facilities (e.g. hospitals) to local/regional economies in terms of both output and employment.<sup>205</sup> A similar study in the UK examines the economic

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<sup>201</sup> Institute of Welsh Affairs (2006).

<sup>202</sup> See Donaldson et al for a discussion.

<sup>203</sup> See Reynolds et al (2004) for an example.

<sup>204</sup> The NHS has an economic evaluation database, which is available online at <http://www.crd.york.ac.uk/crdweb/Home.aspx?DB=NHS%20EED&SessionID=&SearchID=&E=0&D=0&H=0&SearchFor=>

<sup>205</sup> For examples of these studies, see Beyers (2003) and Doeksen (undated). Doeksen et al (1997) also provides a literature review in this area, focussing in particular on economic impacts of hospitals in rural areas.

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contribution of the healthcare sector in Nottingham, focussing on employment, income, and expenditure.<sup>206</sup>

There have been a number of studies that examine the links between the general health of the population and economic performance.<sup>207</sup> Studies that examine the position in developing countries consistently find a link between health, generally measured by life expectancy, and economic growth.<sup>208</sup> There is also evidence that improvements in health have made substantial improvements to economic performance in developed countries in the past. One study attributed 30% of economic growth in the UK to better health and diet over the period 1790 to 1980. Another study, involving ten developed countries found that in the one hundred years to the mid 1990s, better health had increased the rate of economic growth by around 30%.<sup>209</sup>

Studies in developed countries in modern times have not found such a link between life expectancy and economic growth, though one study of 26 developed countries which examined the period 1960 – 2000 (Suhrcke and Urban, 2006) did find a strong link between cardio-vascular morbidity rates and economic growth.

In addition, studies in developed countries show a link between the health of individuals and their earnings.<sup>210</sup> Better health increases the number of hours worked and the probability of employment. It also reduces the likelihood of early retirement, though other factors, such as the rules for early retirement benefits are important too.

### **Primary and secondary education**

The review of economic growth theory (Chapter 7) notes the important contribution that human capital development makes to economic growth. In addition, reviews of early years education (Chapter 9) and of higher education (Chapter 10) point to important contributions from education at these levels. Education in the intermediate years of primary and secondary education also make an important contribution to economic performance.

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<sup>206</sup> See Nottingham Research Observatory (2004).

<sup>207</sup> This section draws heavily on Suhrcke et al (2006).

<sup>208</sup> See Commission on Macroeconomics and Health (2001).

<sup>209</sup> See Arora (2001).

<sup>210</sup> See Suhrcke et al (2006) for a discussion of the evidence.

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At the macro level, whilst there is a range of evidence that suggests that education in general is important for economic growth, much if this is based on the effects of the numbers of years of schooling.<sup>211</sup> This makes conclusions for developed countries more difficult to reach, because the variation in this variable across OECD countries is quite limited, and it also makes it hard to draw a distinction between the effects of different levels of schooling. Nevertheless there is evidence at the macro level that it is primary and secondary schooling which is most closely associated with economic growth in developing countries, but that tertiary education is more relevant in developed countries.<sup>212</sup> Again, this result may reflect the difficulties in distinguishing at a macro level between the effects of different provisions in primary and secondary education between OECD countries.

There is a wide range of other economic evidence of the benefits of education showing higher earnings and lower probabilities of unemployment for those who have been better educated. One recent study (London Economics, 2005) assessed private and social rates of return from investment in various types and levels of education in EU countries. The study concluded that for most countries both private and social returns tended to be highest from upper secondary education.<sup>213</sup> An earlier study (Psacharopoulos & Patrinos 2002) estimated that, across the world, average social returns are 18.9% for primary education, 13.1% for secondary education, and 10.8% for tertiary education. They also found that returns to primary education tend to be considerably larger in less developed countries: average returns are 25.4% for Sub-Saharan Africa compared to only 8.5% in OECD countries.

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<sup>211</sup> See, for example, Sianesi & Van Reenen, (2005) and Bils & Klenow (2000).

<sup>212</sup> See Sianesi & van Reenan (2005). This evidence does not consider early years education.

<sup>213</sup> In comparison with tertiary education, investment in maths, science and technology education and investment in improving literacy.

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