Comparative Analysis, Forecasts and Monitoring of the Northern Ireland Economy

Report 3: Modelling Innovation and Human Capital

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RegionalForecasts

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i. Executive Summary

This report is the third of four scheduled reports for DETI / DFP providing monitoring and evaluation of the EDF targets. However, due to the necessary re-specification of the EDF targets, the reporting structure has changed from that originally laid out in report 1.

This report is therefore focussed on providing detail on how we propose to deal with innovation and human capital in our forecasting model. The report begins with a brief overview of the prevailing macro economic conditions globally, the UK and the Government Office Regions. The chapters are summarised below:

Macro Context

This chapter briefly outlines the latest features of the global economy and then outlines the prospects for the UK regions.

Two features of the economy since our last report are increasing interest rates and increasing oil prices. The Bank of England increased UK interest rates in August for a fifth time since November 2003 (but left them unchanged in September). The current level of 4.75% is considered by the Bank of England to be close to the peak. The justification for the latest rise was that current robust output growth in the face of high demand relative to the supply capacity of the economy could lead to rising inflationary pressures. Recent evidence from both the Halifax and Nationwide house price indices show a deceleration in house price inflation in recent months, with the Halifax actually reporting that prices fell in August for the first time since late 2002.

The press is awash with stories of record breaking oil prices, but the fears of the economy being crippled by soaring oil prices are overblown. The recent Bank of England Inflation report (August 2004) barely mentioned oil prices. Two reasons are offered for this. The sterling price of Brent crude of around £23 per barrel is some way off the price in real terms witnessed in 1979-80 of £60 a barrel. As the Bank also pointed out, all advanced economies have become less reliant on oil. The decline of heavy industry means that oil intensity of OECD is around half that of the early 1970's.

Feature Article: Modelling Innovation

The EDF targets contain a number of indicators aimed at monitoring Northern Ireland's innovation performance. Assessing the returns to innovation is difficult and this chapter will assess current literature before outlining how we plan to model innovation. Drawing on Porter's recent work that shows the link between wages and patents, we use patent information for the UK regions to show the links between patents and wages and the link between patents and expenditure on R&D. This exercise, coupled with a review of relevant literature leads us towards a conclusion that the impact of expenditure on R&D on output in Northern Ireland will be towards the lower end of Griffith's 'conservative estimate of the social rate of return to R&D of 30% and a private rate of return of 7-14%.'

Feature Article: Modelling Human Capital

The EDF targets also contain a number of indicators aimed at monitoring Northern Ireland's human capital performance. Similarly to innovation, little is known about the impact of human capital on a small region like Northern Ireland. A key issue for Northern Ireland is how much of the benefits of training people in Northern Ireland remains in Northern Ireland. We suggest that Northern Ireland does not have a problem supplying highly skilled labour but does that the economy does not create sufficient demand for that skilled labour. As a result, Northern Ireland loses around a quarter of those going into higher education.

Studies such as Gemmel (1996) attempt to quantify the direct effect of education on economic growth. He concludes that for OECD countries a 1% increase in tertiary human capital stock is associated with a 1.1% increase in per capita GDP growth. Barro and Lee (1994) show that an extra year of male secondary schooling is associated with a 1.4% increase in growth of GVA per employee.

The belief that education automatically leads to more growth has not gone unchallenged. Work by Alison Wolf states that the general belief that education delivers growth rests partly on the obvious point that developed societies need a lot of educated people, and that research laboratories - many in universities - are critical to technological progress. However, the fact that a good deal of education is needed in a society does not mean that yet more will be better (in growth terms) any more than the need for investment in a society means you can never over-invest.

Wolf's fear is that since the view of education is now essentially about growth, the 'simplistic link between the number of diplomas or years in education on one hand, and economic growth on the other' has pushed the discussion about educational quality aside.

Chapter 1: Macro Context

Recent reviews of world economic performance by Oxford Economic Forecasting (OEF) reveal that pessimism about global economic prospects has grown in recent months. US growth (2.8% in Q2) was below expectations as was Japan's, with real GDP growing at an annualised rate of 4.4% in Q2 2004. Also, China's inflation rate was 5.3% for the second consecutive month in August raising fears that the government there is unable to rein in the booming economy. Given their importance to UK economic prospects, this chapter highlights OEF's assessment of economic performance of the US and Eurozone before assessing the prospects for the UK regions.

US Economic Performance

Real GDP in the USA expanded at an annual rate of just 2.8% in 2004Q2, considerably below expectations, after rising 4.5% in Q1. Consumer spending, which had been expected to rise about 2½%, managed just a 1.0% gain, as motor vehicle sales plummeted from an annual rate of 17.8 million units in May to just 15.4 million in June. In addition, while stock building was quite strong, it was also revised higher for Q1, resulting in a much smaller contribution to growth in Q2. These constraining factors were only partially offset by a reduced drag from real net trade, as exports rose faster than imports, and the better than expected acceleration in private fixed investment, up at an annual rate of 11.1% after a gain of just 4.5% in Q1.

The GDP performance in 2004Q2 added to the list of recent disappointing economic indicators. New orders have been weaker than expected over the last few months, even considering the gain in June. In addition, Payrolls expanded by 144,000 in August and the gains for June and July were revised higher by a total of 59,000. The pickup in job growth is welcome, but 144,000 is still a relatively modest gain.

One possible explanation for this lacklustre performance is the withdrawal of both fiscal and monetary stimulus. It is certainly the case that the impact of last year's tax cuts and advance rebates has faded. Also, the Federal Reserve has embarked on what is expected to be an extended period of monetary tightening. In addition, the high gasoline prices of the spring cut into discretionary income and so constrained consumer spending.

The scant data available so far on 2004Q3 are mixed. The swing in motor vehicle sales from May to June reflected the extension and then the withdrawal of incentives. With incentives back in place, motor vehicle sales jumped back over 17 million units at an annual rate in July but have declined again in August. Consumer confidence was weaker than expected in August, falling 7.5 points to 98.2. Both the present situation index and the expectations index fell by more than 5 points. Consumers are concerned about job prospects – only 18.1% described jobs as plentiful, down from 19.7% in July. The Institute for Supply Management manufacturing and non-manufacturing indices also fell in August, but both are still well above 50, indicating expansion. The manufacturing index fell 3.0 points to 59, while the non-manufacturing index dropped 6.6 points to 58.2. All of the components for both sectors continued to show expansion, but for both sectors, the new orders index indicated a slowdown.

Combined with oil prices that are again setting new records and continued uncertainties on the global stage, the weakness seen in June and possibly July has led OEF to scale back their forecast for growth in the near term. Real GDP is now expected to accelerate to 3.4% in Q3. 3.8% in Q4 and about 4% in the first half of 2005.

Eurozone Economic Performance

The latest indicators paint a quite consistent picture of a moderation of the pace of growth throughout the euro zone. GDP growth, which slightly exceeded 2% in the first half of 2004, may on current evidence fall slightly below 2% in the second half of this year. The slowdown is due to a moderation in export growth which has not been compensated by an acceleration in domestic demand. Though slowing, exports remain the driving force of the euro zone economy. There are still few signs of a strengthening of domestic demand. Employment is stagnant and consumers reticent to spend. In the corporate sector, surveys point to declining profit margins as competitive pressures apparently inhibit companies from passing on rising input prices.

The purchasing managers' index for the services sector, accounting for around two-thirds of the euro zone economy, slipped in Aug 2004, but remained clearly above the 50 line which separates growth from contraction. Expectations are no longer exuberant, as they were at the start of the year, but quite optimistic nonetheless. New business is still growing, but at a more subdued pace. The employment sub-index improved a little, suggesting that jobs are no longer being lost in services. Only in France, according to the survey, were companies in the services sector able to raise their prices to recoup at least some of the losses from surging input prices. The implication is that profit margins are under pressure.

The purchasing managers' index for the manufacturing sector also slipped by nearly one point, but also remained clear of the 50 mark. The inflow of new business slowed but is still at a quite high level. However, the employment sub-index deteriorated, suggesting that there are still some jobs being lost in manufacturing. Manufacturers too report that they are unable to pass on rising costs. The weakness in consumer spending is demonstrated by the retail sales statistics. In July 2004 retail sales were reported to have risen by 0.3% on the month and 0.9% on the year. In the first seven months of the year sales were a mere 0.4% up on the equivalent period in 2003.

Although Euro zone unemployment in July 2004 remained at 9.0% of the labour force the ECB raised its forecast of euro zone GDP growth in 2004 to 1.9%. The forecast for 2005 was raised to 2.3%. These forecasts are only marginally higher than the previous forecasts and are in line with the current OEF base line forecast.

UK Macro Context

Interest Rates

The Bank of England increased UK interest rates in August for a fifth time since November 2003 (but left them unchanged in September). The current level of 4.75% is considered by the Bank of England to be close to the peak. The justification for the August increase was that current robust output growth in the face of high demand relative to the supply capacity of the economy could lead to rising inflationary pressures. There is growing evidence to suggest that the recent increases in interest rates have impacted on house prices. Both the Nationwide and Halifax indices show a marked deceleration in house price inflation in recent months, with the Halifax actually reporting that prices fell in August for the first time since late 2002. This follows reports from Rightmove suggesting that asking prices for properties in England and Wales had fallen by an average of over £1,200 during the second half of August, and similar reports from the National Association of Estate Agents and the Royal Institute of Chartered Surveyors.

At the same time, latest figures from the Bank of England point to a downturn in activity in the housing market. For example, the number of applications for loans for house purchase fell over 13% in July, having already fallen over 10% in June. Mortgage applications are now down to levels last seen at the time of the Iraq War. Similarly, net mortgage lending fell in July to £8.6 billion from £9.3billion in June and average monthly borrowing of £9.2 billion over the previous year.

While it is increasingly clear that higher interest rates are now reining back the housing market, the recent data do need to be seen in perspective. For one thing, data for July and August need to be interpreted cautiously given the potential impact of the summer holidays; while in principle this should be corrected by seasonal adjustment these procedures are not always reliable. Moreover, even after the August fall, the Halifax data still show house price inflation running at an annualised rate of 7.2% over the last three months, while on the Nationwide index is it is still nearly 13%. Similarly, even after its July fall, mortgage lending remains higher than at any time prior to the last year.

Oil Prices

There are a number of ways in which oil price rises can impact on the economy. Firstly, costs for firms using oil will increase, reducing profitability. This could result in reduced employment and investment. Secondly, petrol prices and home heating oil becomes more expensive, reducing household disposable income. Thirdly, should firms pass on oil price rises to customers, employees may attempt to recover lost income through increased wage demands. Higher oil prices may therefore be a trigger for wage inflation.

Given that two of the last three global recessions were triggered in large part by sharp increases in oil prices, there have inevitably been concerns that the latest 'oil shock' might hamper the global recovery. We think such fears are overblown given the scale of the price increase in real terms seen so far.

Our belief that oil price fears are unrealistic is borne out by the latest Bank of England Inflation Report which barely mentioned oil prices. Two reasons can be offered for this. The sterling price of Brent crude of around £23 per barrel is some way off the price in real terms witnessed in 1979-80 of £60 a barrel. As the Bank also pointed out, all advanced economies have become less reliant on oil. The decline of heavy industry means that oil intensity of OECD is around half as much as in the early 1970's.

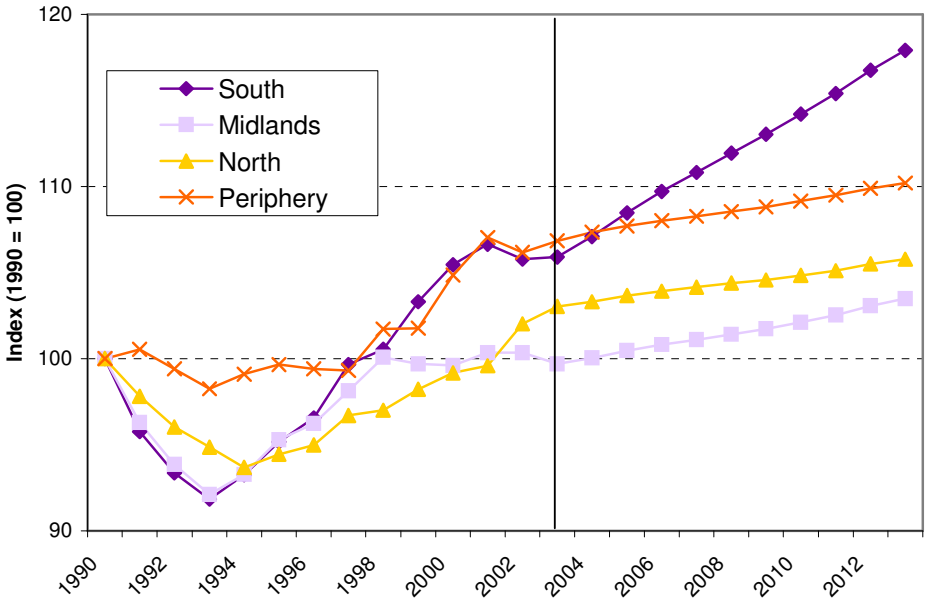
UK Macro Forecasts

GDP growth to expected to slow to 2.9% in 2005 and 2.4% in 2006. Our estimates suggest that such a slowdown should avoid the economy hitting any serious capacity constraints. Moreover, subdued wage inflation and stronger productivity growth as the economy recovers will pull down unit wage inflation. The OEF forecast therefore shows CPI inflation edging up only gradually, to 1.6% at end-2004 and 1.7% at end-2005.

UK Regional Context

Recent data revisions appear to suggest that the marked slowdown in the southern regions may be coming to an end. Short-term employment data suggests that employment loss in the third quarter of 2003 was modest in the South East, East and the West Midlands, with all other regions experiencing some growth. Our view is that this employment growth will continue in 2004 and spread to all regions, with the southern regions accelerating into 2005. We predict the southern regions will return to the top of the UK growth league following the last two years of northern region dominance.

Figure 1.1: Total Employment in Regional Groups (1990 = 100)

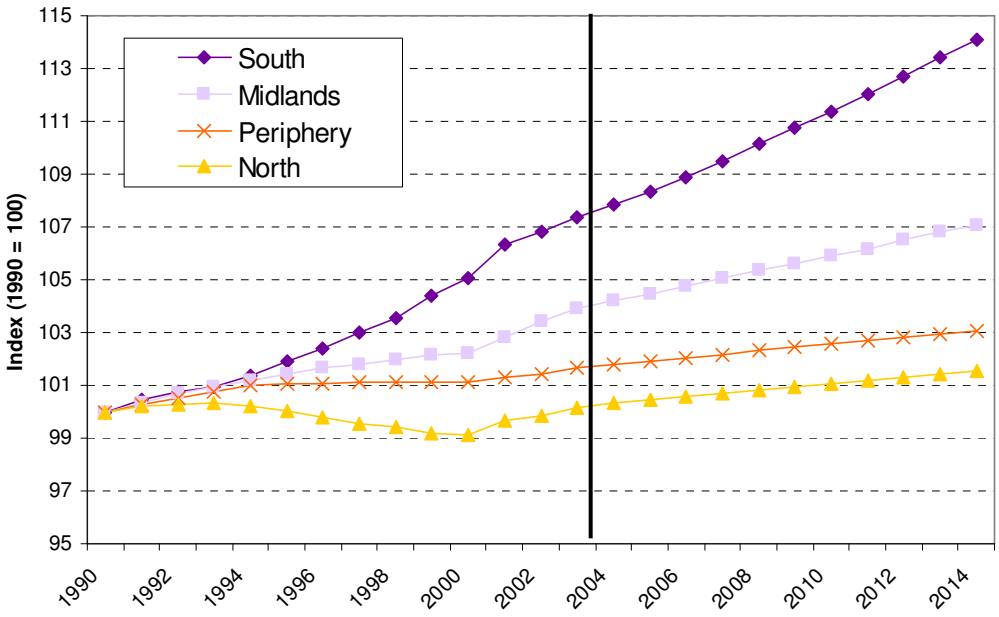


Source: Regional Forecasts/OEF

Population

The pressure, both on land and the transport network, will continue to increase in the south, with population forecast to continue to expand steadily. Migration continues to raise population growth in the southern regions, as they are the destination for most international migrants. There is considerable uncertainty over the levels of international migration in recent years, and it remains entirely possible that working age migration could significantly outstrip the levels built into our base projections (a net in-flow of 100,000 in 2003, declining to a net in-flow of 75,000 by 2013). The impact of EU accession countries on migration is particularly uncertain.

Figure 1.2: Total Population in Regional Groups (1990 = 100)

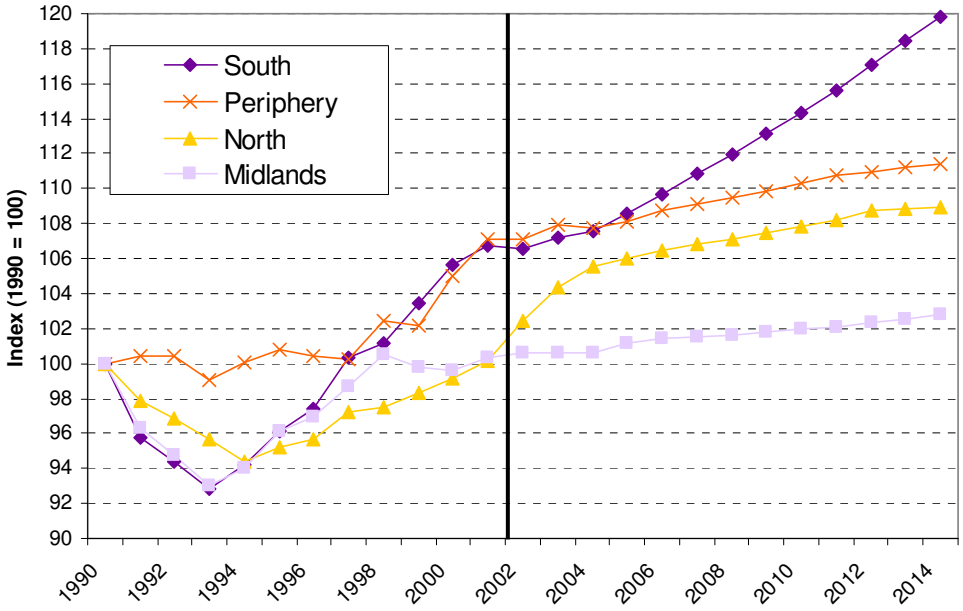


Source: Regional Forecasts/OEF

Output

In line with our employment forecasts, we expect output to grow fastest in the southern regions and more modestly elsewhere in the UK. Our provisional estimates for output growth in 2002 and 2003 are based on regional employment data and national sectoral levels of GVA per employee. The lack of up-to-date GVA data needs to be borne in mind when assessing the forecasts. Assessments made on the basis of regional output data need to be based on a more long-term assessment of output levels as the data lag several years and are subject to significant revision. Although employment data are also subject to revision, we believe that these represent a more timely and robust measure of current economic performance.

Figure 1.3: Total GDP in Regional Groups
(1990 = 100)



Source: Regional Forecasts/OEF

Table 1.1: The Regional Forecasts/OEF Forecast of GDP (per cent per year)

	2002	2003	2004	2005	2006-14
	data	*forecast*	*forecast*	*forecast*	*forecast average*
South East	2.3	2.8	3.2	3.0	3.0
London	-0.7	1.8	4.1	3.1	3.1
East	2.7	1.8	3.5	3.1	2.7
South West	2.1	1.1	3.6	2.8	2.4
West Midlands	2.2	2.1	3.8	2.9	2.2
East Midlands	1.0	1.3	2.6	2.8	2.3
Yorkshire & Humber	1.8	3.0	4.8	2.6	2.2
North West	4.0	2.8	3.7	2.7	2.3
North East	2.2	4.6	4.2	2.8	2.1
Wales	2.3	3.8	1.9	2.2	2.3
Scotland	1.5	1.3	2.7	2.5	2.0
Northern Ireland	3.7	2.6	4.7	3.1	2.8
United Kingdom	1.8	2.2	3.6	2.9	2.6

Table 1.2: The Regional Forecasts/OEF Forecast of Total Employment (per cent per year)

	2003	2004	2005	2006	2007-14
	data	*data*	*forecast*	*forecast*	*forecast average*
South East	1.1	-0.1	0.9	1.1	1.2
London	1.0	0.6	1.2	1.4	1.6
East	0.3	0.4	0.8	0.7	0.7
South West	-0.4	0.6	0.6	0.6	0.5
West Midlands	0.3	0.4	0.5	0.3	0.1
East Midlands	-0.4	-0.4	0.5	0.3	0.2
Yorkshire & Humber	1.9	2.0	0.4	0.3	0.2
North West	1.4	0.4	0.5	0.4	0.4
North East	3.1	1.3	0.6	0.4	0.1
Wales	2.0	-1.0	-0.1	0.7	0.2
Scotland	0.0	-0.4	0.4	0.4	0.2
Northern Ireland	1.4	2.1	0.9	0.9	0.8
United Kingdom	0.8	0.4	0.7	0.7	0.7

Chapter 2: Modelling Innovation

Innovation in the Regional Forecasts EDF Model

Under the Strategic Priority area: Innovation and Creativity, the aim of EDF is to create an innovation culture and environment within which Northern Ireland companies develop knowledge and ideas and then adapt and exploit them. The original targets under this measure have been amended to reflect Regional Forecasts' concerns and EDF's consultation process. The original targets are listed in Table 2.1 with Regional Forecasts assessment and EDF's decision. Table 2.2 presents the new indicators.

Table 2.1: EDF Innovation Targets

	Original EDF 2010 Target	Regional Forecasts' Recommendation / Comments	MTSPs Sub-group Comments
PRIMARY			
Business R&D expenditure growth	1999 to 2010 NI real growth > 100%	Drop - Not necessary to target both levels and growth. Only levels retained. This target is suitable and is on track to be achieved by 2010.	This target should be re-specified to express business expenditure on R&D as a % of GVA. Regional Forecasts should examine the availability of data sources which would allow for the identification of separate figures for (i) all firms; and (ii) excluding the top ten by R&D spend, in order to illustrate the breadth of spend across NI. [In light of the findings of the Lambert Review, EDF may, in future, want to consider developing a specific target on knowledge transfer.]
Business R&D expenditure per person employed	By 2010 £ per person NI / GB => 100%	Retain but re-specify as two targets - This target is suitable but currently is not on track to be achieved by 2010. Regional Forecasts recommend it should be retained but with separate targets for manufacturing and tradable services to reflect the growing importance of tradable services.	This should be re-specified and split into 2 targets for manufacturing and tradable services.
% of plants involved in innovation	Products > 70% Process > 70%	Drop - Data for the next four 'innovation' targets was collected by the Invest NI/Innovation Lab survey – previously the NIERC Innovation Survey. Regional Forecasts noted that no data collection was planned but that if DETI was to revive the R&D survey, to collect data annually or biennially then one or more of the dropped R&D targets could be retained. Others could be monitored without necessarily having targets.	The % of plants involved in product and process innovation should be retained as targets. The Sub-group recommends that the Invest NI Innovation Lab survey be continued to secure the data necessary to measure these targets.
Average number of product changes per plant	> 30	See above comments on % plants involved innovation.	Content to drop.

Strategic Priority Area: Innovation and Creativity – cont'd

	Original EDF 2010 Target	Regional Forecasts' Comments	MTSPs Sub-group Comments
Number of New/Improved products per employee	> 0.6	See above. If data will be collected, Regional Forecasts recommends that the number of new/improved products per employee is the most informative.	Content to drop.
Average % of sales from new products	> 30%	See above	Content to drop.
SECONDARY			
% Business R&D devoted to commercialisation	Maintain 1999 level NI% / GB% = 107%	See above	This should be retained.
Experimental development R&D per employee	2010 £ per employee NI/GB = 100%	See above	Content to drop.
Employment in business R&D as a % of total employment	2010 NI%/UK% = 100%	See above	Content to drop.

Table 2.2: EDF's New Innovation Targets

Business R&D expenditure growth	Business R&D as a % of GVA (i) all firms (ii) excluding top 10 R&D performers
Business R&D expenditure per person employed	(i) Business Expenditure in manufacturing per person employed in manufacturing relative to UK (ii) Business Expenditure in services per person employed in services relative to UK
% of plants involved in innovation	
% Business R&D devoted to commercialisation (experimental expenditure)	

Having identified a new set of targets, it is the aim of the remainder of this chapter to assess the current literature to explore the relationship between innovation and economic performance and outline how we propose to model this in our forecast model.

Literature Review

Importance of R&D and Innovation

Economic theorists have accepted the importance of innovation in economic growth for decades, citing a positive link between technological change, productivity and economic growth. In modern economies, the inputs of capital and labour alone cannot account for a large part of output growth in modern economies (Solow, 1957). Endogenous growth theorists believe that improvements in productivity can be linked to a faster pace of innovation and extra investment in human capital. The rate of technological progress should not be taken as a given in a growth model as government policies may result in a higher level of innovation. An important issue in the literature, and of particular relevance to Northern Ireland is that that R&D activities not only provides productivity benefits for the firms that undertake it but also for firms in similar or somehow un-related areas. The main sources of externalities to economies have been highlighted in endogenous growth theories and are summarised by Cameron (1996). Firstly, technological spillovers reduce the cost of rival firms because of knowledge leaks, imperfect patenting and movement of skilled labour between firms. Also, if there are no technological spillovers, the innovative firm still might not capture all the benefits from the innovation unless they can price discriminate to rival firms.

Possibly one of the best examples of how externalities from R&D are captured over time is Microsoft. If R&D at Microsoft was contained within the local economy at its base in Seattle then the impact on productivity would be negligible. However, the research and development which led to the introduction of Microsoft Windows and Microsoft Office applications have benefited not only Microsoft and Seattle but also global productivity.

Porter (2003) offers further evidence on the importance of innovation by demonstrating a positive link between regional wages and patents. He states that while the patent system does not capture all innovative activity, patenting is the best available and comparable measure of innovative activity across regions. Porter believes that high patenting signals more advanced products and processes and thus higher productivity that support a higher wage.

Studies of Innovation and Economic Growth

Cameron (1996) identifies the difficulty involved in trying to measure the innovative output of an industry stating that studies by Griliches (1980), Mansfield (1980) and Nadiri (1980) typically derived estimates of total factor productivity growth using a Cobb-Douglas approach, and then regressed these estimates against various measures of innovation input. The latter was normally research and development spending (either aggregated, or broken down into components such as basic and applied, private or government).

Cameron goes on to identify how in practice, estimates of the effect of innovation on total factor productivity can be obtained in two ways. The first is to use a measure of the stock

of R&D capital (R&D capital stock is generally calculated from cumulative past investment in R&D, allowing for depreciation) in a regression of the *level* of total factor productivity which gives the following equation:

$$\log TFP = \log A + \gamma \log RDK_t + \beta t \, .$$

The second is to use a measure of R&D intensity (relative to output) in a regression of the *change* in total factor productivity which gives

$$d \log TFP_t = \rho \frac{RD_t}{Q_t} + \beta \, .$$

RDK in the equations refers to the stock of R&D capital and RD is the flow of R&D. The first equation provides a measure of elasticity of output with respect to knowledge and the second provides a measure of the social rate of return to knowledge.

Cameron's paper highlights a number of studies that have been undertaken at firm, industry and country level, the majority of which (based in equation 1) found a strong link between R&D capital and output – typically a 1% increase in the R&D capital stock is found to lead to a rise in output levels of between 0.05% and 0.1%). The table below from Cameron's paper demonstrates the wide variation in estimates of the returns to R&D. Coe and Helpman argue that previous estimates of the return to R&D under-estimate the true impact, finding that a 1% increase in the R&D capital stock will lead to an increase in output of around 0.23%. The Cameron and Muellbauer study listed in the table involved constructing a model of UK manufacturing output for three decades up to 1992. They also find that R&D spending makes a significant contribution to productivity growth, with a 1% increase in the stock of business enterprise R&D capital leading to an increase in output of around 0.15%.

Table 2.3: Estimates of the Output Elasticity of R&D

Study	Country	Elasticity	*Level of Research*
Griliches (1980a)	US	6%	*Firm level*
Griliches (1980b)	US	0-7%	*Industry level*
Nadiri-Bitros(1980)	US	26%	*Firm level*
Nadiri (1980a)	US	6-10%	*Private sector level*
Nadiri (1980b)	US	8-19%	*Manufacturing sector level*
Griliches (1986)	US	9-11%	*Firm level*
Patel-Soete (1988)	US	6%	*Whole economy level*
Nadiri-Prucha (1990)	US	24%	*Industry level*
Cuneo-Mairesse (1984)	France	22-33%	*Firm level*
Mairesse-Cuneo (1985)	France	9-26%	*Firm level*
Patel-Soete (1988)	France	13%	*Whole economy level*
Patel-Soete (1988)	Germany	21%	*Whole economy level*
Patel-Soete (1988)	UK	7%	*Whole economy level*
Cameron-Muellbauer (1995)	UK	15%	*Manufacturing sector level*
Cameron (1995b)	UK	0-27%	*Industry level*
Coe and Helpman (1993)	*G7*	*23%*	*Whole economy level*

Source: Cameron (1996)

Studies based on the second equation have also found a strong link between R&D and productivity growth with the social rate of return to R&D being estimated as between 20% and 50%. Griffith (2000) urges caution when interpreting the results of these and other studies as estimates that are carried out at firm level will only capture the return to that firm. Those that are at industry level will capture the rate of return to that industry but not spillovers to other industries. Also, estimates conducted at the national level capture within country spillovers but not those between countries.

The key issue for our modelling exercise is to make a reasonable estimate of what the benefit from R&D/Innovation is to the whole Northern Ireland economy. In assessing how important R&D is for economic growth, Griffith provides a comprehensive review of the issues, citing several academic studies that attempt to estimate the returns to R&D. In particular, Griffith highlights a study by Jones and Williams (1998) who integrate the social rate of return into a macroeconomic model of endogenous innovation and growth and as a result believe that the estimates of the social rate of return in the R&D literature actually provide a lower bound to the true social rate of return. Jones and Williams think this under-estimation occurs due to the assumption that imitation is costless whereas it takes time to explain new ideas and train people.

In relation to private rates of return, Griffith notes a lack of estimates of private rates of return to R&D with many studies focusing only on US firm level data. Griliches (1992) for example estimates the elasticity of output with respect to R&D of around 0.07 meaning that a 10% increase in R&D expenditure will result in 0.7% increase in output.

In the 2004 Spending Review, HM-Treasury published a 10 year investment framework for science and innovation. Outlining the importance of R&D to innovation, this report

draws on Griffith's work stating that 'research clearly shows that investment in business R&D generates substantial returns. A review of the literature reports that estimates of the private return to R&D cluster around 10-15 per cent, although they can be as high as 30 per cent. When one takes into account that benefits from the R&D also accrue to other firms or industries, then rates of return can reach 100 per cent.' To answer the question of whether or not the government should promote R&D Griffith settles on a 'conservative estimate of the social rate of return to R&D of 30% and a private rate of return of 7-14%.'

Localised Benefits from R&D

The fact that Northern Ireland is a small open economy adds a further obstacle to estimating the benefits to R&D as the extent to which benefits from R&D carried out in Northern Ireland remain within Northern Ireland and conversely, to what extent R&D carried out elsewhere benefits Northern Ireland are unknown. Roper, Hewitt-Dundas and Love (2003) highlight several studies that show the tendency for knowledge spillovers to be spatially concentrated around knowledge sources drawing upon a study by Egeln et al. (2002) who show that of 2000 public research spin-outs in Germany, 66.5% located within 49km of their incubator institution. Roper et al. also point out that lagging regions may find it difficult to appropriate spillover benefits due to limited absorption capacity or receptivity. This may reflect specific limitations in the regional innovation system such as a predominance of economic activity in SMEs in old economy sectors, weak inter-firm association or a weak skill base; or, it may reflect the impact of limitations in the wider national innovation system such as a lack of technology transfer and co-ordination institutions (e.g. Walker, 1993).

The issues discussed above clearly indicate the difficulties in attempting to quantify the benefit of R&D/innovation on the economy and the following section outlines our efforts to overcome these issues and model R&D in the EDF model.

Support for R&D and Innovation

The importance of innovation has been widely recognised. This includes the European Union level, nationally by the UK government and locally by DETI. Concerned with the productivity gap between the EU and USA, EU leaders formulated a goal for the EU to 'become the most competitive and dynamic knowledge based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion' (Lisbon summit, 2000).

The 2002 HM-Treasury publication 'Investing in Innovation' placed innovation 'at the heart of productivity growth and social gain.' To this end, one of the key strategies of the Department of Trade and Industry is to increase technological innovation in the UK with a view to improving productivity. To achieve this aim, the Innovation Report published in 2003 emphasised the importance of developing a technology strategy and programme. The technology programme, underpinned by funding of £150m over the first three years, aims to support R&D and the sharing of knowledge in technology. This programme will

be delivered through open, competitive calls for proposals using two new DTI business support products: collaborative R&D and knowledge transfer networks.

A major strand of the Government's aim to increase R&D is through R&D tax credits. Introduced in April 2000 for small firms and April 2002 for large firms, the tax credit works by allowing firms to deduct up to 150% of their qualifying expenditure on R&D activities when calculating their profit for tax purposes. It is estimated that between April 2000 and May 2004 over 10,000 claims for R&D tax credits were made with around £570 million of support provided.

DETI recognised the importance of innovation in economic growth when it launched the Regional Innovation Strategy 'Think,Create,Innovate' in 2003. This Strategy was launched after a report by the Northern Ireland Economic Council recommended 'it is vital that Northern Ireland has a research and development innovation strategy, given the long established close connections between research and development, innovation and economic performance. The aim of the strategy is to create a culture and environment within which Northern Ireland will prosper by using its knowledge, skills and capacity to innovate.

Invest NI also offers a number of specific support packages to firms engaged, or hoping to be engaged in R&D. During 2002/03 Invest NI made offers totalling £12.4 million in respect of 154 projects through a number of support schemes. These programmes, outlined in the Invest NI annual report 2002/03 are worth outlining in detail.

- The Compete programme helps companies to improve their national and international competitiveness through support for innovative new products and manufacturing processes. During the year, there were a total of 184 applications. Of these, 134 companies accepted 139 offers of assistance totalling £7.3m against total project costs of £22.1m. Forty per cent of the participating companies were engaging in R&D for the first time.
- The Start programme assists technology based, pre-competitive R&D. The total value of research projects currently being assisted under the START programme amounts to over £43 million.
- The Smart programme assists very small companies and individuals to carry out feasibility studies which will help develop innovative ideas into commercial products. SMART is organised on an annual competitive basis. In the UK, this scheme has been replaced by a grant for R&D.
- Invest NI also manages the International Fund for Ireland's Radiane programme which helps local companies develop new products and processes through joint ventures with partner companies in the USA, Canada, Australia, New Zealand and other EU countries.
- A £3 million venture capital fund was established in February 2003 (NITECH growth fund) to finance the commercialisation of technological research in new start up and existing businesses. The aim of the fund is to encourage and support R&D activities and enable businesses to develop products that will meet market needs.

- Invest NI's flagship technology transfer programme is the Knowledge Transfer Partnerships programme which is aimed at stimulating innovation through collaborative partnerships between businesses and the knowledge base contained within Northern Ireland's higher and further educational institutions.
- The Centres of Excellence programme, funded by Invest NI and Peace II funds will lead to 20 new R&D facilities (17 had been agreed at the time of Invest NI's annual report) which will carry out leading edge, industrially-related and, above all, commercially exploitable research. The centres will have strong university-industry links and cover a wide range of research fields. The total public/private investment is expected to result in excess of £115 million.
- Invest NI also helped establish 19 companies which emerged from R&D carried out within Northern Ireland's research base.

R&D Innovation and Patents in the UK

Before analysing how innovation is modelled in the Regional Forecasts EDF model it is worth assessing the extent and types of R&D within Northern Ireland and across the UK regions to motivate further our understanding of the issues. The results from the third Community Innovation Survey (a survey which takes place every four years across Europe) were published in May 2004. The Community Innovation Survey complements other indicators of innovativeness by providing a regular snapshot of innovation inputs and outputs and the constraints faced by UK businesses in their innovation efforts, across the range of UK industries and business enterprises. The UK regional results from the most recent survey indicate that of all the UK regions, firms in Northern Ireland engage least in product innovation. Northern Ireland was the second worst UK region for firms engaged in process innovation and was the region with the lowest likelihood of enterprises reporting innovation expenditure.

In terms of R&D in businesses, results from the DETI annual R&D survey show that there was a slight decline in real terms (-1.7%) in business R&D between 2001 and 2002. This is unsurprising in light of the collapse of the high-tech boom at the beginning of 2001 with major effects in some of Northern Ireland's electronic firms. Looking back over a longer period does show that between 1996 and 2002 business expenditure on R&D increased by 43% in real terms compared to around 22% in the UK as a whole. However, as a proportion of GVA, Business Expenditure on R&D in Northern Ireland remains particularly low as the tables show. Business Expenditure on R&D per employee in Northern Ireland is one of the lowest in the UK at £225. On current employee numbers, BERD in Northern Ireland would have to increase to over £330 million to match UK BERD per employee levels.

Table 2.4: R&D Expenditure by Businesses per Employees, 2002

Region	Manufacturing (£)	Services (£)	Other (£)	*Total (£)*
North East	130	647	29	0
North West	567	3305	53	24
Yorks & the Humber	169	840	30	15
East Midlands	615	2403	96	731
West Midlands	304	1277	58	53
East	1224	5826	470	394
London	247	2774	76	86
South East	906	6071	241	510
South West	614	3255	181	179
Wales	169	857	22	14
Scotland	285	2021	40	89
Northern Ireland	225	1160	71	0
UK	508	2796	129	204

Source: National Statistics, Regional Forecasts

Table 2.5: R&D Expenditure by Businesses as a proportion of GVA

Region	2000	2001	*2002*
North East	0.6	0.4	0.4
North West	1.7	1.7	1.8
Yorks & the Humber	0.5	0.5	0.5
East Midlands	1.7	1.7	1.8
West Midlands	0.9	1.0	1.0
East	3.4	3.4	3.0
London	0.6	0.5	0.6
South East	2.2	2.4	2.2
South West	1.4	1.6	1.9
Wales	0.5	0.4	0.5
Scotland	0.6	0.7	0.9
Northern Ireland	0.8	0.8	0.7
UK	1.4	1.4	1.4

Source: National Statistics

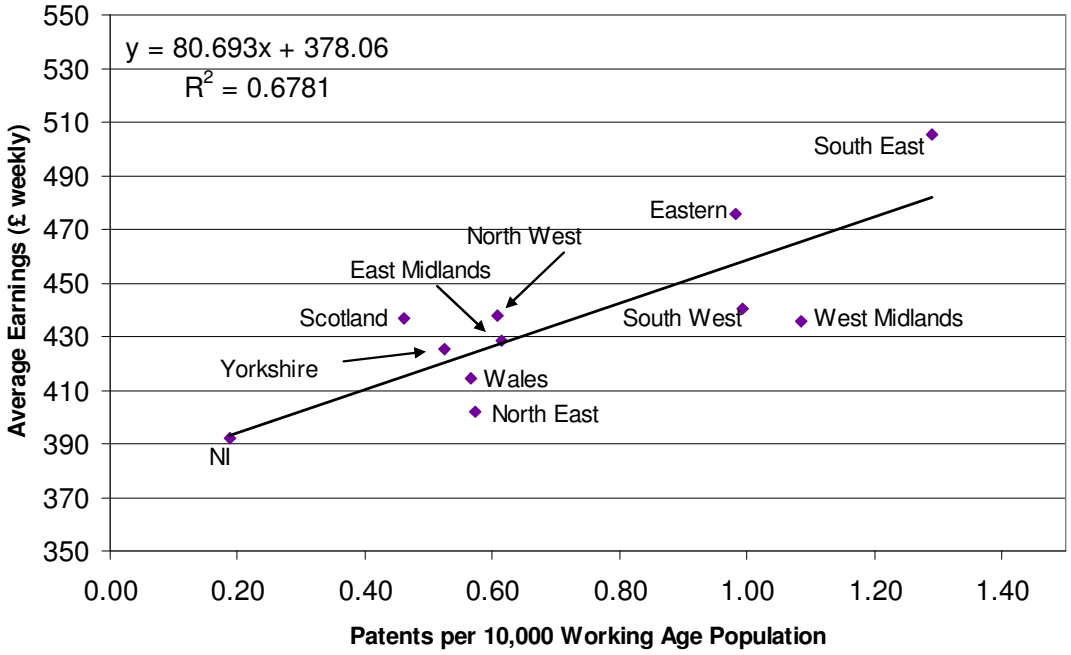
Table 2.6: R&D Expenditure by Manufacturing Businesses as a proportion of Manufacturing GVA

Region	*2001*
North East	1.7
North West	7.3
Yorks & the Humber	1.8
East Midlands	6.0
West Midlands	3.4
East	15.8
London	3.7
South East	14.0
South West	7.6
Wales	1.6
Scotland	3.8
Northern Ireland	3.5
UK	6.6

Source: National Statistics

While Porter's work, discussed earlier, focuses on patents in regions in the USA, we have analysed the relationship between wages and patents for the UK regions in the chart below. Patents have been averaged over four years to smooth out fluctuations in the data. Also, London has been removed from the scatter plot as an outlier and the chart shows the strong positive link between regional patent intensity and wages. A ten-fold increase in patents associated with a 25% increase in average wages. We will show in the next chapter that average wages are also closely related to the proportion of graduates among the working age population in each area. Both patents and graduates are related through the need for research activities for highly qualified staff. Graduates are also likely to be employed in greater numbers in high value added activities which result from successful R&D activity. The association between patents and wages is thus complex and likely to involve indirect as well as direct effects.

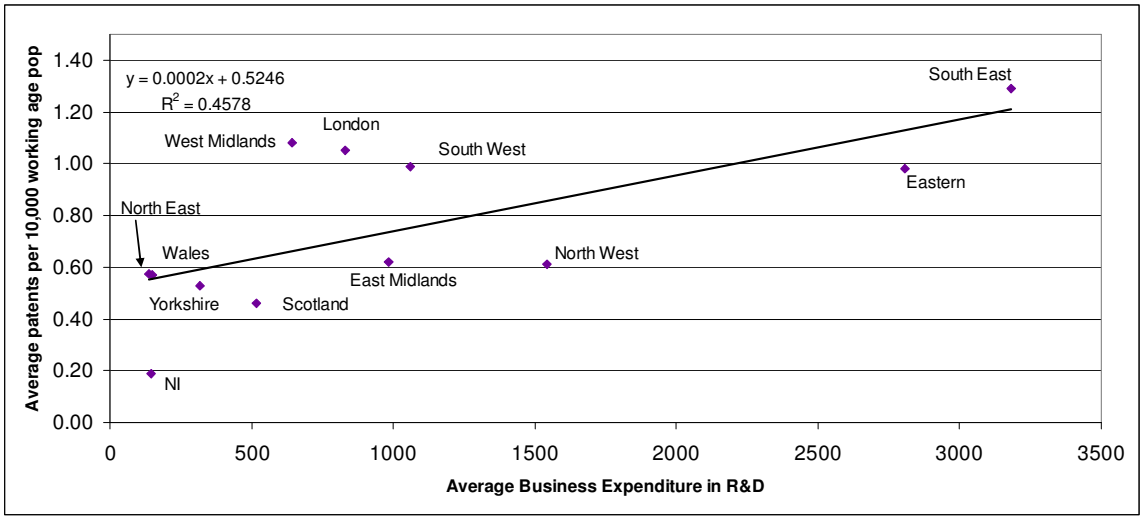
Figure 2.1: Scatter plot of average patents per 10,000 working age population and average weekly wages, 2003



Source: UK Patent Office, New Earnings Survey

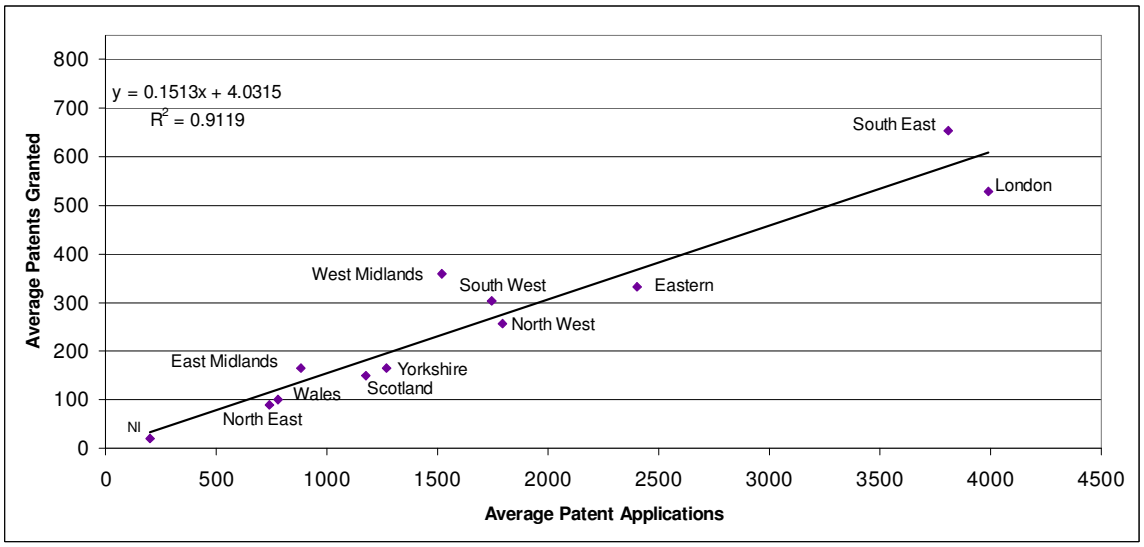
The scatter plot for patents and wages clearly show the link between a higher level of patents and higher regional wages. We can analyse the patent data further to show the links between patents applied for and patents granted and the link between BERD and patents. Patent data and BERD data have been averaged over four years (3 years for BERD) to correct for fluctuations. What is clear from the plots is that there is a relation ship between the amount of money spent on R&D and the number of patents. The second scatter plot below is particularly interesting. In relation to success rates of patents (patents granted as a proportion of applications) there is an obvious linear relationship. What is interesting however is that Northern Ireland's success rate is lower than every other UK region. 24% of patent applications in the West Midlands are successful; the highest rate in the UK, whereas only 10% of Northern Ireland's patent applications are granted.

Figure 2.2: Scatter plot of average business expenditure on R&D and average patents per 10,000 working age population



Source: UK Patent Office

Figure 2.3: Scatter plot of average patent applications and average patents granted



Source: UK Patent Office

Conclusion

As discussed in the literature review, the HM-Treasury 10 year investment framework for science and innovation outlines the importance of R&D to innovation and drawing on Griffith's work states that 'that estimates of the private return to R&D cluster around 10-15 per cent, although they can be as high as 30 per cent. When one takes into account that benefits from the R&D also accrue to other firms or industries, then rates of return can reach 100 per cent.' To answer the question of whether or not the government should promote R&D Griffith settles on a 'conservative estimate of the social rate of return to R&D of 30% and a private rate of return of 7-14%.'

Our analysis of patent information shows the positive link between business expenditure on R&D and patent applications. As Northern Ireland is delivering the second lowest level of patents granted to business expenditure on R&D rations (0.14 patents granted per £1 million BERD) the estimates of the impact of R&D expenditure in our model will be at the lower end of the 'conservative estimates' Griffith decides upon in her report. In modelling the effects of Business Expenditure on Research and Development we propose to show the impact of expenditure on patents and then flow through to an impact on wages and productivity. The results of this will be presented in our final report due in November.

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Chapter 3: Modelling Human Capital

Human Capital in the Regional Forecasts EDF Model

Under the Strategic Priority area: Human capital – enhancing capabilities and skills, the aim of EDF is to ensure that the Northern Ireland workforce is equipped with appropriate skills to support the current and future needs of the economy. Again, the original targets under this measure have been amended to reflect Regional Forecasts concerns and EDF's consultation process. The original targets are listed in Table 3.1 with Regional Forecasts assessment and EDF's decision. Table 3.2 presents the new indicators.

Table 3.1: EDF Innovation Targets

	Original EDF 2010 Target	Regional Forecasts' Comments	MTSPs Sub-group Comments
PRIMARY			
Proportion of working age population qualified to NVQ level 2	No 2010 target[1] (see footnote 1 below)	Drop - Revise targets to focus on the higher and lowest qualifications. Intermediate indicators are viewed as less pressing.	This should be re-specified to refer to Level 2 (rather than NVQ Level 2). A value will have to be set and agreed with DEL – NB DEL targets don't go beyond 2007 The primary aim in relation to skills targets is to reduce the gap between low and high skilled and to raise the overall average. Regional Forecasts should examine the availability of appropriate benchmarks.
Proportion of working age population qualified to NVQ level 3	No 2010 target (see footnote 1 below)	Re-specify – Express relative to UK average.	This should be re-specified to refer to Level 3 (rather than NVQ Level 3). A value will have to be set and agreed with DEL – NB DEL targets don't go beyond 2007 The primary aim in relation to skills targets is to reduce the gap between low and high skilled and to raise the overall average. Regional Forecasts should examine the availability of appropriate benchmarks.
Proportion of working age population qualified to NVQ level 4	No 2010 target (see footnote 1 below)	Re-specify - Express relative to UK average.	This should be dropped as a specific target as the primary concern is to address the issue of lower level skills where the biggest problems currently lie. Regional Forecasts should monitor the proportion of working age population qualified to Level 4/5 to understand the changing skills profile.
Proportion of working age population with no qualifications	No 2010 target (see footnote 2 below)	Re-specify - Express relative to UK average.	This should be dropped as a target with the focus on raising the proportion of the working age population qualified to Levels 2 & 3, the percentage with no qualifications should therefore decrease.
Level of essential skills for living	10,500 learners supported	Re-specify - suggest investigating the use of the International Literacy Survey.	This should be retained. [DN – DEL advice is that Essential Skills is now based around a new qualification. Further discussion with DEL will be needed to establish an appropriate baseline and 2010 target.]

[1] At the time of publishing the MTSPs structure, EDF agreed to use the DfES targets for Education and Skills as no alternative was available at that time. This contained 8 level 2, 3 & 4 targets for schools, young people and adults. For each of levels 2, 3 & 4 an indicator, comparing NI to the UK, was selected however there were no explicit DfES targets for Education and Skills.

Strategic Priority Area: Human Capital – cont'd

	Original EDF 2010 Target	Regional Forecasts' Comments	MTSPs Sub-group Comments
SECONDARY			
High income measure – proportion of employees earning more than £400 per week	April 2010 NI = 38.6%	Drop – This indicator is unhelpful, as inflation will reduce the real value of £400 per week over time. As NES data are presented in 'bands' it is not possible to convert the data into constant prices. Regional Forecasts suggests that this is not a priority target.	Content to drop.
Higher level jobs (% of employees in SOC 1-3)	NI% / UK% = 100%	Drop - Numbers in these occupation groups are heavily influenced by the public sector in NI.	Content to drop.
Higher level jobs (% of employees in SOC 1-2)	NI% / UK% = 100%	Drop - Numbers in these occupation groups are heavily influenced by the public sector in NI.	Content to drop.
Proportion of organisations with IIP – more than 200 employees	NI% / UK% = 100%	Drop - Regional Forecasts suggest that this target could be retained but since many of the IIP organisations are not in the 'export' sectors its relation to competitiveness is not direct.	Content to drop.
Proportion of organisations with IIP – more than 50 employees	NI% / UK% = 100%	Drop - Regional Forecasts suggest that this target could be retained but since many of the IIP organisations are not in the 'export' sectors its relation to competitiveness is not direct. The sub-committee also took this view.	Content to drop.
Proportion of leavers gaining 5+ GCSE's at grades A*-C and those gaining NVQ level qualifications	New Target	New Target – This adds an indicator for school leavers.	Content to include this as a new target but should be re-specified as follows: Proportion of pupils with 5+ A* - C GCSEs or comparable Level 2 qualifications.

Table 3.2: EDF's New Human Capital Targets

Proportion of working age population qualified to at least level 2
Proportion of working age population qualified to at least level 3
Proportion of working age population qualified to at least Level 4/5
Level of essential skills for living
Proportion of pupils with 5+ A* - C GCSEs or comparable Level 2 qualifications

Much more is known about the impact of human capital on economic performance. As well as the literature that attempts to measure the impact on economic growth of education, there is an increasing body of work that contests the belief that more education equates to more economic growth. Again, we focus this chapter around some of the current literature on the issue and outline how we will fit human capital into our forecast model.

Literature Review

Sianesi and Van Reenen (2000) offer an extensive summary and discussion of the body of econometric literature trying to measure the links between education and economic growth and the following review is based in their work. They state that taking previous studies as a whole, there is compelling evidence that human capital increases productivity, suggesting that education really is productivity-enhancing rather than just a device that individuals use to signal their level of ability to the employer. However, it is less clear that this conclusion applies to marginal additions to investment in education within advanced economies.

The empirical literature, they state, is still largely divided on whether education affects the long-run level or growth rate of the economy. Most of the evidence is from "Barro" style growth regressions that suggest that increasing school enrolment rates by one percentage points leads to an increase in *per capita* GDP growth of between 1 and 3 percentage points every year. An additional year of education in the population leads to over 1 percentage point faster growth. This is an extraordinarily large effect. Sianesi and Van Reenen think the effect is overstated due to methodological problems such as correlation with omitted variables and unduly imposed restrictions, concluding that the evidence in favour of the new growth theories (especially for OECD countries) is quite weak.

Sianesi and Van Reenen find that returns to schooling are generally higher in less developed countries than in the OECD. Also, the impact of increases in various levels of education appears to greatly depend on the level of a country's development (with tertiary education being the most relevant for OECD countries) and education yields additional indirect benefits to growth (in particular, by stimulating physical capital investments and technological development and adoption). The literature they review also suggests that the returns to human capital are larger for firms than individuals,

suggesting that not all of the productivity gains are captured by workers. Before discussing their work further it is helpful to highlight some theories of human capital.

Theories of Human Capital

In the neoclassical model there is no explicit role for education (at any level) and no externalities - capital owners and workers are independent inputs and each is fully rewarded for their contributions to output. Recent growth theories have introduced human capital explicitly into production functions and allow for the possibility of externalities. Although higher education is not typically the specific focus of attention, there is a prima facie case for a role for higher education because of its twin outputs of research which generates new knowledge, and graduates embodying potentially labour-augmenting training. The two main macro approaches to measuring the impact of Human Capital on economic performance are the augmented Solow neo-classical approach the new growth theories.

Externalities

The benefits of human capital accumulation may not be restricted to the direct recipient but might spill over to others as well. The existence of such externalities derives from the observation that human capital often flows to countries already endowed with a high stock of such capital ('brain drain'), suggesting that the return to this 'unconventional' input is negatively related to its scarcity. In fact, external social impacts of investments in human capital can in turn have indirect economic effects. More education has been found to be associated with better public health and parenting, lower crime, better environment, wider political and community participation and greater social cohesion, all of which is in turn likely to feed back into economic growth (OECD 1998).

The existence of positive economy-wide educational spill-overs is an important economic justification for the public support of education, although the difficulties of actually verifying their size and thus calculating true social returns are formidable.

New Growth Theories

Human capital is introduced in new growth theories both with and without externalities. These are modelled either by incorporating human capital as a factor input or by explaining the process of knowledge accumulation by relating it directly to human capital accumulation, or indirectly via research and development activity.

The factors leading to endogenous growth are explicitly related to the stock of human capital. This may be either because human capital is assumed to directly produce new knowledge or technology or because it is an essential input into a research sector which generates new knowledge or technology. One of the most prominent models developed to explain the role of human capital was offered by Lucas (1988). The Lucas model assumes that the driving force behind economic growth is the rate of accumulation of human capital, in which the rate of economic growth is proportional to the rate of accumulation of human capital, and since human capital imposes externalities upon production, the rate of economic growth will respond more than proportionally to increases in human capital accumulation rates, leading to an increasing returns to scale.

The Lucas approach allows for some non-excludability i.e. some of the gains from education spill over to others but one criticism levelled at the Lucas model is that, while it is relatively easy to conceive of abstract 'knowledge' being at least partially non-excludable, it is not clear why educated individuals are unable to maintain property rights over the productivity gains from their education.

Augmented Neo Classical Model

The augmented neo-classical model extends the basic production function to allow human capital to enter the production function as an input. Mankiw, Romer and Weil (1992) have demonstrated that if a production function $Y = K^a(A_tL)1\text{-}a$ (where K is capital, L is labour, A_t is knowledge and $0<a<1$) is augmented to include human capital so that $Y = K^aH^b(A_tL)^{1-a-b}$ and solved for the equilibrium growth rate in the manner of the Solow model, this yields a (per capita) income growth equation with physical capital and human capital investment rates (i.e. as ratios of GDP) entering separately among the arguments. Alternatively the initial level of human capital can replace the human capital investment rate. By proposing a role for the human capital investment rate this approach provides a link between educational expenditures and growth.

Returns to Human Capital

Before summarising a number of studies, Sianesi and Van Reenen highlight some methodological concerns. The major issue is how to define, measure and compare skills and competencies over time and between countries. The best measures would be in terms of the output of education, but due to the difficulties of obtaining such measures, input measures tend to be used. It is very difficult to know how close proxies such as school enrolment; average years of education or the proportion of the labour force, which has received primary, secondary or tertiary education, are to their conceptual equivalents, so that failure to find positive evidence could be due to poor proxies. As well as this, aggregate measures such as these are likely to be affected by the fact that the quality of education is not taken account of and that they refer to formal education only and not informal education such as on the job training.

Endogeneity

A further methodological issue with previous studies is 'endogeneity bias.' As income grows, educational standards rise. However, we cannot be confident that economic growth is caused by higher educational standards. There are in fact reverse causality problems with education. The association of education and productivity may reflect the demand for education as well as its supply effects. According to Sianesi and Van Reenen, education contains a large consumption component; if the demand for it is highly income-elastic, income growth is likely to lead to an increased demand for education. Industrialised countries' governments in turn will be more able to respond with an increase in public spending for education and an enlargement of access to it. Also, in countries at higher income levels that have already gone through the stages of development, a larger incidence of the service sector and of the modern, high-tech production sectors will require a better-educated workforce. The question is whether the upgrading process is made possible by an (exogenously) increasingly available educated workforce (impact of human capital accumulation on growth) or whether the structural

change induces larger fractions of the population to achieve higher educational standards (impact of economic growth on human capital accumulation). The most plausible answer is that both influences are simultaneously at work, so that there is a bi-directional causality between human capital accumulation and economic growth.

Inter Regional Differences

Cross country studies tend to focus on countries at different levels of development in order to maximise samples. In fact, most authors note that the estimates for the OECD subgroup alone are much less precise. Splitting the sample according to the level of development clearly shows however that various regressors have a different impact for the two (or three) sub-samples. Such a heterogeneous impact is also consistent with the micro evidence, which points out that the (individual) returns to education vary considerably across countries, and even across regions within countries. Given this, using an estimate derived from a pool of diverse countries to infer the impact of educational expansion in the UK or indeed, Northern Ireland is unlikely to be a sensible approach.

In Sianesi and Van Reenen's review, they find that correlations found in the literature depend on the choice of the additional regressors included. In particular, most regressors have been found to be fragile in the sense that their estimated parameter changes sign or becomes statistically insignificant when a different group of regressors is included. Together with the fact that many alternative regressions have equal theoretical status, such findings call for a great deal of care in the interpretation of cross-country results.

Diminishing Returns

The final methodological issue offered is that due to the mostly *ad hoc* nature of the macro-economic specifications there is no strong reason to assume a linear relationship between human capital and productivity levels or growth. In fact one might expect diminishing returns to a factor (as in the conventional log-log Cobb-Douglas production function). One study that has examined this issue is Krueger and Lindahl (1998). They find evidence for non-linearities, in particular they find that a quadratic form for schooling fits the data better (a squared term is significant). The inverted-U pattern suggests that there are diminishing returns to education, with the peak effect at about 7.5 years.

Older studies based on growth accounting methodologies such as Jorgenson and Fraumeni (1992) point to the importance of factor intensities and accumulation in explaining differences in cross country output and find that investments in human and physical capital accounted for 83% of economic growth in the USA between 1948 and 1986. More recent studies have however questioned the relevance of such results believing instead that the contribution of productivity is more important in explaining output differences. Hall and Jones (1999) for instance claim that 60% of differences in international output are accounted for by differences in productivity and differences in growth rates of income per worker derive from differences in growth rates of total factor productivity. Sianesi and Van Reenen stress that output elasticities with respect to inputs are either imposed (typically around 0.3 for both physical and human capital) or equated

to their shares in value added (the latter requiring perfect competition and constant returns to scale). In this framework, then, the question of how much output would increase if human capital were increased by 1% is misplaced, the answer being imposed and not resulting from the analysis.

Key Policy Questions

Sianesi and Van Reenen usefully provide a summary of studies that attempt to answer several key questions which are important to policy makers and relevant to our attempts to model human capital in the EDF model. The first of these questions is 'what are the relative growth returns to different stages of education?' In relation to secondary education, a 1 percentage point increase in secondary enrolment rates is shown to lead to a 2.5 – 3 percentage point increase in growth. The effect is smaller for OECD countries (around 1.5 percentage points or even 0). One of the main studies in relation to the effect of tertiary education is Gemmel (1996). For OECD countries, a one percentage point increase in the annual growth of human capital increases GVA growth by 5.9%.

When assessing the impact of an additional year of education on economic performance, all cross-country regressions implicitly assume that one year of secondary schooling is equivalent across countries. Hanushek and Kim (1995) attempt to adjust for differences in schooling quality by attempting to measure schooling quality by using measures of cognitive skills of individuals, often interpreted as measures of schooling outcomes. One of the main implications of controlling for labour force quality considerably reduces the magnitude of the measured impact of years of schooling in macro regressions.

Levels of Education

A further question of importance for policy makers is to make some assessment of different types of education, i.e. what is the impact on growth of vocational versus academic education. One study which has tried to investigate if the allocation of students to different types of education matters for growth, is Murphy et al. (1991). They find that for countries with a large student population (over 10,000 students) the relative importance of engineering in education has a positive impact on growth, while the relative importance of legal studies has a negative effect. Saniesi and Van Reenen however, question the reliability of these findings due to a small sample size.

Vocational Qualifications and Productivity

The feature article on productivity in our first report highlighted a succession of studies of Northern Ireland-Germany comparisons undertaken at NIERC for a series of industries including textiles and clothing, mechanical engineering and food products (Hitchens, Wagner and Birnie (1990), Roper and Hofman, (1993). Hitchens et al. presented the table below which compares the physical output per person between West Germany and Northern Ireland. The table shows that average German comparative productivity in the matched trades lies between 33% and 138% above the Northern Ireland level.

Table 3.3: Physical Output per person. West Germany compared with Northern Ireland

Industry	(NI = 100)	*Number of Pairs*
Engineering	248	*6*
Miscellaneous	175	*7*
Food, Drink, Tobacco	190	*5*
Textiles	145	*5*
Clothing	133	*16*
Total number of matchings		*39*

Source: NIERC

The results of these studies suggested that better trained workforces in Germany, resulting from the superior German occupational training system, allowed more efficient working practices and hence higher productivity. Machines were linked more efficiently into integrated operations and downtime was reduced through a superior ability to read manuals and deal with faults. Such studies followed a long tradition of detailed comparisons of physical productivity over the last century prompted by concerns of lagging UK productivity compared with the USA, Germany and to a lesser extent France. The reasons for lower productivity in Northern Ireland compared to Germany are unlikely to have changed since the 1990 and 1993 NEIRC studies. The fact that 75% of workers in Germany were trained to the levels equivalent to NVQ3 and above, compared to 40% in Northern Ireland, meant that many local firms could remain profitable only in activities demanding less labour skill and by paying lower wages than in Germany.

In relation to returns to skills, the Northern Ireland New Earnings Survey 2003 clearly shows the considerably lower returns to lower skills levels. The average gross weekly wage in 2003 for full time employees was £404. However, people with skill level 2 (general education and work related training or work experience) commanded an average weekly wage of £287, less than half the average wage for people with skill level 4 (degree or equivalent period of relevant work experience).

Table 3.4: Average Gross Weekly Earnings by Skill Level (£), April 2003

Full-time employees on adult rates of pay, not affected by absence	Skill level 1	Skill level 2	Skill level 3	Skill level 4	*All*
Men	278.7	315.1	454.1	658.2	*437.7*
Women	226.0	261.6	426.1	532.4	*355.2*
All	*266.4*	*286.9*	*445.7*	*608.8*	*404.5*

Source: New Earnings Survey, 2003

One element of the Republic of Ireland's economic success can be attributed to increased investment in technical education. While this has undoubtedly played a part, other factors such as low corporation tax levels have attracted a lot of FDI to absorb the skilled workforce. In a small open economy such as Northern Ireland increasing the skill levels

of the working age population will have to be coupled with job creation in sectors that require skilled labour.

Schooling Inputs

There are few macro studies that aim to identify a role for educational inputs in economic performance. However, these fail to find any significant effect. In relation to per capita GDP growth, the student-teacher ratio at secondary level is insignificant (Barro, 1991) and in relation to the measure of quality, inputs to education such as pupil-teacher ratios and expenditure on schooling do not display any systematic significant effects (Hanushek and Kim, 1995). Sianesi and Van Reenen state therefore that as a result, the finding in previous studies that differences in labour force quality offer an important contribution to growth lacks specific policy implications, since no relationship has been found between the measure of quality and measured inputs into schooling.

Indirect Effects of Human Capital on Growth

In addition to its direct impact on economic growth, human capital may also have an effect on other factors which affect growth. Human capital appears to be associated with significantly larger physical capital investments (Gemmel 1996). For OECD countries in particular, the stock of secondary human capital appears particularly important in stimulating these investments, while direct growth effects come through increased tertiary human capital stock and accumulation. Human capital has consistently been found to display a positive effect on rates of productivity growth by raising the rate at which leading-edge foreign technologies are adopted (Cameron, Proudman and Redding 1998).

Challenging the Consensus

The belief that all additions to investment in education automatically lead to more growth, and the idea that this can be fostered by government policy, has been challenged by Alison Wolf. She states that the general belief that education delivers growth rests partly on the obvious point that developed societies need a lot of educated people, and that research laboratories - many in universities - are critical to technological progress. But the fact that a good deal of education is needed in a society does not mean that yet more will be better (in growth terms) any more than the need for investment in a society means you can never over-invest.

Wolf states that, very often, the case for growth rests on examples of particular countries such as Korea or Singapore, where governments had highly interventionist education policies or ascribing the problems of the UK economy in the period before the late ‘80s to various manifest problems with its education system. She believes that comparisons among OECD countries produce no simple linear relationship between education and wealth. Switzerland, the richest per head of all, has by far the lowest university participation rate of wealthy OECD nations while America does badly on most international literacy and numeracy surveys. Also, within the developing world, Wolf fails to find any clear relationship between educational expenditure and growth. Some of the ‘Asian tigers’ certainly spent a great deal on education from early on, but not all:

Hong Kong, did not adopt a strong government-led policy to expand education, and did not obviously suffer as a result. Among the countries that have made very little economic progress in recent decades there are plenty (Egypt, Sri Lanka) where governments have repeatedly spent large amounts on education, including enormous expansion of not just secondary but also university enrolments.

Wolf's fear is that since the view of education is now essentially about growth the 'simplistic link between the number of diplomas or years in education on one hand, and economic growth on the other' has pushed the discussion about educational quality aside. Also, the obsession with growth seems to help explain why UK vocational education policy has been such a repeated failure. Instead of seeing mainstream education as being about broad education for citizenship, governments have been obsessed with a modern variant on central and manpower planning. They convinced themselves that they could and should fine-tune the education and training system to meet immediate, narrow vocational requirements. Wolf believes that young people, with a life-time ahead of them and a clear, if intuitive, grasp of labour market realities, have naturally turned their backs on this. We have, at present, the rather puzzling phenomenon of a huge increase in the staying on rate post-16, and of aspirations to higher education: plus high drop-out rates (at 17) for those not succeeding in an HE-bound track. But that isn't really paradoxical at all, because education has to involve the offer of something worth staying for – which, in this country, means something that actually adds value to one's GCSEs.

Wolf fails to see the sense, in a modern society, of offering young people a narrow training for a highly specific job. They will almost certainly change jobs frequently well into their 30s – most people do – and do so in the context of a rapidly changing economy in which even jobs with the same name change their content every few years. It is an economy, moreover, where a growing body of evidence indicates that the skills which turn out to be really valuable over a lifetime are close to the heart of the traditional school curriculum – good command of written and spoken language, and mathematics.

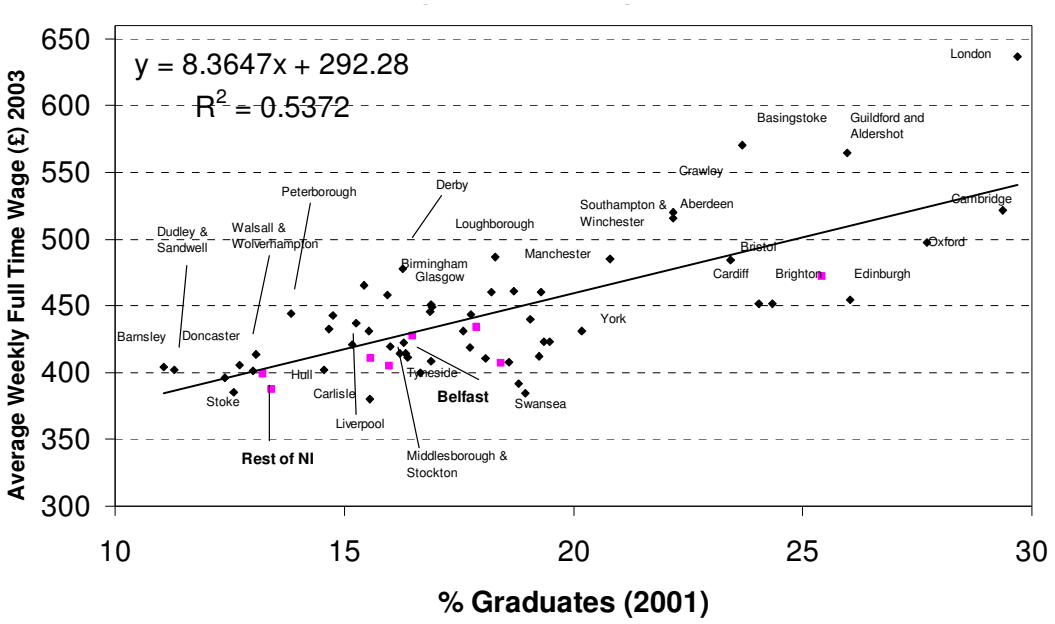
Literature Conclusions

On balance, the available evidence suggests that education has a positive impact on growth. The two main findings from studies of OECD countries are that firstly, care needs to be taken when drawing conclusions from these studies as the small sample size and homogenous nature of the OECD countries makes it difficult to identify precise individual effects. Secondly, the impact of increases in various levels of education appears to vary greatly according to the level of a country's development. In particular, while primary and secondary skills appear to be related to growth in the poorest and in intermediate developing countries respectively, it is tertiary education that is important in OECD countries. As we show in the following section, it is clear that education has an important effect on wages paid in the labour market. What is not clear however is whether this is due to the role that education plays in raising the productivity of workers or whether education simply reflects the ability of the worker through signalling?

Human Capital in the UK

There is little doubt that a correlation exists between higher levels of education and incomes either for individuals or countries. The chart below based on Census 2001 and the New Earnings Survey demonstrates that this is also true at the level of local labour markets within the UK.

Figure 3.1: Graduate/Earnings Relationship in UK Travel To Work Areas and UK Regions



Source: New Earnings Survey, Census 2001

Once again it is not possible to infer causal relationships from a simple correlation. Since in general graduates are more highly paid than non-graduates it is not surprising that average wages are higher in areas with more graduates. However, the pure compositional effect of a greater number of graduates would account for only a fifth of the observed wage differentials in Figure 3.1. The other 80% appears to be the effect of the higher average wages for all employees in areas with high proportions of graduates. This suggests that there are large externalities associated with higher wages for non-graduates as well as graduates. In the previous chapter we described one of the characteristics. Regions with more graduates produce more patents. They also have more people in higher productivity industries and also have tighter labour markets. Each of these factors could tend to generate higher wages.

It thus seems clear that local economies with more graduates are more likely to have higher incomes and higher per capita GVA. Graduate intensive economies would thus seem to be a desirable policy goal. The problem is that such a goal may be very difficult to attain. Certainly as we have observed in Northern Ireland, simply producing more graduates, or more people qualified to go to university has relatively little impact on the average qualifications of the workforce as a whole, because many graduates leave to work in areas where wages and prospects are more favourable.

Northern Ireland has traditionally had a very strong education system, with the highest qualifications among school leavers. However a drain of skilled labour has resulted in a paradoxical situation whereby the working age population is one of the lowest qualified in the UK. The following tables demonstrate this paradox, showing that over 50% of Northern Irish students obtained 5 or more GCSE's at grades A*-C and only 6% failed to achieve any grades. Conversely, the figures for the working age population by highest qualification show that nearly a quarter of people of working age have no qualifications, a figure which is considerably higher than any other UK region.

Table 3.5: Examination Achievements of Pupils in their last year of compulsory education, 2001/02

	5 or more grades A*- C	1-4 grades A*-C	Grades D-G only	*No Graded GCSEs/SCEs*
North East	40.5	24.2	27.3	*8.0*
North West	44.7	25.2	23.3	*6.8*
Yorks & the Humber	40.2	23.7	28.4	*7.7*
East Midlands	45.8	23.1	24.8	*6.3*
West Midlands	44.3	25.0	24.1	*6.6*
East	50.1	23.5	20.9	*5.5*
London	45.4	25.6	22.4	*6.6*
South East	51.5	22.7	20.2	*5.6*
South West	50.3	23.1	21.1	*5.5*
Wales	44.8	23.9	22.0	*9.2*
Scotland	55.2	28.0	11.6	*5.2*
Northern Ireland	51.9	23.6	18.3	*6.1*
UK	*47.2*	*24.4*	*22.0*	*6.4*

Source: Regional Trends 38, National Statistics

Table 3.6: Population of working age by highest qualification, spring 2003

	Degree or Equiv	Higher education quals	A level or equiv	GCSE A*- C or equiv	Other quals	*No quals*
North East	11.3	9.1	25.1	22.7	12.6	*18.8*
North West	13.3	8.3	24.6	24.1	11.4	*17.5*
Yorks & the Humber	13.4	7.7	25.6	22.1	14.4	*16.2*
East Midlands	13.0	7.6	25.1	22.6	13.4	*17.1*
West Midlands	12.7	8.3	23.6	22.7	14.1	*17.6*
East	16.2	7.7	22.7	25.0	14.0	*14.0*
London	24.7	6.0	18.5	16.7	20.2	*13.4*
South East	19.9	8.6	24.2	22.4	13.7	*10.6*
South West	16.2	9.8	24.9	24.1	13.4	*10.7*
Wales	14.6	8.8	23.2	23.4	11.6	*17.1*
Scotland	15.4	13.3	29.9	16.4	9.7	*14.7*
Northern Ireland	13.1	7.7	26.9	21.0	6.7	*23.7*
UK	*16.3*	*8.5*	*24.1*	*21.7*	*13.7*	*15.0*

Source: Regional Trends 38, National Statistics

The Northern Ireland compendium of higher education statistics provides further evidence of the drain of qualified people from Northern Ireland and lends more weight to our belief that the issue facing education in Northern Ireland is not one of supply but that demand has never been strong enough to support the skilled labour the education system produces. The tables below show the shares of students domiciled in Northern Ireland who studied in British institutions and the first destination of NI domiciled students who studied in GB. What is clear is that on average 35% of students leave Northern Ireland to study in GB. Of those students from Northern Ireland who study in GB, around two-thirds remain in GB when they leave university.

Table 3.7: Percentage of NI Domiciled Students Studying outside Northern Ireland

	Students	Leavers	*% Leaving NI*
1995	7584	2588	*34.1*
1996	7950	2825	*35.5*
1997	8204	2991	*36.5*
1998	8220	2850	*34.7*
1999	8253	2985	*36.2*
2000	8324	2927	*35.2*
2001	8733	3084	*35.3*
2002	10580	3433	*32.4*
Average	8481	2960	35.0

Source: HESA

Table 3.8: First Destination of Students Domiciled in Northern Ireland and studied in GB

	% NI	% GB	% RoI	% Other EU	% Other	*Number*
1995	31.0	63.1	1.9	1.5	2.5	*1570*
1996	28.7	64.9	1.6	2.2	2.6	*1787*
1997	27.2	64.7	3.6	2.1	2.4	*1895*
1998	30.4	61.8	3.4	2	2.4	*1894*
1999	29.9	63.5	2.6	1.6	2.4	*2034*
2000	27.6	65.7	3.9	1.3	1.5	*1636*
2001	29.1	63.8	2.7	1.5	2.9	*1757*
2002	28.1	65.3	2.9	1.4	2.2	*2229*
Average	29.0	64.1	2.8	1.7	2.4	1850

Source: HESA

Human Capital in the Regional Forecasts EDF Model

The problem facing Northern Ireland is that in a small open economy such as Northern Ireland's, the traditional arguments in relation to returns to education are not directly applicable due to the out migration of skilled labour from the region.

We reiterate our view from our feature article in Report 1 that the UK's past failure to produce enough graduates and other highly skilled personnel has starved regions outside the south and east of skills, innovation and enterprise. London and the South East have developed an economic base sufficiently strong to be able pay wages high enough to ensure that it attracts the skills it needs; as a result the proportion of graduates working in London is almost twice as high as in the rest of the UK.

This is of particular importance for Northern Ireland which has one the UK's best school education systems but is unable to retain enough of the highly educated products of the system to build a highly educated workforce. Indeed many of the best educated products of Northern Ireland's schools become part of the workforce of London and the South East. The problem is thus one of generating sufficient demand (and high enough wages) for the flow of well educated pupils and graduates generated by Northern Ireland's education system.

Generating a high wage, high productivity economy is an intensively difficult matter, and the experience of Northern Ireland appears to indicate that a good local education system has little impact on the local economy, (although it does a lot to raise the earnings of its pupils and graduates albeit often in other regions). In our view the task is also becoming more difficult as economies become more dependent on services rather than manufacturing. There is some evidence above that GVA per employee in Northern Ireland manufacturing may have at last converged with the UK average. With manufacturing becoming a small part of the total economy this has less impact on the wider economy than might once have been the case.

Our main focus in relation to Human Capital in the EDF model will be on the demand side. Taking the Warwick Institute for Employment Research (IER) forecasts of

employment by occupation we will calculate a share that each occupation contributes to each industry. By applying this to our employment data, we can produce forecasts of occupation levels for the Northern Ireland economy that will be consistent with our own employment projections. Using estimates of qualification levels in each occupation from the Labour Force Survey will allow us to make an estimate of the qualification levels required to service projected occupation levels between now and 2010. This will allow us to make an assessment of whether or not there will be a sufficient change in demand for highly qualified staff in Northern Ireland to result in changes in the qualification levels of the working age population.

The supply side is more difficult. Firstly, we will model the proportion of people with different qualification levels who leave Northern Ireland. The coefficients for this part of the model will be motivated by the tables above that show the proportions of students leaving Northern Ireland and those returning after their studies. Secondly, we will use coefficients from the literature review above to relate educational attainment to productivity. The results of this work will be incorporated into the final forecast model to be delivered in November.

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