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BERR ECONOMICS PAPER NO. 2

Five Dynamics of Change in Global Manufacturing

Supporting Analysis for 'Manufacturing Strategy: New Challenges, New Opportunities'

SEPTEMBER 2008

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Foreword

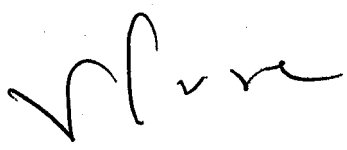
I am pleased to be able to introduce this second BERR Economics Paper.

As part of the review of the Government's Manufacturing Strategy, we were keen to consider how the environment facing manufacturers had changed since the strategy was last reviewed, to ensure Government focused on the policy areas that most mattered for UK firms in the changing global economy.

Our consultations with stakeholders, as well as academic and survey evidence, pointed towards five inter-related and changing dynamics that have been instrumental in reshaping global manufacturing: The increasing prevalence of **Global Value Chains**; renewed emphasis on **Technology Exploitation**; growing importance of **Intangibles**; recognition of the vital role of **People and Skills**; and the move to a **Low Carbon Economy**.

Most important has been the growth of global value chains, as firms are increasingly sourcing goods and services from across the globe. This places a premium on the ability of firms in the relatively higher wage developed economies to compete, not through price, but through differentiation of their products. This in turn increases the emphasis for manufacturing firms on their implementation of technology, investment in intangibles, such as design, branding and R&D, including ICT, and investment in people and skills. In addition, the growing political consensus around the need to meet the challenge of climate change creates both new challenges and opportunities for manufacturing firms.

This paper sets out the empirical evidence underpinning these five global dynamics and examines how UK manufacturing is performing against them. It then considers the appropriate role of Government in supporting UK manufacturers as they seek to harness the dynamics as a means of competing successfully in the global economy. We are grateful for the support we have received from stakeholders in developing this report, particularly the Confederation of British Industry and EEF, who carried out a survey of their members to examine the changing nature of global manufacturing.



Vicky Pryce
Chief Economic Adviser and Director General, Economics
Department for Business, Enterprise and Regulatory Reform

Executive Summary

UK manufacturers are operating in a changing global environment. Our analysis and consultation with stakeholders has pointed in particular to the importance of five global dynamics.

Most important has been the growth in the extent and complexity of **global value chains;** developments in ICT have facilitated new trade in services and made it easier for firms to source a larger proportion of inputs from across the globe. Firms are responding to increasing global competition through greater product differentiation, placing a premium on firms' implementation of **technology**, investment in **intangibles**, such as design, branding and R&D, including ICT, and investment in **people and skills.** In addition, new opportunities and challenges are being created for manufacturers by the growing importance of the **low carbon economy**.

This paper sets out the evidence underpinning the growth of these five dynamics, examines relative UK performance in each area and outlines the broad, market-failure rationales underpinning Government action.

Growth in Global Value Chains

Technology, trade liberalisation and the economic rise of emerging economies are driving the most recent phase of globalisation. A particularly important outcome of these forces has been the unbundling across the globe, of different stages of the production process. The growing capacity for firms to outsource internationally has led to the growth of what have been termed 'global value chains'. For UK manufacturers, the growth of global value chains presents both opportunities – the prospect of increased sales through successful specialisation and reduced costs through more efficient outsourcing – as well as challenges from other firms competing in the global economy.

Whilst strong relative growth in UK manufacturing exports and imports indicates that the degree of openness of the UK is increasing, evidence from the World Bank and UKTI shows that UK firms still face significant barriers in accessing global markets. Government intervention is focused on enabling companies to access global markets and value chains by addressing the market failures at the heart of these barriers, such as uncertainty over the return to overseas market entry, or knowledge spillovers that accrue as a result.

Renewed Emphasis on Technology Exploitation

The process efficiencies and productivity improvements that are essential for the global competitiveness of manufacturing are critically underpinned by advanced technologies. Leading on, and adapting to, rapidly changing technology can drive competitive advantage by providing the capacity to adopt more efficient

processes and develop higher quality or better customised products that enable companies to capture higher value components of the value chain.

The UK is taking the lead in adapting to increasingly globalised innovation platforms. It is also building on the success of its world class science and technology base, having made improvements in recent years in the levels of technology transfer from UK universities. But there remain areas where performance can be improved, with the UK continuing to lag behind leading countries on some measures of R&D investment and technology exploitation.

Government continues to play a key enabling role in allowing markets to fulfil their potential as powerful drivers of technological innovation. It supports broad-based science and technology research, and provides incentives to invest in technology, so that full account is taken of the broader economic and social benefits that can result from technology development and exploitation.

Investment in Intangibles

Firms in the UK, and other developed economies, are increasingly investing in intangibles or knowledge assets, such as software, design and other aspects of product-development, brand-building, training and improvements to business processes, in order to improve their competitiveness and enable their products to meet the changing needs of consumers.

Measurement of intangibles is still in its infancy, but an indication of their importance is shown in unofficial data which suggests that British manufacturing spent £32billion on intangible assets in 2004, more than double the official measure of investment. Initial indications suggest that overall investment in intangibles in the UK is at least in line with overseas counterparts.

Firms presently use a combination of formal intellectual property rights (IPR) and techniques such as speed to market and open innovation to capture the value from intangibles. There is an important role for Government in ensuring that firms have the right incentives and information to continue investing in intangibles.

The Changing Nature of Skills Requirements

The increasing prominence of low wage economies in the global labour market and developments in technology have increased the importance of developed economies raising skill levels in their manufacturing workforces. In particular, firms are reporting a requirement for both specialist high level skills, including STEM, along with demand for a generic set of soft skills that enable people to work across disciplines.

Evidence suggests the UK labour force has responded well to this challenge in recent years, with both an occupational shift towards traditionally higher skilled

jobs as well as improvements in overall educational attainment levels. However, other evidence highlights management skills as a potential area of weakness.

Government is developing a high level skills strategy[1] that recognises the importance of high level skills for innovation and the potential spillovers benefits from such workers. Strong management and leadership is also vital for the operation of global value chains and making the most effective use of the skills of the workforce to deliver high value added products and services.

Growing Importance of the Low Carbon Economy

The transition to a low carbon and more resource efficient economy is presenting both challenges and opportunities for businesses, in manufacturing and all other sectors, through greater environmental efficiency and sales of 'greener' products and technologies.

Research suggests there are firm level synergies between good commercial and environmental performance, but there will inevitably be trade-offs between the short-term costs of transition to clean technologies and the uncertain long-term economic benefits.

Establishing a robust carbon price will play a key role by ensuring businesses prioritise carbon efficiency in their production decisions. Recent evidence suggests the most viable way for the UK to exploit business opportunities in green business is to stimulate green products and services in areas where the UK already holds a comparative advantage, such as, high tech manufacturing and business/financial services sectors. The EGS sector in the UK is already worth £25 billion, employs over 400,000 people, and is expected to grow rapidly to £35 billion by 2010. The UK is also the largest clean technology venture capital market in Europe with a cumulative investment of €186 million since 2001 (30 per cent of the European total)

The economic arguments surrounding climate change have risen in prominence since the publication of the Stern Review. The UK Government has therefore set out a long term policy framework to provide clear long-term signals to industry; address market, institutional, regulatory and co-ordination failures to create the necessary conditions to encourage investment and innovation in environmental products, processes and technologies; and provide information to help business and consumers make more informed choices.

Conclusions

Evidence shows that UK is responding well to the new challenges and opportunities in global manufacturing and harnessing a number of the dynamics of global change in order to move toward a higher value manufacturing sector. In

1 DIUS, 2008

particular, as well as engaging effectively in global value chains, an increasingly highly skilled labour force is being complemented by greater investment in, and use of, new technologies and intangible assets. But there is scope for further progress, particularly regarding R&D; non-technological innovation; and management skills, if the sector is to continue to develop and compete effectively. UK manufacturing is well placed to benefit from the opportunities presented by the shift towards a low carbon economy, but there is a continuing need to ensure investment in skills and technology, alongside exploitation of global value chain opportunities, to enable us to realise this potential.

The greatest scope for policy as a facilitator of UK manufacturing performance lies in targeting market failures that create barriers or reduce the incentives for UK manufacturers to respond effectively to the five dynamics that are driving change in global manufacturing. Across areas such as exporting, investment in skills, technology and intangibles and entry into low carbon markets, such failures tend to be focused around informational asymmetries, spillovers and regulatory failures. The accompanying policy document to this Economics Paper, '*Manufacturing Strategy: New Challenges, New Opportunities*', sets out in detail the policies the Government is putting in place to address these issues.

1. Global Value Chains

SUMMARY

Technology, trade liberalisation and the economic rise of emerging economies are driving the most recent phase of globalisation. A particularly important outcome of these forces has been the unbundling across the globe, of different stages of the production process. This separation has included, not only the fabrication of physical components, but the accompanying knowledge intensive services, such as Research and Development, inventory management, quality control, and other professional and technical services.

The growing capacity for firms to outsource internationally has led to the growth of what have been termed 'global value chains'. For UK manufacturers, the growth of global value chains presents both opportunities – the prospect of increased sales through successful specialisation and reduced costs through more efficient outsourcing – as well as challenges from other firms competing in the global economy.

Success in global value chains can in some cases be supported by local clusters, even though markets have become increasingly global**.** Specialised firm networks, labour pools and infrastructure can provide a strong basis for the comparative advantage and attractiveness of regions as locations for manufacturing.

The increasing globalisation of the world economy has been well documented[2]. Whilst globalisation is certainly not a recent phenomenon (the period 1870-1913, for example, seeing significant increases in international trade, capital and labour), the current wave of globalisation has seen spectacular changes. The main drivers have been:

- Increasing Openness: The adoption by a large number of countries of more open economic policies in the post-WWII era, which has increased international trade in goods and services, and cross-border flows of both capital and labour (Figure 1).
- Emergence of developing, low-wage economies: The arrival of these countries on the world stage stems mainly from political and economic changes – such as China's accession to the WTO in 2001 and economic reform in India.
- Rapid technical progress: Particularly developments in the field of Information and Communications Technology (ICT). This has sharply lowered transport and communications costs and increased the tradability of goods and services.

2 The IMF for example describe globalisation as, 'the process through which an increasingly free flow of ideas, people, goods, services and capital leads to the integration of economies and societies'.

Figure 1: Increasing Globalisation: Global exports and FDI as a percentage of global GDP

Sources: IMF WEO2008, UNCTAD

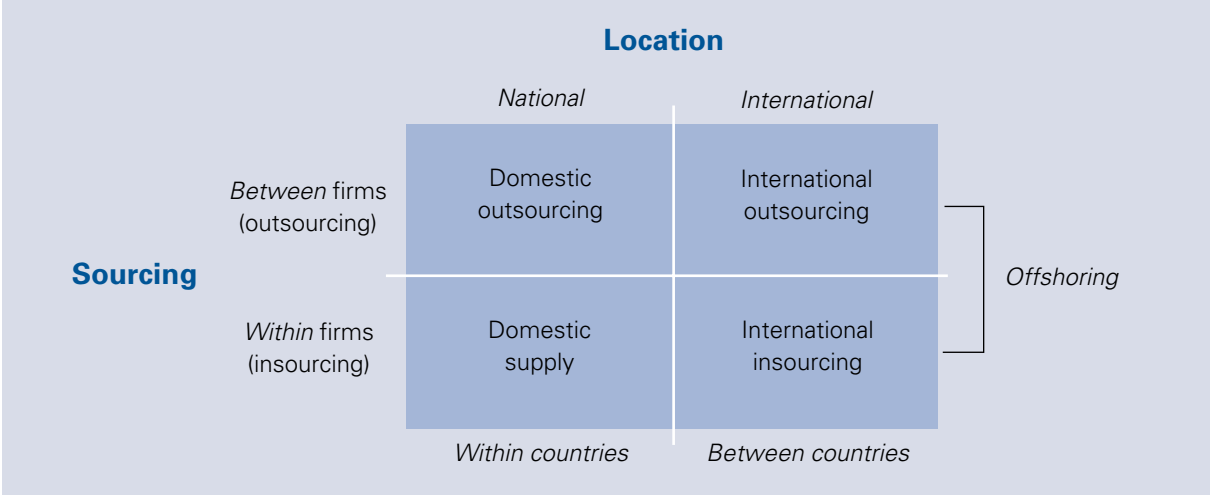
The combination of these three processes has enabled the separation, or unbundling, of the production and consumption of information-intensive service activities, such as Research and Development (R&D), inventory management, quality control, professional and technical services, banking and insurance, and government administration. Technological progress has also made it possible to reduce the complexity of production, for example, through the modularisation of production systems.

The result has been an increase in both outsourcing, which typically involves switching from in-house provision to purchasing intermediate goods and services from outside specialist providers, and off-shoring, whereby firms purchase intermediate goods and services from foreign providers or transfer particular tasks to a foreign subsidiary.

The phenomenon of offshoring has given rise to the term 'global value chain', whereby different businesses add value by different processes or activities at each stage of production[3]. In this respect, the traditional production model whereby firms were responsible for all stages of the production process of a particular product has changed. Many manufacturers now choose to specialise on particular steps in the production process, such as design, research and development or sales and marketing, either within individual geographic locations or through participation in the sort of stylised global value chain shown below, or through utilising outsourcing possibilities, (either as outsourcers or supplier).

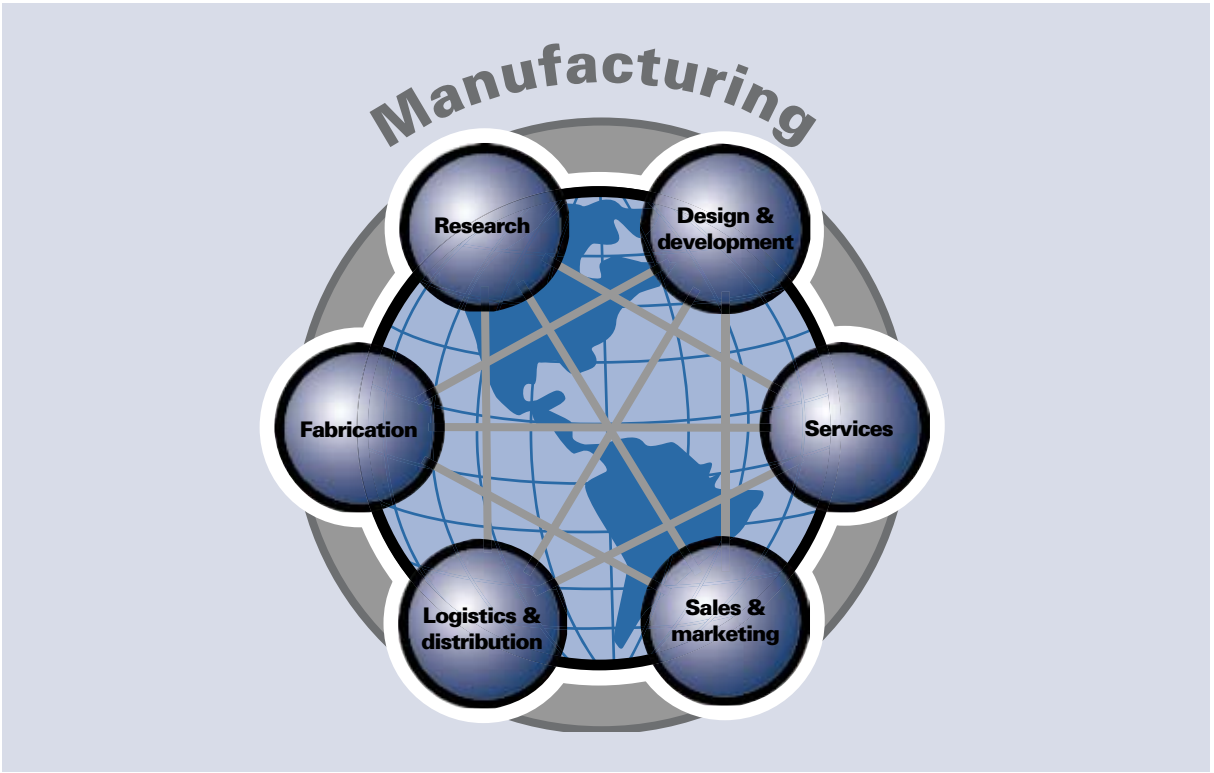
3 OECD, July 2007

Figure 2: Outsourcing and Offshoring



Integration into global value chains is important to the economic performance of UK manufacturers. Initial evidence[4] suggests that it is having a positive effect on the productivity and innovation performance of UK manufacturers. Participation in global value chains can also help manufacturers engage with other global networks, for example in different product markets, or global innovation systems. The changing role of UK manufacturers in global value chains indicates where the UK economy is developing new comparative advantages, and how this is affecting national economic performance.

Figure 3: A Global Value Chain for Manufacturing[5]



4 Criscuolo and Leaver, 2005 and OECD, 2008
5 Based on IfM, DTI, CBI, 2006

CASE STUDY 1: HOZELOCK LTD

Hozelock is a long-time leader in the domestic market for garden watering products and responding to market volatility is fundamental to the company as a business. If there is a sudden hot spell, demand for some products can increase in days by 300 to 600 percent. To respond quickly, the company utilises ICT to control its value chain and takes data from point-of-sale terminals to feed into its production schedules. The company has to work within three days from the receipt of an order to delivery to store, efficient logistics are therefore essential.

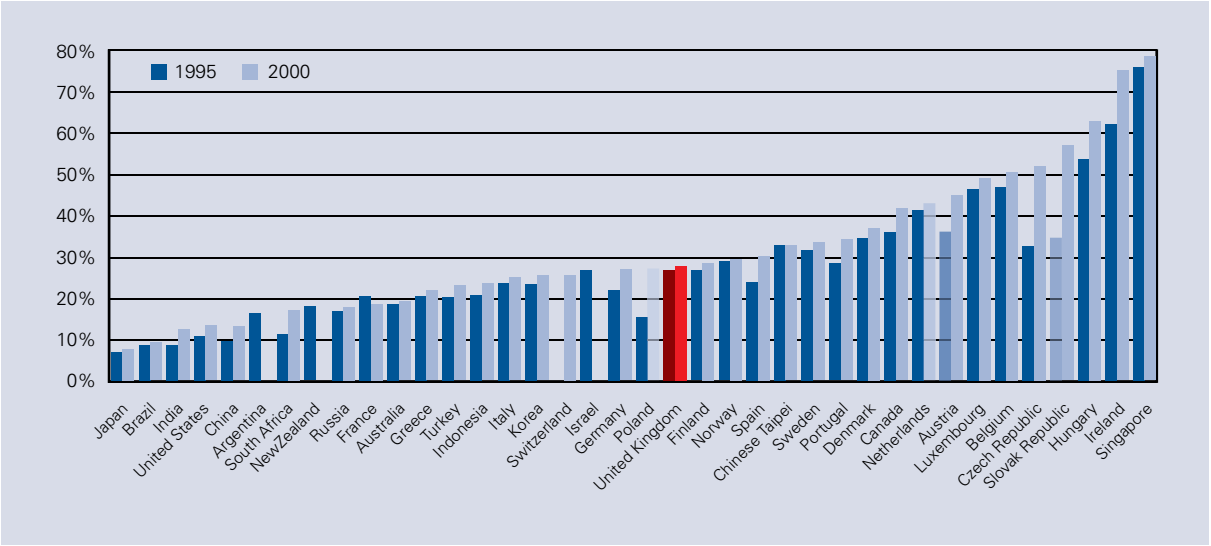
Previously Hozelock had a complex structure – five separate UK sites for manufacturing, administration and logistics, resulting in parts and finished products being shipped around the country. Hozelock has responded by creating a more integrated global value chain. The five production sites were consolidated into a single site at Sutton Coldfield, near Birmingham and within the plant itself there was a comprehensive reorganisation and integration of production lines.

The products manufactured in the UK are predominantly the bulky, high market volatility items which are more expensive to transport due to their respective size and weight. Complex, cube efficient products are manufactured and packaged to saleable single stock unit (sku) level – offshore and supplied against defined forecast models using historical data and planned orders. In the event that orders significantly exceed expectations alternative methods of supply are assessed. These can include airfreight or a switch to local manufacture (short term).

Alongside UK consolidation of value adding activities, Hozelock has also embarked on a programme to outsource products that can be made securely offshore. Managing Director, Peter Rush says: "Although we have offshored the majority of our complex manufacturing processes, we still keep a considerable amount of manufacturing in the UK", he says, "A detailed analysis was carried out across the entire product range to determine which items could be supplied on a long lead time basis and which had to be made locally in the UK to respond to the vagaries of volatile demand driven by unpredictable UK weather patterns."

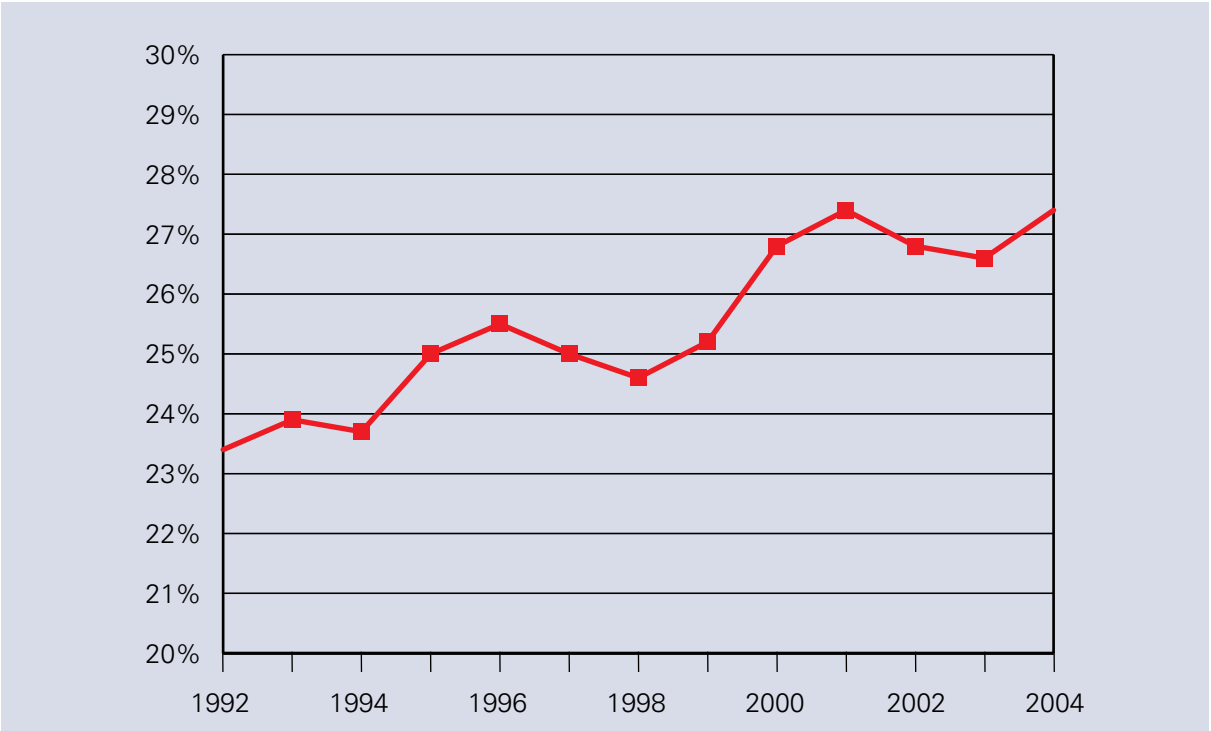
Figures 4 and 5 illustrate the growth of international outsourcing and the increasing prevalence of global value chains. Figure 4 shows that imported intermediate inputs, as a proportion of overall inputs, have been growing in the majority of OECD economies in recent years, with Figure 5 illustrating the UK trend in more detail.

Figure 4: Share of imported intermediates in total intermediates, Manufacturing Industries[6]



Source: OECD Input-Output Database.

Figure 5: Share of imported intermediates in total intermediates, UK Manufacturing



Source: ONS Input-Output Tables.

6 1995 data is 1994/95 for Australia, 1995/96 for New Zealand, 1996 for Turkey, 1997 for Argentina, 1996 for Chinese Taipei, and 1993/94 for India; no data for Iceland, Mexico and Switzerland. 2000 data is 1998/99 for Australia, 1999 for Greece, 2002/03 for New Zealand, 1998 for Turkey, 2001 for Chinese Taipei, and 1998/99 for India; no data for Iceland, Mexico, Argentina and Israel.

CASE STUDY 2: OXFORD INSTRUMENTS PLC

Oxford Instruments PLC was established in 1959 as a spin-out from Oxford University and specialises in the design, manufacture and support of high-technology tools and systems for industry, research, education, space, energy, healthcare, and environment protection. Oxford Instruments have been quick to exploit the opportunities global value chains offer in terms of access to new and emerging markets. China is now the fastest growing market for the company and has seen an average annual sales growth of 50%. In fact, Oxford Instrument products can now be found in every Chinese province. Starting with a representative office in Beijing in 1997 the company now has offices in Beijing, Guangzhou, Chengdu and Shanghai. Oxford Instruments believes another important product it exports to China is co-operation and has set up unit-laboratories with many universities, institutes and factories. In this way the company is playing an important role in the growth of China, and in strengthening the relationship between the peoples of China and the UK.

Charles Holroyd, Executive Director of Oxford Instruments comments "We believe firmly that our future growth will come in partnership with the rapid development of emerging economies and markets, and we will be vigorous in changing the ways in which we work to ensure that we can satisfy fully their requirements".

Production is mainly carried out in the UK, with some in EC partner countries and the USA. Oxford Instruments have also set up a WFOE (Wholly Foreign Owned Enterprise) in Shanghai that assembles some product for local and export markets. In addition, this facility serves as a base for customer support activities and as a source for local procurement to supply the company's UK factories.

Regarding other emerging markets, Charles Holroyd adds "The BRIC (Brazil, Russia, India and China) markets have very high visibility and are important targets for Oxford Instruments plc. In addition to China where we are approaching 100 personnel (out of a total Group headcount of some 1600), we have recruited our own people in India and Russia and intend to increase our presence and grow strongly in those markets."

In 2008, Oxford Instruments won the KMPG 2008 Business Award for UK Exporter of the Year for demonstrating the utmost energy, novelty, patience and persistence, in the field of exports from the UK to China during the year.

LIMITS TO GLOBAL VALUE CHAINS

As the global market becomes more competitive, there is increasing pressure for manufacturers to meet the strategic challenges that global value chains present and to make critical decisions on how to manage and exploit them to sustain competitive advantage. For UK manufacturers the growth of global value chains presents both opportunities and challenges. Alongside more traditional, direct, exports routes, such as that pursued by successfully by Oxford Instruments

(Case Study 2) in exporting to China, firms have the opportunity to access global markets through selling to other firms engaged in global supply chains. At the same time, firms can use global value chains to reduce costs and help address the challenge of rising global competition, through more efficient outsourcing.

Finding the right balance between outsourcing parts of the production process, as opposed to producing internally, is a key question of manufacturers. While offshoring may provide the opportunity for firms to reduce costs and focus on core competencies, there may be downsides to such fragmentation, with some firms having recently brought parts of the supply chain back to the UK ('on-shoring) as a result of difficulties with offshore operations.

The recent CBI/EEF survey which asked firms to consider how important it is to locate parts of the supply chain in geographical proximity demonstrates such limits to outsourcing. The survey (Table 1) shows that adjacent activities in the value chain, in particular, appear to benefit most from co-location. Around two thirds of firms attributed importance to the co-location of 'Production and Assembly' with 'Design and Development' and 'Logistics and Integration'. Two thirds of firms also valued the importance of Branding and Marketing being co-located Sales[7].

Table 1: Percentage of firms saying it is important/very important to co-locate pairs of manufacturing activities

	Research	Design & Development	Production & Assembly	Logistics and Integration	Brand and Marketing	Sales
Design & Development	63					
Production & Assembly	36	64				
Logistics and Integration	10	22	68			
Brand and Marketing	23	31	18	10		
Sales	23	38	27	28	67	
Service Provision	14	28	36	34	35	56

Source: CBI, 2007

While offshoring is often associated in the media with job losses to lower-wage economies, notably China and India, it can also provide the route through which manufacturers can raise their competitiveness and enable them to strengthen high-value activities in the UK. A recent report[8] by the House Of Commons

7 These results are indicative, since the strength of adjacencies will vary greatly across sector.

8 'Marketing UK plc—UKTI's five-year strategy', House of Commons trade and Industry Select Committee Report, session 2006-1007.

Trade and Industry select committee quoted EEF evidence that for many firms, rather than 'exporting jobs', such outsourcing has 'often been key to survival'. Recent research from University of Nottingham (Hijzen and Swaim 2007) used OECD data on more than 66,000 UK firms from 1996 to 2005 to examine the impact of 'offshoring'. They found that 100,000 additional jobs had been created generating £10bn in additional turnover for British companies. CSR PLC provides an example of a company that has successfully offshored parts of production to raise competitiveness.

CASE STUDY 3: CSR PLC

CSR is currently the world's leading supplier of Bluetooth chips with approximately 50% market share. Founded in 1998 as a spinout company from Cambridge Consultants, CSR's leading product is a 2.4GHz, single-chip Bluetooth® standard integrated circuit for radio-signal communication. This advanced technology has found application in a wide variety of devices including many mobile telephones and communications systems.

Bluetooth connectivity has now become a virtual tick box item in smart phones and feature phones, defined by functions such as a high quality screen, camera, memory, and applications outside of basic telephony. This category makes up the largest proportion of the cellular handset market and is set for the highest growth over the next few years. Through its global relationships, IP and technical expertise, CSR is well positioned to take advantage of this fast growing market.

"We either have the technologies that are being integrated or we have them in an advanced stage of development" said Alan Woolhouse, Vice President Marketing Communications. "These technologies are Bluetooth, Bluetooth low energy, High Speed Bluetooth (UWB & Wi-Fi), eGPS, FM Receive, FM Transmit, and advanced audio processing for both mono (voice) and stereo (music)."

The global value network that is now part of CSR's strategy includes over 1000 employees with offices in UK (Cambridge, Edinburgh), the US (Dallas, Detroit), Sweden, Denmark, France, Korea, China, Taiwan and Japan. In addition, CSR outsource to high-volume production facilities, including the Taiwan Semiconductor Manufacturing Company Ltd. (the world's largest dedicated semiconductor foundry) for fabrication and assembly.

LOCAL VALUE CHAINS: THE IMPORTANCE OF NETWORKS AND CLUSTERS

The above analysis highlights the growing importance of value chain links at a global level, but local supply chain linkages continue to have importance. Such local linkages and network effects are often summarised by the term 'cluster', defined by Michael Porter as "Geographic concentrations of inter-connected companies, specialised suppliers, service providers, firms in related industries,

and associated institutions, for example universities, standards agencies, and trade associations in particular fields, that compete but also co-operate"[9].

Industrial concentration within regions can support comparative advantage through the development of linkages between specialised buyers and suppliers, technological spillovers, and specialised knowledge infrastructure (links to university research, local knowledge and best practice transfer mechanisms, and specialised skillsets. Local clusters of SMEs can in some cases overcome some of the challenges faced by smaller firms, such as access to technology, specialised skills, finance and specialised external services.

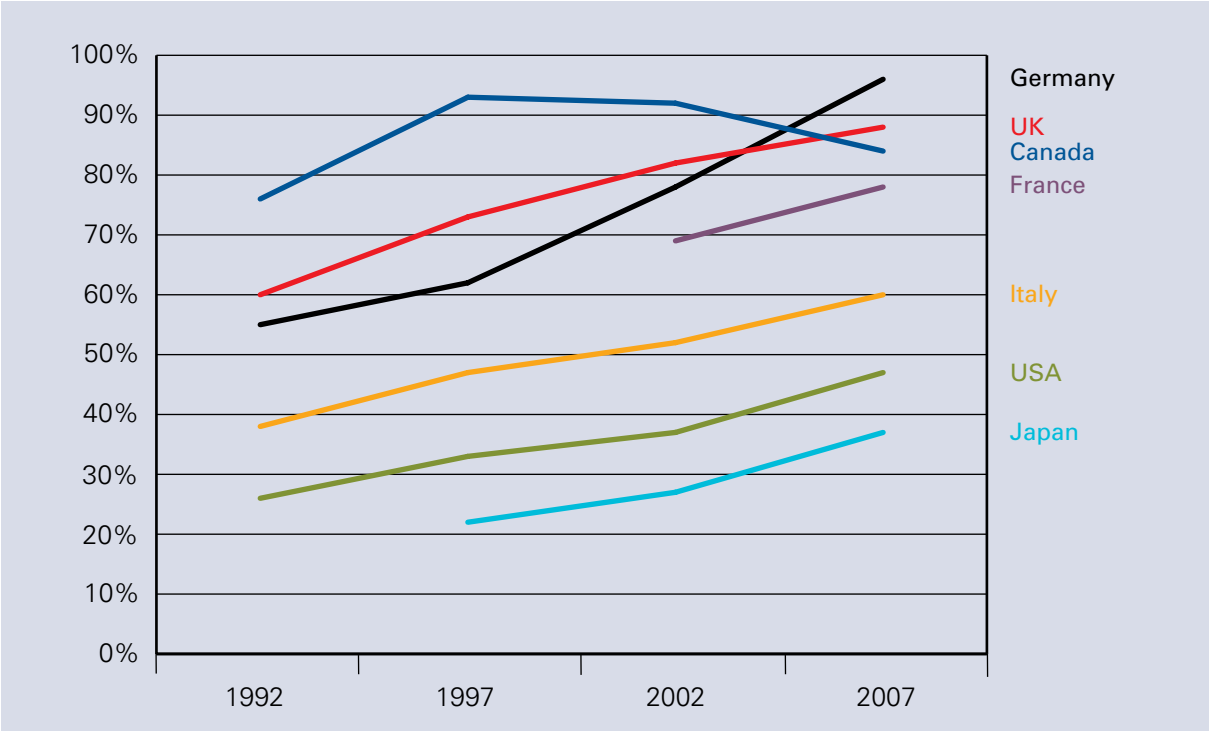
There has been considerable international interest by governments in identifying actual and potential clusters, and developing policies to support their growth. In the UK, an initial cluster map was produced in 2001, and this mapping work has since been taken forward by the RDAs. At European level, where comparable data is difficult to obtain, a report has been produced mapping employment concentrations in 31 countries.[10]

1.1 How the UK is performing

There are no recognised measures to assess whether a country, is engaging effectively in global value chains. Figure 6 below demonstrates that the UK has arguably increased its engagement in global value chains in recent years, and has a level of engagement in line with similar sized OECD economies. But we should be careful not to make judgements on such measures, both as a result of there being no 'right' level of engagement, and due to the number of different possible measures. Nevertheless, it is clear that the UK manufacturing sector has increased in openness to the global economy in recent years[11].

9 Porter, 1998
10 European Commission DG Enterprise & Industry 2007
11 German manufacturing has become even more open to global markets through a combination of offshoring lower value added production to countries on its Eastern border, and remarkable success in selling into developing markets such as China.

Figure 6: Manufacturing imports and exports as a percentage of manufacturing output



Source: UN Comtrade and OECD.stat databases and BERR estimates

DESCRIPTION OF UK EXPORTERS

Evidence on how UK manufacturing is engaging with global value chains is also indicated by the extent to which firms are selling into overseas markets, and by the extent to which their export customers are other businesses. Recent survey evidence[12] from UKTI found that some 58 per cent of the exporters interviewed were selling to other businesses as opposed to supplying consumer markets directly. More generally, around 70,000 UK firms exported goods in 2007[13]. Of these, 65,100 exported outside the EU, and 16,700 within the EU[14] (some firms export both within and outside the EU, hence these do not sum to the total).

Analysis of data from the Community Innovation Survey (CIS4) indicates that:

- Some 47 per cent UK manufacturers export, with larger and more innovative firms more likely to export. When only R&D active manufacturing firms are considered, this rises to 72.5 per cent[15].
- Some 73.4 per cent of R&D active manufacturing companies under 5 years old are already active exporters, compared with 72.5 per cent all R&D active manufacturers;

12 OMB Research, 2006
13 It should be noted that the precise number of UK exporters is not known as some firms export via an intermediary and consequently are not included in statistics.
14 HMRC, 2007
15 Harris, R and Li, Q Cher, 2006. Interim Report to UK Trade and Investment

- Exporters have markedly higher R&D intensity than non-exporters, and born global companies in turn spend significantly more on R&D per employee than other exporters;

Table 2 shows in more detail that a higher proportion of manufacturing enterprises export than those in service sectors. It also indicates that a higher percentage of larger enterprises export (than smaller enterprises); although analysis by Harris et al (2006) shows SMEs dominate in terms of absolute numbers.

Table 2: Percentage of UK establishments exporting by size (2004)[16]

Size by employment	Manufacturing	Services	Total	% of R&D active UK establishments that export (manufacturing only)
0-9	26.6	15.1	16.5	61.1
10-49	39.4	18.6	22.9	65.4
50-249	65.6	25.7	37.0	79.9
250+	72.9	28.9	42.1	83.4
Total	47.0	19.9	25.7	72.5

Source: Community Innovation Survey 4, Harris, R and Li, Q. Cher (2007) and Harris, R., Li, Q Cher (2006)

BARRIER TO EXPORTING

An alternative means of assessing engagement in global supply chains is to analyse the relative size of administrative and legal barriers that firms are reporting. The latest version of the World Bank Doing Business Report[17] suggested that such barriers may be relatively high in international terms for UK companies, ranking the UK only 27th (of 178 countries) on the issues of '[ease] of trading across borders'. Closer analysis suggests the ranking derives from the time taken to prepare necessary documents with the 7 days required in the UK, compared with 2 days in Denmark (the EU leader) and 1 day in Singapore (the global leader), despite the documents being of the same type. As we observe below, the Government is working to address this issue.

A report to UKTI[18] has considered the barriers that firms themselves face to exporting, splitting the sample between users and non-users of UKTI services. The results suggest that while legal and regulatory barriers are significant, particularly for younger firms, barriers related to the fixed costs of exporting, language barriers and the difficulty in obtaining relevant contacts are more widespread constraints.

16 Although CIS4 data is presented for firms with 0-9 employees, this data is not captured in the CIS4. Thus, the data presented here is an approximation and only gives an indication of the proportions of firms which export.
17 World Bank, 2008
18 OMB, 2008

Table 3: Summary of barriers to export reported by UK firms.

Proportion experiencing[19]	Non-Users of UKTI			UKTI Users		
Age of firm	1-5 yrs	6-10 yrs	>10 years	1-5 yrs	6-10 yrs	>10 years
Base	148	127	143	71	46	194
At least one barrier 'to a significant extent'	47%	57%	50%	82%	87%	80%
Legal and regulatory barriers	19%	15%	13%	25%	28%	22%
Contacts barriers	22%	22%	23%	55%	54%	47%
Information barriers	10%	6%	5%	15%	17%	11%
Fixed cost barriers[20]	32%	38%	34%	56%	61%	61%
Language and cultural barriers	12%	17%	13%	23%	26%	25%
Bias barriers	10%	14%	15%	20%	33%	25%

Source: OMB Research, 2008

1.2 The Role of Government

The accompanying policy document, Manufacturing Strategy: New Challenges, New Opportunities', sets out how Government will encourage and support companies, especially Small and Medium Enterprises to take advantage of the opportunities in the global market place, by:

- Selling directly to new global markets.
- Utilising the opportunities to sell to global markets through global value chains.
- Using global value chains to raise firms' competitiveness.

In addition, the Government also works to increase the attractiveness of the UK as a location for high-valued added manufacturing activities, through working to promote regional development through the RDAs, including through the development of local networks and clusters.

The rationale for Government support for exporters was set out in DTI Economics paper 18[21] and the UKTI Strategy it accompanied[22]. The paper notes market failures affecting both the **costs of overseas market entry** for firms (relating both to the potential under provision of advice and market information and the potentially unique role of government as an international intermediary given its strong trust reputation, enabling firms to overcome barriers to access to

19 Firms are classified as encountering significant difficulties if they scored 4 or 5 on a 5 point scale.
20 Fixed cost barriers included the marketing costs associated with doing business in an overseas market, or exchange rates and foreign currency, or not having an office or site in an export market or logistical problems.
21 'International trade and investment – the economic rationale for Government support', DTI Economics Paper No. 18.
22 'UKTI Five Year Strategy – Prosperity in a Changing World', UKTI 2007

networks and contacts overseas) and the potential for firms to underestimate the **benefits from overseas market entry** (for example from exposure to new ideas and technologies). It also cites monitoring and evaluation evidence which demonstrates that well-focused government action can be effective in overcoming these market failures, generating excellent tax payer value for money. The analysis concludes that government action should be focused on the following areas:

- Strengthening the social networks which underpin international trade and investment flows, and helping individual businesses to gain access to key contact networks, by serving as a trusted intermediary.
- Strengthening the internationalisation capabilities of innovative and high-growth businesses.
- Providing access to information and advice which the private sector alone would not or could not provide.
- Facilitating beneficial co-operation among businesses, enabling them to work together, for example, to take a more strategic approach to promoting and showcasing UK sector capabilities in overseas markets.

The accompanying policy document sets out a range of policies, including a number of new proposals, to help manufacturing firms overcome such market failures and access global value chains, including helping build firms' exporting expertise and to support the marketing of key exporting industries. This builds on existing work being carried out across government to establish an international trade single window, which aims to respond to concerns around the administrative costs of exporting by simplifying the regulatory requirements for businesses involved in international trade.

In terms of cluster development, a report[23] to DTI identified the following success factors for the development of successful clusters based on international evidence:

- The presence of functioning networks and partnerships.
- A strong innovation base, with supporting R&D activities where appropriate.
- The existence of a strong skills base.

Alongside these, four additional factors were seen as important to contributing to successful cluster development:

- An adequate physical infrastructure.
- The presence of large firms.
- A strong entrepreneurial culture.
- Access to sources of finance.

23 DTI, 2004

The RDAs use this basic structure to guide their investment activities in their areas, seeking to complement the market where there may be knowledge spillovers, public good arguments for intervention or asymmetries of information which justify government involvement.

For example, Advantage West Midlands has recently identified 12 key clusters for the period 2008-11[24], which include aerospace, automotive, building technologies, environmental technologies, information & communication technology, interiors & lifestyles and medical technologies. Each cluster plan identifies and assesses regional strengths and achievements, picks out key target markets and sets out a programme of work for increasing the impact of the cluster in these markets. While the RDA is committing £56m of its own budget to cluster development over this three-year period, it sees the key success factors as the ability to exploit other public sector resources (such as business support and funding for the development of skills and R&D) and, most importantly, to facilitate collaboration and networking between the businesses participating in the clusters.

Other RDAs, and devolved administrations, are taking similar initiatives based on their own regional strengths. More generally, through helping to provide links between different firms in the region, the RDAs play an important role in helping firms engage successfully in global value chains.

24 Cluster plans can be accessed at www.advantagewm.co.uk

CASE STUDY 4: PRODRIVE LTD

Prodrive is one of the world's largest motorsport and vehicle technology businesses with annual revenues exceeding £100m. While its roots are in motorsport, the company has evolved since its creation in 1984 into a business that has differentiated its offering through developing a specialisation in the development of advanced technology for road vehicles. Its business model is based upon partnering with customers thereby creating strong linkages between the respective value chains.

Today Prodrive has broadened its areas of business still further, transferring its skills into sectors including aerospace, marine and defence. These include the development of new technologies for the reduction of carbon emissions in everything from cars to domestic heating systems. Prodrive also has its own manufacturing facilities and supplies components for everything from Formula One cars to space satellites and high performance winches for racing yachts.

Despite this diversification into new markets, Prodrive has continued to focus on its core competencies and has essentially broadened its offering to exploit global opportunities through linkages to its customers' value chains. Prodrive will often embed its own value chain in their customer's value system by offering a turnkey solution that can include intangible activities such as design, all the way through to prototype builds and testing. One of the best examples of this is the relationship with Subaru. For nearly 19 years, Prodrive has worked closely with the Japanese car manufacturer to develop and run the Subaru World Rally Team. Over the years, this partnership has grown to include road car projects where Prodrive has worked with Subaru to develop a number of limited edition performance cars to enhance the brand.

Prodrive operates on a global scale and offers mainstream automotive manufacturers an opportunity to differentiate their own products through limited editions that employ Prodrive technology. A recent example of this is the Alfa Romeo Brera S launched in May 2008. Tony Butcher, managing director of Prodrive's automotive technology business, said: "We were able to bring our skills in chassis, engine and suspension development to bear on this classic Italian sports car. Alfa saw so much value in the work we were carrying out for them that the marketing of the car was based around our involvement, with the product's proposition *'Best of Italy, Best of Britain'* emphasising the international cooperative nature of the project."

2. Technology Exploitation

SUMMARY

The process efficiencies and productivity improvements that are essential for the global competitiveness of manufacturing are critically underpinned by advanced technologies. Leading on, and adapting to, rapidly changing technology can drive competitive advantage by providing the capacity to adopt more efficient processes, and develop higher quality or better customised products that enable companies to capture higher value components of the value chain.

The UK is taking the lead in adapting to increasingly globalised innovation platforms. It is also building on the success of its world class science and technology base, having made improvements in recent years in the levels of technology transfer from UK universities. But there remain areas where performance can be improved, with the UK continuing to lag behind leading countries such on some measures of R&D investment and technology exploitation.

The Government continues to play a key enabling role in allowing markets to fulfil their potential as powerful drivers of technological innovation. It supports broad-based science and technology research, and provides incentives to invest in technology, so that full account is taken of the broader economic and social benefits that can result from technology development and exploitation.

Technology has become an integral part of life in modern societies. Advanced economies need to exploit technology to increase productivity and enhance national competitive advantage. Historically, those countries that have been most effective at exploiting technology have also been those that have shown the highest manufacturing output growth. In an increasingly globalised economy where the creation and exploitation of knowledge are not necessarily co-located and the service sectors become key beneficiaries of technological change, the nature of this relationship has substantially changed. However, leadership in the generation and use of technology has become an even more important driver of competitive advantage by providing the capacity to adopt more efficient processes, and develop higher quality or better customised products that enable companies to capture higher value components of the value chain.

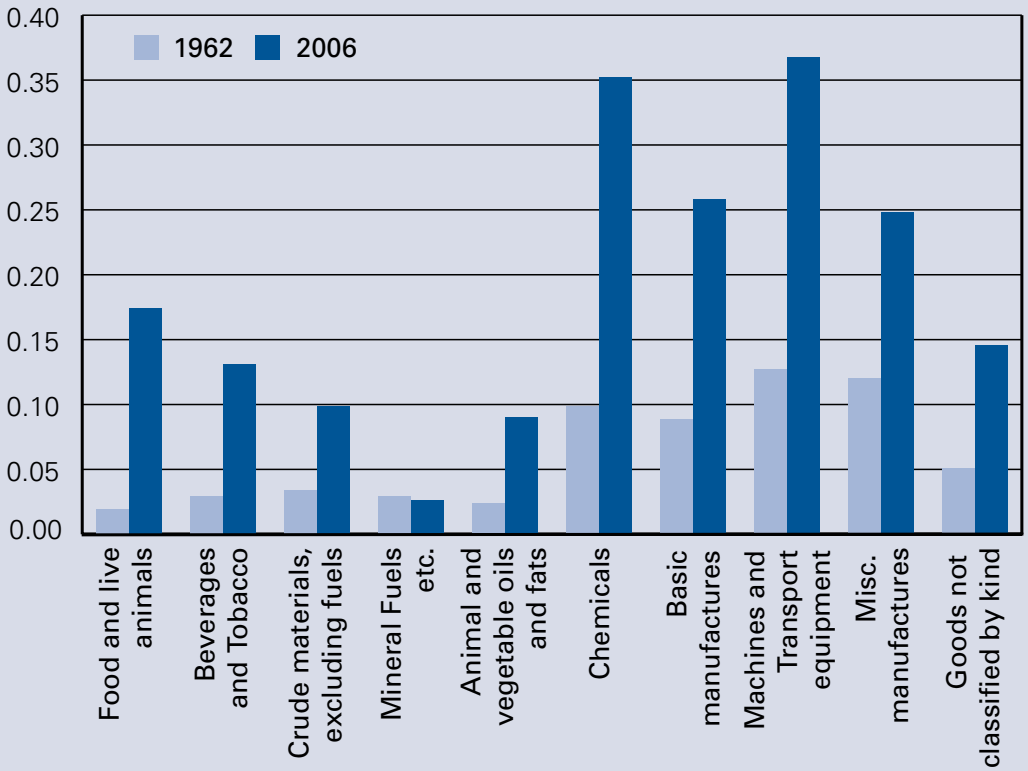
Recent developments in technology fields such as information and communication technologies (ICT), genetics and biotechnology, advanced materials and nano-technology, to cite just a few, have helped create new opportunities for business. For example, recently introduced ICT systems are now at the heart of global operations and product flows, with scheduling, inventory control, logistics and many other activities dependent upon the effective management of information flows.

BOX 1: TECHNOLOGY AND PRODUCT DIFFERENTIATION:

In response to increasing globalisation and low-wage competition, firms in developed economies are differentiating the way they place products in the market place. This involves producing products and services which are increasingly customised to consumers' needs and therefore command a premium price in the market place. Evidence of such a phenomenon is provided both by the increasing focus of UK manufacturers on more high-technology/skilled activities, and more broadly by increasing global intra-trade, where countries increasingly import and export similar goods, e.g. cars. Data from Brulhart (2008) shows that the global level of intra-industry trade has grown steadily since 1962.

Figure 7 shows that the main product categories which achieved growth in intra-industry trade from 1962 to 2006 were manufactured goods, with particularly large growth in chemicals, basic manufactures and machinery and transport equipment.

Figure 7: Global Index* in Intra-industry Trade



*Note: Global intra-industry trade by Standard International Trade Classification (1 digit), Grubel – Lloyd index, 5 digit. See Brulhart, 2008 for more details.

Manufacturers' strategic response will differ greatly from firm to firm, depending on their relative capabilities in each area of the value chain and how these interact and add value to the activities of their customers. Broadly speaking, the strategic choices involve Specialisation (which includes outsourcing, withdrawal and consolidation) and Diversification (which includes market penetration, product development, new market development and unrelated diversification).

In line with the rising importance of global value chains, manufacturing businesses are increasingly internationalising their R&D supply chains and customer bases and adopting "open innovation" models. The OECD compiled data for a large number of member countries[25] and showed that R&D expenditure under foreign control has gone up from US$33.5 billion in 1995 to $69.3bn in 2003. Industrial R&D is in fact becoming internationalised, and over the last ten years it has become the most dynamic activity of multinational companies, just behind mergers/acquisitions and international investment.

Processes leading to the development and successful exploitation of new or improved technologies have become increasingly fragmented as the rising complexity of technologies has required further specialisation and external collaboration. As global value chains continue to develop so the importance of protecting a company's ideas and reputation through intellectual property-rights (IPR) increases. Legal IPRs include trade marks, copyright, confidential information and patents. It is important to note that IPRs are not granted globally but rather jurisdiction by jurisdiction. The year 2007 saw over 1.6m patents filed world wide including basic protection and further protection sought in secondary countries. This reflects globalisation and the fact that innovation is being protected in more and more countries. One method of assessing the country of origin for innovation is to look at the priority country for the patent. Although most developed economies have seen growth in published priority country patents, China, USA and South Korea have seen particular recent growth. This reflects the growing importance of Asian countries as sources of innovation in absolute terms[26].

In this changing environment, manufacturing companies have reacted to these changes by assessing more carefully their position in the innovation chain, appraising the opportunities and challenges brought about by moving towards alternative innovation strategies.

Technology – which can be either embedded in plant, machinery, computers, software, know-how, formal intellectual property or even people – drives efficiency improvements within the value chain. Technology may provide enhanced efficiency at the local company level within operations but also at a national and global level through increased productivity and speed to market. For instance, the rapid development and take-up of information technology and communication technologies has been the primary enabler of the trend towards global value chains. Value chains rely on information for both individual activities and in the creation of the linkages between them.

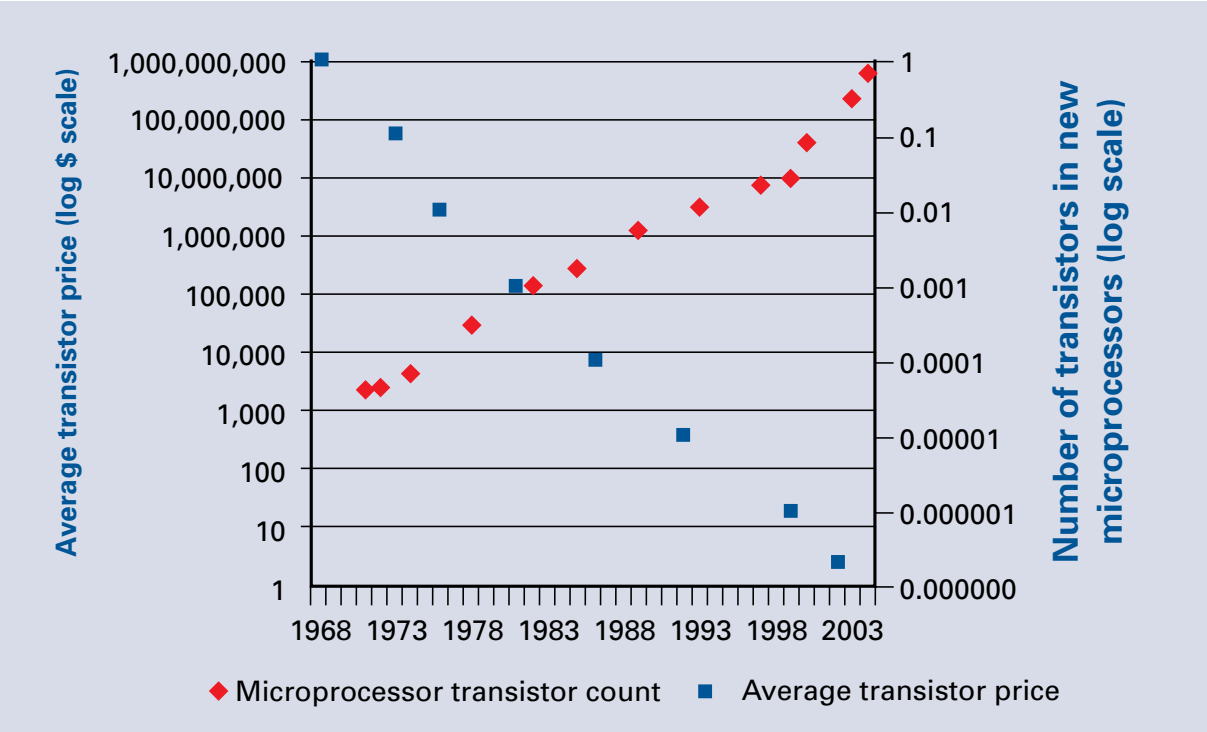
The process efficiencies and productivity improvements that are essential for the global competitiveness of UK manufacturing also rely on data gathering, analysis and control using ICT systems. Figure 8 illustrates how rapid improvements in

25 Group of countries includes US, UK, Germany, Japan, France, Canada, Czech Republic, Finland, Hungary, Ireland, Poland and Sweden. As reported in http://ec.europa.eu/information_society/istevent/2006/cf/document.cfm?doc_id=2087

26 Thomson Reuters, 2007

the efficiency and affordability of microprocessors have paved the way to the massive adoption of ICT across the piece, transforming the way we live.

Figure 8: Technological change in ICT: Microprocessors' efficiency and prices



Source: Intel[27]

One of the explanations put forward as a cause for the US's increased productivity growth relative to the EU is the potential role that ICT exploitation has played. Several sources argue that investment in ICT capital made the second most important contribution to US labour productivity growth in the market economy between 1995 and 2003 – largely through the improved performance of intensive ICT-using industries (rather than just producing sectors).[28]

27 Intel ® http://www.intel.com/technology/mooreslaw/index.htm
28 O'Mahoney and Van Ark, 2003.

CASE STUDY 5: RENISHAW PLC

Since the early 1970's Renishaw has been a leading innovator in metrology equipment. The company currently employs over 2100 people worldwide and generated £201m of revenues in the year ended June 2008. The company's first product, the touch-trigger probe was invented by Sir David McMurtry, Chairman and Chief Executive, and was developed to solve a specific inspection problem for the Olympus engines used on Concorde. Research and Development continues to be the cornerstone of Renishaw's business and in 2008 the company invested approximately 18% of its revenues in R&D and engineering. The company continues to revolutionise post-process inspection of machined components and has recently launched its Renscan5™ high speed 5-axis measurement technology for co-ordinate measurement machines (CMMs).

Geoff McFarland, Group Engineering Director said "For Renishaw to continue to thrive in a globally competitive marketplace, differentiation is absolutely vital. Heavy investment in our R&D and manufacturing has allowed us to greatly expand our core skills and technologies. By placing innovation at the heart of our business and using our core competencies, we have diversified into exciting growth areas such as dentistry and neurosurgery, and have developed unique automated manufacturing processes that allow us to maintain high added-value manufacturing in the UK."

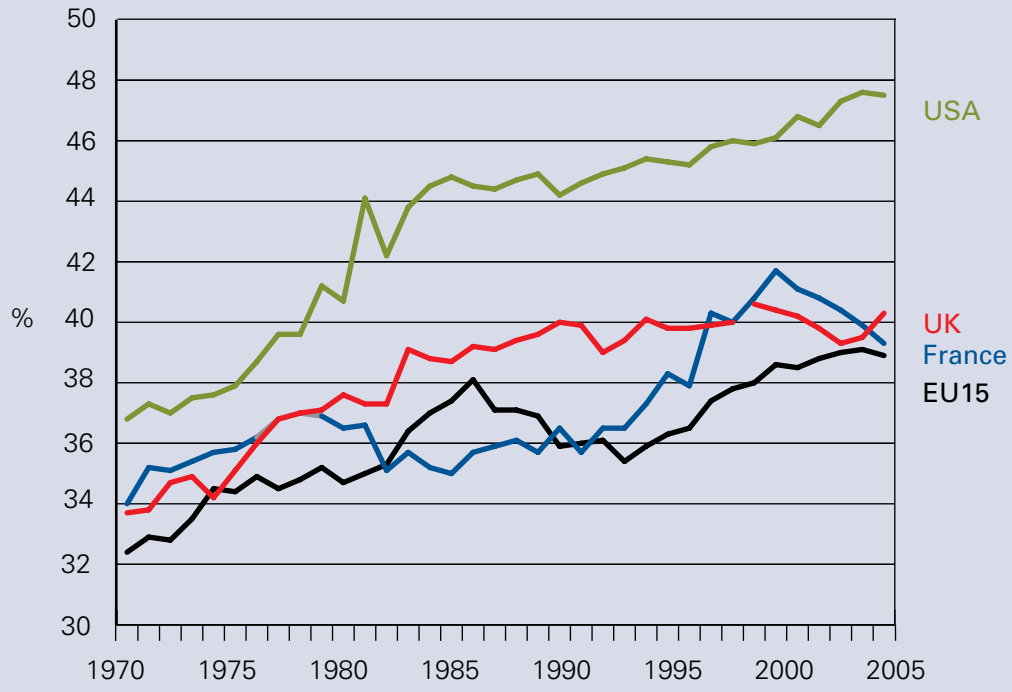
Renishaw differentiates itself through patented, highly innovative products and processes that include ultra high-resolution encoders, highly accurate dimensional measurement systems and high speed motion controllers. Their trademark of 'apply innovation™' emphasises their focus on new product development and continuous improvement throughout its engineering and manufacturing processes. Renishaw has continued to specialise in metrology and develop its core touch probe technology but its drive for innovation has also led it to diversify into new markets through a number of product developments, partnerships and acquisitions. These markets include dentistry, spectroscopy and neurology. Crucially however, Renishaw's presence in these markets is driven by careful strategic thinking and the company's continued focus on precision and accuracy. For instance, the incise™ dental restoration system combines core touch probe technology with precise machining to generate highly accurate and close fitting, custom dental restorations.

2.1 How the UK is performing

Technology has indeed become a key driver of specialisation and competitive advantage for UK manufacturers, as it has for many other advanced economies. Figure 9 shows that developed economies are experiencing an increase in the share of manufacturing GVA generated within high-tech companies, demonstrating the extent to which technology is becoming a focus of competitive

advantage. High tech UK manufacturing accounted for 40 percent of UK manufacturing's GVA in 2005, compared to 34 percent in 1970, this substantial progress lags that of the US, which further strengthened its leading position by rising from 37 to 47 percent over the same period.

Figure 9: Share of Manufacturing Value Added in High Technology Sectors



Source: BERR analysis of EUKLEMS data[29]

Technological leadership from a knowledge producer, or user perspective, continues to drive the competitive advantage of UK firms in a considerable number of broadly defined markets and within specific market niches. UK manufacturing has considerable strengths in many technology areas with world-class academic research and a number of leading edge businesses.

For example, several technology and R&D intensive industrial sectors continue to show strong levels of performance in internationally traded markets:

- Of the 73,000 people employed in the pharmaceutical industry in 2003, 27,000 were employed in R&D. Two of the largest companies in the world – AstraZeneca and GSK – are UK head quartered and the UK benefits from the R&D and production presence of a number of other global leaders.

29 High tech manufacturing sectors considered include chemicals, electrical and optical equipment and transport equipment.

- The UK aerospace industry currently comprises 13 per cent of turnover in the world aerospace market, second only to the US. Like pharmaceuticals, aerospace is R&D intensive (accounting for 11 per cent of all manufacturing R&D) and has high GVA per employee due to high capital intensity and a relatively highly qualified skills base (one third of all employees in the sector are graduates).

CASE STUDY 6: AESSEAL

AESSEAL specialises in the design and manufacture of mechanical seals and support systems for pumps and rotating equipment to prevent liquids and gases from escaping into the environment. Based in Rotherham, Yorkshire, AESSEAL has experienced growth in excess of 20 per cent per year since it was founded in 1983 and has become the only major international new entrant, to the mechanical seals industry, in the last twenty years. The company's differentiated position is based on customer service, people and innovation. "Everything we do must add value" said production director Richard Cook. The bespoke nature of the company's products puts a big emphasis on logistics and resource efficiency. The company has a policy of vertical integration and makes as much of its products in-house as possible.

AESSEAL is continually involved in product innovation and has developed 60 patents in recent years. The sales growth from patented products has gone up from £324,000 in 1999 to more than £30 million a year today and the company aims to become technology leaders in the seals and support systems market. The company is on target to turnover £100m by the end of 2009 and by the time of the company's 50th anniversary in 2029 aims to be biggest mechanical seals company in the world.

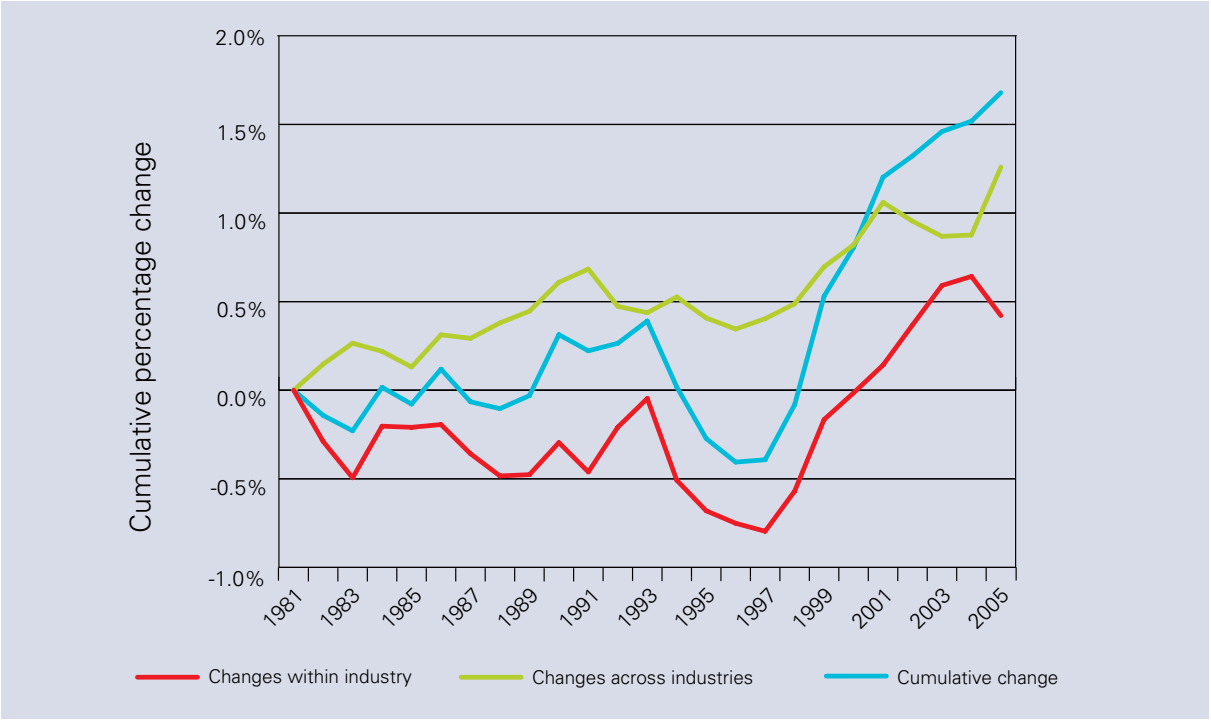
MANUFACTURING'S ROLE IN GENERATING TECHNOLOGICAL INNOVATIONS

The Government's Sainsbury Review argues that the relatively low level of patenting in the UK when compared to our closest international competitors is partly due to the relatively low levels of business R&D in the UK. The OECD examined the link between R&D and patenting for 19 OECD countries over the period 1986–2000. It found that for both domestic patents and for triadic patents there is a clear positive link between R&D and subsequent patenting, and that the principal effect comes from R&D in the business sector.[30]

Overall, the evidence indicates that UK manufacturing has been a significant contributor to the pattern of specialisation of the UK economy in technological knowledge generation. On the one hand, the contribution has been negative because manufacturing, which is relatively R&D intensive, has been declining in its share of the whole economy's GVA. On the other hand, UK manufacturing has become more R&D intensive, as demonstrated by the trends on R&D intensity displayed in Figure 10.

30 Jaumotte, F. and Pain, N., 2005.

Figure 10: Changes in R&D intensity in UK manufacturing



Source: BERR analysis of ONS GVA and BERD data by industry.[31]

This shows that after a period of stagnant, if not declining, R&D intensity over the mid-1990s, UK manufacturing's ratio of R&D expenditures to GVA has recently accelerated, leading to an overall increase from 5.6 per cent in 1981 to 7.2 per cent in 2005. This has been driven by a combination of higher R&D intensity within individual manufacturing industries and an increased preponderance of highly R&D intensive industries amongst manufacturing.

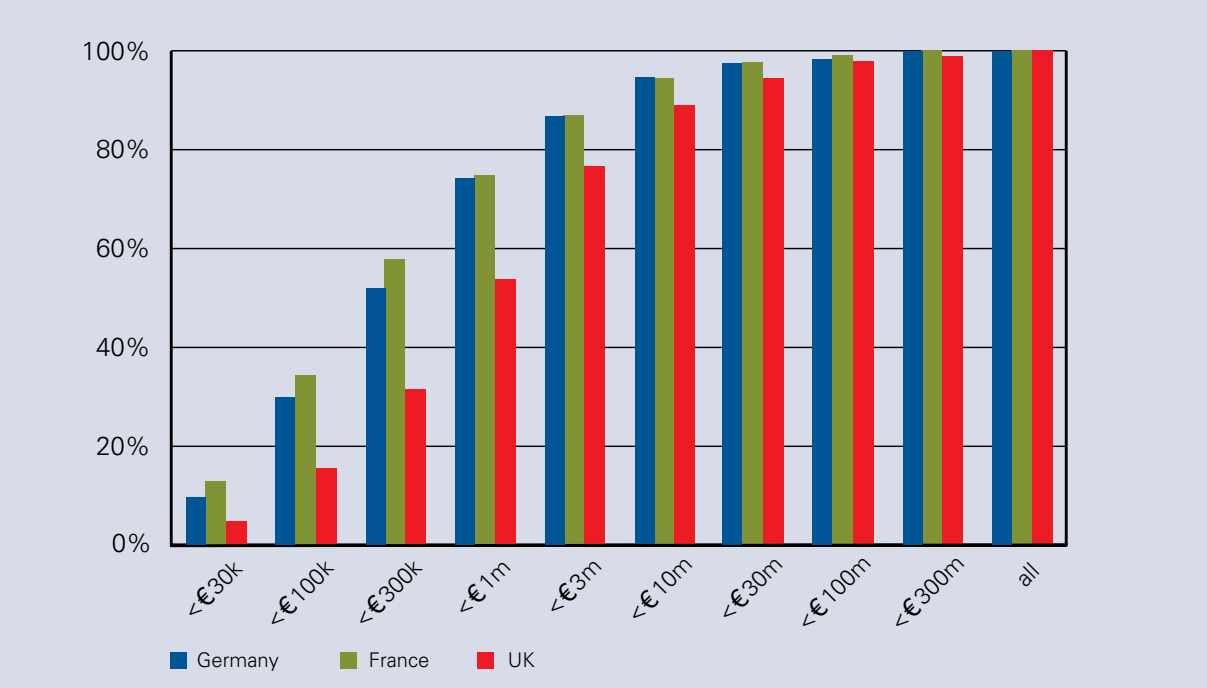
R&D and patent activity does indeed vary by sectors, in particular. The 2007 R&D Scoreboard which contains data on the largest 1,250 R&D active companies worldwide shows that UK patent intensity (US patents granted in 2006 per £10 million R&D investment) varies dramatically across sectors, with the highest ratios in the electronics, technology hardware and personal goods sectors, and a lower ratio in the pharmaceuticals industry.[32] The pattern of sectoral differences in patent activity is important however when comparing innovation in terms of relative patent outputs across international competitors. For instance, Japan historically has over five times the patent output of the UK. The sector strength of Japan in the relatively patent-intensive industry of electronics goods compared to the UK strength in the relatively low patent-intensive industry of pharmaceuticals may go some way towards explaining this difference. In summary, national specialisation affects patent output and patent data should therefore be interpreted carefully when used an indicator of innovation.

31 Cumulative changes to R&D intensity since 1981. Decomposition of R&D intensity changes based on a shift-share analysis.

32 This reflects the amount of R&D spend that goes into getting new drugs to market and the associated regulatory and validation requirements. This does not reflect the value of patents and it should be noted that patents in the pharmaceutical industry often provide very high returns on investment.

Nonetheless, based on the results from a survey of inventors linked to European Patent Office's (EPO) patents invented across selected EU countries, [33] and their inventors' self-assessment of the value of their patents, the UK's performance appears remarkable. While Germany accounts for twice as many patents as the UK according to this survey, UK patents are worth on average (£10.1million) more than twice as those in Germany (£4.45million), implying similar values for the total patent stock.[34] As the Figure 11 shows, the distribution of UK patent values in the UK is more skewed towards high value patents than in Germany or France.

Figure 11: Distribution of estimated patent values



Source: EU PatVal survey – Percentage of patents in each value range

While these results are based on responses from a sample of inventors and do not reflect actual market valuations, it is encouraging to see that the UK is effective at transforming R&D into valuable intellectual property even if the actual patent numbers appear to lag other countries' performance .

GLOBALISATION OF TECHNOLOGICAL INNOVATION

There have also been significant changes in the overall nature of technological innovation, probably the most significant of all being its increased integration in the global economy. According to Balance of Payments data from ONS, the UK has become a significant net exporter of R&D services to the rest of the world. The balance has gone up from below £1bn in 1997 to £2.6bn in 2004. This

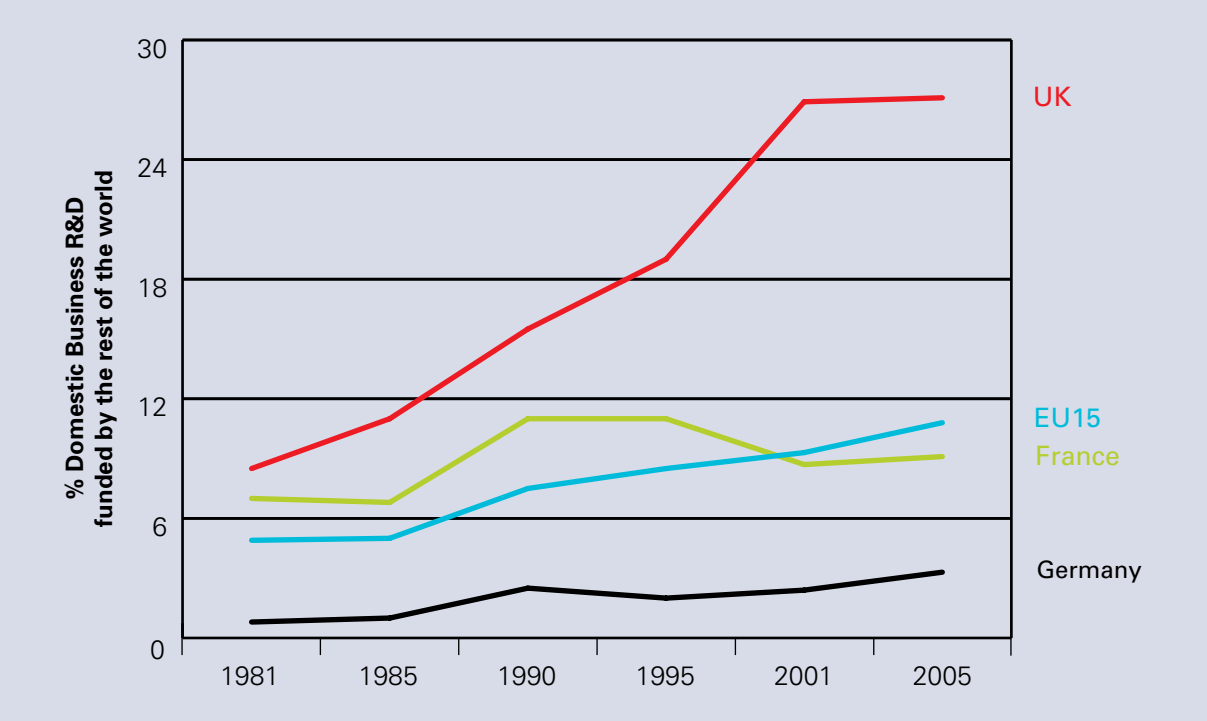
33 Results from the PatVal EU project, a survey of inventors associated with a sample of EPO patents invented in Germany, France, UK, Italy, Netherlands and Spain http://www.alfonsogambardella.it/patvaleu.htm

34 These high values are driven by a very skewed distribution where a few highly valuable patents drive up the average value, while the median value of a patent will tend to be lower.

reveals a considerable competitive advantage in the generation of technological knowledge, a significant part of which is undertaken within manufacturing firms or affiliated R&D labs. Not only does the UK benefit from a positive balance in R&D services, but it also has a net surplus in royalty payments received from other countries for the use of intellectual property, much of which is linked to the licensing of technology.

The development of new technology in the UK is clearly integrated with the rest of the world. The UK has adapted particularly well to changing circumstances enabling the increasing internationalisation of R&D. The UK has been able to attract significantly more international investment for technological R&D than other key competitors. According to official R&D statistics reproduced in Figure 12 below, more than 25 per cent of business R&D in the UK is funded by overseas – well above Germany (less than 5 per cent) and France (about 10 per cent).

Figure 12: Increased internationalisation of R&D dynamics



Source: OECD Main Science and Technology Indicators

UK firms, particularly those in manufacturing, have been able to tap into knowledge generated overseas. Between 1996 and 2003, R&D by UK PLC increased by more than 40 per cent whilst R&D in the UK grew by just over 20 per cent.[35] Moreover, new research shows that companies with innovative links to the US in technologies where the latter leads have benefited from larger improvements in productivity.[36] This demonstrates the importance to UK manufacturing companies of being strategically active in both the generation and exploitation of new technological knowledge.

THE USE OF TECHNOLOGY

Because technology underpins value chain activities it is an important driver of cost and differentiation. Cost can be driven by the type of value chain efficiencies and information flows described above but also by other individual activities within the value chain. For example, over many decades automation has been a primary driver of cost reduction and quality improvement in many advanced economies. In the future there is likely to be an increasing focus on new technologies that enable lower costs through more efficient and alternative use of resources. In addition to cost positioning, the attributes of a product that are most valued by a customer and that differentiate it from competitors can also be enhanced by technology. This differentiation may be achieved by exploiting new technologies or simply by exploiting existing technology in a new way. This is illustrated in case study 7 below.

There is no single straightforward indicator that can describe how well the UK is doing in terms of exploiting available technology. One of the most researched areas concerns the utilisation of information and communication technologies. One study in particular shows that amongst firms based in the UK, US-owned multinationals appear to be more productive at exploiting comparable levels of ICT hardware to those used in other firms, including other types of multinational affiliates.[37] A number of competing explanations for why non US firms (and this includes UK firms) are less effective at using information technologies have been put forward. Many of them relate to the quantity and quality of co-investment by firms that may enhance the use of ICT. These are the subject of further discussion in the following sections on intangible investment and skills.

35 Abramovsky L, R Harrison and H Simpson, 2004
36 Griffith, Harrison and Van Reenen, 2006
37 Bloom, Sadun and Van Reenen, 2005

CASE STUDY 7: PLASTIC LOGIC LTD

Plastic Logic Ltd is the global leader in plastic electronics (a revolutionary advanced technology for applying organic electronics on thin, flexible plastic substrates) and is set to become the first company to utilize the technology in a fully commercial application – a flexible active-matrix display distinguished by its large display size, thin depth, low weight, long battery life, and robustness. The company's first product will incorporate its groundbreaking displays into portable consumer electronics devices for the acquisition, organization, and reading of digital content for work, education and recreation.

"Today, we are focused on display-based products, but our potential includes not only displays but memory and logic for a whole host of new, exciting, and innovative products; we are revolutionizing the traditional semiconductor industry," said Plastic Logic CEO Richard Archuleta.

The company was originally spun out of Cambridge University's Cavendish Laboratory in 2000 and has the potential to transform the electronics industry. Plastic Logic solves the critical issue in manufacturing high-resolution transistor arrays on flexible plastic substrates by using a low temperature process without mask alignment. The process is now much simpler, with lower costs and environmental impact than conventional amorphous silicon processes on rigid glass substrates used in traditional semiconductors.

The company's first mass production facility is opening in September, 2008 in Dresden, Germany. Much of the value derived from the technology exploitation will be retained in the UK through its research and development in Cambridge, where activities include those functions linked to the advanced technology inherent to the products value including fundamental science, R&D, and prototyping.

TECHNOLOGY TRANSFER FROM THE SCIENCE BASE

The previous case study shows that a strong link between the science base and industry is also essential for the successful exploitation of cutting edge science and technology. As part of their many contributions to the UK economy and society, universities are encouraged to carry out commercially relevant research and create spinout companies when appropriate. The number of research papers published in journals and the number of subsequent citations are two of the main indicators used to denote the scale and quality of university research activity. The UK consistently ranks highly in this regard and in 2005, was ranked second in the world to the USA in its proportion of world publications (9 per cent) and world citations (13 per cent). The UK also produces a high proportion of the world's most influential papers relative to its share of all publications, producing over 13 per cent of the most cited 1 per cent of papers[38].

38 DTI, 2007.

Although the UK clearly has a world-class science base, it has been noted in the past that the country's invention record was not being sufficiently translated into successful commercial exploitation. By almost all measures, there has been a dramatic increase in the amount of knowledge transfer and technology exploitation by UK universities, as presented in Table 4.

Table 4: Knowledge-transfer indicators for Higher Education Institutions

Knowledge transfer indicator	1995-1996	1996-1997	-	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	% change 2001/2 to 2005/6
Number of new patent applications filed by HEIs	306	371	-	896	960	1,222	1,308	1,649	1,537	72
Number of patents granted	45	56	-	250	198	377	463	711	576	130
Number of licensing agreements	n/a	n/a	-	728	615	758	2,2563	2,099	2,699	271
Income from licensing intellectual property (£ million)	10.1	9.9	-	18	47	37	38	57	58	215
Income from business (value of consultancy contracts) (£ million)	n/a	n/a	-	104	122	168	211	219	236	128

Sources: Howells et al, Nedeva and Georghiou (1999)[39] for 1995/6-1996/7 Higher Education–Business and Community Interaction (for 2000/01–2005/06).

This recent evidence shows that UK businesses are increasingly benefiting from improved interactions with universities, as demonstrated by the fact that the number of licensing agreements and total IP licensing income for UK universities have increased by more than 200 per cent from 2001 to 2005[40]. Evidence from the Community Innovation Survey also appears to corroborate this point.

2.2 The Role of Government

Government plays a key enabling role in allowing markets to fulfil their potential as powerful drivers of technological innovation. Because of the high degree of uncertainty and coordination that typifies the innovation process and the potential for spillovers to occur. Government is also directly engaged

39 Howells, Nedeva and Georgio, 1998, Industry-Academic Links in the UK http://www.hefce.ac.uk/pubs/hefce/1998/98_70.htm#key

40 Higher Education Funding Council for England, 2007,

in supporting technological innovation in a number of ways. For example, this comprises the following activities:

- Funding of the broad-based science and technology research base, supporting the creation – in higher education and public sector research establishments – of more speculative knowledge upon which further innovations can build.
- Providing the right framework and incentives for universities to transfer their knowledge to business and the wider community.
- Supporting business investment in R&D when the market alone generates insufficient incentives, e.g. via the Technology Strategy Board or through R&D tax credits.
- Procuring technologically advanced solutions to deliver key public services – such as health or defence.
- Supporting aspects of the technological information infrastructure that businesses can draw on for their innovations. These are available in codified form as well as expert advice and include the public standardisation framework, both national and international.

Interventions are underpinned by the objective to address market failures. Although most are not targeted towards specific sectors in the economy, the manufacturing sector is a clear beneficiary of government policy in support of innovation and technology exploitation as a result of its substantial engagement in this type of activity. Due to the importance of technology exploitation for national, regional and sectoral competitive advantage, most advanced economies have policies directed at stimulating technology development. However, it is not enough to simply foster development, successful policy must also focus on the wider regulatory, enterprise and skills requirements for successful technology exploitation.

The Government is working hard to ensure this wider innovation framework is in place for the UK through the Science and Innovation Investment Framework 2004–2014[41] and the recommendations of the 2007 Review of Government's Science and Innovation Policies[42] and the White Paper 'Innovation Nation', published by DIUS in 2008[43].

The Technology Strategy Board created in 2004, was established as a non-departmental public body in July 2007 and has a broad remit to stimulate innovation across UK business. Crucially it achieves this through a focus on key technologies and application areas where the UK has the capacity to develop and exploit the technology for economic growth. The collaborative R&D projects funded through the Technology Strategy Board provide one mechanism through which it seeks to achieve this, and since 2004, it has invested in a portfolio now

41 HM Treasury 2004
42 Lord Sainsbury of Turville, 2007
43 Department for Innovation, Universities and Skills 2008.

worth £1bn in collaborative R&D business-business and academia-business project partnerships.

The Government recognises the importance of the science base for innovation and technology exploitation and has introduced a number of schemes that, on account of the indicators shown previously, appear to have produced a major culture change within the UK's universities and made Higher Education Institutions (HEI) more accessible to business.

Collaborative R&D has many additional benefits including the development of skills, people and knowledge transfer. This spillover of technology is often regarded as a key part of innovation policy and a route for technology exploitation in a wider national context. Explicit mechanisms are also being used to encourage spillovers of technology and knowledge transfer more generally. The Knowledge Transfer Networks and Knowledge Transfer Partnerships are two mechanisms the Government has implemented through the Technology Strategy Board which focus on speeding the rate of innovation within key UK sectors.

Government also has the responsibility of ensuring new technologies are safely introduced and supporting those who see their livelihoods negatively affected as a result of the introduction of disruptive new technologies, encouraging the transition to new jobs and emerging industries.

3. Intangibles

SUMMARY

In response to both increasing globalisation and the growing importance of global value chains, the means by which firms in many OECD economies maintain and develop competitive advantage is changing.

Firms in both the UK and other developed economies are increasingly investing in intangible or knowledge assets, such as software, design and other aspects of product-development, brand-building, training and improvements to business processes, in order to improve their competitiveness and enable their products to meet the changing needs of consumers. Firms presently use a combination of formal intellectual property rights (IPR) and techniques such as speed to market and open innovation to capture the value from intangibles. There is an important role for Government in ensuring that firms have the right incentives and information to continue investing in intangibles.

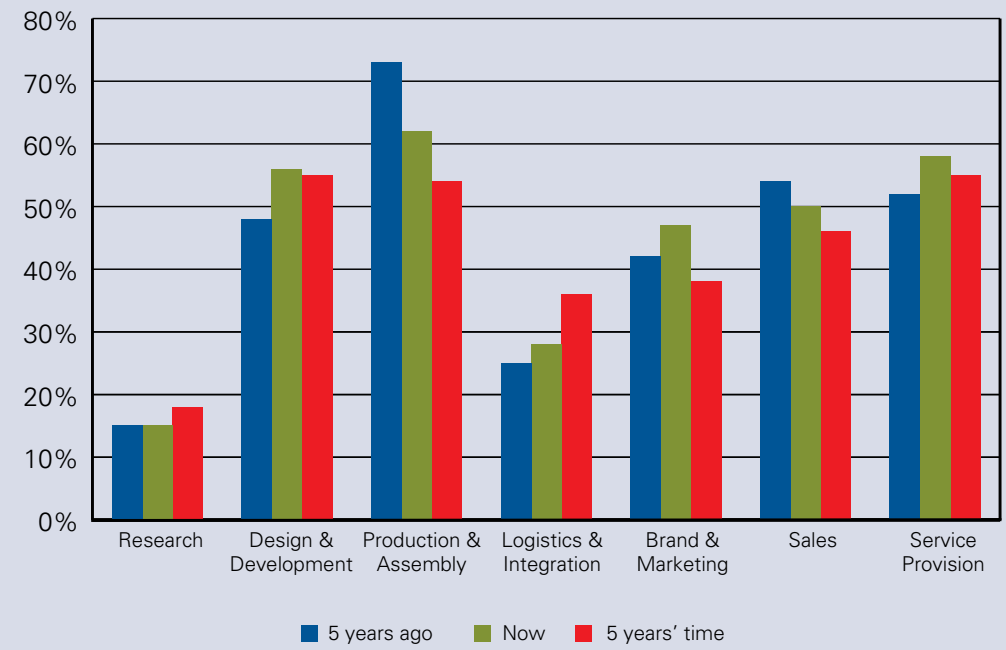
The previous sections have explained how firms in developed economies, including the UK, are increasingly differentiating products and services as a means of creating competitive advantage in the market places and the role that advanced technology plays in that process. This section outlines how firms are increasingly investing in intangible or knowledge assets such as design, branding and business processes as a means of achieving non-technical innovation in order to differentiate their products in the market place.

The changing nature of manufacturing in the UK, and particularly the means by which firms are maintaining a competitive advantage in the changing global market place is well illustrated by recent surveys of UK-based manufacturing companies by the EEF and the CBI. The CBI survey[44] asked firms to identify their top three sources of competitive advantage five years ago, at present and in five years' time. While a majority of firms still consider Production (Fabrication) and Assembly to be among their prime sources of competitive advantage, it is clear that this activity is losing ground to other aspects of business.

It is of little surprise to see manufacturers placing less emphasis on low-skill-intensive activities such as assembly in view of the increasing importance in the world economy of states with abundant low-cost labour. The counterpart to this change is the advancing importance of Design and Development, Service-Provision and Logistics and Integration.

44 CBI, 2007

Figure 13: What are your top three sources of competitive advantage? (Percentage of respondents)



Source: CBI, 2007

Many firms are aware of the importance of intellectual assets and intellectual property (IP) to their business. The number of UK businesses that use IP protection and regard it as important has increased since 2005[45] and, in a survey of 197 technology company executives, 85 per cent expected the importance of intellectual capital to their business to increase[46]. Furthermore, there is evidence that links a firm's use of IP with improved performance: Greenhalgh and Rogers find that a firm's value is positively associated with the incidence and intensity of its trade mark activity and also argue that there is a link with productivity, although this is more pronounced in service sector firms than for manufacturing[47]. A study by Griffiths et al. indicates that a company's stock of trade marks is associated with greater firm profits, controlling for other types of IP and tangible/intangible assets[48].

International standards for official statistics now recognise software, copyrights for artistic, literary and music originals and oil and mineral exploration as productive activities leading to capital formation (i.e. investment). The recognition of software development as an asset-building activity has proved particularly valuable in helping understand the impact of the ICT revolution on recent economic growth[49]. Expenditure on other intangibles is currently treated

45 Robson and Haigh 2008
46 PriceWaterhouseCoopers, 2007
47 Greenhalgh C. and Rogers M, 2005
48 Griffiths W., Jensen P. and Webster E., 2005
49 Christensen J and P Maskell 2003

as current expenditure, although, following the 2008 revision of the UN System of National Accounts, R&D is to be treated as investment.[50]

CASE STUDY 8: TAYLORS EYE WITNESS LIMITED

Taylors Eye Witness Limited (known as Harrison Fisher until 2007) was founded by John Taylor in Sheffield during the early 19th Century and has since become synonymous with fine cutlery. However, the increased competition from cheaper foreign imports meant that the company has had to rethink its product offering and focus on differentiating its products through added customer value and specifically the intangible value that can be captured through good design.

In 2002, Harrison Fisher joined the Design Council's Designing Demand programme which invited a design team led by Design Associate Jonathan Ball to examine every aspect of the business. At the heart of the rethink was the company's 'Taylors Eye Witness' consumer brand which faced stiff competition from cheap supermarket own-brand products. The design team's response was to redesign the brand to move towards being an independent consumer brand and develop a signature product range to reflect the core values of tradition and quality but in a more contemporary style.

Managing director, Alastair Fisher believes the £80,000 pounds invested in design was money very well spent: "We had been under a lot of pressure and were losing business. The Design Council Designing Demand programme helped us get ahead of the competition instead of playing catch-up." In addition, the company was even able to exploit the government's R&D tax credits to recoup some development costs.

Instead of competing with low-cost competition from Eastern Europe and Asia, Taylor Eye Witness Ltd now confidently compete with upmarket, quality and design led German rivals and is differentiated through the intangible value that the design makeover has added.

3.1 How the UK is performing

Analysts have only recently begun to examine the extent of intangible investment other than R&D. In the absence of either national or international agreements on measurement, all estimates to a certain extent require the authors to make quite strong assumptions and should therefore be treated with caution. The most robust data for intangible investment in the UK was published alongside the 2007 Pre-Budget Report[51]. The analysis suggested that intangible investment in the overall market sector in 2004 was £123bn, 28 per cent higher

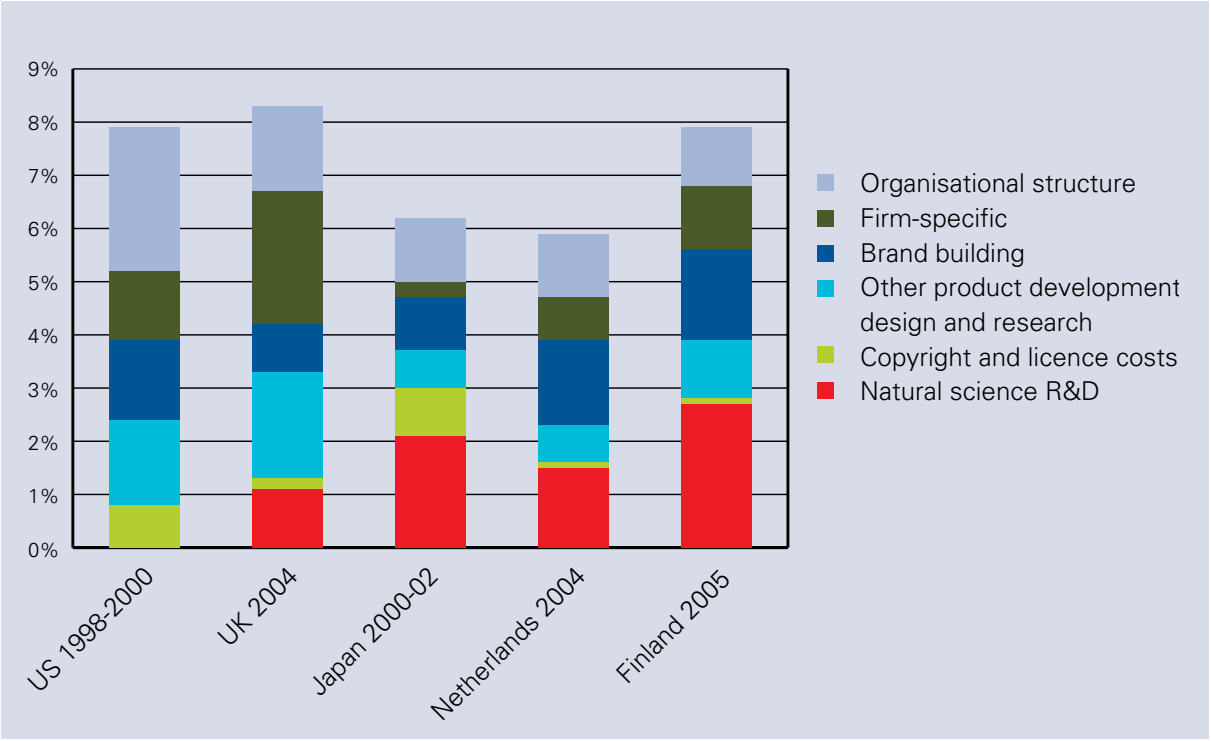
50 The EU Commission is currently in the process of deciding how this methodological change will be implemented through a Satellite R&D account. Because manufacturing accounts for most of R&D usage in the business sector, the new treatment of R&D will imply a larger manufacturing share of total GVA of approximately one percentage point.

51 Marrano G, J Haskel and G Wallis, 2007.

than the equivalent figure for tangible investment. The historic data showed that intangible investment as a proportion of business output more than doubled between 1970 and 2004[52].

The OECD has brought together international analyses of intangibles. Whilst the work has followed pioneering research for the USA[53], it has been carried out independently by researchers in the respective countries and it should therefore not be seen as a definitive international comparison[54]. Nevertheless, as Figure 14 shows, all five economies appear to be devoting in the region of ten percent of GDP to investment in intangible assets. While results may not be strictly comparable, the data suggest that the rate of intangible investment in the UK compares favourably with rates in other countries.

Figure 14: Intangible Investment in five OECD Countries, Percentage of GDP



Source: 'Intellectual Assets and Value Creation, Synthesis report' OCED Science Technology and Industry Directorate, 2008. p 13.

BERR has commissioned more detailed research on intangible investment exclusively in UK manufacturing. Work to measure intangible investment at the sectoral level has not been taken forward outside of the UK and so this

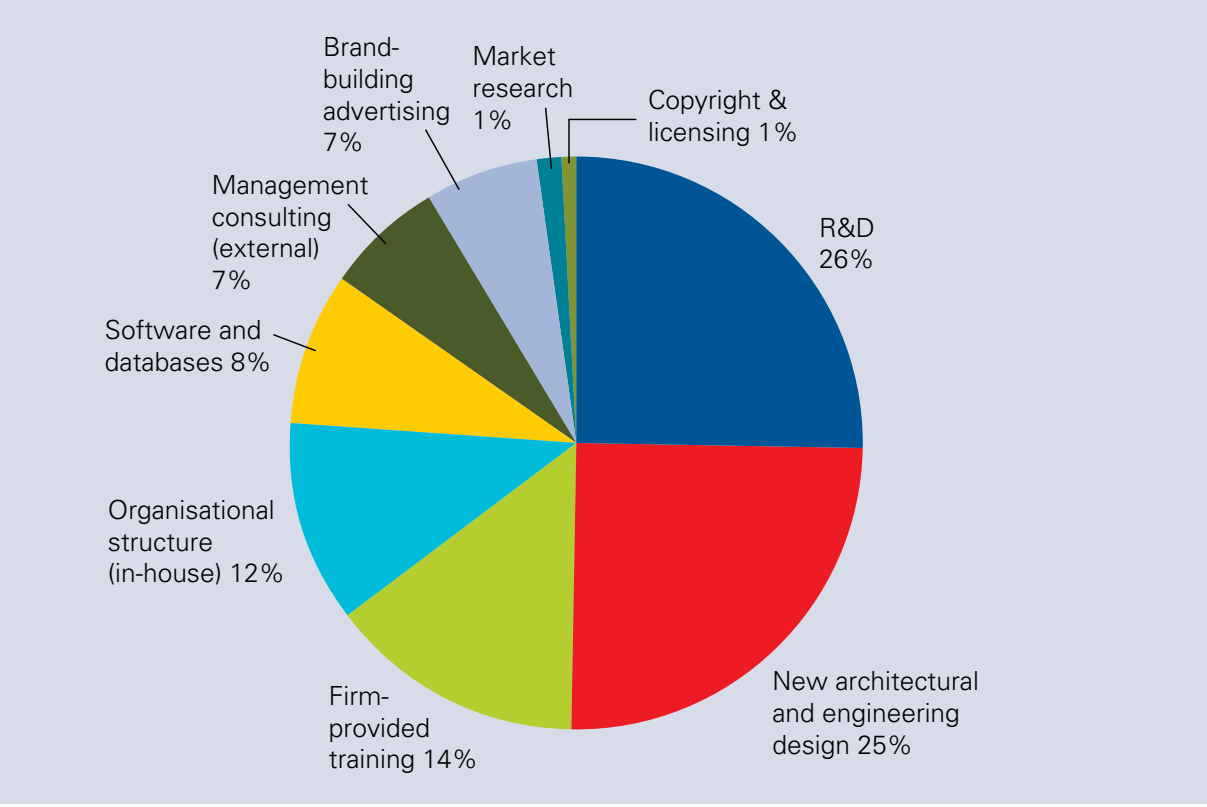
52 The increase in nominal intangible investment relative to tangible investment may in part be due to more rapid price rises for intangible investments (no official deflator is provided for intangible investment, but a proxy can be devised from price and wage data for relevant industries), meaning the relative shift in real terms may be less marked. The relative increase in nominal intangible investment relative to tangibles could be viewed as the capital-goods equivalent of the long-term shift towards services forecast by Baumol (1967) for consumption expenditure.

53 Corrado, Hulten and Sichel, 2002, 2006

54 The research on Japan, in particular, did not achieve complete coverage of some elements, and the figure of 8.3 per cent of GDP for that country must be taken as a lower bound.

pioneering work should be treated with particular caution[55]. Nevertheless, the work suggests that total spending on intangible assets by British manufacturing in 2004 amounted to £32bn (the breakdown of potential investment across the various types of intangible assets is shown in Figure 15). This compares with a figure for traditional investment (gross capital formation[56]) of £13.7bn according to ONS estimates. The work reported here suggests that this item merits some revision and that, if both intangible and traditional investment by manufacturing were accounted for, overall investment might be more than three times as large as currently reported.

Figure 15: Intangible Investment in UK Manufacturing 2004



Source: Gil and Haskel, 2008

Further indication of the importance of intangible investment for the overall UK economy is provided by data on international transactions for the use of intellectual property, that is, royalties and license fees. Table 5 below shows that while debits rose by 34 per cent 1996-2006, credits advanced by 75 per cent over the same period, with the effect that the surplus under this heading increased from £211m to £1,974m.

55 This project also set out to distinguish between the production of intangibles and their acquisition. Broadly speaking, at a national level, the difference is implied by net exports. In the case of intangibles, the UK is a net exporter of related services and hence aggregate investment is less than output.

56 This mainly consists of buildings, plant, machinery and equipment and vehicles though the figure also includes an element representing some intangible investment, notably software.

Table 5: UK International Payments for Intellectual Property 1996-2006

Royalties and licence fees in £m	1996	2006
Credits	4,253	7,381
Debits	4,020	5,407
Balance	211	1,974

Source Pink Book 2007

Case study 9 below describes how Protomold Ltd employs ICT in design and engagement with customers to create its high value products.

CASE STUDY 9: PROTOMOLD LTD

Protomold is a rapid injection moulding company based in Telford, Shropshire providing product designers and engineers across Europe with a unique, fast and low cost method for obtaining low volumes of plastic injection moulded parts. Protomold is an example of a manufacturing business that has embraced modern technologies to push manufacturing capabilities and in turn revolutionise the customer experience. With a 1.9 Teraflop backbone and a proprietary IT driven manufacturing system Protomold makes it possible to receive off tool, off process real injection moulded parts as fast as the next business day from receipt of 3D CAD data.

Interaction with the system occurs through the company's website. Customers upload the 3D CAD models of the parts that they require. Protomold's software then analyses the design to assess what can be produced and this data forms the basis of the quote. This information is presented to the customer in the form of an interactive graphical annotation of the customers' part presented in a 3D viewer within the quote. Quotes are guaranteed within a business day and include all the relevant information such as mould pricing, the price of samples and the part price for production orders – all calculated automatically by software. The parts can then be ordered over the internet, with the 3D model acting as the basis for all the subsequent mould design. The software developed by Protomold has automated much of the manufacturing process.

"We are selling time, so speed is important in everything we do" says Damian Hennessey, the commercial manager. "We have a business model that is fresh and new; that realistically makes it possible for the innovators of Europe to competitively develop their new products and then reap the rewards of being first-to-market with their revolutionary ideas."

3.2 The Role of Government

Government's role in the broadest sense is to ensure that the incentives for business to invest in intangibles assets are in line with those that reflect the

wider costs and benefits to society of such investment. In practical terms, this means ensuring that firms both understand the potential benefits of such investment and enabling them to realise the benefits of such investment through development and effective enforcement of appropriate IP protection.

Systems of IP protection need to balance the interests and incentives of, on the one hand, the creators of radical inventions and, on the other, the 'fair followers' who make incremental improvements. The Gowers Review (2006) reviewed the UK IP protection system and concluded that it was fundamentally strong. However, it did question the flexibility and accessibility of the system as well as the costs of registration and litigation.

Such conclusions were in line with feedback from business surveys which suggest the main barriers to using formal IPR are high costs and limited information. Research by the Austrian Institute for SME Research on firms already using high quality IP information services[57] suggested that SMEs consider costs to be the primary barrier to using formal IPR, particularly patents, more intensively. Surveys also suggest that awareness among British firms (including manufacturers) regarding IP protection is in some cases constrained[58]. To illustrate, the CBI is reported to have estimated that approximately 70 per cent of businesses are unaware that domestic IP does not provide protection abroad[59].

As a result, firms spend significant sums of money on obtaining and maintaining IPRs. According to a survey by the UK Intellectual Property Office[60], micro firms average around £1,000 a year, small firms £3,300, medium firms just over £18,000 and large firms a substantial £2.8m per annum. Nonetheless, many firms see the potential to do better: 62 per cent of respondents in one survey indicated that their company could extract significantly more value from IP with additional effort.

While larger firms see threats from IP infringements and opportunities to create more value from IP through collaboration[61], it has been suggested that SMEs struggle to make effective use of IP protection. For example, research for the European Commission[62] indicates that SMEs consistently report less use of formal IP and of non-formal appropriation methods than large firms (though UK small firms made more use of these methods, with the exception of patent applications, than those from any other Member States). However, this may be a consequence of the way the research was done, using activity per firm rather than per employee.

57 KMU Forschung Austria, 2007
58 UK Intellectual Property Office 2007
59 Gowers, 2006, p37
60 UK Intellectual Property Office, 2007. While respondents were drawn from a wide range of sectors, there may have been a bias toward firms with an interest in IP.
61 See PrticeCoopersWaterhouse 2007 for similar findings
62 European Commission's DG Enterprise and Industry, 2007 (2)

BOX 2: FIRMS' STRATEGIES FOR IP PROTECTION

While Intellectual Property Rights (IPR) are an important element in firms' protection of their IP, it is important to bear in mind that less formal, 'strategic' mechanisms such as speed to market, secrecy and selective openness (for example, use of open-source software) also form an important part of many firms' IP protection strategies.

Roles that different forms of IP can have in meeting various strategic objectives:

Objective	Patents	Trademarks	Know-how	Relationships
Conflict avoidance/ resolution	• Protection (exclude others) • Design freedom • Cross-licensing (defensive) • Litigation bargaining power	• Protection (exclude others)	• Protection (trade secret)	n/a
Revenue generation	• Patents: sales, licenses, infringement policing • Increased bargaining power • Market penetration • Increased speed to market	• TM: sales, licenses, co-branding, infringement policing	• Sales, licenses, joint ventures, strategic alliances, integration, increased speed to market	
Cost reduction	• Tax donation • Litigation avoidance • Access to technology of others • Improved knowledge transfer	• Litigation avoidance • Access to technology of others	• Litigation avoidance • Improved knowledge transfer	• Reduced marketing costs
Strategic position	• Reputation / image • Competitive blocking • Barrier to competition • Consumer/ supplier control • Optimization of core technology	• Name recognition • Consumer loyalty • Barrier to competition • Joint venture • Strategic alliance	• Reputation / image • Barrier to entry	• Reputation / image • Consumer loyalty • Barrier to entry

Source: *Sullivan P. and Harrison S, 2008.*

ENFORCEMENT OF IP RULES

Evidence shows multinational firms are particularly concerned about the effects of intellectual property infringement, particularly from emerging economies but also from more developed nations – and from their own staff. The largest risks to companies' IPR identified in one survey of 405 executives in Europe[63] were patent infringement from competitors in emerging markets (43 per cent) and developed

63 Economist Intelligence Unit, 2007

markets (31 per cent) and "unauthorised action" by employees (36 per cent). 40 per cent of respondents saw China as the country posing the most serious threat to their company's IP, while 14 per cent were most concerned about the USA, 9 per cent India, 8 per cent Russia and 6 per cent the UK. The most effective remedies were seen as being a formal intellectual asset management strategy and organisation (with dedicated staff), getting new products to market quicker and improving awareness and training of staff. But they also saw a range of opportunities based on collaboration in R&D, standards development and open innovation.

Responding to business concerns regarding IP infringements, the OECD have investigated the scale of such cases and concluded in 2008 that pirated or counterfeit goods to the value of some $200bn may be entering international trade annually[64]. Firmer action against counterfeiting in the UK was also a strong conclusion of the Gowers Review[65].

There may also be additional opportunities for firms (including, but not limited to manufacturers) to make commercial use of IP created by the Government or in universities. The Office of Fair Trading has identified the potential for £700m of additional value to be generated from the commercial use of public sector information[66], while rises in most forms of IP exploitation by HE institutions since 2000[67] suggest that there may be further potential for business to create value from IP owned by universities.

64 OECD, 2008
65 Gowers, 2006
66 Office of Fair Trading, 2006
67 Higher Education Funding Council for England, 2007

4. People and Skills

SUMMARY

A skilled workforce is essential for attracting the high value added design and research activities of manufacturers operating on a global level. Evidence suggests that a transition in manufacturing is already taking place with an increasing proportion of employment being in more highly skilled occupations.

Firms frequently report that the skills required involve both specialist high level skills, including STEM, along with a generic set of soft skills that enable people to work across disciplines. Strong management and leadership are also vital for the operation of global value chains and making the most effective use of the skills of the workforce to deliver high value added products and services.

The previous sections have described how developed economies, including the UK, are moving from low value production processes towards differentiated high value production processes and intangible activities such as design and additional services. This shift of specialisation in high value activities continues to have a knock on effect on the skills and people that are required for manufacturing companies.

The emergence of economies like China and India has led to a rapid increase in the global supply of labour. The IMF[68] estimate that the effective global labour supply quadrupled between 1980 and 2005 with East Asia accounting for half of the growth. Most of this global growth, however, has been in unskilled labour, while the economies of Europe have experienced an increase in skilled labour which is forecast to continue[69].

Most developed economies cannot compete with emerging economies on the basis of labour costs, increasing the importance of the availability of skilled labour for attracting mobile manufacturing investment. In addition, skill biased technological change is placing an increasing premium on skilled labour. Emphasising this, the CBI[70] found that 39 per cent of firms reported that skills were the most important factor for influencing the location decision of firms' design and development activities.

AgustaWestland are an example of a UK company that is proactive in developing its people and is described in case study 10 below.

68 IMF, 2007, Chapter 5.
69 CEDEFOP, 2008
70 CBI, 2007

CASE STUDY 10: AGUSTAWESTLAND

AgustaWestland, based in Yeovil, Somerset, manufactures a range of rotorcraft and provides industry leading support solutions and services for commercial and military customers around the world. AgustaWestland employs approximately 3,500 people in Yeovil and offers some of the most prestigious staff training courses in the South West of England. In addition to engineering and technician apprenticeships AgustaWestland provide structured training programmes and undergraduate and graduate training programmes specifically aimed at meeting the business and administration requirements of modern global manufacturing companies.

The Business Support Programme places trainees in a number of business areas including procurement, project management and sales and marketing whilst simultaneously qualifying the trainees up to foundation degree and NVQ Level 3 in Business and Administration. "Manufacturing is not purely about production – it offers a broad range of business opportunities to meet the needs of the global operation in driving the strategy forward" says Sarah Cook, Vice President of Human Resources.

AgustaWestland also supports their employees in learning to help them carry our their day to day work with their Italian colleagues and to facilitate opportunities with their parent company, Finmeccanica

The Undergraduate and Graduate programmes at AgustaWestland are available in business or engineering and offer twelve month industrial placements and 2 year structured training programmes respectively. The undergraduate placement programme allows students in full time education to benefit from a year in industry with the further benefit of a competitive salary. The graduate training programme involves working across a variety of subject relevant departments over a 2 year period whilst working towards Chartered status in the individual's area of expertise.

AgustaWestland currently has 101 people on engineering and technician apprenticeships, 12 on Business Training Programmes, 23 on Undergraduate placements and 9 on the Graduate Programme.

A key requirement for manufacturing is people with qualifications in science, technology, engineering and mathematics (STEM). Employers also note the importance of combining such specialist skills with a wider set of skills including team-working and communication that enables people to work flexibly across a range of activities within companies.

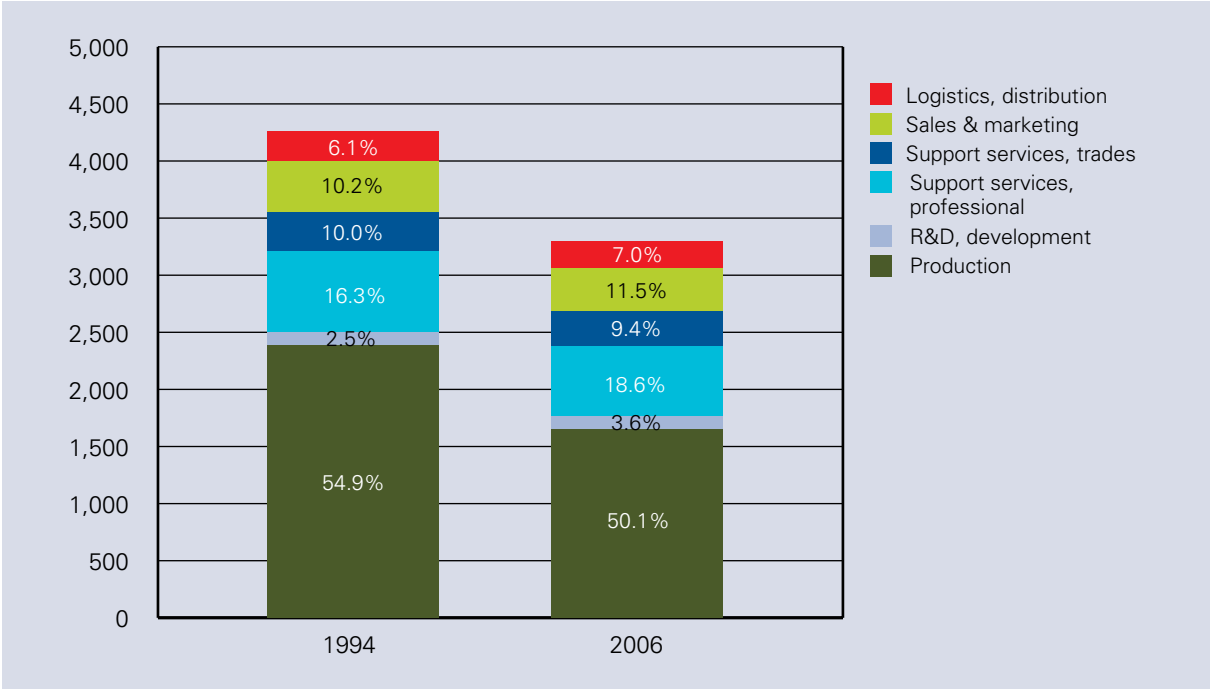
The growth of global value chains, with firms potentially undertaking different activities in different locations across the globe, also places increased emphasis on strong leadership and management skills to deploy all resources effectively

and profit from the opportunities available. These skills are difficult to define and measure in a consistent way across countries but studies that have been undertaken for manufacturers support the perception that UK management capability is below that of the US, Germany and Japan.

4.1 How the UK is performing

There is clear evidence that the UK's labour force is responding to the changing skill needs placed upon it by changes in the global economy. While there has been a fall in overall employment in manufacturing, as Figure 16 shows, this fall has been more focused on traditional, less skilled production jobs, with the proportion of manufacturing workers in occupations such as R&D – normally considered to be more highly-skilled – increasing.

Figure 16: Total Manufacturing Employment in 1994 and 2006 and the Share of Employment Accounted for by a Broad Set of Occupational Groups ('000s)



Source: Labour Force Survey

There has also been an improvement in the educational attainment of workers across occupational groups. Table 6 reclassifies the six occupational groups presented in Figure 16 into two broad groups. For the first group (production, support services & trades, logistics & distribution) the proportion holding a degree or equivalent qualification increased from 4.8 per cent in 1994 to 8.7 per cent in 2006. Educational attainment is considerably higher in the remaining group of occupations (R&D and development, professional support services, sales & marketing) and has also experienced rising attainment over time – 31.7 per cent held degree level qualifications in 2006 compared to 19.8 per cent in 1994.

Table 6: The Educational Attainment of Individuals According to Broad Occupational Group

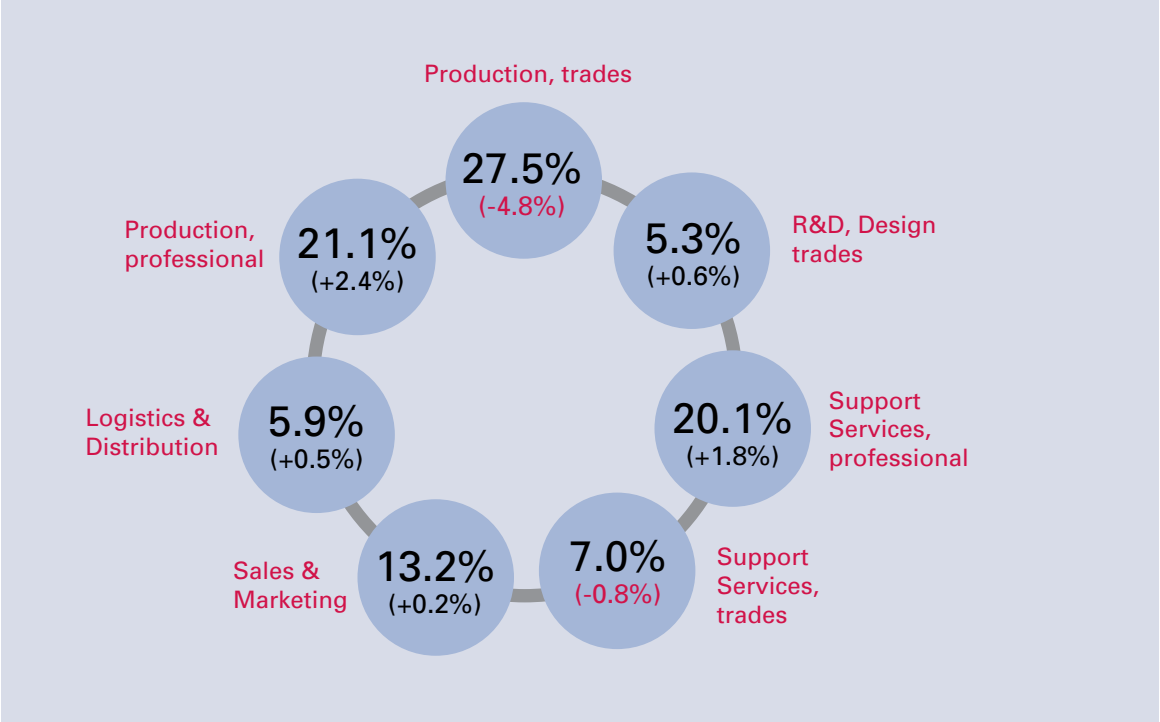
	Employment share (%)		Proportion with NVQ level 3 and above (%)		Proportion with degree or equivalent (%)	
	1994	2006	1994	2006	1994	2006
Production, support services & trades, logistics & distributions	71.0	66.4	42.0	48.0	4.8	8.7
R&D and development, professional support services, sales and marketing	29.0	33.6	55.1	64.1	19.8	31.7
All manufacturing	100	100	45.5	53.4	8.9	16.4

Source: Labour Force Survey

The upskilling of individuals across all occupational groups combined with a shift in employment towards occupations that are already more highly skilled has led to an overall rise in educational attainment in manufacturing. The final row of Table 6 shows that the proportion with degree level qualifications almost doubled between 1994 and 2006.

As a result of both the changes in employment share and qualification levels of the occupational groups within manufacturing, the relative contributions these groups make to value chains is also changing. Figure 17 reports the share of total earnings in manufacturing received by each of the occupational groups in 2006 and the change in this share between 2001 and 2006. For example, those employed in professional support services received 20.1 per cent of total manufacturing earnings in 2006, an increase of 1.8 percentage points since 2001.

Figure 17: Share of UK Manufacturing Earnings across Value Chain 2006
(Percentage point change in share from 2001-6 shown in brackets)



Source: BERR analysis of LFS micro-data, ONS

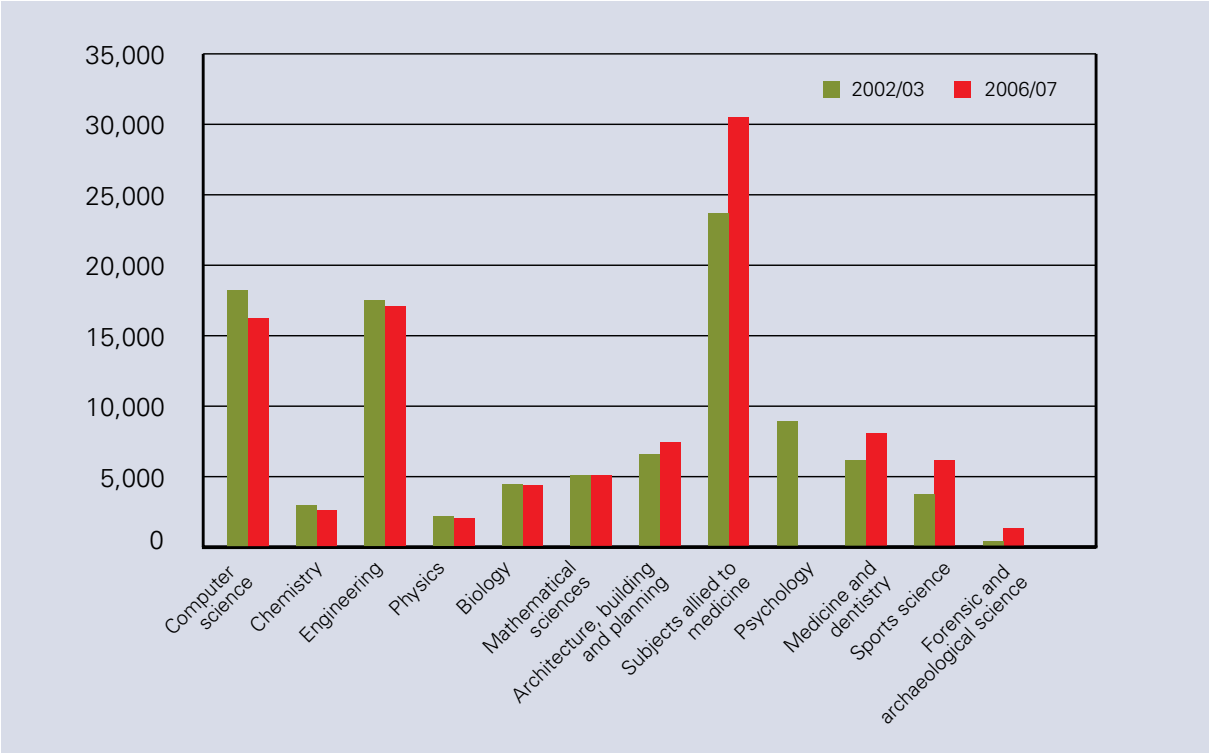
STEM SKILLS FOR MANUFACTURING

The continued movement towards high value added manufacturing activities will create additional requirements for more highly skilled labour. Although Government policy is aimed at improving the UK skills base at all levels, higher level skills are often considered more important for the creation of new technology and innovation. For manufacturing, the supply of people with high level skills in science, technology, engineering and mathematics (STEM) is important for long term competitiveness. Surveys by the CBI[71] and Sector Skills Councils have emphasised the importance of STEM to employers and reported some difficulties faced by employers in recruiting people with the appropriate qualifications.

For graduate level STEM qualifications, the data from the Higher Education Statistics Agency (HESA) show that between 2002/03 and 2006/07, the number of people obtaining first degrees in STEM subjects increased by 11 per cent, from 118,000 graduates to 131,000. This compares to a 15 per cent growth in non-STEM subjects over the same period. The number of STEM Masters and PhD qualifiers increased by 35 per cent and 18 per cent respectively.

71 CBI, 2008

Figure 18: First degrees obtained by STEM subject, 2002/03 and 2006/07



Source: Higher Education Statistics Agency

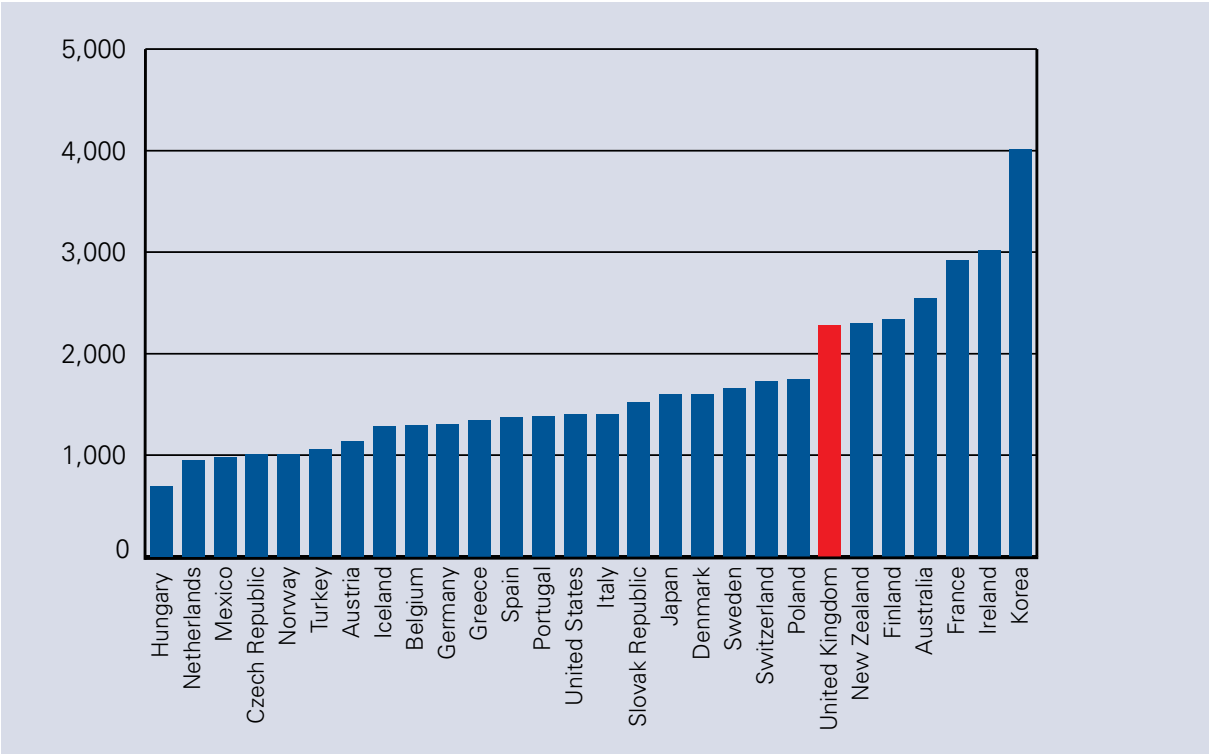
For first degrees, most STEM subjects have seen an increase in the number of qualifiers between 2002/03 and 2006/07. However, as presented in Figure 18, some declines have been recorded in Chemistry (-10 per cent), Computer Science (-11 per cent) and Engineering (-2 per cent). The number of entrants onto these courses has also been in decline – down 34 per cent for Computer Science and 8 per cent for Engineering.

The UK compares favourably with other OECD countries in terms of the number of science graduations relative to employment (Figure 19). There are 2,300 science graduates per 100,000 25 to 34 year olds in employment, which is greater than that in Japan (1,600), the US (1,400) and Germany (1,300). France has proportionately more science graduates (2,900) but Korea is considerably ahead of all other countries with 4,000 graduates per 100,000 employed.

Although the focus is often on high level STEM qualifications, it is also important to analyse the teaching of STEM in schools and colleges in order to fully assess the future pipeline of people with STEM skills. In the latest survey for the OECD's Programme for International Student Assessment (PISA) the UK was ranked 9th out of 30 countries in terms of proficiency in science amongst 15 year olds. However, 2.9 per cent of young people in the UK reached the highest level of science proficiency compared to an OECD average of 1.3 per cent. Only Finland (3.9 per cent) and New Zealand (4.0 per cent) recorded a higher proportion.[72]

72 OECD, 2006

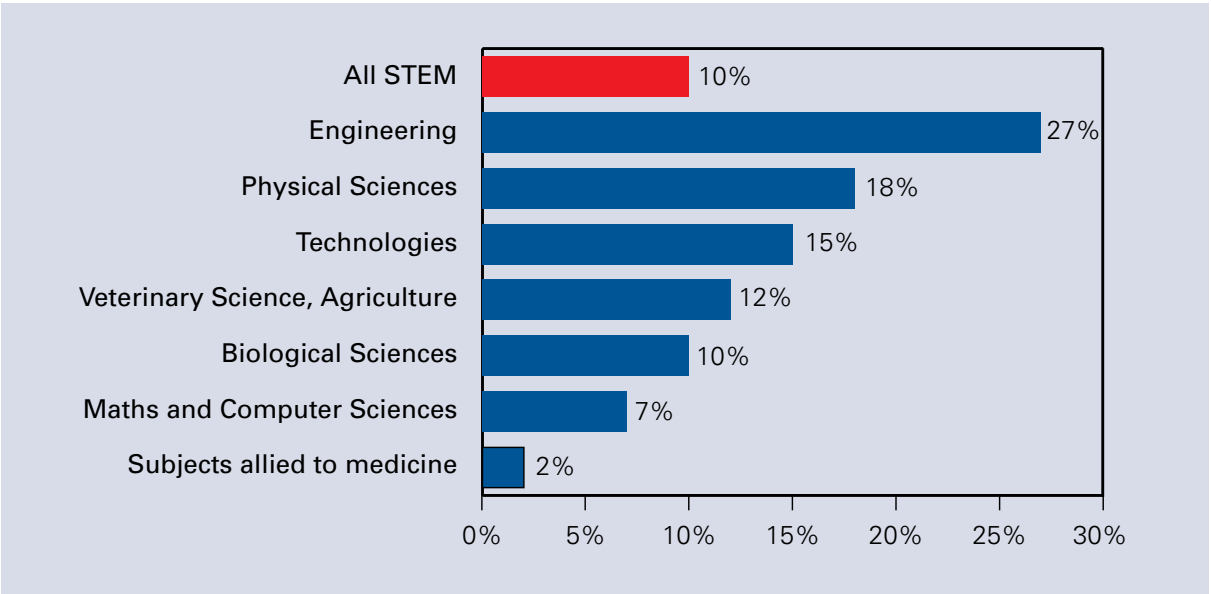
Figure 19: International comparisons of science graduates per 100,000 employed 25–34 year olds



Source: OECD Education at a Glance, 2007

Between 1999 and 2004 there were significant falls in the number of A Level entries in Biology, Chemistry, Physics and Maths amongst 16-18 year old students in schools and colleges. With the exception of Physics, however, the number of students entering these subjects has recovered since 2004.

Figure 20: Percentage of STEM graduates employed in manufacturing



Source: Labour Force Survey, 2008 Q1, 20-59/64, UK

In addition to the number of people gaining qualifications in STEM related subjects, the proportion of these people who go on to work in manufacturing is also important for the future supply of skills. The decision to pursue a career in manufacturing will be determined by a range of factors including the perceptions of the jobs available and the economic return in the form of wages. For all those holding degrees in any STEM related subject, 10 per cent are employed within manufacturing (Figure 20). This proportion varies by subject studied with 27 per cent of Engineering graduates finding employment in manufacturing. STEM graduates, however, are employed in a wide range of industries and occupations within these industries. Estimates suggest that 40-50 per cent of STEM graduates work in STEM related occupations.

CASE STUDY 11: ASTRAZENECA

AstraZeneca is a major international healthcare business engaged in the research, development, manufacture and marketing of prescription pharmaceuticals and the supply of healthcare services. A global pharmaceutical company employing 65,000 people worldwide, AstraZeneca has research and development and production sites throughout the UK where approximately 4,000 people are employed in R&D.

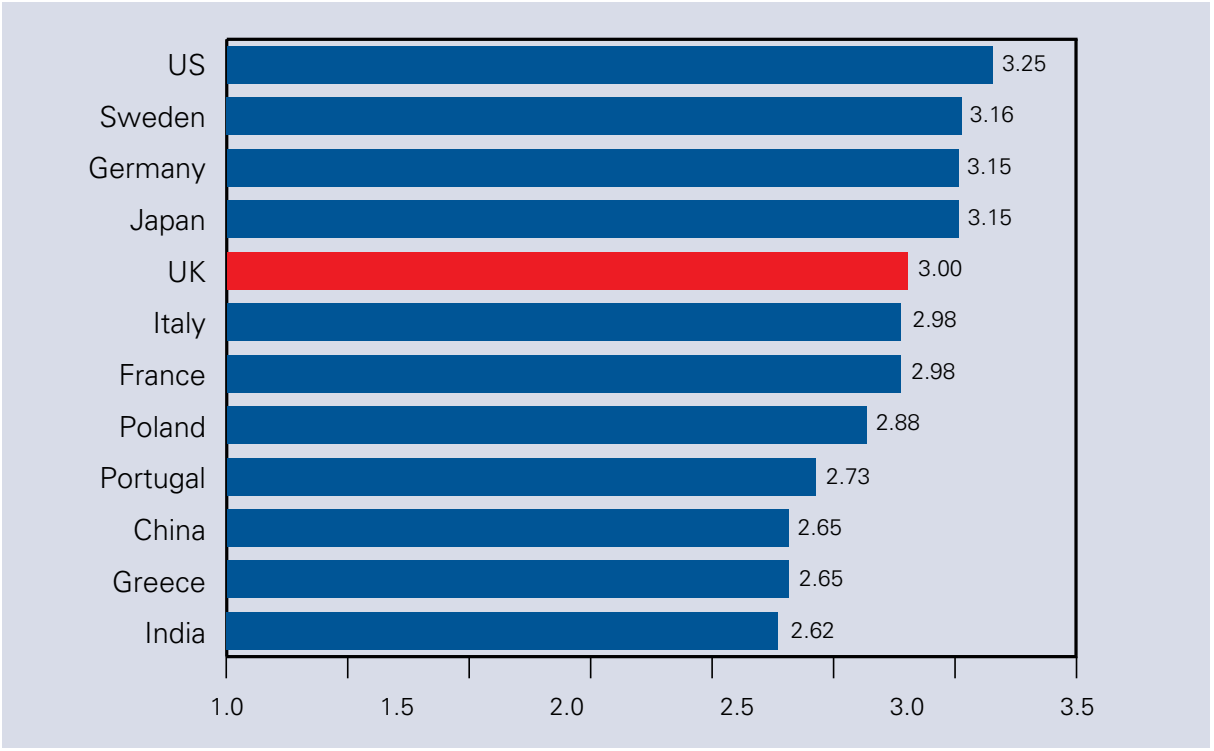
The pharmaceutical sector relies on the UK science base to supply trained scientists and engineers and the dynamic interactions with academia that engender the creation of ideas and promote innovation. AstraZeneca remains concerned that the erosion of the science base both in the UK and Europe is having a negative impact on the level of innovation. In order to sustain a vibrant and flourishing environment for economic growth it is imperative that the teaching of science, technology, engineering and mathematics (STEM) subjects and provision of skilled scientists and engineers is elevated in importance and pursued vigorously.

As part of its commitment to the science base, AstraZeneca works with the Association of British Pharmaceuticals Industry (ABPI), the Sector Skills Council for Science, Engineering and Manufacturing Technologies (Semta) and other stakeholders to develop and strengthen the UK STEM education and research training systems. Jackie Wilbraham, R&D Science Policy Director at AstraZeneca and member of Semta's bioscience Sector Strategy Group (SSG) is passionate about the need to strengthen the UK's science base – "The strength of the science base is critical to the development of a flourishing economy," she says. "We rely on a strong science base to provide the talented individual and interchange with the academic community that we need to sustain development of our business and the delivery of a flow of new medicines that bring benefit for patients and add value for wider society."

MANAGEMENT SKILLS

The ability to identify and exploit the competitive advantages associated with global value chains places increased importance on the management and leadership capability of UK manufacturers. There is a common perception that the UK has a deficiency in terms of its management capability which reduces the ability of companies to compete in terms of high value added and innovative goods and services. In reviewing UK competitiveness, Porter and Ketels (2003) argue that "UK managers might either fail to understand the opportunities of competing in premium segments, or might indeed be better at low cost processes, products and services"[73].

Figure 21: Management index (1-5) by country



Source: McKinsey and Company and LSE/CEP, 2007

Unlike other skills, like the number of people with STEM degrees, management skills are considerably more difficult to define, measure and compare in a quantitative way. Much of the evidence for UK management capability is qualitative and based on perceptions. One of the most influential studies was done by McKinsey/CEP (2007) who interviewed 4,000 medium sized manufacturing firms in the US, Europe and Asia in order to reach an assessment of the quality of management on a five-point scale across 18 different management practices. These practices could be grouped into three main categories – shop floor operations, performance management and talent management. Figure 21 shows that, taking the average score across all 18 practices, the UK is behind the US, Sweden, Japan and Germany, but ahead of both China and India. Although the US is ranked highest overall, it is particularly strong on people management.

73 Porter and Ketels, 2003.

Germany, Japan and Sweden score more highly than the US in terms of shop floor operations management. Across all countries the analysis also shows that multinational companies are associated with greater management capability compared to those that are domestically owned.

The data for manufacturers shows that management capability is positively correlated with measures of performance including labour productivity, sales growth and the return on capital employed (ROCE) even after controlling for the country the firm is located in and the skills of the workforce. A one point increase in the five-point management index is estimated to lead to an increase in output equivalent to increasing the size of the labour force by 25 per cent or increasing the amount of capital invested by 65 per cent[74].

4.2 The Role of Government

Government policy has a role in addressing some of the most commonly identified market failures that lead to underinvestment in skills in the UK. Externalities are likely to occur for investments made in skills as additional costs and benefits are experienced by other individuals and employers beyond those making the initial investment. The incentive for employers to invest in skills that are equally valuable to all other employers may be reduced if there is a fear that trained staff will be poached by other employers. Policy has therefore concentrated on subsidising these general skills, particularly at the lower levels where individuals and employers may also face credit constraints for funding the investment. Basic literacy and numeracy, level 2 and apprenticeships provide a platform for these skills that are of value to manufacturers and their supply chains.

Information failures have also been cited as a reason for why underinvestment in skills may occur. Employers may have difficulty in identifying what type of training is available from providers and the individuals that would derive the most benefit. Manufacturers frequently report that the skills landscape is too complicated and are unclear as to how to access the most relevant forms of training. Where Government has a clearer view of the system, the asymmetry of information with employers may be corrected through brokerage schemes and other forms of information, advice and guidance to assist employers in accessing the appropriate training.

74 McKinsey & Company and CEP/LSE , 2007, p. 5

5. Low Carbon Economy

SUMMARY

The transition to a low carbon and more resource efficient economy is presenting both challenges and opportunities for businesses, in manufacturing and all other sectors, through greater environmental efficiency and sales of 'greener' products and technologies.

Research suggests there are firm level synergies between good commercial and environmental performance, but there will inevitably be trade-offs between the short-term costs of transition to clean technologies and uncertain long-term economic benefits.

Establishing a robust carbon price will play a key role by ensuring businesses prioritise carbon efficiency in their production decisions. London has already become a global hub for carbon trading in a global market estimated to be worth US$64 billion in 2007 – up from US$32 billion in 2006.

Recent evidence from Ernst and Young suggests the most viable way for the UK to exploit business opportunities in green business is to stimulate green products and services in areas where the UK already holds a comparative advantage, such as, high tech manufacturing and business/financial services sectors. The EGS sector in the UK is already worth £25 billion, employs over 400,000 people, and is expected to grow rapidly to £35 billion by 2010. The UK is also the largest clean technology venture capital market in Europe with a cumulative investment of €186 million since 2001 (30% of the European total).

The economic arguments surrounding climate change have risen in prominence since the publication of the Stern Review. Market and coordination failures represent barriers to the climate change response in terms of mitigation and adaptation. Externalities mean that market prices do not represent the true cost of production and consumption to society, whilst informational asymmetries and complexities give rise to sub-optimal investment, and coordination failures misalign incentives between producers and consumers.

The UK government has therefore set out a long term policy framework to provide clear long-term signals to industry; address market, institutional, regulatory and co-ordination failures to create the necessary conditions to encourage investment and innovation in environmental products, processes and technologies; and provide information to help business and consumers make more informed choices.

Increasing global competition for natural resources, new environmental regulations and growing consumer demand for 'greener' products are presenting challenges for businesses which they may nevertheless be able to convert into commercial advantage both in terms of greater cost efficiency and enhanced revenue potential.

For example, the Commission on Environmental Markets and Economic Performance[75] state the environmental market potential is significant, global and growing rapidly. There are opportunities for businesses that have the foresight to take steps to improve operational performance through greater environmental efficiency and sales by offering goods and services that are more attractive because of their environmental performance.

The UK is already a net exporter of environmental goods and services (EGS), with an estimated €1.5 billion of exports and €1 billion of imports in 2004. The EGS sector in the UK generates revenues of £25 billion annually and employs over 400,000 across 17,000 companies. The size of the sector is expected to grow rapidly to £35 billion by 2010.

Overall added value in the low carbon energy technologies sector according to some estimates could also be worth as much as $3 trillion per year by 2050 and employ up to 25 million people world-wide. A recent estimate already puts the current global market for new low-carbon energy technologies at around US$100 billion per year, having grown by 43 per cent over the previous year.

Economic research has identified a number of synergies at the firm level between good commercial performance and environmental performance. For example, the OECD has found that firms, that are active in international markets, have stock exchange listings and robust management practices, are also likely to be good performers in both environmental and commercial terms principally due to their visibility to consumers and equity providers[76].

However, there will unavoidably be trade-offs between the short-term costs of transition to low carbon, resource efficient production and the uncertain longer-term economic benefits in terms of increased profitability, growth and job creation. This raises a set of practical and intellectual choices both for business and for governments.

5.1 The transition to low carbon and clean technologies

The transition to low carbon and more resource efficient production will inevitably involve transformation in business products, processes and organisation. Business and technological change will re-shape markets and incumbent positions. Those businesses best prepared for the transformation will minimise the costs and capture the economic rewards.

75 CEMEP, 2007
76 Johnstone, OECD Sustainable Development Studies, 2008

Establishing a robust price for carbon and growing the Global Carbon Markets will play a key role in the move to a low carbon economy by ensuring that the carbon price is integrated into the relevant industries' business decisions stimulating innovation and cost effective carbon abatement as well as making the low carbon agenda a consideration for all industries and businesses. There are already clear signs this is happening.

In the UK London has become a hub for carbon trading in a global market estimated to be worth US$64 billion in 2007 – up from US$32 billion in 2006 (see Table 7 below)[77]. The international scope of the market and specific trading and settlement skills provide the UK with clear advantages in this emerging market.

Within Europe, the European Union has established the EU Emissions Trading Scheme (ETS), a market-based mechanism designed to internalise the external costs of carbon dioxide emissions. The carbon price under EU ETS has fluctuated around €20/tonne of CO_2 (EUA 2008) in 2008 and it is assumed to reach €40/tonne by 2020 according to European Commission analysis used in DEFRA's EU ETS Impact Assessments[78]. Other carbon markets outside the EU ETS have recently developed in other geographical locations like the New South Wales GHG abatement scheme in Australia or the Chicago Climate Exchange.

Table 7: Global Carbon Market 2006/7

	2006		2007	
	Volume (MtCO2)	**Value** (M US$)	**Volume** (MtCO2)	**Value** (M US$)
Allowances				
EU ETS	1,104	24,436	2,061	50,097
New South Wales	20	225	25	224
Chicago Climate Exchange	10	38	23	72
Project based transactions	611	6,536	874	13,641
TOTAL	**1,745**	**31,235**	**2,983**	**64,035**

The International Energy Agency estimates[79] that to reduce CO_2 emissions by 50 per cent (from current levels) by 2050 will require additional investment of US$45 trillion, covering additional R&D, larger deployment investment in technologies not yet market-competitive and commercial investment in low carbon options across the power, transport, buildings and industrial sectors. Directly or indirectly, manufacturing industry accounts for more than one-third of global energy use and CO_2 emissions. Manufacturing industry has a good record of energy efficiency gains in recent years, driven by the need to manage energy costs[80]. The IEA has also estimated the potential for the manufacturing

77 World Bank,2008
78 DEFRA, 2008
79 OECD/IEA 2008
80 OECD/IEA 2008

industry to improve its energy efficiency by an impressive 18 – 26 per cent, while reducing the sector's CO_2 emissions by 19 – 32 per cent based on proven technology.[81] This result did not consider the development and introduction of new technologies.

A 2006 survey undertaken by AMR Research of 150 companies in the UK, US, France and Germany found that among executives, energy and emissions reductions was the top environmental concern as a means to gain competitive advantage over others. Increased global environmental pressures and public awareness have (amongst other issues such as high energy prices) led to an increase in capital markets acceptance with many of the world's major public and private equity investment entities and several market indices now focusing on clean technologies.

Investments in clean technologies are growing globally, led by the US and to a lesser extent the EU. Total US and EU venture capital investments in clean tech surged to almost US$3 billion in 2007 with over 80 per cent being invested in the US. However, despite this global growth, clean tech still accounts for a relatively small share of overall venture capital investments – around 5.4 per cent in the US and 4.4 per cent in Europe.

US activity has been focused on relatively late-stage, capital investment in global markets where government intervention is a key driver of demand. The leading position of the US is in large measure due to the relative scale of US capital markets and strength of the high-tech sector, in terms of knowledge base, entrepreneurial skills and experience of innovation in new technologies[82] .

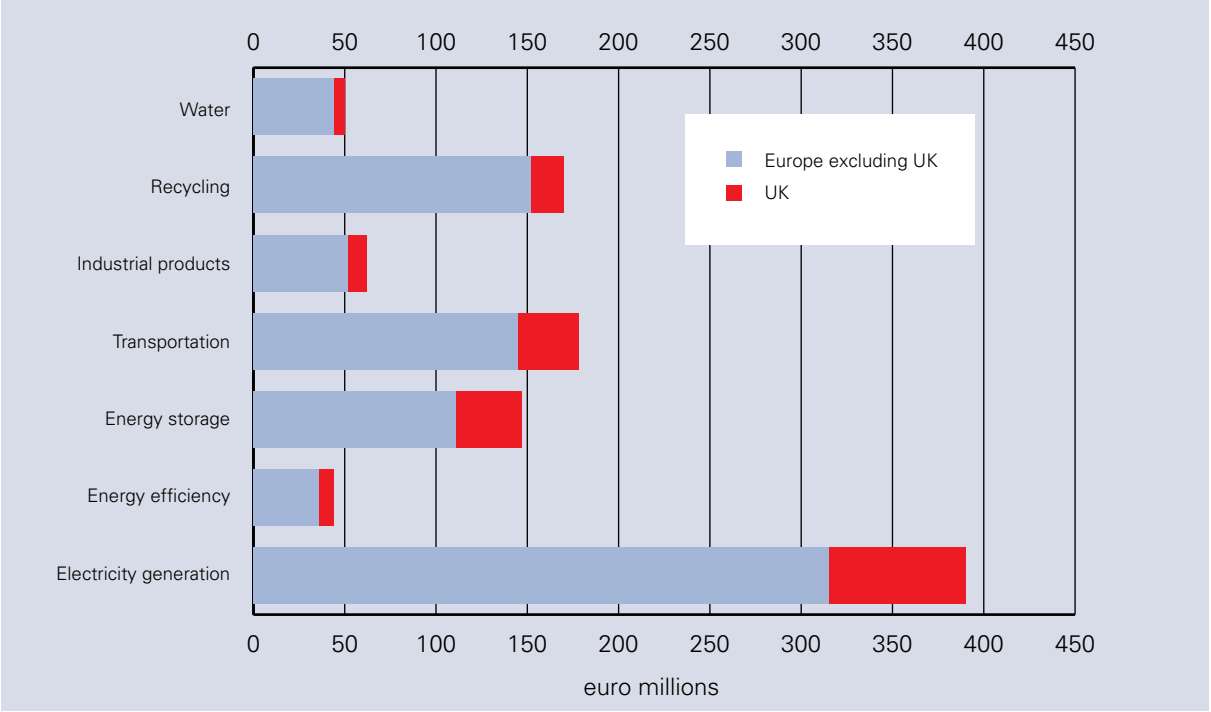
Europe had traditionally been at the forefront in clean technologies until 2004 principally due to tighter EU and national environmental regulation and stronger consumer awareness of green issues[83]. Early stage investments in the development of products have also been dominated by government-backed funds. According to a study by Library House and the Carbon Trust, the public sector participates in 45 per cent of all clean tech investments in the UK and 15 per cent in the rest of Europe[84].

In recent years EU investment has been concentrated in energy generation technologies, accounting for around 37 per cent of capital invested in clean technologies between 2001 and 2007. There has, however, also been a significant increase in investments in industry focused products and services, particularly related to transport technologies including hybrid electric drive systems and exhaust purification. In 2007 capital invested in these increased by €58 million to €81.1 million and accounted for 30 per cent of the total invested that year.

81 Tam, OECD Sustainable Development Studies 2008
82 Ernst and Young, 2008
83 Ernst and Young, 2008
84 Library House , 2007

The UK is already the largest clean tech venture capital market in Europe and is therefore well placed to take advantage of further investment and market growth in the sector. In 2007, it hosted 34 private venture capital backed technology companies with a cumulative €186 million invested, around 30 per cent of all European clean tech investment.

Figure 22: European venture capital investment in clean technology 2001 – 2007



Source : Ernst and Young 2008

The strength of the financial sector in the UK and ease of access to capital, and the creation of clusters of activity around key companies' headquarters and key scientific centres located in high quality universities are cited as key reasons for this UK success. For example, the Carbon Trust in their report 'Investment trends in UK clean technology 2000 – 2004'[85] identified mini-clusters around recognised UK technology centres including London, Cambridge, Cardiff, Oxford, Manchester and Edinburgh. Around 185 of clean tech companies in the UK originate from UK universities, notably Cambridge, Imperial College and Cardiff.

85 Carbon Trust, 2005

CASE STUDY 12: ITI ENERGY LIMITED

ITI Energy Limited formed in 2003 is based at Innovation Technology Centre, Rotherham. The company manufactures a compact and highly efficient thermal destruction technology based on a patented advanced gasification design. Combined with commercially available gas clean-up systems the technology generates a synthetic gas that is clean enough to fuel an internal combustion engine. The company's strategy is to provide gasification equipment that will treat all biomass and wastes at source eliminating transport costs and the adverse effects transport would have on the environment.

The system was developed in collaboration with the University of Newcastle and ultimately commercialised by ITI Energy Limited who in conjunction with sister company ITI Limited own all the rights, patents and IPR for the technology. Developed over ten years at Newcastle University the ITI Energy Gasifier was specifically designed to handle a wide range of "difficult" or negative-value feedstocks and is particularly suited to the conversion of Refuse Derived Fuel (RDF) into energy. Gas from approximately 2.5 kg of biomass has the energy of one litre of petrol.

The use of biomass fuel, especially biomass wastes (e.g. wood waste and refuse derived fuel), for distributed power production can be economically viable in many parts of the world. Biomass is a clean and renewable fuel. The potential applications for biomass gasification include the following:

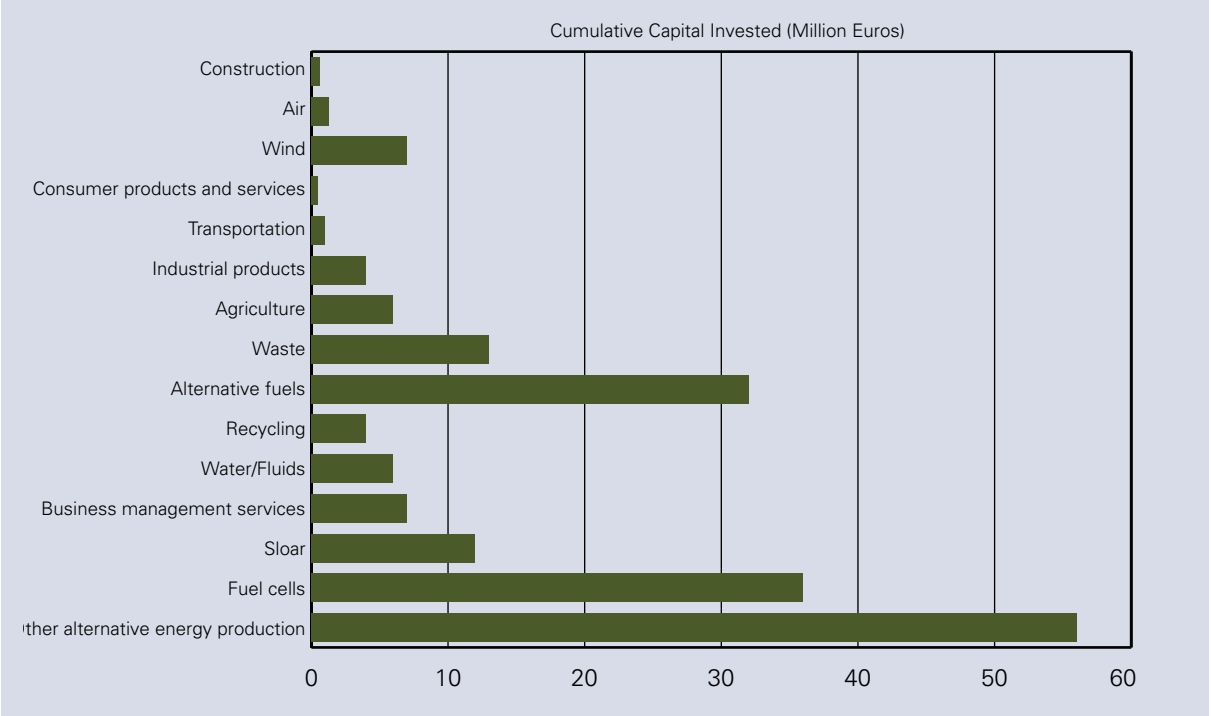
- Replacing current natural gas or diesel fuel use in industrial boilers or furnaces
- Providing distributed power generation where power demands are less than a few megawatts
- Displacing gasoline or diesel fuel in an internal combustion engine generator

ITI is working with over 30 potential partners and clients to develop projects ranging from single unit sites to multiple unit 11MW projects. Several of these partners already have multiple projects on identified sites in their pipelines. Of the lead projects, one is a 7MWe Nett installation in partnership with a substantial renewable energy company for which planning permission is consented.

The main areas of venture capital investment in the UK have been in generation and energy storage technologies and alternative fuels (see Figure 23). However, a recent report by Ernst and Young for BERR notes the UK appearing to lag behind in clean transportation projects and also in clean tech industrial products[86].

86 Ernst and Young, 2008

Figure 23: UK Private clean technology portfolio 2007



Source : Ernst and Young, 2008

5.2 Opportunities for business

Areas of the economy where significant opportunities could arise from the transition to a low carbon and more resource efficient economy are:

- Power Sector (low carbon technologies such as wind power, and nuclear).
- Buildings Sector (improvement in residential buildings; zero carbon homes).
- Transport Sector (engine efficiency, biofuels, electric vehicles).
- Industry (remanufacturing and recycling, low carbon sources of energy).

These are areas of the economy the Stern Review and the CBI Climate Change Taskforce consider as having the biggest contribution to make to carbon abatement. The investment in low carbon, clean technologies required to deliver this will be considerable, presenting opportunities for business that can develop and install new, clean solutions and capture the demand for them.

However, one of the principle conclusions of the Ernst and Young study into green business opportunities commissioned by BERR (2008)[87] was that "a green economy will be one in which lower carbon and resource efficiency will permeate all products and services throughout the entire economy". This goes beyond the current definition of the Environmental Goods and Services (EGS) sector covering activities ranging from pollution control to the development of

87 Ernst and Young, 2008

cleaner processes, environmental consultancy and renewable energy (see Table 8 below).

Table 8: Classification of EGS Sub-Sectors (CEMEP and UK CEED)

- Air pollution control
- Cleaner technologies and processes
- Decommissioning/ decontamination of nuclear sites
- Environmental consultancy
- Environmental monitoring, instrumentation and analysis
- Energy management and efficiency
- Marine pollution control
- Noise and vibration control
- Remediation and reclamation of land
- Renewable energy
- Waste management, recovery and recycling
- Water supply and wastewater treatment

UK CEED[88] estimated the global EGS sector was worth $548bn in 2004, with the EU, US and Japan accounting for around 94 per cent of the total. The sector is expected to grow by 45 per cent by 2015 presenting significant global business opportunities for the future. In the UK waste management and water/ wastewater treatment are forecast to remain the largest sectors. Rapidly growing sectors, however, are forecast to be in energy management, renewable energy, environmental consulting services and contaminated land remediation.

The global growth of the EGS market is driven primarily by legislation as well as rapidly rising resource and commodity prices and scarcity of resources. Environmental legislation is expected to become tighter and more global in the future which in turn guarantees significant business opportunities. Demand for clean technologies is becoming global and North America and Europe remain the primary providers of innovative technology at the moment but as demand continues to increase, investment in clean technologies will continue to grow in developed as well as developing countries.

According to Ernst and Young therefore, the definition of Environmental Goods and Services (EGS) is not sufficiently broad to assess the opportunity for comparative advantage in low carbon, resource efficient business. 'Green' business itself is a loosely defined term, which allows expansion of green business to include businesses in potentially all sectors of the economy. Some sectors will be able to survive the transition to a green economy more readily than others, and these can be distinguished from those sectors or businesses that are expected to be reactive rather than proactive in their adoption of solutions to shift to a low carbon economy.

88 UKCEED, 2006

The report identifies two possible routes to achieve comparative advantage in green business: stimulating comparative advantage in sectors or activities considered green or stimulating green products and services in areas where the UK already holds a comparative advantage. Both routes were investigated and the conclusion was that artificially stimulating comparative advantage in 'green' areas where there is no existing comparative advantage is likely to be expensive and ultimately unsustainable.

The focus of the Ernst and Young study was therefore on identifying key sectors where the UK currently exhibits comparative advantage (based on existing trade and investment data) and could develop green business opportunities in specific sub-sectors. The main sectors identified were high-tech manufacturing and financial and business services. In particular, within manufacturing were software and electronic equipment, aircraft, pharmaceuticals, chemicals, and precision (optical and medical) instruments.

The UK is therefore considered to be well positioned to gain from developments of clean tech product markets particularly in the software and electronic sector, and business and financial services. It has also the potential to benefit from developments in the machinery equipment sector (especially in machinery linked to electricity generation technologies) and to a lesser extent in the aircraft sector, with change in many of these sectors and particularly in their leading companies already underway.

However, the report also advises some caution in their assessment given difficulties mapping trade sub-sectors to clean tech product categories due to differences in coverage and classification.

Key characteristics underpinning current advantage in these sectors were defined as the ability to attract capital including venture capital due to the existence of strong financial markets, the supply of high quality services to start and promote a new business (including strong software and business/management services), and the presence of a sophisticated and high-tech manufacturing base.

Table 9: Sectors where UK has a comparative advantage[89]

	Relevance for low-carbon or clean tech	Type of clean tech product	UK comparative advantage	Opportunity for clean tech in the UK
Financial services	High	Investment in carbon trading; carbon offsets; green or clean tech indices; socially responsible investment funds; providing investment capital in clean tech and environmental products/ projects	Key destination for investment and capital Skilled workforce London cluster	High
Boilers and Machinery	High	Energy generation components (e.g. turbines) and industrial equipment	UK enjoys comparative advantage in key sub-sectors. UK leads investment in clean generation technologies such as marine	High
Software	High	Energy efficient data centres Energy/Data management software	UK is primary destination for software investment. South East England act as a key cluster	High
Electronic equipment	High	Energy efficient electrical components and electrical appliances	UK is leading exporter and investment destination. High tech and capital intensive sector.	High
Aircraft	Medium	Efficient engines, turbines	UK is a net exporter. Capital intensive sector. Leading manufacturer based in the UK	Medium
Business services	Medium	Efficiency management services. Environmental consultancy services; environmental marketing	Key destination for investment and capital Strong skills base in related and transferable activities (e.g. consultancy, media, legal etc.)	High
Chemicals	Low	New compounds for plastics and other (building) materials; cleaning products. Waste treatment chemicals. Enabler for fuel cells development	UK is a net exporter.	Medium
Pharmaceuticals	Low	n/a	UK specialised in high-tech and end-consumer goods. Leading investment in Europe	Low

Source : Ernst and Young, 2008

89 Ernst and Young define 'Comparative Advantage' on the basis of sectors' performance on terms of trade and investment attraction.

CASE STUDY 13: HEATKING LTD

Heatking, an operating division of TEV Ltd, is a leading designer and manufacturer of Air Source Heat Pumps (ASHPs) based in Brighouse, West Yorkshire. Its product range offers cost-effective and energy-efficient heating, hot water and cooling solutions for households and small businesses. Cost savings and environmental benefits can be substantial when compared to conventional heating systems: Heatking ASHPs can cut energy costs by up to 75% and reduce carbon emissions by up to 66%, depending on the technology it displaces.

The company has sold nearly 1,000 ASHP units, which represents more than half of the total number of units sold in the UK to date. The majority of them have been installed in households and many in hard to heat properties or those in off-gas areas where, traditionally, relatively expensive and carbon-intensive oil burners have been used.

Heatking is planning a significant expansion of its product offering, with the launch of a Ground Source Heat Pump (GSHP) range in Autumn 2008.

EEF's analysis of modern manufacturing similarly looked at high performers in different manufacturing sectors in the UK[90]. It concludes that the areas of UK manufacturing that have experienced higher rates of growth against the manufacturing sector average in the last five years are those with high volumes of exports but also where a competitive edge has been developed, for example by responding to global environmental concerns, developing unique products and solutions or offering customers a 'whole life' service. It also identifies UK sectors already benefiting from the increase in worldwide environmental concerns as manufacturers of industrial process control equipment (used by companies wanting to increase their resource efficiency), the motor vehicle industry and those in their supply chain developing more efficient engines, and specific chemicals manufacturers (from production of chemicals to improve fuel efficiency and reduce engine emissions to producing eco-friendly cleaning or paint products).

According to the CBI Climate Change Task Force report there are also considerable opportunities for SMEs in areas such as commercial buildings, renewable electricity and road transport fuels, domestic energy efficiency and housing which could generate markets worth nearly £3bn in the period to 2010 in the UK.

90 EEF, 2008

5.3 Responding to the challenge of climate change

Scientific and empirical evidence provided by the Stern Review[91] and the Intergovernmental Panel on Climate Change (IPCC) have highlighted the very urgent and real need for co-ordinated action to be taken to tackle climate change.

Stern argues that meaningful action to address climate change could be undertaken at a cost of some 1 per cent of current GDP. In contrast, by delaying action the economic cost would be far greater at around 5 per cent to 20 per cent of global GDP and irreversible.

The IPCC highlighted that to avoid dangerous climate change the global climate would need to stabilise at two degrees Celsius above pre-industrial times. This would require global emissions to be reduced by at least 50 per cent by 2050 and to achieve that emissions would have to peak in the next 10-15 years.

The challenges presented by climate change not only require mitigating actions aimed at reducing greenhouse gas emissions, but also adaptation. IPCC defines adaptation as "adjustments in natural and human systems in response to actual and expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities".

Given that some climate change already appears to be inevitable, firms will have to find ways of adapting to threats such as increased flood risk and the rise of heat related threats to human health, such as the increased incidence of asthma. Costs will include the installation of flood defences, improved but also more energy efficient air conditioning systems, and greater insurance payments. Flooding and extreme weather events could also have a detrimental effect on energy supply, and there may be a need for firms to structure their plants in such a way that they can withstand interruptions in energy supply without incurring damage to plant and equipment.

The climate change debate has also had the important effect of focusing attention on other aspects related to the impact of economic activity on the built and natural environment. In particular, more firms are focusing on enhanced resource efficiency and waste disposal, seeking to maximise the efficiency through which resources are sourced and used, and also to minimise energy usage and waste by-products of the production process.

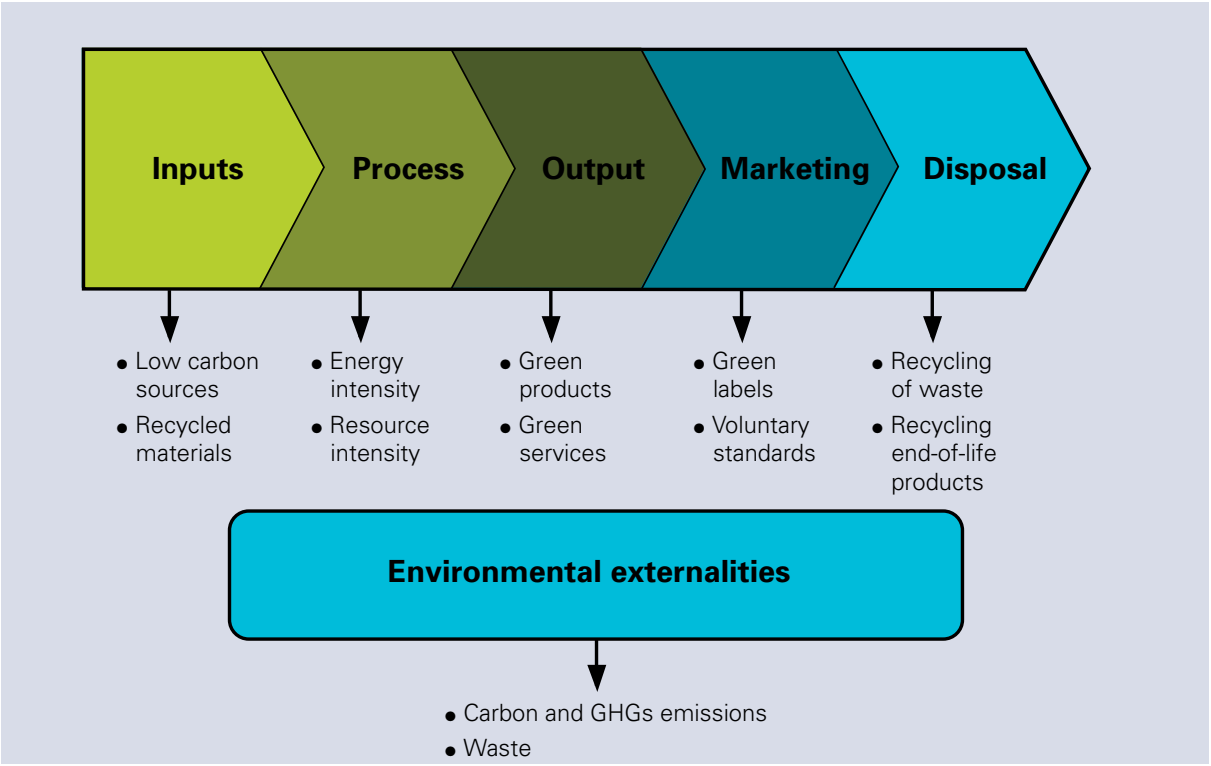
Waste minimisation, recycling and re-manufacturing will all therefore contribute to combating climate change by reducing unnecessary carbon emissions while at the same time providing benefits in terms of reduced costs and business opportunities. For example, a study for DEFRA estimates that the overall resource efficiency gains available to UK business, from energy, waste and water are £6.4 billion per year with energy accounting for 52 per cent and water 41 per cent.

91 Stern, 2006

Waste disposal currently costs UK business 4 per cent of their annual turnover – projected to rise to 6 per cent with increases in landfill tax.

Figure 24 illustrates how opportunities to lower environmental impact exist at all stages of the production process and throughout the supply chain.

Figure 24: Framework for Low Carbon Production



Source: Based on Ernst and Young, 2008

The Government is determined that UK business should position itself to be at the forefront of the low carbon revolution. To enable this it has set out a long term regulatory and policy framework to provide clear long-term signals to industry to help shape investment decisions, principally through participation in the EU Emissions Trading Scheme to establish a robust carbon price and also through the Climate Change Bill which commits the UK to a statutory targets for emission reductions by 2020 and 2050. The policy framework also seeks to remove barriers, including those resulting from information failures and regulatory design, to investments in new technologies, innovations and human capital required to establish a leading low carbon economy.

Within this overarching framework, sector-based low carbon frameworks are also being established in energy, transport, buildings, waste and products. For example, in housing the Government has agreed a timetable for all new homes to be zero carbon from 2016. At the same time the Government's waste strategy has set ambitious targets to 2020 for the recycling of waste to reduce emissions from landfill sites, with certainty of incentive created by the landfill tax cost escalator.

The policy framework therefore recognises the relevance of the following market failures where public intervention may be appropriate and beneficial:

- Significant externalities resulting from missing markets and market prices that do not reflect in full the negative impacts of production or consumption decisions.
- Information asymmetries resulting from incomplete information or preclusive search costs for consumers on the environmental performance of different products, and for producers on the environmental impact of their purchasing and production decisions and the availability of and net costs of alternatives.
- The complexity of available information and options combined with a high degree of outcome uncertainty giving rise to bounded rationality and resulting in sub-optimal investment, production or consumption decisions.
- In turn information complexity or asymmetries can give rise to principal – agent problems resulting in a mis-alignment of incentives between producers and consumers.

There may in addition be institutional, regulatory and co-ordination failures that distort market outcomes and reduce incentives to invest and innovate in low carbon and more environmental efficient technologies and products.

The Government's response to Commission on Environmental Markets and Economic Performance (CEMEP) in November 2007[92] and the newly published Manufacturing Strategy therefore set out a number of measures focused on the following four, mutually reinforcing areas:

1. Supporting the development of high value added manufacturing in low carbon supply chains.

For example, the newly formed Office for Nuclear Development (OND) and the intention to create the Office of Renewable Energy Deployment (ORED) will work with UK supply chains in these sectors to ensure they are able to compete for and deliver nuclear new build and renewable energy technologies and supplies into the longer term.

The desire to create a world class manufacturing supply chain able to service the global nuclear market will be reinforced by the creation of a Nuclear Manufacturing Cluster for Specialist Metals and Materials in northern England through collaboration with a number of the Regional Development Agencies and the Specialist Metals Forum.

92 Commission on Environmental Markets and Economic Performance (CEMEP) – 2007

2. Creating the necessary demand and supply side conditions for investments and innovations in environmental products, processes and technologies.

3. Providing information and advice to help business and consumers make more informed and sustainable production and consumption decisions.

The 2008 Budget announced plans to establish a 'centre for expertise in sustainable procurement' and has published a new procurement policy framework emphasising the need for public purchasing to consider the environmental impact of goods and service purchased by the public sector. Government spends around £150 billion annually on goods and services. By demonstrating the priority given to low-carbon and sustainable products, it can stimulate investments in their development.

Individuals, through their consumption choices, can also drive transformations in product development and manufacture. Consumers also control more than a third of current emissions through their direct consumption of energy. However, as the European Environment Agency reports, eco-efficiency improvements in production sectors are typically offset by growth in consumption[93]. Targeted information campaigns, better environmental labelling and wider carbon disclosure can all therefore help consumers make more informed choices to reduce their energy intensity and carbon footprints through alternative consumption patterns.

Supply side measures will complement those designed to stimulate market demand and scale in the provision of low-carbon and more sustainable goods and services. The centrepiece of the Government's strategy to encourage business investment in innovation is the R&D tax credit. This is complemented by supports targeted at investments in low carbon and sustainable production. For example, the Technology Strategy Board in collaboration with Regional Development Agencies and the Research Councils will jointly invest over £1 billion over the next three years with a particular focus on developing and commercialising new innovative platforms including low carbon vehicles and low impact buildings. Over the next 5 years Government will also provide an additional £90 million for the research, development and demonstration of low carbon vehicles.

93 Mortensen, OECD Sustainable Development Studies 2008

CASE STUDY 14: FORD MOTOR COMPANY

As a result of investment totalling over £775m over recent years, Ford has turned its Dagenham Diesel Centre into its global centre for diesel engineering design and production. This has been achieved by combining the manufacturing expertise of over 2,000 skilled production staff at Dagenham with an industry leading engineering team at their nearby Dunton Research and Development Centre. With the aid of 500 newly recruited manufacturing specialists 2007 saw Dagenham begin production of Ford's new class leading 1.4 and 1.6 litre TDCI engines on a new purpose built assembly line. These low CO_2 emission engines are at the forefront of Ford's commitment to the low carbon vehicle agenda and feature in the new ECOnetic range of vehicles. Demand for these products will see Dagenham's production top one million engines by the end of 2008.

Not only is Dagenham building a range of new and innovative low carbon products, but the plant itself is leading the way in eco-efficient production. Currently powered by two 3.6MW capacity wind turbines, with a third due for installation in 2009, the facility is unique amongst Ford operations. Use of wind power has seen gas and electricity consumption cut and 6,500 less tonnes of CO_2 produced per year. Waste elimination also is key to the company's strategy with the diversion of over 12,500 tonnes of material from landfill – old concrete from the site was recycled for use in the new engine production hall floor. Mineral oil use too has been cut with over 500,000 litres saved as the plant moves to increased use of 'Green' vegetable oil for metal working and other uses.

4. Developing the necessary skills for a low carbon and resource efficient economy.

The expansion of environmental industries has so far been unmatched by a growth in a supply of labour with relevant skills to develop, install and utilise new technologies. This will ultimately constrain further expansion in these areas. In response, the Government is forging partnerships with employers, the Sustainable Development Commission, Sector Skills Councils and others to develop and encourage high-quality training solutions and knowledge transfer. Through the Sector Skills Councils employers also have the opportunity to articulate their skills needs effectively and influence the future design and delivery of qualifications (see also Section 4)

Knowledge transfer will also be encouraged through partnerships with business, local and regional bodies, the further education and third sectors. For example, through the Carbon Trust, Envirowise and the RDA network, Government has established a network of advice and support for businesses to examine their environmental impacts and develop tailored reduction strategies.

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