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Innovation

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Creator: Skills Research Team, West Midlands Regional Observatory, andy.phillips@wmro.org

Publisher: West Midlands Regional Observatory, enquiries@wmro.org

Contributor: Dr. Barbara Tilson, BCT Research Associates (BCTRA)
E-mail: btilson.bctra@blueyonder.co.uk

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Document Contact: Andy Phillips, Head of Skills Research, West Midlands Regional Observatory, andy.phillips@wmro.org

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1.1 Introduction: The Importance of Innovation

Why is innovation important? For two reasons, which are interconnected. Firstly, because globalisation makes the old adage ‘compete or die’ even more of a universal truth. And, secondly, because the link between innovation and higher performance, productivity and competitiveness makes a better standard of living possible. [9] Most of the benefits of innovation arise from the *diffusion* of innovation rather than its initial introduction.[10] Economists call the unintended consequences of innovation that can benefit everyone ‘spillovers’ or ‘positive externalities’.[11]

The underlying impetus for innovation is the desire for increased prosperity, whether that prosperity equates to social improvements, or whether it denotes economic prosperity, business success, or financial wellbeing for individuals. Innovation is not only significant for wealth creation. A strong social consciousness has the end-view of easing the burden of disease, poverty and disadvantage whether through innovative products, organisations or services. The development of a clockwork radio for use in Africa is a case in point, or medical advances which provide innovative ways to eradicate endemic suffering in Third World communities.

Innovation acts as the transformational element in the economy. It is both the stimulus to as well as the consequence of competition.[12] The digital communications age has ensured that the competitive arena is now worldwide – global markets, global operations, and also global threats as well as opportunities. “Only those companies that constantly seek to improve and innovate will be in a position to grasp the major opportunities that increasing globalisation offers,” asserts the DTI’s Innovation Report (2003). Global competition is a major driver of business innovation through new technologies, products, ways of doing business, and forms of organisation.

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[9] DTI, Innovation Report, 2003
[10] Frenz and Oughton (2005)
[11] Tether, What is Innovation? 2003
[12] Metcalfe (2005)

Employee skills are the foundation stone of innovation, and are essential to the creation of competitive advantage.[13] That premise is the impetus for this literature review on innovation skills undertaken for the Regional Skills Partnership and Innovation and Technology Council by Dr Barbara Tilson, BCTRA, during February to April 2006, commissioned by the Skills Team at the West Midlands Regional Observatory.

1.2 Definitions of Innovation

Definitions of innovation (a few are shown in Text Box 1) generally agree that *ideas* are the basis of innovation. Ideas denote *creativity*, whether by creative thinking, technologies and processes, organisation, ways of working, or services. [14] Others point out that, further to achieving commercial exploitation, innovation must also *generate profit* and contribute to *economic prosperity*, whether to create wealth or social advantage. Actions *complementary* to the innovation process, such as *market development*, are necessary to ensure its success. The importance of *new knowledge* is fundamental, and this introduces the notion of a relationship between *innovation* and the acquisition of *expertise*.

Text Box 1: Definitions of Innovation – some examples

A report for the DTI (2005)[15] asserts:

> "Innovation is defined as the development and commercial exploitation of a new idea for a product or process that contributes to wealth creation and profitability."

According to the US Department of Labor, innovation is:

> "The ability to transform new ideas and new knowledge into advanced, high-quality products or services."

The European Commission's (2003)[16] concise definition of innovation is:

> "The successful production, assimilation and exploitation of novelty in the economic and social spheres."

While for the Netherlands Ministry of Economic Affairs:

> "Innovation is modernisation that manifests itself in products, services,

[13] Swart and Kinnie (2002)
[14] Munshi et al, Advanced Institute of Management Research, 2005
[15] Tether et al, A Literature Review on Skills and Innovation, September 2005
[16] CEC, Innovation Policy, Brussels, 2003

processes or forms of organisation. The essence of innovation within companies is converting knowledge into money. Innovation leads to sustainable economic value and exploits knowledge for solving social problems. The transfer and application of existing knowledge is important, especially in small and medium-sized enterprises. Innovation involves human effort and does not merely demand the development of technology. Innovation also depends on factors such as management, logistics and marketing, certainly in the service sector." [17]

1.3 Innovation drivers and enablers

In its 2005 Budget, the government reasserted its commitment to making the UK a world class knowledge economy with innovation and skills as drivers of growth and productivity.[18] Its Innovation Strategy identifies entrepreneurial and management flair as essential to achieve successful innovation, together with a stable macroeconomic environment, a financial and ICT structure that supports new products and processes, and a flexible and highly skilled workforce that possesses the practical knowledge needed. [19] Seven critical success factors for innovation are noted:

1. Sources of new technological knowledge.
2. The capacity to absorb and exploit new knowledge.
3. Access to finance.
4. Competition and entrepreneurship.
5. Customers and suppliers.
6. The regulatory environment, and
7. Networks and collaboration.

The existence of a knowledge stock creates potential for innovation. Investment in knowledge may occur through expenditure on R&D, higher education and software, it may relate to the design of new goods, may accrue through job-related training, or through organisational change.[20] A high value added, high performance work context which is conducive to innovation activity is characterised by:

- Greater employee involvement.
- Improved skills, motivation and ability, and

[17] Ministry of Economic Affairs Netherlands, Action for Innovation, October 2003
[18] Tether et al, A Literature Review on Skills and Innovation, September 2005
[19] DTI, Innovation Report, 2003
[20] OECD, Science, Technology and Industry Scoreboard, 2005

- More trust, loyalty and identity.[21]

It is crucial to the achievement of high performance work organisations that a highly skilled and knowledgeable workforce is developed and maintained through continuous learning. It is therefore imperative that: "...an efficient and open educational system and labour market" exists. [22] But high performance working is not attained through skills alone. It has to be achieved through a change in the organisation of work, and/or in the relationships within the working environment.[23]

Addressing skills and workplace change also has to be complemented, energised, facilitated and supported within the regional context. The United States Department of Labor maintains that regions that innovate successfully: "...demonstrate the ability to network innovation assets – people, institutions, capital and infrastructure – to generate growth and prosperity in the region's economy." They are successful because: "...they have connected three key elements: workforce skills and lifelong learning strategies, investment and entrepreneurship strategies, and regional infrastructure and economic development strategies." [24] A recent analysis notes simply: "The challenge for regional partners is to ensure that their innovation, business support and skills initiatives are joined up."[25]

It is apposite to look more closely at the regional policy and strategic context.

1.4 The Regional Dimension

Policy makers in the West are united in believing that the battlefield for fighting the challenge of globalisation is at *regional and local level*. The European Union's economic growth strategy, the Lisbon Strategy, was agreed in Lisbon in 2000. It set a target for the EU to become the most dynamic, competitive knowledge-based economy in the world by 2010. Innovation is "a cornerstone" of the Strategy and the growth of regional and local innovation poles to supply focus and drive for the innovation agenda is a key priority.[26] During a 2005 mid-term review the Lisbon Strategy for 2005 – 2008 was relaunched to focus on growth and jobs. [27]

The cross-cutting themes addressed by the Lisbon Strategy include:

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[21] Sissons (2005/6), citing Thompson (2002)
[22] Ashton and Sung, Supporting workplace learning and high performance working, 2002
[23] Sissons (2005/6)
[24] US Dept. of Labor, Workforce Innovation in Regional Economic Development Selected Regions, undated
[25] Hepworth et al, Regional Employment and Skills in the Knowledge Economy, undated (c.2005/6)
[26] Commission of the European Communities, Innovation Policy, 2003
[27] Local Govt. International Bureau (LGIB), Lisbon Strategy, LGIB website, accessed March 2006

- Economic development and competitiveness.
- Employment and social inclusion.
- Sustainable development and use of natural resources.
- The use of information and communications technologies.
- Regional and local innovation poles.
- Active ageing, and
- Lifelong learning.

In October 2005, the British government published its own forward-looking national reform programme for 2005 – 2008 in response to the Lisbon Strategy, including the regional dimension.[28] Priorities include building a more enterprising and flexible world class business sector able to compete successfully in the global economy. Measures to promote innovation are to the fore, to turn scientific research into business innovation. Knowledge-intensive industries are considered of growing importance. Sustained investment in the science base is needed, and action to address barriers to the diffusion and adoption of new ideas. It is essential that the right skills mix is available to enable the move into more innovative sectors and businesses. This means that people must be able to take higher value added jobs and possess the flexibility to retrain and adapt to new technologies and innovation. An innovative approach to the improvement of resource efficiency is also high on the agenda, safeguarding the earth's natural resources and protecting the environment, while promoting low-carbon sources of energy.

The US Department of Labor maintains that regions must innovate in order to stimulate innovation in their workforces and established the WIRED initiative to foster this in regional economic development. The criteria for WIRED support include the presence of certain market and economic conditions such as declining and/or growth industries, strategic partnership and strong regional leadership teams. Also considered is how regions demonstrate they will transform via: "The implementation of new efforts designed to drive integration among workforce economic development and education systems; innovation in addressing challenges; and utilizing and building upon existing structures, resources and legislatively funded programs." [29]

Porter (2003) notes the important role of Regional Development Agencies in improving UK competitiveness. He observes that the clustering of interconnected companies, suppliers, service providers and associated institutions is linked by their commonalities and complementarities, where *proximity* allows the efficient interaction

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[28] HM Treasury, Lisbon Strategy for Jobs and Growth, October 2005
[29] United States Department of Labor, Workforce Innovation... , undated

and flow of goods, services, ideas and skills. Frenz and Oughton (2005) note that proximity facilitates the transfer of tacit knowledge and learning, both of which are important determinants of innovation. They observe that regional economies need to be ‘learning regions’ which are able to generate, assimilate and transform knowledge.

In innovative-supporting regions the inter-linking of co-operative partnerships ranging from work organisations inside firms to different sectors of society – “regional development coalitions” – are of strategic importance. Porter points out, though, that clustering can stretch across regional and even national borders. Indeed, the government recognises the cross-regional geographical dimension of clustering (and so of learning and innovative activity), and envisages Knowledge Transfer Networks stretching across the UK and internationally. Its provision of technology support (through its Technology Strategy) is also aimed at collaboration between regions.[30]

1.5 The West Midlands Policy Context and Skill Issues

UK regions take up the challenge of globalisation from unequal standpoints. The West Midlands has been hard hit by intensifying global competition. Not only has manufacturing contracted significantly - notably in the automotive industry and supply chain, materials processing like metals and plastics, and the ceramics sector – but the Region also has relatively few jobs in the knowledge-intensive manufacturing sectors which are seen as the route to economic competitiveness and growth. The historical North-South Divide still exists, with the South, parts of the East and South West - along with the Welsh capital and the Glasgow-Edinburgh corridor - possessing much of the UK’s knowledge capital and the Midlands and North attempting to catch-up from a vantage point of comparable disadvantage on skills and job quality.

A report on Regional Employment and Skills in the Knowledge Economy[31] asserts that the challenge for the Midlands and North is: “Economic re-invention” and concludes: “...for this reason, social capital in the form of far-sighted leadership and a new entrepreneurial culture is as important to success as human capital and creative capital.” It is crucial that the West Midlands Region, indeed the Midlands more generally, builds: “...a diversified knowledge economy based on innovative, globally oriented manufacturing and service businesses and a dynamic, entrepreneurial public sector.” In modernising the public sector, it is advised that the focus should be on skills, innovation and entrepreneurial talent applied to local and regional economies.

[30] DTI, Technology Strategy, Annual Report 2005
[31] Hepworth et al, undated report (c.2005/6) for the DTI

2 The Components of Innovation

2.1 Introduction: Innovation, Knowledge, and the Learning Organisation

The supreme importance assigned to innovation has prompted extensive investigation of what it is and, more particularly, how it can be stimulated and supported. The European Commission,[32] analysing the various *routes* to innovation, noting four possibilities:

- The exploitation of an invention.
- Adaptation of a technology or idea from another sector.
- Reconfiguration of existing products and services, or
- A new business approach.

Innovation can be radical (denoting a step change) or incremental (via many small modifications). According to Kanter (1996, 1997) innovation is produced within an organisation through four creative phases:

1. Idea generation.
2. Coalition building (where colleagues are persuaded to support the ideas).
3. The realisation of ideas, and
4. Their transfer or dissemination.

Leadership can promote innovative behaviour through such means as team building, communicating and persuading. Changes in power and resources, cross communications and increased information flows also stimulate innovation activity. The role of *workers* is more important to ideas generation than structures and rules. [33]

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[32] CEC, Innovation Policy, Brussels, 2003
[33] Williams and Yang, in Sternberg (1999)

It is one step further to the concept of the *knowledge worker* as the lynchpin of an innovative organisation. We have already noted the significance of knowledge – acquiring, managing and exploiting it – as the key to economic success. Knowledge workers were traditionally thought of as either professional, scientific or managerial, or craft workers (e.g. apprentices). Now there is a much deeper understanding of who 'knowledge workers' are, how they learn, and how they operate. In high performance work organisations, where (typically) management is devolved and people are multi-skilled, junior managers and manual workers are now also considered to be knowledge workers.[34] But, clearly, every employee has the potential to be one, given that knowledge workers develop and share their ideas and expertise, may operate in teams or work groups, may be multi-skilled, or mentor and coach others. The role of knowledge workers is particularly significant for the diffusion of *tacit knowledge* which is communicated via shared experiences, dialogue, interaction and learning, as distinct from *explicit or codified knowledge* which is encapsulated in formats like text, operating manuals, codes or guidelines.[35]

Work has been transformed through the use of ICT, providing a more effective means of sharing information and introducing devolved management. The speed of technological change and the growing sophistication of ICT usage make it crucial for employees to continue to learn throughout their working lives. These factors are also transforming the need for learning, how learning is delivered, how people communicate, and how they work.

The workplace is a source of continuous learning for all employees. It is the most important source of learning for technicians and professionals, through everyday interaction rather than formal training courses. In the learning organisation, the opportunities for learning are being extended to groups such as shopfloor employees who previously received only minimal instruction. This change is in recognition of their crucial input to innovation activity and targets. In organisations where continuous learning occurs, employees need to possess technical skills, and they also have to: "...use their intellectual faculties to tackle unexpected problems...They have to resolve day-to-day production problems, they have to communicate solutions to colleagues and clients and they have to learn how to work effectively in teams."[36]

What is evident here is the prime importance of managing human resources effectively. Indeed, the *convergence* of HRM and business strategy is a phenomenon which became particularly visible in the early 2000s: "...with words like 'innovation',

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[34] Ashton and Sung (2002)
[35] Frenz and Oughton (2005)
[36] Ashton and Sung (2002)

'knowledge', 'networked', 'organisational flexibility', 'organisational learning', 'the virtual organisation', [and] 'the knowledge-based firm'." [37]

2.2 Components of the Innovation Process

There is no all-defining ideal innovation process to perfect, since it may vary for individual firms according to their sector, size, objectives, resources and business environment. Tether (2003) advises: "We should understand that innovation is a relative not an absolute concept – innovation can only be understood in its context – that is the time and space (geographical and technological) in which it occurs." [38] Mina et al (2004) confirm this perception: "Innovation systems evolve over time and their internal dynamic is to be found at least in part in the evolution of the defining problem sequence...Progress means finding new problems...(which lie) in different domains of knowledge and communities of practice."

In understanding the components of innovation we need to appreciate the interaction of the various factors and their functioning in the entire process, how they co-operate, compete and communicate. Mina et al (2004) make the crucial observation that we need to understand where the *boundaries* are drawn and how *connections* are made within a system in terms of its construction, purpose and functioning.

So, having established that the innovation process is not an absolute, what range of factors combine to create it? The components of innovation form three groups:

1. **Human resources factors** - people's qualities, skills and engagement in innovation.
2. **Technological factors** such as research and development, horizon watch and technology transfer, also related activities such as market analysis and collaboration.
3. **Performance factors** including productivity, financial acumen and profitability, investment, and customer service.

These components of innovation are set out in Text Box 2. Some are cross-cutting – for instance: ideas generation, creativity, communication, networking and collaboration, and performance improvement. Similarly, the level of capital investment is a financial measure, and it is also relevant to the development of new technologies, products and markets.

[37] Purcell, Business strategies and human resource management, undated (c.2003/4)
[38] Tether (2003), What is Innovation?

Text Box 2: The Components of Innovation

a. Human Resources Factors

- Entrepreneurship
- Management and leadership - championing change; change agents
- The labour pool and workforce's calibre; skill development, retention; HRM processes and skills
- Motivating and involving workforces; giving opportunity
- The ideas culture at all workforce levels, constantly
- Organisational responsiveness and change; dismantling silos, sharing not protecting knowledge
- Communication, upwards, downwards and horizontally, also two-way externally

b. Technological Factors

- Market analysis, responsiveness
- Technology/new horizon watch
- Research and development
- Technical expertise
- Collaboration, partnerships and networks – internal and external
- Technology and knowledge transfer
- Process and product development and change
- Patenting, protecting intellectual property

c. Performance Factors

- Market development/ product commercialisation
- Competitor analysis
- Benchmarking – internally, externally
- Financial acumen including locating and accessing funding; managing risk
- Investment
- Profitability
- Performance improvement, productivity, cutting waste
- Customer service and responsiveness

Source: writer's research and sources consulted for this literature review

It is worth looking more closely now at specific innovation components.

2.3 Human Resources Factors

Essential to successful innovation are human resources factors. At the macro level, it entails providing the right economic conditions to stimulate, facilitate and support entrepreneurship and innovation. At the micro level, it means achieving workplace cultures and organisational structures and processes that encourage and enable people to engage innovatively, and to work to their optimum towards the organisation's performance and innovation objectives. This section examines major skill areas including entrepreneurship, leadership and people management, and the labour pool.

2.3.1 Entrepreneurship skills

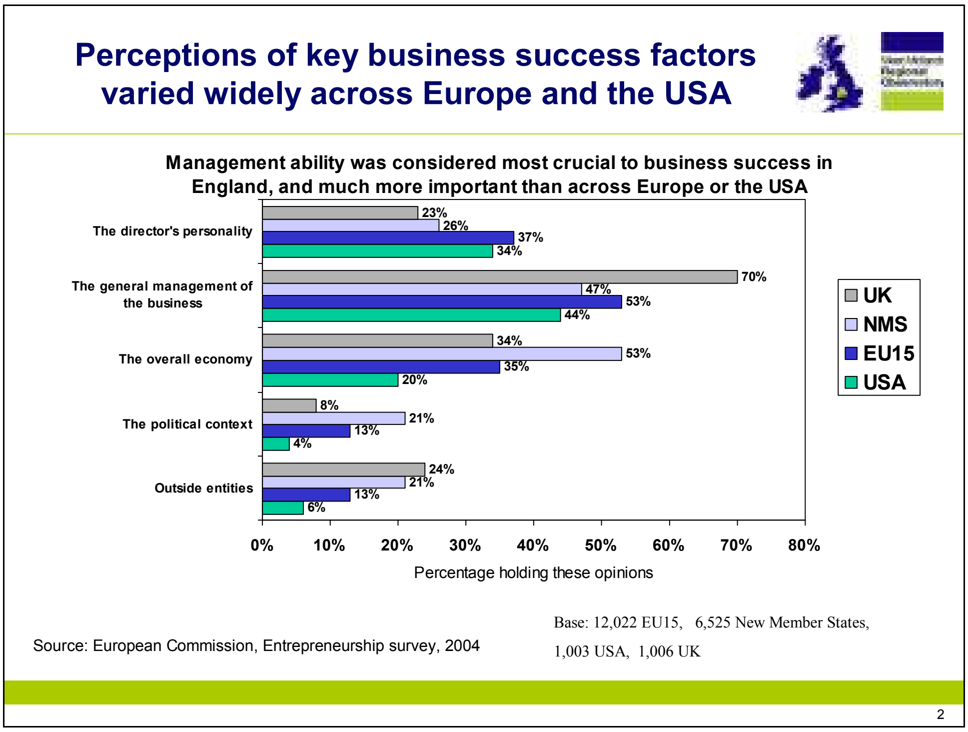
The European Commission's Enterprise and Industry Commissioner, Gunter Verheugen, following publication of a 2004 survey of entrepreneurship in 29 countries, described entrepreneurs as: "...the economic DNA which we need to build competitiveness and innovation." [39] Entrepreneurship is defined as: "The mind set and process needed to create and develop economic activity by blending risk-taking, creativity and/or innovation with sound management, within a new or an existing organisation." [40] Entrepreneurs are likely to think laterally, 'outside of the box', are creative thinkers and doers, and have the drive and focus for high achievement.

Attitudes to entrepreneurship exhibit national differences. The EC's 2004 entrepreneurship survey, contrasting attitudes among both European and US citizens to enterprise, found that a strong influencer of entrepreneurial behaviour was the overall economy or the political context, though less among Americans than for Europeans. A key success factor in business was said to be good management, and it was a particularly strong opinion among UK respondents (Figure 1, overleaf).

External factors which the entrepreneur perceives could affect their potential success have a strong bearing on their confidence about whether to launch a business. Stimulating greater entrepreneurship is clearly not just a question of instilling skills which help people to develop an ideas culture and the tools to identify and exploit an opportunity, but of creating alongside this the kind of supportive and non-bureaucratic external environment that encourages and facilitates risk taking.

[39] European Commission, Entrepreneurship, 2004; ibid, press memo, April 2004
[40] Euractiv, The EC's February 2004 Action Plan on Entrepreneurship, summary, 31 January 2006

Figure 1: Key Success Factors for new businesses in Europe and the US



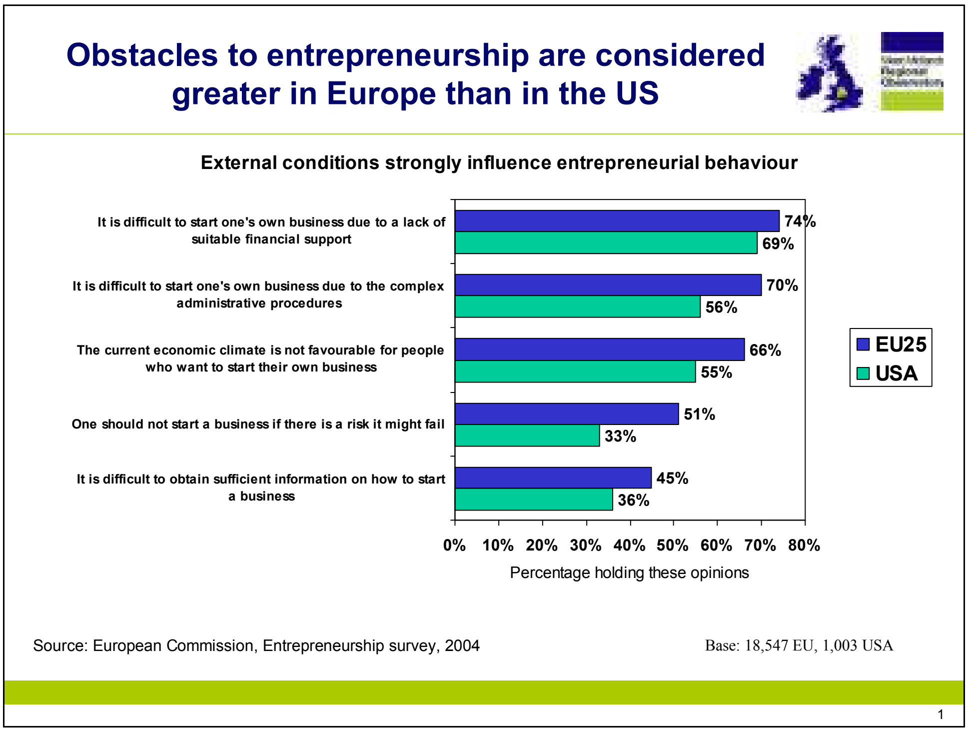
At its 2004 Spring Summit the EC called on Member States to boost the entrepreneurial mindset through education and training and also through improving the regulatory environment for businesses, facilitating access to finance, and strengthening the dialogue between entrepreneurs and policy makers.[41]

The European Commission's 2004 survey of Europe and the US found that the economic, business and regulatory context in which entrepreneurs operated created a veritable obstacle course for wishful entrepreneurs. Interestingly, US citizens believed that the obstacles were less severe than did people in Europe (Figure 2).

A further issue is whether specialist advice and support is available from venture capitalists to whom entrepreneurs commonly turn for funding. Venture capitalists not only provide financial support, but are also frequently relied on to provide management expertise for incubating companies whose founders do not have the expertise or time to commit.

[41] Euractiv (2006)

Figure 2: Obstacles to Entrepreneurship in Europe and the US



Interestingly, a study of clustering for innovation compared the UK experience poorly against the capabilities of US venture capitalists, saying: "VCs do not always have the competence, resources or/and willingness to get involved in firm management. Such a provision of 'real services'...tends to be confined to the US, while UK venture capitalists tend to be less involved with the business given they do not generally have a specialist background." [42]

2.3.2 Leadership of Innovation

There is a broad acceptance of the link between leadership and innovation which, simply, is that: "Leadership is required to create a climate where innovation thrives."[43] This places great significance on leadership characteristics and behaviour. Innovation-promoting leaders should be:

- Convincing rather than ordering.
- Build teams.
- Hold meetings and disseminate information.
- Seek information from users and collaborators.

[42] Welsh Economy Research Unit (2005)
[43] Munshi et al, Advanced Institute of Management Research, 2005

- Accept peer reviews.
- Acknowledge other people's efforts.
- Show political sensitivity, and
- Be generous in sharing acknowledgements and rewards with colleagues. [44]

The relationships between people are a key facet of inspired leadership. Inspired leaders demonstrate trust and respect for colleagues and workforce as well as customers, have strong relationship skills, and let people know that their efforts are valued and make a difference. Important in leaders is: "The ability to create organisational structures that foster not only performance, but also a sense of pride and fun." Successful leaders focus intensely on getting *results*, as well as focusing on *developing people*. Exceptional communication skills are used to share the vision with their people but also to demonstrate the leader's commitment and care for them. Leaders also use storytelling to communicate, while the communication process is two-way - they listen a lot. [45]

The transformational/transactional leadership model of Bass and Avolio (1994)[46] encapsulates these leadership behaviours. This model sees leaders as role models; as motivating and inspiring others; encouraging innovation; attending to people's development needs; providing rewards for attaining performance targets; and taking action when things are not going to plan (see Table 1, overleaf).

The concept of leadership styles, qualities and behaviours implies the existence of leadership *skills*. This is an important progression because it marks a transition from a perception of the innate possession of desirable individual characteristics – at its extreme, the notion of the charismatic individual born to lead - to the concept that leadership skills can actually be instilled by professional and personal development throughout a person's career, and nurtured by external agencies. Indeed, leadership is now recognised as a transferable skill.[47] The leader's role is as designer, teacher and steward, designing the learning processes so that people can deal productively with the issues they face and develop their expertise.[48] '*Un*learning' is also required in driving innovation, to avoid knowledge and expertise becoming outdated. Leaders are therefore 'social architects' and require new skills in relation to:

- Building shared visions.
- Surfacing and challenging mental models, and

[44] Kanter (1996)
[45] DTI, Inspired Leadership, undated (2004/5) using 2003 by the Chartered Management Institute
[46] Munshi et al (2005), citing Bass and Avolio (1994)
[47] DTI, Inspired Leadership, in association with Chartered Management Institute and NOP, 2004/5
[48] Munshi et al, Advanced Institute of Management Research, 2005, citing Senge (1990, 1996)

- Engaging in systems thinking.

Table 1: Leadership behaviours and attributes

	Leadership behaviour	Specific attributes and actions
Transformational behaviours	Idealised influence	Leaders act as role models, are admired, respected and trusted, consider the needs of others over their own; are consistent in their behaviours; share risks with others and conduct themselves ethically
	Inspirational motivation	Leaders motivate and inspire others by providing meaning and challenge, they rouse team spirit; are enthusiastic and optimistic; communicate expectations and demonstrate commitment to shared visions
	Intellectual stimulation	Leaders encourage innovation and creativity through questioning assumptions and reframing problems. They avoid public criticism
	Individualised consideration	Leaders attend to individual needs for achievement and growth, engage in coaching and mentoring, create new learning opportunities, value diversity and avoid close supervision
Transactional behaviours	Contingent rewards	Leaders provide rewards on the condition that followers conform with performance targets
	Management by exception	Leaders take action when task related activity is not going according to plan

Leadership occurs at all levels of an organisation – in a manufacturer from the boardroom to the shopfloor – and accordingly leadership skills should be developed throughout.[49] But - how best to develop leadership skills, and how to adapt leadership development for different situations? We neither fully understand leadership, nor how best to develop it and achieve the systems that enable it to operate effectively. The Chartered Management Institute asserts that: “Too often, the training of managers is either neglected or an early casualty of cost cutting, because it is seen as a cost rather than an investment.” And where it is done, it is “often non-strategic and piecemeal.”

2.3.3 The link between people management and organisational performance

Numerous writers have drawn a direct link between the innovative orientation and flexibility of firms and their achievement of sustained superior performance, their possession of a strong set of core managerial values and ways of conducting

[49] Such issues were raised in an automotive survey for Skills4Auto (Tilson, 2005)

business.[50] A DTI report,[51] found that high performance firms tend to be industry leaders, and (significantly) that they *create* best practice rather than just following it.

There is extensive ongoing interest in the constituents of high performance work practices. The CRIC (September 2005) report for the DTI on innovation and skills notes that the 'systemic integration' all-inclusive model of innovation which involves the skills of the entire workforce has superseded the 'science push' model that suggested that innovation is produced by a small elite possessing degree and higher level science and engineering skills. The workforce is now seen as an essential repository of knowledge, expertise and ideas. Motivating and engaging their active participation in innovative activity and performance improvement is vital. This places great onus on providing opportunities for their active input, and encouraging their take-up. Attaining a working environment that is conducive to innovation, and the organisational set-up that enables and facilitates it, is crucial. It emphasises the need for leadership skills at all levels to drive innovation, and for strong people management, influencing, relationship and communication skills, as well as the provision of rewards and incentives formal and informal, financial and social.

A Bath University study of the link between human resources management and organisational performance[52] discussed the motivation and engagement of workforces for improving organisational performance and optimising their input to innovative practices and objectives. They found that people perform well when:

- They can do the job and possess the necessary knowledge and skills.
- They are motivated. They do the job because they are adequately incentivised, and
- Their work environment provides the necessary support and avenues for expression – e.g. functioning technology and the opportunity to be heard when problems occur.

Ashton and Sung (2002) comment that in high performance firms employers show a concern for developing their workforce. They also make use of teamwork, job redesign, and employee involvement in decision-making. Communication is extensive, and performance-related pay is used to enhance organisational performance. In Pfeffer's (1998) view successful organisations provide employment security, undertake selective hiring, operate self-managed teams and decentralised authority, and provide comparatively high compensation. They train their workforces

[50] Purcell (2004), citing Barney (1986); Ashton and Sung (2002); Guest (2000)
[51] DTI and CIPD (2005), building on the work of Ashton & Sung (2002); Thompson (2002)
[52] Purcell J, University of Bath School of Management, The HRM-Performance Link, 2004

extensively, there are minimal distinctions in status, and financial and performance information is shared with employees.

The kind of human resources practices which stimulate high performance, knowledge intensive, behaviours are brought together in Text Box 3.

Text Box 3: Human resources practices which underpin high performance

1. High employee involvement practices

High employee involvement practices include:

- Circulating company information on organisational performance and strategy
- Providing all employees with a copy of the business plan and [performance] targets
- Self-managed or self-directed teams
- Work improvement teams; problem solving groups
- Quality circles and total quality management
- Kaizen – specific efforts on continuous improvement in work systems;
- Cross function teams
- Staff suggestion schemes
- Internal staff surveys
- Staff Association

2. Human resources practices

Human resources practices which underpin high performance include:

- Reviewing vacancies in relation to business strategy
- Sophisticated recruitment processes e.g. formal assessment tools to evaluate competences, including psychometric testing
- Annual review of employees' training needs
- Annual performance appraisals
- Formal feedback on job performance from superiors/employers
- Formal feedback on job performance from customers/clients
- Training to perform multiple jobs; multi-skilling
- Continuous skill development programmes
- Structured induction training
- Work [re]design for improved performance
- Mentoring
- QA assurance e.g. ISO 9000 or similar schemes
- The Business Excellence Model or equivalent

3. Reward and commitment practices

Practices which give incentives to achieve high performance include:

- Performance pay for all or some employees
- Profit sharing for all or some employees
- Share options for all or some employees
- Flexible job descriptions
- Flexible working e.g. hours, locations, job-share
- Family friendly policies

- Non-pay benefits e.g. free meals, gifts or health packages
- Benefits covering spouse or family members
- Harmonized holiday entitlement
- Job rotation; job interest/challenges
- Nature of the work gives opportunity to keep skills at cutting edge
- No compulsory redundancies
- Avoidance of voluntary redundancies
- Commitment to single status
- Listening to and respecting people's opinions
- Rewarding softer skills like good people management, not just hard measures related to budgets and cutting waste

Source: Sung & Ashton (2005); Purcell (2004); Ashton & Sung (2002); Swart & Kinnie (2002)

In high performance work environments, it is vital that everyone operates to their optimum and that teams maximise their effectiveness. To drive this throughout the organisation leadership is devolved. The Advanced Institute of Management Research refer to the importance of "leadership distributive systems" through which organisational leadership acts, supported through administrative co-ordination systems.[53] The role of line managers – team leaders, supervisors and section managers - is particularly crucial to effective people management, and in dissolving the gap between "espoused and enacted policy", i.e. between what is supposed to happen, and what actually does happen. Incentives and rewards help to motivate people and retain their commitment to achieving targets, given that a climate of trust is in place, and front line managers are well placed to engender that trust. Line managers' role has become much more important, they are now required to do more, and their employment relationship is more individualised through performance appraisal, coaching and guidance roles, and managing teams. Indeed, the relationship between line managers and employees is viewed as a crucial determinant in organisational commitment and job satisfaction.[54]

Purcell, in Sustaining the HR Link in Difficult Times, notes that although junior managers' possession of good people management skills is crucial, it is not always rewarded by senior managers. Instead, other behaviours are often rewarded, such as budget compliance or waste rates. A DTI report[55] also noted that over half of managers work in organisations which appear not to have evolved fully to meet the needs of today's high performing workplaces. Bureaucratic and authoritarian command and control structures are still too prevalent in UK organisations. These behaviours have a tendency to inhibit, rather than improve, individual and organisational performance.[56]

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[53] Munshi et al, Advanced Institute of Management Research, 2005
[54] Purcell, The HRM-Performance link, 2004
[55] DTI, Inspired Leadership, 2004/5, using research by the Chartered Management Institute, 2003
[56] DTI, Inspired Leadership, 2004/5

Improving the people management skills of front line managers is imperative, that they understand and embrace the values and objectives of the company – what Purcell (2004) calls 'The Big Idea' – and also form the positive working relationships that encourage and enable this in their colleagues. The Big Idea may signify quality, mutuality, aspirational or other values and objectives. It is enduring, is embedded throughout the organisation, and encapsulated in collective routines about how work is done and people behave. It connects, and derives from the same root, the way customers are treated and employees managed. It can also be measured and managed, and involves an inclusive approach.

Key policy areas to improve people management skills are considered to include:

- Careers.
- Training/development/learning.
- Job design – job challenge and job autonomy.
- Involvement and communication.
- Appraisal.
- Work-life balance.
- Line managers – bringing policies to life, and
- Values and cultures.

The appropriate policy mix to engender commitment varies according to whether individuals are professional staff, front line managers, or workers. [57] The positive and negative aspects of policies linked to commitment and those which damage it are set out in Appendix 1.

It is also pertinent to consider the effect on employees of their engagement in high performance and innovative work practices, since these have the potential to increase job intensity (e.g. job strain, needing to work faster, tight schedules, higher workload) and therefore have negative worker outcomes, including decreased job satisfaction. Research by Kalmi and Kauhanen (2005) acknowledges that innovative work practices - such as self-managed team working, more flexibility in work organisation, and greater worker-management co-operation - do not necessarily mean working harder nor lead to greater job intensity. Their research into the Finnish labour force revealed some ambiguity, however, in that:

- Team work can lead to higher job intensity, but is apparently dependent on the specific products and services involved.

[57] Purcell, The HRM-Performance link, 2004

- Training can also lead to higher job intensity, perhaps because training increases job demands.
- Information sharing leads to decreased job intensity.
- Incentive pay is not associated with increased job intensity.
- Job security seems not to be influenced by workplace innovations.
- All work innovations, including team working, are associated with higher wages.

2.3.4 Multi-skilling and continuous learning

The link is drawn between job rotation and skill development, since people's expertise is broadened and strengthened through multi-skilling as they become adept in a range of operations. [58] This means that workers need to be adaptable to changing circumstances, and open to new ideas.[59] Job rotation and multi-skilling can lead to higher performance. Job rotation increases people's *commitment* to the companies they work for. It is not hard to see, too, how job rotation in a company can be an important impetus to and part of the innovation process due to the sharing of ideas and knowledge that occurs when people break out of their functional silos. A non-Tayloristic approach to work prevents people from being robotised. This means that job design (or redesign) is important to work transformation.[60]

The workplace is an environment for *continuous learning*, for learning in the knowledge economy is thought to occur mainly in workplaces (not in classrooms) via:

- Informal learning by doing.
- Learning by interacting, and
- Coaching.[61]

The DTI/CIPD report[62] on high performance work practices also observed the role of continuous learning in relation to both high performance and innovation as it enables people to develop their skills and creativity: "Skills policy is about creating a work environment in which employees can learn all the time as part of their normal work and where they can take advantage of the system to effect performance and innovation." Tailoring the training to high performance requirements was also

[58] Purcell, The HRM-Performance link, 2004
[59] Tether et al, CRIC (September 2005), report for the DTI
[60] Purcell, The HRM-Performance link, 2004
[61] Hepworth et al, Regional employment and skills in the knowledge economy, undated (c.2005/6)
[62] Sung and Ashton (2005)

advised. In many cases training may not relate entirely to technical skills. Others are needed, such as listening and communication skills. The distinction is drawn between 'learning' and 'personal development,' both important. Personal development includes any self-development activity which will make an employee more interesting and (it goes without saying) more *interested.* Swart and Kinnie (2002) note that a challenging and interesting job which gives employees scope to keep at the leading edge in their field can help to attract and retain top people even if salaries are not high. The message is – job quality is important to employees.

2.3.5 *Skill Issues in the Labour Pool*

Without the right calibre of managers and employees a company cannot innovate. As the European Commission notes: "The knowledge and learning capacities of people are instrumental for innovation processes, as are their powers of creativity, initiative and drive, determining to a large extent the innovative capability of organisations."[63]

Therefore the availability in the labour pool of the right skills, at the right level of competence, is crucial. Deficiencies may be due to skill shortages (not enough people with the requisite skills) as well as skill gaps in individuals' competences. Talent attraction and retention is a major competitive factor for innovation and economic growth in the knowledge economy.[64] It is important to be able to attract and retain people with the appropriate mix of attributes and qualifications who can be trained and who are also motivated to develop themselves.

Competition from careers which offer better prospects, higher salaries, more kudos, or better working conditions can cream off the best people. The mobility of the labour pool can also impact on innovation through exerting skill shortages in high-demand disciplines like biotechnology, materials science, chemistry, ICT, and engineering. Typically, specialist skills which are in short supply and are likely to command a high salary may be difficult for businesses to locate and retain, particularly SMEs. The European Commission65 points out that skills in ancillary occupations such as venture capital operators can also be in short supply and affect the ability to manage investments in innovative enterprises in new technological fields. They also highlight other skill needs which contribute to innovation, such as entrepreneurship skills, and the skills to thrive in new and changing work situations.

Innovative firms can find that the skills they need are in short supply because training courses are not yet set up to produce the new skills they require. A leading edge firm which has produced a 'new to the world' innovation may find that specific skills may

[63] CEC, Innovation Policy, Brussels, 2003
[64] Hepworth et al, Innovation in the East Midlands knowledge economy, 2005, citing Florida (2002)
[65] CEC, Innovation Policy, Brussels, 2003

not exist in the labourforce at all.[66] An additional problem can arise since workers may lack any personal incentive to *develop* the skills required of them because of a lack of demand for those specialist skills in the wider labour market and the conclusion that those skills would not tradeable. The EC further notes that demographic changes in society are reflected in the composition of the labour pool, and the importance of updating and reskilling older workers. Organisational changes such as flexible working may help their continued contribution to economic activity.

2.4 Creativity, Research and Collaboration

"It is not possible to conceive innovation without creative ideas, as these are the starting point," stated a European Commission report on Innovation in 1998.[67] "Creativity creates the basis of innovation, which, in its development, raises difficulties that must be solved, once again, by creativity." Creativity and innovation are therefore complementary. The creative class has a central role in modern economies. Its rise underpins the importance of skills and learning as a key element in the innovation process and the competitiveness of local economies with a highly skilled and educated workforce.[68]

Creativity can occur at personal, team, or organisational level. Hemlin (2002) established that personal characteristics in creative people include openness to new thinking and experiences, lesser conventionality, strong motivation, the possession of specialised knowledge and skills, and a love of their work. Thinking in new ways is important for both individuals and groups. The characteristics of creative people can include ambition, dominance, hostility, lack of conscientiousness, and impulsiveness. Indeed, where these latter qualities exist the sharing of knowledge and ideas that Hemlin regards as fundamental to creativity in teams emphasizes the need for achieving a workable team dynamic.

Important to creativity in work teams is *knowledge* work, both:

- Access to and the sharing of knowledge, as well as
- Applying knowledge and information to generate new knowledge.

Of prime importance to creativity and knowledge enhancement is the flow of information which ensures that ideas generated can be communicated and

[66] CRIC (September 2005), report for the DTI
[67] European Commission, Innovation management techniques in operation, Luxembourg, 1998
[68] Discussed in Hepworth et al, Innovation in the East Midlands knowledge economy, May 2005

developed.[69] Changes in organisational structures are considered to achieve a working environment more conducive to creativity, such as moving from hierarchical to flatter organisational structures to increase communication between workers. Generating ideas occurs best when group members act individually before coming together and continuing to generate them as a group. 'Social factors' - what we would now call 'interpersonal, influencing or relationship skills' - enable the creative individual to get acceptance of their ideas by colleagues. Hemlin (2002) indicates that creative activities in work teams are steered by an expectation of results and sharing relevant information about results, as well as by showing good role models.

Creativity works less well where no expectation of results occurs, where standardised control routines are in place, where information flows are poorer, and where no role models exist. Sefertzi (2000) points to the necessity of ensuring the reduction of mental blocks to creativity, such as people's fear of failure.

2.4.1 Creativity Techniques

A report on creativity for the European Commission-funded INNOREGIO project[70] addressed how creativity can be stimulated, developed and facilitated in individuals and groups. Sefertzi drew particularly on a 1998 study of innovation management techniques by the European Commission, as well as a body of academic writing. She noted that everyone has the propensity to be creative, asserting: "It can be learned, practised and developed by the use of proven techniques which, enhancing and stimulating the creative abilities, ideas and creative results, help people to move out of their normal problem-solving mode, to enable them to consider a wide range of alternatives and to improve productivity and (the) quality of work."

Specific techniques to generate creativity can be used in functions such as marketing, product or service development, strategic planning and decision-making, design, human resources, finance, and quality management. Creativity can also ease the adaptation to change, optimise organisational performance and transform workforce attitudes, as well as being fundamental to every stage of research and development. The expected outcomes include:

- Innovation through [implementing] new product and process ideas.
- Continuous improvement of products or services, and their higher quality.
- Increased productivity and high performance.
- Greater efficiency, rapidity and flexibility.

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[69] Sefertzi (2000); Hemlin (2002)
[70] Sefertzi (2000). INNOREGIO: dissemination of innovation and knowledge management techniques

Tools to develop creativity include computer based support software for organising information and modelling, as well as analytical techniques (following a logical sequence of steps). Intuitive techniques which are non-sequential (i.e. tending towards whole solutions rather than using step-by-step processes) are considered more appropriate for poorly defined questions.

Creativity-supporting techniques[71] include:

- Brainstorming.
- Story Boarding.
- Checklists.
- Mapping processes.
- The Excursion Technique, and
- Computer techniques (see Appendix 2).

Work groups employing creativity techniques require a leader and probably an external facilitator to advise on the various techniques, define the problem, and run the proceedings. Managers can be trained to implement creativity techniques themselves. They can also be trained in how to stimulate and motivate creativity in employees more generally, achieve a creative working environment, and encourage the use of creativity techniques. This poses questions about the need for awareness raising and the availability and suitability of training provision and access.

2.4.2 Research Skills

In his review of the international academic literature on creativity-enhancing factors, Hemlin (2002) found that the successful organisation of research groups and environments is contingent on:

- Creativity – a richness of ideas.
- Steering and organisation.
- The size of research groups, and
- Resources and incentives.

[71] These are detailed in some depth in Sefertzi (2000), including various computer-based techniques.

The factors conducive to successful research (see Text Box 4) were drawn up for scientific research, though they are generic to successful organisation and achievement in any research environment.

Text Box 4: Factors Conducive to Successful Scientific Research

- Clear objectives functioning in a co-ordinated way for researchers.
- Activity focused solely on research.
- A research culture built up over time.
- A positive group dynamic.
- Group members should participate in the group's research leadership.
- Flat and decentralised group structures are most favourable.
- Internal and external communications should be lively and supporting.
- Necessary resources comprise staff, time, research financing, research equipment and library resources.
- Differentiation (presumably including staff specialisms) is favourable to productivity.
- Collaboration, both locally and internationally, is of the utmost importance.
- Rewards (e.g. financial, prestige and awards) have a favourable impact on productivity.
- Selection of suitable staff is important, also hiring policy.
- Leadership of the research group is crucial.

It is worth observing that a 'research culture' is not a discrete element within this exhaustive analysis of the salient factors. Instead, a research culture is what is produced by, or results from, the combination of all the factors listed above. Note, too, the presence of collaboration, leadership, communication, and rewards.

2.4.3 Process and product development and change

The impetus of competition from producers in low wage countries is spurring British industry towards competing via high-end product strategies involving complex product specifications and less on low price unless other competitive advantages are in place, such as prohibitive long-distance transportation costs. Mason (2005) - in his surveys of plastics processing, printing, logistics and insurance - noted the link between businesses' capability to achieve high value added goods and services and their skill-intensiveness. High value added products and services are defined as:

- One-off or low volume.
- Highly complex specifications.
- Not price dependent.
- Competing in a market for premium quality, not standard or basic quality.

- Developed by companies often leading the way in developing new products, services or techniques.

Product and process innovation can be either new to the market or industry, or new to the individual firm.[72] A greater diversity of competences and disciplines is now needed for product and process innovation than a single enterprise, or even a single locality, can possess. This is spurring businesses to open up their knowledge creation processes and share intellectual property rights. Information and communication chains – and therefore innovation networks - are increasingly global and virtual.[73] This places added emphasis on the ability to collaborate and network successfully. Its primacy positions inter-firm collaboration high among the objectives of innovation policy, and for this reason it is apposite to look in some detail at the skills element.

2.4.4 Skills for Successful Collaboration and Networks

Collaborative working is the key to generating major innovations in new technologies, asserts the government's 2005 response to the Lisbon Strategy.[74] Perception of the crucial role of collaboration in generating innovations is behind the government's provision - through its Technology Strategy launched in 2004 - of £370 million available for businesses to collaborate on achieving innovation outcomes by working together on developing and commercialising the new and emerging technological opportunities identified in the Technology Strategy.

Networking and collaboration can stimulate innovation between businesses because:

- Businesses learn from and do business with each other.
- They are more likely to collaborate on strategic projects.
- This helps to build critical mass to better exploit commercialisation opportunities.[75]

Existing examples of innovation-generating and supporting models include the BioConcepts Hub in Cambridge focusing on biotechnology, and the Enterprise Hubs located in the South East. In the latter, some 22 networked centres offer business incubation services to high-growth start-ups and early stage companies with the facility to share sophisticated scientific equipment they could not afford themselves.

The creation of knowledge (expertise) and the management of knowledge (access, transfer, organisation, utilisation) are vital components of the innovation process.

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[72] Frenz and Oughton (2005)
[73] Welsh Economy Research Unit, 2005
[74] HM Treasury, Lisbon Strategy for Jobs and Growth, October 2005
[75] HM Treasury (October 2005), citing Regional Development Agencies

Knowledge is a value to businesses and Hemlin (2002) maintains that the organisation of it (i.e. knowledge management) is even more important than its possession. Essential to creativity in work teams is access to and the sharing of knowledge, as well as its application and information to generate it anew. This is also true for the exchange of knowledge externally to the organisation through its capture and transfer from external sources.

Research into collaboration raises questions as to the conditions conducive to its success. The Advanced Institute of Management Research (2005) notes that: "For some innovations, joint ventures, alliances and outsourcing can play a useful role. But for others, they are inappropriate and strategically dangerous." [76] They see the issue of whether to collaborate or not as contextual and dependent on the strategy adopted for the particular type of innovation activity. Other research reveals no statistically significant correlation between inter-firm co-operation and innovation.[77] In contrast, a positive correlation occurs between firm-university collaboration and patenting.

As we have seen, though, innovation is enhanced and facilitated by the exchange of knowledge, and collaboration provides an environment and the mechanisms for learning. Indeed, a straightforward correlation between networking activity and innovation is confirmed by research into the impact of networks on the learning and skills of businesses. [78] Research into SMEs in Scotland and the North East[79] also found empirical evidence that inter-firm co-operation with suppliers and public institutions is linked to innovation, and networks are important. Furthermore, the innovative performance of science-based firms is linked to university co-operation.

Research confirms that businesses' objectives in networking are primarily to acquire new skills or knowledge. [80] This promotes and enables workforce learning and in that way contributes to their performance improvement. Other reasons include business development, accessing guidance and support, or developing business credibility. A major conclusion is that the possession of relationship skills is crucial if businesses are to make the most of their networking activities, whether undertaken with suppliers, customers, general social contacts, sector organisations, business or personal member organisations.

However, smaller firms are less actively engaged in networking.[81] Resources must be targeted to support the development of professional network facilitation. Where networks support the provision of publicly funded learning and skills development, it is advised that the administrative burden on them should be minimised as 'red tape'

[76] Munshi et al, AIMR, citing Chesbrough and Teece (2002)
[77] Frenz and Oughton (2005), citing Fritsch and Franke (2004)
[78] Turner et al, report for the DTI, 2006
[79] Frenz and Oughton (2005), citing Freel (2003)
[80] Turner et al, report for the DTI, 2006
[81] Turner et al, report for the DTI, 2006

can act as a disincentive. External support like R&D is an important substitute in smaller firms for the lack of internal skills. [82]

2.4.5 Clusters, Learning and Innovation

A cluster is: "A pool of interdependent and complementary competences associated with related manufacturing and service activities" and not simply a sector.[83] The production chain can include a number of manufacturing and service activities. Clusters vary – they may be traditional manufacturing or high-tech, for example – but all tend to be characterised by high degrees of mobility of people between different firms and other organisations. Consequently, they are an important source of inter-firm learning through 'knowledge spillovers' in the same way that multi-skilling spreads ideas and know-how within individual organisations. Inter-firm relationships that occur in clustering can be both vertical (i.e. involving companies in the same supply chain) or horizontal (whether in different sectors, or competing in the same market). Innovation can be supply chain driven.

The knowledge-generation and diffusion potential of clusters – and therefore their contribution to innovation - makes it important to understand the mechanisms involved and to learn from their example. In the Silicon Valley cluster, for example, formal and informal networks of engineers, scientists and professionals exist, also forums for exchanging ideas and improving practices.

Successful clusters also develop their own mechanisms for delivering (and also evolving and modifying) training - and this includes training by some larger firms as well as public sector employers. Higher education is key to delivering training in high-tech clusters. The social networks between education/training and businesses enable the development of 'communities of interest'. Service companies – like venture capital firms and intellectual property specialists – also spring up in an innovative cluster. These also have an important role in inter-firm learning and the diffusion of new practices.

As significantly, successful clusters act as a magnet for qualified people, technical and managerial, both in established high-tech areas like Silicon Valley and in emerging clusters, in the way that has occurred in Israel and Bangalore, India. They also create an environment which encourages entrepreneurial behaviour because they provide the conditions to motivate and facilitate people starting new businesses.

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[82] Frenz and Oughton (2005), citing Freel (2003)
[83] Welsh Economy Research Unit, Challenging Clusters, 2005

2.4.6 Skills for Successful Technology Transfer Networks

Analysis of the European Commission's Sprint programme provides valuable insights into the skills needed to run a successful network, in this case involving international member companies engaged in technology transfer (see Text Box 5).[84] This raises numerous pertinent points about network membership, working towards targets and keeping on track, also on communication and sharing information.

Text Box 5: The Components of Successful Networks

a) Membership

- The successful identification of suitable network members.
- Achieving cohesion between members.
- Mutual trust – perhaps facilitated externally initially e.g. by a consultant.
- Shared interests which make it possible to overcome difficulties due to differences in size and resources of member companies and their respective specialisations, and turn these to the network's advantage, even if their individual goals vary.

b) Working towards targets

- Identification of objectives, needs and ways forward.
- Instilling a sense of purpose.
- The allocation of tasks. Devolved responsibility.
- Autonomy of partners. Respect for individual business backgrounds and expertise.
- Willingness of individuals to accept the network's working culture.
- Rules of conduct informally adhered to rather than a laid down, unless a broad consensus is for a formal code of conduct, or agreed for specific activities e.g. finance for cross-licensing or market research.
- Targets are set, also methods for speedy decision making and enquiries response.
- Plenary meetings set an agenda structured to keep their efforts on track via:
  - An administrative report.
  - Project/activity report/development update.
  - Introduction of new products.
  - Discussion of queries/problems.
  - Work plan for next period.
- Flexibility exists of structure, strategy and operations, and the ability and willingness to change if results are poor e.g. via greater specialisation or focus, or the identification of blockbuster opportunities.
- The use of external expertise to supplement those within the network.
- A focus on quality of input and output.
- Investment by the partners in time and finance.
- Agreement is achieved between partners about the equality of their individual effort (input) and their receipt of equal financial resources.

[84] Coopers & Lybrand, undated.

c) Communication, information and know-how

- Members are supportive of each other in giving advice – sharing know-how, ensuring knowledge dissemination.
- Good interpersonal relations exist, not inhibiting information flows and sharing.
- Reliability is displayed by each partner and members can depend on each other.
- Existence of a leader among the partners if the network identifies a requirement for one. If not, one partner may act as the lead contact and information broker.
- Local network partners/brokers are appointed for each country/region. In transnational networks language skills are important for the broker to communicate between international partners on behalf of the local partners, as well as acting as a 'cultural translator' and intermediary between members.
- An appropriate communication method is drawn up for use by the network.
- Open, easy and frequent contact methods/communication channels exist.
- Unified communication/marketing materials/outputs express the network's image.
- Intentional leakage externally of achievements and innovation e.g. through seminars, papers, consultancy, to achieve market buy-in to changes/developments within the network, e.g. to professional/trade organisations, and to source ideas.

The SPRINT analysis advises that network members should be selected for their existing specialisms and technological expertise, i.e. what they would bring to the network (identified as 'technology offers'), or on what they need to develop or acquire ('technology requests'):

i) Criteria for selection via 'technology offers':

The criteria for selecting members on the skills they would bring to the network are:

- Clear management commitment to sell technology.
- Capacity to effect and support technology transfer agreements.
- Potential on world markets.
- Advanced stage of development (or already commercialised).
- Existing patent and/or know-how protection.
- Well defined manufacturing procedures.

ii) Criteria for selection via 'technology requests':

The criteria for selecting members on what they need to develop or acquire are:

- Clear management commitment to acquire technology.
- Appropriate existing manufacturing, marketing and R&D functions.
- History of new product introduction.
- Financial and managerial resources available, and
- Well defined new product/process specification.

Problems can inhibit the successful operation and outcomes of international technology transfer partnerships as follows:

- Language barriers prevent the free exchange and flow of information and know-how.
- Cultural differences between members prevent mutual understanding and acceptance.
- Individual differences – differences of opinion.
- National differences e.g. in legislation and educational systems.
- Different sized companies with varying resources and investment potential.
- Lack of focus on getting results.
- Diffidence and lack of commitment of one or more partners, lack of engagement with network goals, unequal participation.
- Disagreement among members about how to divide costs.

2.5 Performance Factors

The link between high performance and innovation suggests that improving performance can heighten an organisation's capacity to innovate. Indeed, Mina et al (2004) state that: "Innovation systems are constructed for a purpose, namely to solve problems...Innovations...are trajectories of improvement sequences in which devices or procedures are progressively refined and extended in their scope of application." A detailed discussion of performance and productivity is given in chapter 3 and Part Two. This section looks instead at market issues and financial performance.

2.5.1 Market issues and financial performance

Innovation activity is embedded in the market process. The entrepreneur relies on market signals to indicate the feasibility of their venture. The commercialisation of products and market development go hand in hand. Market information is used to acquire knowledge and outwit competitors. Market processes influence the outcomes of innovation and the ability to innovate.[85]

The size and structure of the market, as well as its proximity, have a key effect on the speed of diffusion of an innovation. Other major contributors include co-operation between firms, and institutional, social and cultural factors.[86]

Existing innovative firms and new businesses are greedy consumers of investment capital for development and growth. This exerts pressure for the innovative company to possess sound financial and business management skills. Challenges include the sourcing and accessing of finance – loans, investments, venture capital - and dealings related to intellectual property and the route to commercialisation – licensing, prototyping, testing, joint ventures – as well as maintaining profitability through day-to-day operations, the cost of adopting new technology, and investment in fixed capital. Inadequacies in financial acumen can hold innovators back or, in the worst case scenario, threaten their business survival.

The achievement of profitability is a fundamental test of innovation's success.[87] Profitability is also fundamental for mature businesses to consider engaging in any innovative activities, and lack of profitability can hinder their desire to. For these firms: "Business survival alone is a major challenge, and the pressures of meeting short term goals and making a profit leave little room for innovative thinking." Further impediments are exerted by the fear of failure, difficult trading conditions and too many rules and regulations.[88]

2.6 Barriers to Innovation

We have already seen how obstacles to entrepreneurship, ineffective leadership, and network and financial problems act as inhibitors to successful innovation. Looking more broadly at barriers to innovation, it is clear that these are among a whole raft of factors that can cause impediments. Barriers relate to *external inhibitors* connected with, say, economic and fiscal and market contexts; and/or, they relate to *internal*

[85] Metcalfe (2005); Munshi et al, Advanced Institute of Management Research, 2005
[86] Frenz and Oughton (2005)
[87] Metcalfe (2005); Munshi et al (2005)
[88] DTI, Innovation Message Project, 2005

inhibitors within businesses arising from their organisational structures, working practices, and human and capital resources (see Text Box 6):

Text Box 6: Barriers to Innovation

a) External inhibitors

- Legislative and regulatory instruments which do not provide the framework to encourage and support entrepreneurs.
- Economic conditions which affect businesses' investment potential, limit their profitability and diminish the availability of funding and other support.
- Lack of demand for innovative products.
- Lack of a culture of innovation in economies, local, regional and national.
- Skill deficiencies in the labour pool and the research infrastructure.
- Lack of opportunity to be innovative, as can occur due to a parent company's business strategy restricting subsidiaries' operations to narrow limits.
- Limitations in the training and workforce development infrastructure to provide the skills needed by innovators.

b) Internal inhibitors

- The lack of clear, winnable goals and strategies.
- Lack of vision; lack of ambition.
- Absence of a culture of innovation at individual and organisational level.
- Narrowly defined regimes, programmes and curricula; bureaucratic command and control structures.
- Inadequate financial resources.
- Skill deficiencies in managers and workers.
- 'Firefighting' due to time pressure e.g. to meet deadlines.
- Lack of information related to key elements of the innovation process, or problems in accessing it.
- Technological limitations.

Source: writer's research and sources consulted in this literature review

A review of the 3rd European Community Innovation Survey (2001) to investigate the contribution to business innovation made by the science base (publicly funded institutes and universities)[89] concluded that access to technology was not amongst the most significant impediments to innovation for businesses. Instead, it was other factors such as market conditions, lack of ambition, access to finance, and the quality of demand, which impacted more greatly on the innovative performance of firms. The relatively limited links that firms had with the science base were explained by their lack of commitment to innovation.

Further light is shed on this issue by a 2005 study by Frenz, Michie and Oughton. This indicates that *underlying issues* are instrumental, since they conclude that:

[89] Tether and Swann (2003)

"...firms must have a certain level of absorptive capacity (captured by the proportion of science and engineering graduates in the workforce, the level of firm R&D expenditure and organizational capability) before they can enter into a cooperation agreement with a university."

3 INNOVATION PERFORMANCE: THE UK AND WEST MIDLANDS IN THE INTERNATIONAL CONTEXT

3.1 Introduction: Innovation Performance

A knowledge-intensive economy acts as a key driver of innovation and positions it well to compete globally. Comparison of the UK against economies worldwide and, assessment of how the West Midlands matches up to other regions gives a relative indication of performance. This section examines the UK's and West Midlands' innovation performance in the international context, looking first at innovation indicators and measures. It then goes on to present the UK and Regional data on innovation performance.

3.2 Innovation Indicators and Measures

Innovation occurs via a wide range of business practices.[90] Since skills are established as essential to innovation, and managerial and workforce expertise, knowledge, learning and development is crucial, it is helpful for policy makers to measure performance, change and improvement. Commonly used performance indicators for innovation include R&D expenditure, numbers of research personnel, and patents.

Patents and R&D expenditure alone are imperfect measures of innovation, since not all innovations are patented, and therefore not all innovative activity is captured by R&D spend or by patent applications. Other indicators of innovative activity include non-pecuniary knowledge acquisition; co-operative agreements between firms; and networking between firms and research organisations.[91]

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[90] Robson and Ortmans (2005)
[91] Frenz and Oughton (2005)

3.2.1 Overseas national innovation indicators: some examples

Other organisations which have developed a set of benchmarks for measuring organisational innovation include the OECD's Science, Technology and Industry Scoreboard, and the Index of the Massachusetts Innovation Economy, an annual publication produced by the Massachusetts Technology Collaborative. Many of these measures relate to science and engineering, research and collaboration, and the fiscal context, but they also include indicators on:

- Internet connectivity.
- Pay.
- Employment clustering by sector, and
- The difficulty in hiring personnel for selected technical positions and functions.[92]

The Science Council of the Canadian province of British Columbia established a set of proposed innovation indicators in 2003 which included 5 skills indicators, 9 indicators for knowledge performance, 7 indicators of the innovation environment, and 5 on innovation outcomes. They intended to benchmark British Columbia against Canadian national average performance.

The British Columbian innovation skills indicators and other related performance indicators include:

- Percent of the population 15 years and older with post-secondary credentials.
- Bachelor degrees in science and engineering per 100,000 population.
- Grade 8 results in maths and science.
- Education spending.
- Research personnel per 100,000 population.
- The workforce in natural and applied science related occupations (numbers).
- Number of immigrants aged 25 years + with 16 or more years of education.
- New business starts.[93]

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[92] See Science Council of British Columbia and Industry Canada, 2003, for a table comparing the range of indicators used by the OECD, Massachusetts, and Canadian provinces.
[93] This list includes all the innovation skills indicators and several others. For the complete list see Science Council of British Columbia and Industry Canada, 2003

British Columbia has also developed a set of high-tech indicators including measures of venture capital investment and entrepreneurship.

3.2.2 UK innovation indicators

The UK Innovation Survey, which feeds into the Community Innovation Survey undertaken across European Union countries every 3 years, employs a swathe of broader measures of innovation activity, protection and performance.[94] These include:

- Engagement in innovation projects, whether not yet complete or abandoned, and the resources allocated to innovation activity.
- The effects of innovation, including strategic changes, and
- The protection of intellectual property/innovation outputs (see Text Box 7).

Text Box 7: Innovation Measures used by the UK Innovation Survey and Community Innovation Survey

Innovation activity

- Introduction of products/processes new to market
- Ongoing or abandoned innovation activities
- Innovation-related expenditure: R&D, training, knowledge acquisition, machinery or equipment linked to innovation activities
- Co-operation agreements: with suppliers, clients/customers, other group enterprises, competitors, consultants, higher educational institutions, government research organisations

Effects of innovation activity

- Improved quality or range of goods or services
- New market entered/increased market share
- Reduced costs per unit produced or provided
- Improved flexibility of production/service provision
- Increased capacity for production/service provision
- Increased value added
- Met regulatory requirement
- Reduced environmental impacts or improved health and safety
- Strategic changes e.g. change in marketing strategy, new organisational structure, change in corporate strategy, use of advanced management techniques

Protection of intellectual property/innovation outputs

- Confidentiality agreements.

[94] Robson and Ortmans (2005).

- Trademarks, copyright, registered designs
- Patents
- Lead-time advantage over competitors (this also an effect of innovation activity)
- Secrecy
- Design complexity

3.2.3 Further issues about innovation benchmarks

Although benchmarking provides a way for businesses and other organisations to compare their own innovative attainments and approaches with others, it is relevant to ask: how do they know whether they are measuring themselves against the best in class – world class? A recent survey of UK businesses[95] found that independent innovators innovate to the level of their peers. Do they know what their competitors are doing? How often do they benchmark, and what criteria do they employ? How do they use this information? Much remains to be learnt about this important process.

This review suggests that a comprehensive set of indicators for benchmarking innovation skills and the success of organisational change and external interventions awaits further development. Their development would not be an easy task given the complexity of the components of innovation and the alternative nature and detail of the data which would need to be gathered. Speculatively, in addition to the usual measures of qualifications, levels and training, additional innovation skills indicators might be developed based on (among other possible examples):

- The use of creativity tools and techniques; purpose; how many people were involved; their occupations; outcomes.
- Changes in organisational structures and methods, such as moving to a flatter or matrix structure from a hierarchical one.
- The use and effects of using different communication methods.
- Team working: teams and groups operating and the specific purposes; what groups were involved; how they operated.
- Multi-skilling and knowledge transfer: areas of skill; techniques used; the occupations involved.

[95] DTI, Innovation Message Project, 2005

3.3 Innovation Performance

A government report on UK productivity and competitiveness[96] observed that the UK continues to have a world class science base, but has unrealised potential for that science base supporting a strong UK performance in relation to innovation. Levels of R&D expenditure and patenting remain low, partly because innovation tends towards non-R&D outcomes and methods of intellectual property protection other than patenting. Skill deficiencies occur, with a high proportion of people having only basic-level skills. There is an issue about vocational qualifications, and a management quality deficit compared to our competitors. But the UK is catching up in relation to intermediate-level skills and performs fairly well in terms of high-level skills. On enterprise the UK stands out from most of its competitors, having a more entrepreneurial culture than Germany or France, for example, but lagging the US. Access to finance does not appear to be a major problem.

The productivity and competitiveness report also posited that the considerable productivity gap between the UK and the US can probably be explained by the latter being more innovative. Since 1999: "Total factor productivity improvements" (i.e. the efficiency with which the labour and capital inputs are combined to produce output), "reflect innovation and technological spillovers amongst other factors."

3.3.1 Regional Innovation Performance in Europe

The European Innovation Scoreboard compares the innovation performance of European regions based on seven indicators:

1. Tertiary education.
2. Participation in lifelong learning.
3. Employment in medium-/high-tech manufacturing.
4. Employment in high-tech services.
5. Public R&D expenditure.
6. Business R&D expenditure, and
7. High-tech patents.

The Scoreboard places the West Midlands 29th of the top 50 most innovative regions in Europe. Only the East of England (4th) and the South East (8th) come within the first 10.

[96] DTI and HM Treasury, The 2005 Productivity and Competitiveness Indicators 2005

Overall, among the top 50, northern European countries perform best, notably Sweden, Finland, the Netherlands and Germany. Table 2 shows the top 10 regions and the positions of all UK regions in the top 50.

Table 2: European Innovation Index: UK regions in the top 50 rankings

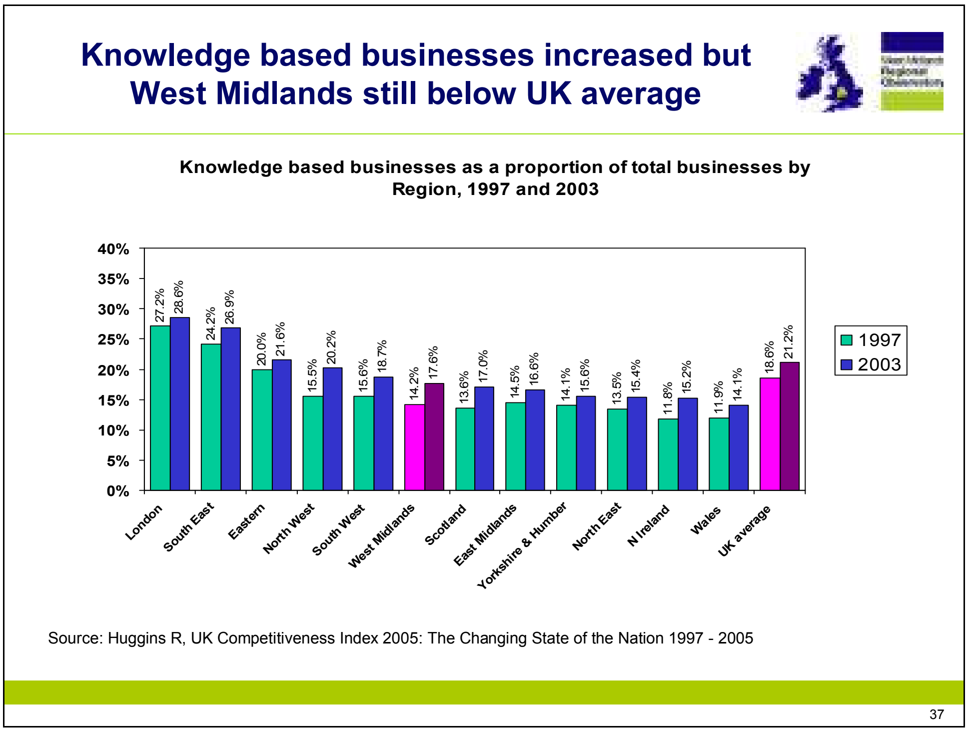
Region	Country	Rank
Stockholm	Sweden	1
Uusimaa	Finland	2
Noord-Brabant	Netherlands	3
Pohhois-Suomi	Finland	4
Eastern	UK	5
Ile de France	France	6
Bayern	Germany	7
South East	UK	8
Comunidad de Madrid	Spain	9
Baden-Württemberg	Germany	10
South West	UK	14
West Midlands	**UK**	**29**
North West	UK	36
Scotland	UK	38
London	UK	41
East Midlands	UK	44

OECD, Local Governance and the Drivers of Growth, 2005

3.3.2 Regional contrasts in knowledge based businesses 1997 to 2003

In terms of the proportion of knowledge based businesses in the Regional economy, the West Midlands improved substantially between 1997 and 2003, but remains at a disadvantage to London, the South East, the Eastern and North West regions, and is somewhat lower than the UK average (17.6% compared to 21.2%) (see Figure 3 and Appendix 3).

Figure 3: Proportion of knowledge based firms: regional contrasts 1997 and 2003



3.3.3 Regional innovation activity pre-2003

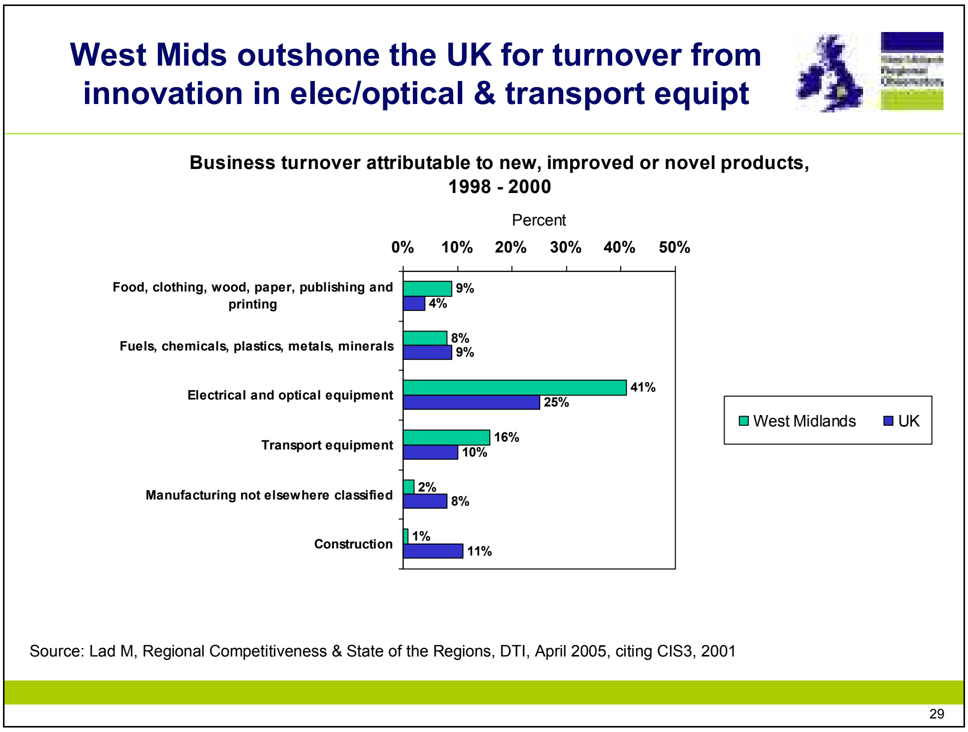
A generally positive picture for the West Midlands' creation of new, improved or novel products was given by the Third Community Innovation Survey (2001), covering the years 1998 – 2000 (Figure 4).

Figure 4 shows that:

- Across all broad industry groups, including services and industries such as the utilities and financial sector, a higher proportion of turnover in West Midlands businesses (14%) was attributable to the creation of new, improved or novel products than in any other UK region except Scotland (15%). The English and UK average was 9%.
- In manufacturing the West Midlands stood out particularly strongly, since the Region recorded the second highest percentage of turnover attributable to new, improved or novel products in the electrical and optical equipment industries (41%) after the North West (49%), against a UK average of 25%.
- In fuels, chemicals, plastics, metals and minerals the West Midlands figure was 8% of business turnover attributable to product innovation, compared to a high of 15% in the East, also in Scotland and Northern Ireland.

- In transport equipment, the percentage of West Midlands business turnover attributable to product innovation was 16%, on a par with the East Midlands, though behind the highest attainments by the North East (24%) and Scotland (31%).

Figure 4: The percentage of turnover attributable to new, improved or novel products, 1998 – 2000: West Midlands and UK contrasts

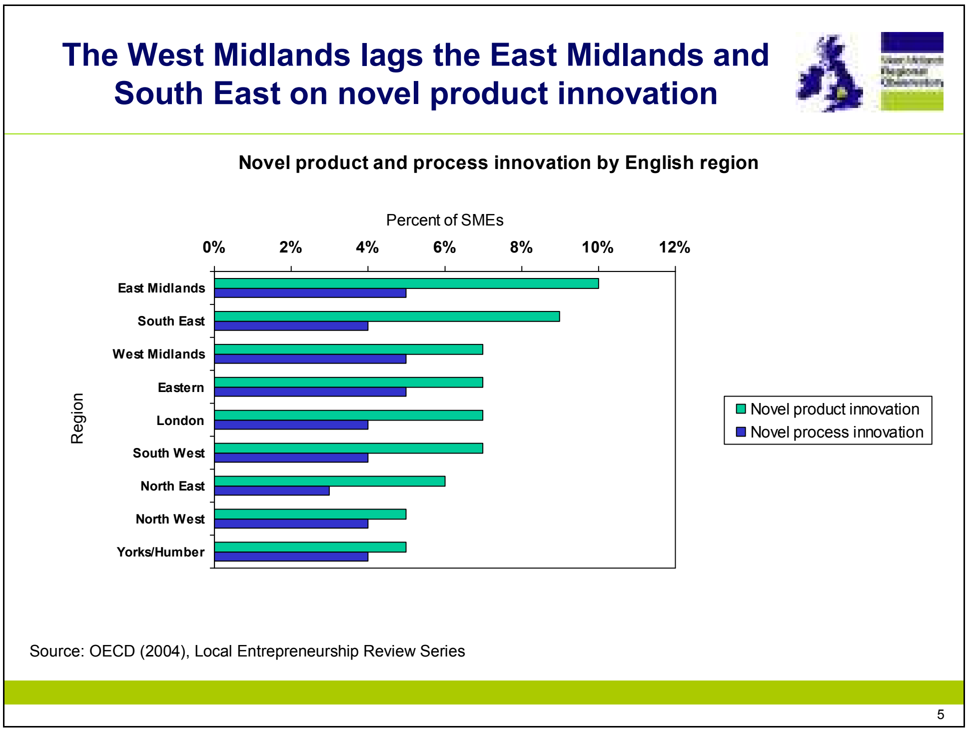


A cross-European survey by the OECD on the subject of entrepreneurship showed the West Midlands was a middling performer among UK regions in terms of novel product and process innovation, the latter being markedly stronger (see Figure 5).

The OECD points out that the relatively low expenditure on R&D, and its employment profile, help to explain why process innovation is stronger in the West Midlands than the generation of novel products, since in the former it exceeds the English and UK averages (5% compared to a UK average of 4% of SMEs).

Although the OECD data indicate that the West Midlands performed quite well compared to most other English regions in the percentage of SMEs generating novel products, and equalled the UK and English average (7% of SMEs) (see Appendix 4), it is important to consider that the achievement should be higher given the West Midlands' significance as the highest concentration of manufacturing among the English regions.

Figure 5: Novel product and process innovation by English region



3.3.4 The UK Innovation Survey 2005: regional and sector contrasts

First results from the latest UK Innovation Survey (2005) suggest that the West Midlands may have slipped relative to other UK regions in the level of business innovation activity.[97] The 2005 survey sampled over 28,000 enterprises of 10 or more employees in sections C to K of the Standard Industrial Classification. In addition to a range of distribution and services industries, the survey sample included the following production and construction sectors:

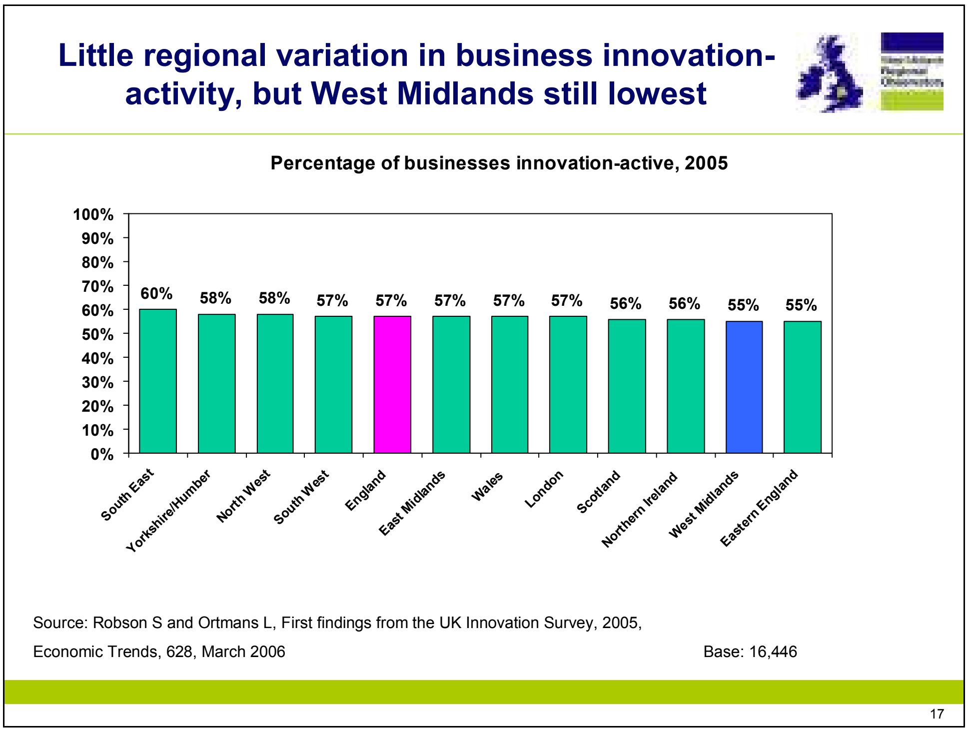
- Electrical and optical equipment.
- Transport equipment.
- Fuels, chemicals, plastics, metals and minerals.
- Food, clothing, wood, paper, publishing and printing.
- Manufacturing not elsewhere classified.
- Construction.
- Mining and quarrying, and
- Electricity, gas and water supply.

[97] Only outline data were available in Spring 2006.

The data were weighted upwards to represent the national population of firms of this size. Questions asked about their innovation activity and performance during the three years 2002 – 2004 since the previous UK survey of 2001.

Very little variation occurred across the UK regions in relation to the proportion of innovative-active businesses, according to the 2005 survey results. It is notable, however, that the West Midlands parallels Eastern England in the bottom of the field, with only 55% of businesses innovation-active, compared to 60% in South East England and 58% in Yorkshire and the Humber and the North East, and 57% on average across England (Figure 6).

Figure 6: Proportions of innovation-active businesses by UK region, 2002 - 2004

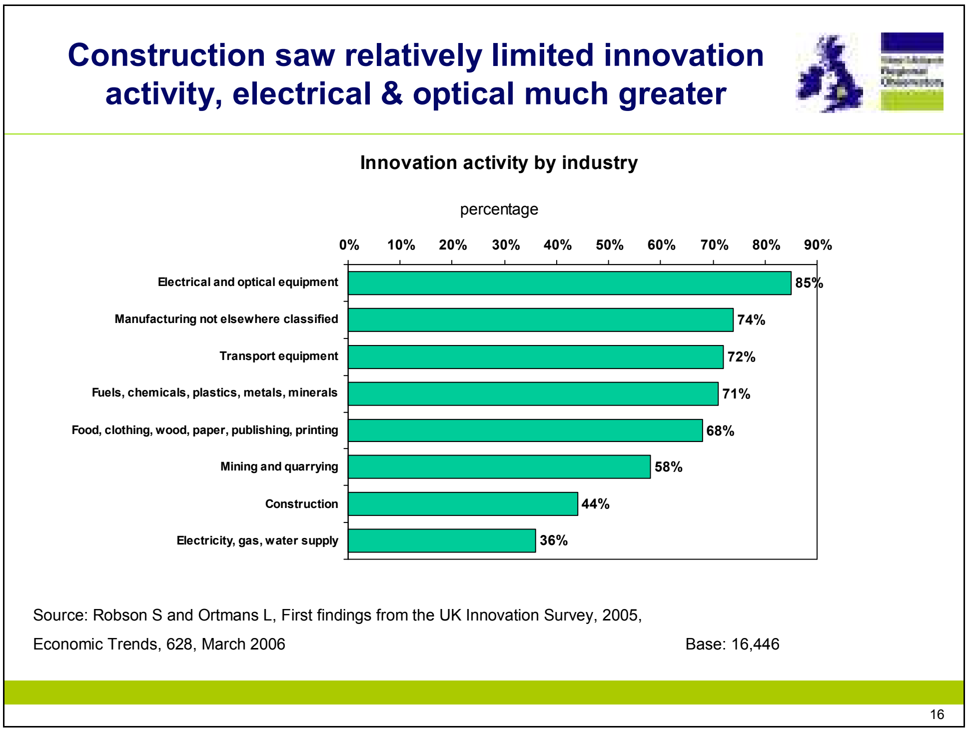


The level of innovation activity by UK businesses varies considerably across different sectors. The UK Innovation Survey 2005 showed that, in the production and construction industries during 2002 – 2004, firms producing electrical and optical equipment were the most prominently innovation active (85%), compared with a much lower 44% in construction (Figure 7). The limited innovation orientation of the construction sector was borne out by the West Midlands Regional Observatory's Construction Sector Profile of 2005 and represents substantial cause for concern.[98]

In contrast, Figure 7 shows that approaching three quarters of firms in manufacturing not elsewhere classified (nec) and transport equipment were innovation active (74%

and 72% respectively), and over two thirds (68%) in fuels, chemicals, plastics, metals and minerals.

Figure 7: Innovation activity by UK industry sector, 2002 – 2004

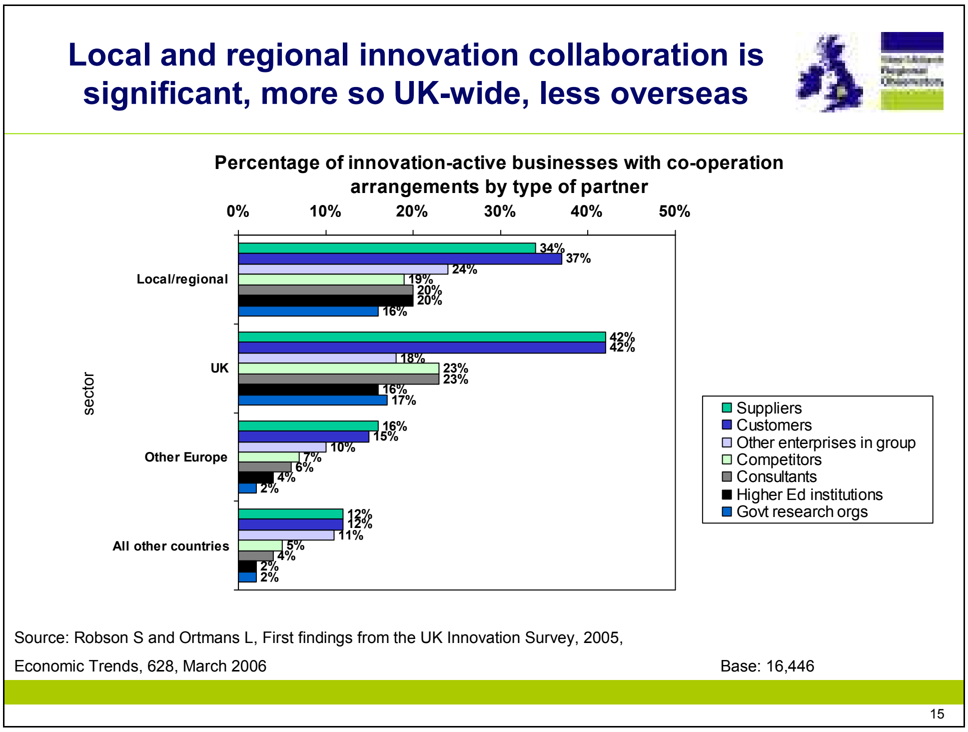


In terms of co-operative arrangements for innovation, the UK Innovation Survey 2005 showed that UK firms were most likely to link up with customers or suppliers, rather than with other enterprises within their groups, or with competitors, consultants, higher education institutions or government research organisations (see Figure 8).

It is significant for regional policy to note that local and regional linkages were generally slightly less prevalent than those UK-wide (65% compared to 69%) except where relating to links with other enterprises within their group or with higher education institutions, where the trend was reversed and innovation linkages were more likely. Also noteworthy is that, overall, one third (32%) had international co-operation arrangements in Europe and one quarter (25%) elsewhere, mainly with suppliers or customers, but also to a lesser extent with other bodies

[98] West Midlands Regional Observatory (Tilson, B), for the Regional Skills Partnership, 2005

Figure 8: The extent of co-operation arrangements regionally, nationally and overseas, 2002 – 2004, by type of partner



The UK Innovation Survey 2005 also showed that, during 2002 - 2004:

- Customers, other enterprises in their group, and suppliers were also important sources of information related to innovation.
- Businesses were less likely to be innovation active if smaller (10 – 250 employees) than larger (250+) (57% of smaller firms compared to 72% of larger ones).
- One quarter of smaller firms (25%) had introduced a product new to the market, compared to 39% of larger firms, and 15% of smaller firms were process innovators compared to 31% of larger firms.
- Financial pressures on smaller firms for innovation investment are suggested by the lower proportion incurring innovation-related expenditure (54%) compared with larger firms (68%). Furthermore, 12% raised the cost of finance as a potential barrier to innovation, and 11% cited problems in the availability of finance, compared to 9% of larger firms in each case.

3.4 Research and Development Investment

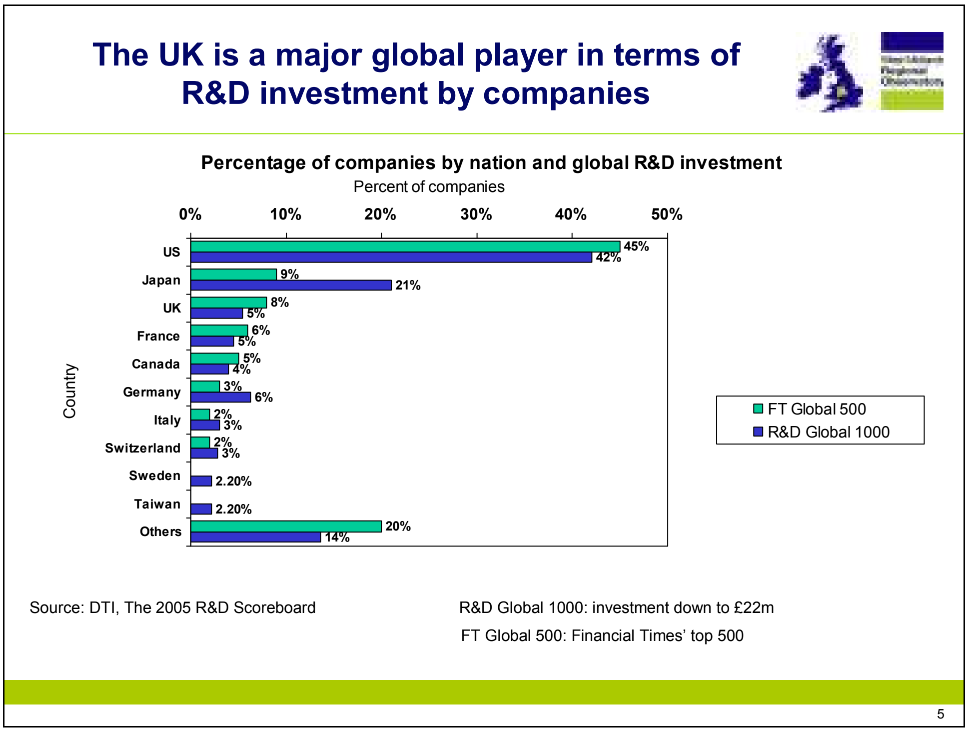
The DTI's annual R&D Scoreboard is a key analysis of UK R&D activity in the international context and by sector. It provides a major indicator of innovation-led growth because industrial R&D "helps to create higher value added products, processes and services on which the future of UK companies increasingly depends."

The 2005 R&D Scoreboard notes the importance of skills, sound business management expertise and strong operational performance in relation to R&D activity, observing that:

- There are well-established links between R&D and company performances (sales growth, wealth creation efficiency) and market capitalisation. However, the point is emphasised that company success depends not only on wise and balanced investment in R&D and other factors including skills and market development, but also on good strategic choices and operational excellence.
- R&D is concentrated in 6 countries – the US, Japan, Germany, the UK, France, and Switzerland. The business climate for R&D has improved most in North America. However, the OECD Science, Technology and Industry Scoreboard 2005 states that China has become third largest R&D performer behind the US and Japan, mainly due to rapid growth in researchers' salaries. In 2003, China had the world's second largest number of researchers (862,000), behind the US (1.3 million in 1999) but ahead of Japan and the Russian Federation (675,000 and 487,000 respectively).
- The 2005 R&D Scoreboard indicates that the largest R&D concentrations globally are automotive, IT hardware and pharmaceuticals. Pharmaceuticals, automotive and aerospace grew most rapidly amongst the top 10 sectors since the previous year.
- UK R&D activity is more vigorous than in 2001, and is particularly strong in pharmaceuticals and aerospace/defence. The software sector is also growing. Whereas UK R&D in automotive, IT hardware and electronics is far lower than the global average, the converse is true for pharmaceuticals, aerospace, food, and oil and gas.
- The UK receives a high proportion of its R&D investment from large foreign companies. Pharmaceuticals is a majority overseas-owned sector in the UK. In contrast, smaller overseas firms are less R&D intensive (R&D as a % of sales) than UK-owned ones.

The UK's global position on R&D intensity is shown in Figure 9.

Figure 9: Percentage of companies in the FT global 500 and R&D global 1000

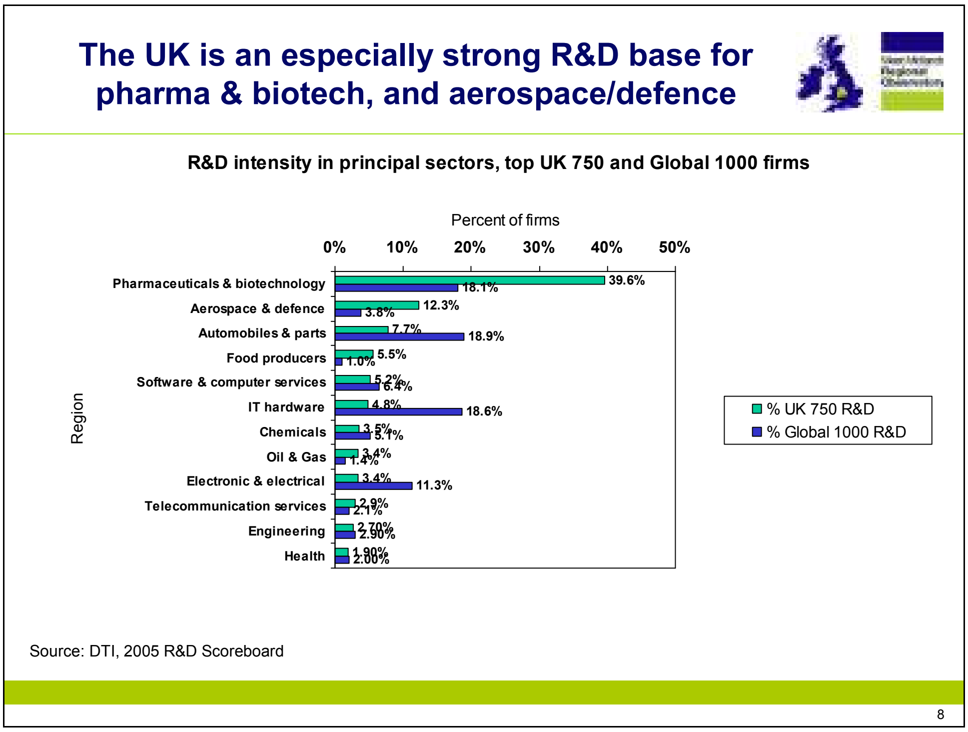


A detailed analysis of the UK's business R & D investment performance shows that UK R&D performers allocated similar levels of resources compared to international competitors, in sectors where they were active. In other sectors which are R&D intensive – such as motor vehicles, IT and electronics, where foreign owned multinationals predominate – it is from the overseas facilities these multinationals possess that R&D outcomes and technologies tend to come. The analysis optimistically speculates that these businesses may increasingly look to local suppliers (i.e. those in the UK). SMEs in research-intensive sectors like IT are also growing. [99]

The principal sectors for R&D intensity (R&D as a % of sales) among the top 750 UK firms are pharmaceuticals & biotechnology, and aerospace and defence (39.6% and 12.3%, respectively). The strength of the UK's research base in these disciplines is demonstrated by the comparison with the top 1000 global companies where R&D intensity in these two sectors is significantly lower. In most other sectors, notably IT hardware and electronics, the UK's R&D intensity is below – sometimes far below – the global rate (see Figure 10).

[99] HM Treasury, Lisbon Strategy for Jobs and Growth, 2005, citing DTI economics paper 11; the 2004 UK Science and Innovation Investment Framework; a 2003 review of business-university collaboration; and the UK Technology Strategy launched 2004.

Figure 10: The principal UK sectors for R&D intensity



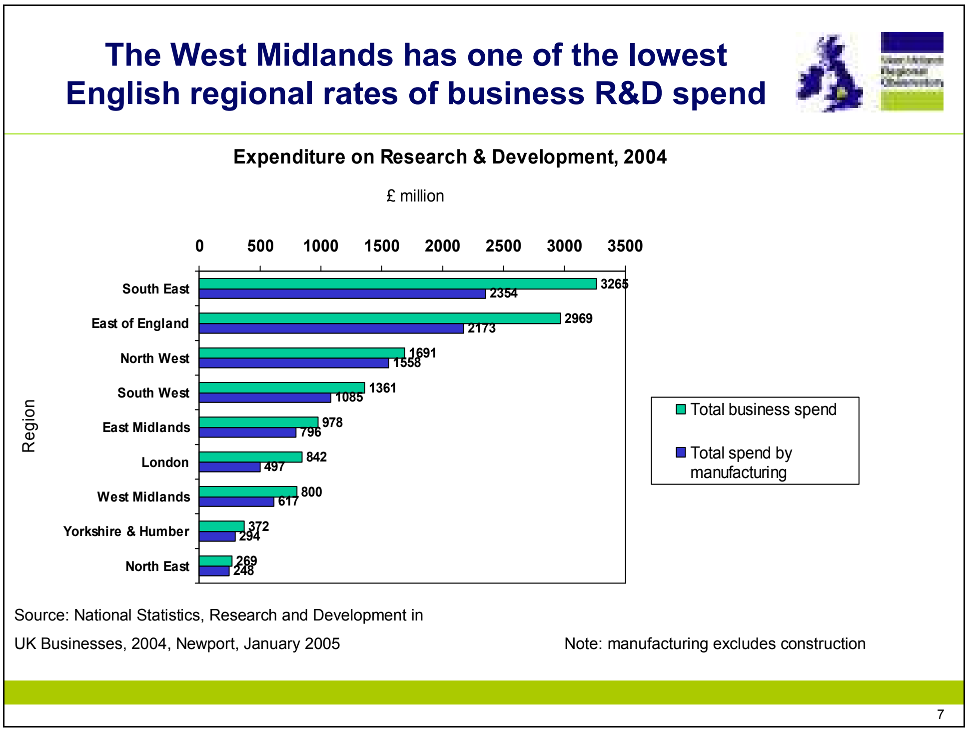
3.4.1 *West Midlands business R&D and cross-regional contrasts*

The OECD inter-regional analysis of innovation performance found that the expenditure of West Midlands businesses on R&D in 2000 was mediocre, at £108 per head, compared to an English regional average of £218.[100] In 2004, the picture was rather similar, with West Midlands businesses spending £800 million on R&D, compared to £978 million in the East Midlands and £1,691 million in the North West, far behind the South East at £3,265 million, but considerably greater than the North East or Yorkshire and the Humber. The English regional average was £1,394 million. The picture was little better in relation to manufacturing alone (Figure 11, overleaf).

National statistics on business R&D between 1995 and 2002 indicate that the trend for R&D as a percentage of total workplace Gross Value Added was generally downwards in the West Midlands across all industries, though level for the UK on average. Furthermore, manufacturing R&D in the West Midlands in these years increased by only 0.3% compared to 1.8% for the UK overall. In 2002 it reached only just over half the level of the UK average (3.8% compared to 6.9%).[101]

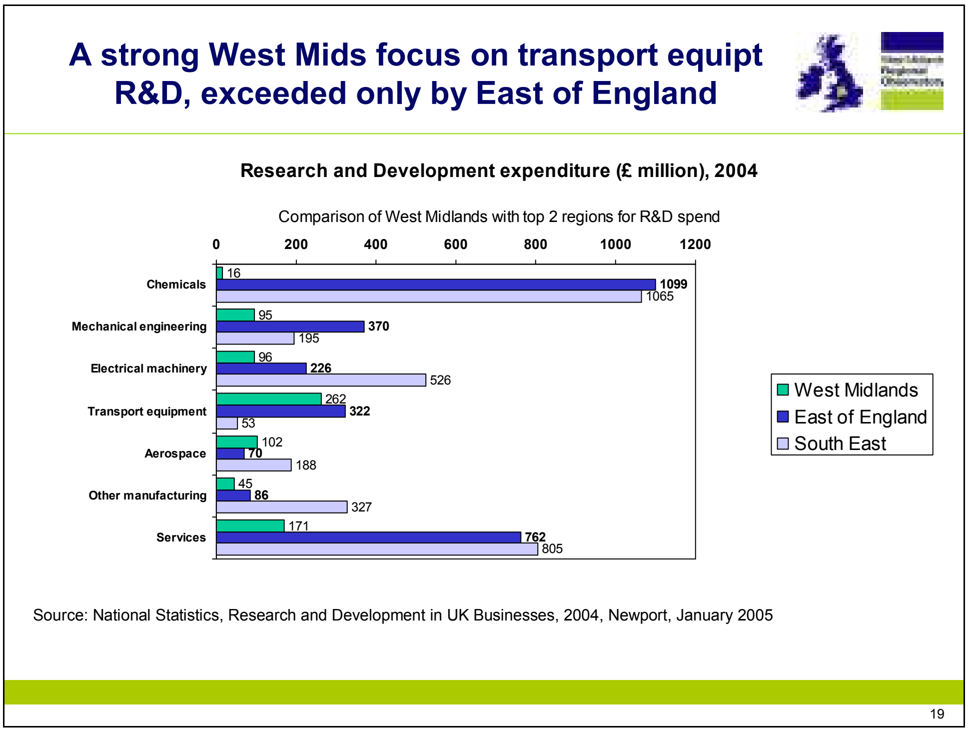
[100] OECD, Local Entrepreneurship Review Series, 2004
[101] Lad (DTI), Regional Competitiveness & State of the Regions, April 2005, citing ONS

Figure 11: Business expenditure on R&D by Region, 2004



Total Research and Development expenditure by UK businesses in 2004 was £13,504 million of which over three quarters (£10,352/77%) was invested by manufacturing industries. The regional breakdown by broad product groups (manufacturing only) is given in Appendix 5 and a summary showing the West Midlands compared to the leading two regions for R&D spend – the South East and East of England – is shown below (Figure 12). This reveals that R&D spend by West Midlands businesses is generally far exceeded by these major players, except where transport equipment is concerned, for there the West Midlands devotes the second highest spend on R&D of all the UK regions, exceeded only by the East of England. Aerospace R&D is also significantly higher in the West Midlands than most other regions except for the South East and South West.

Figure 12: West Midlands R&D spend by broad product groups contrasted with the top two UK regions, 2004

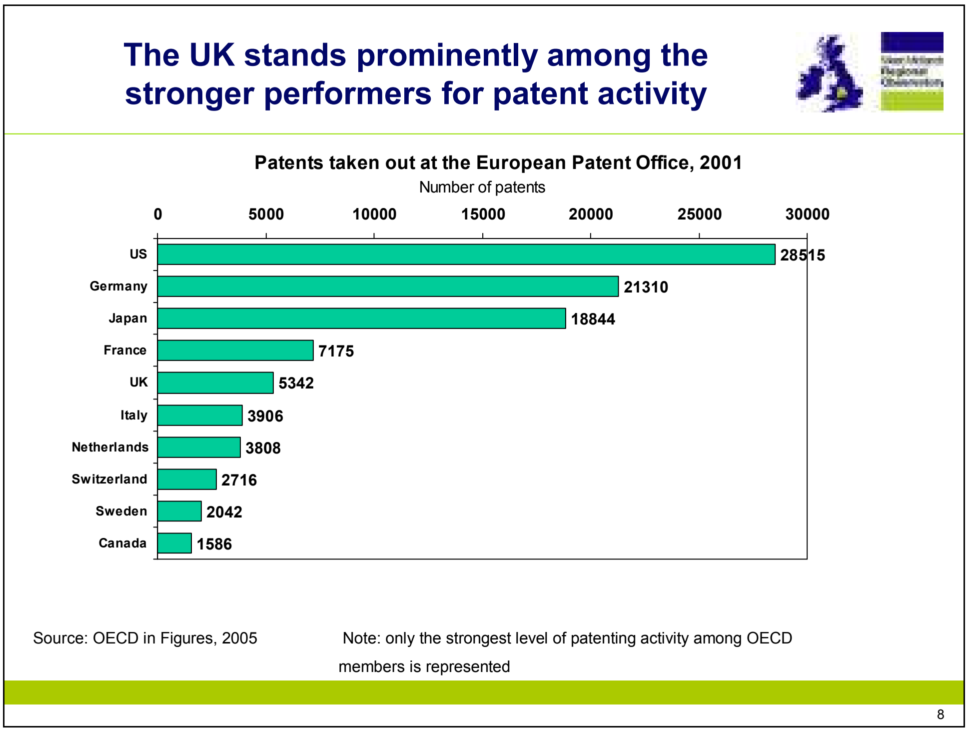


3.4.2 Patenting and other forms of innovation protection: the UK and international contrasts

Patenting is an important measure of innovation activity. Among OECD members the UK features prominently among the stronger performers outside the United States, though the latter – as well as Germany and Japan - far exceeds any of them in patenting levels (Figure 13).

In relation to patents taken out at the European Patent Office in 2001, the UK (at 5,342) was well behind Germany, France and (particularly) the US and Japan, but ahead of the Netherlands, Sweden and Switzerland and other member countries. Nearly one quarter (23.3%) were taken out with foreign co-inventors. Substantially more than one half of these patents (1,968) were for ICT, over one sixth (341) were for biotechnology. For patents jointly taken out in Japan, Europe and the US (i.e. triadic patent families) the UK was again 5th highest performer among the OECD countries in 2001 with only France, Germany, Japan and the US itself ahead on patenting levels (see Appendix 6).

Figure 13: UK Patenting Activity in the OECD context



3.4.3 The Ratio of UK R&D to Patenting Activity

It is clearly important that the R&D undertaken by firms realises new products and processes and that the intellectual property that this represents is protected. One measure of the fruition of R&D is the ratio of this to patenting activity.[102]

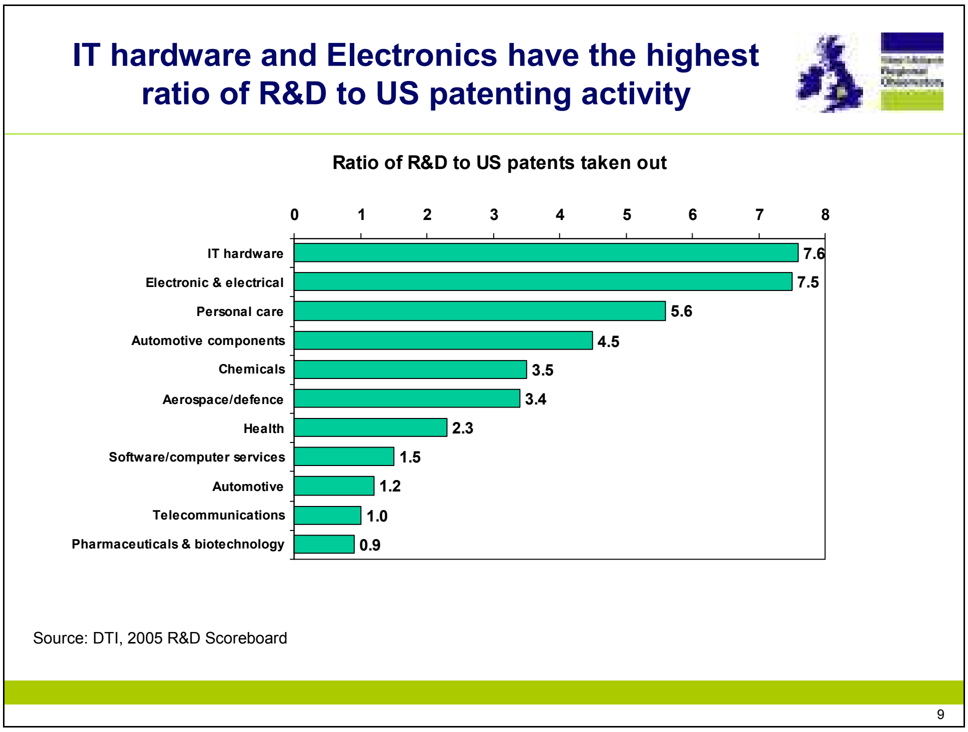
The patent to R&D ratio by sector (but not by the UK alone) shown in the DTI's 2005 R&D Scoreboard indicates that IT hardware constituted the highest level of US patents by R&D activity (7.6), followed by electronic and electrical products (7.5). Automotive components was also fairly prominent (4.5), similarly chemicals (3.5), and aerospace and defence (3.4) (see Figure 14).

Alternative means of intellectual property protection, such as registered design and trademarks, show the UK in the top tier of EU and OECD comparator countries. The UK Innovation Survey 2005 indicates that confidentiality agreements are more likely than trademarks, copyright or patents. However, the OECD data reveal that, although many highly successful UK businesses are also active in sectors where traditional measures of technology development, such as patents, are less prevalent, they appear

[102] It is not an absolute measure because some patents are more important than others, and patenting activity can vary according to each firm's policy on patenting.

to be mainly in sectors like financial services and creative industries rather than those with a strong scientific and technological base. [103]

Figure 14: The patent to R&D ratio by sector for US Patents, 2004



The West Midlands is reported to have a strong record of patent activity compared to other UK regions.[104]

3.5 Research and technical employment in UK businesses

OECD data confirm the UK's position near the bottom among member countries in terms of the numbers of professionals (including scientists and engineers) and technicians in the country's labour force, and below the EU25 average.[105] It is postulated that the greater use of IT in R&D activities explains the need for fewer technicians and support staff per full time equivalent researcher, but this is counteracted by reports that researchers *do* draw attention to the lack of these staff in

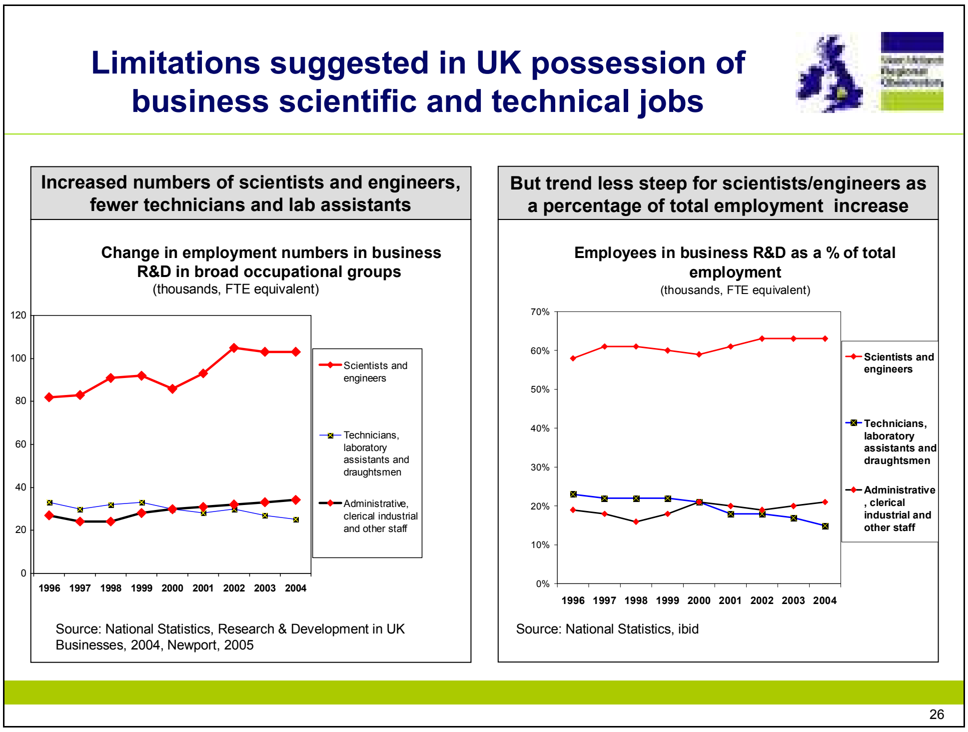
[103] HM Treasury, Lisbon Strategy for Jobs and Growth, 2005, citing DTI economics paper 11; the 2004 UK Science and Innovation Investment Framework; a 2003 review of business-university collaboration; and the UK Technology Strategy launched 2004.
[104] AWM, Manufacturing in the Regions: West Midlands, undated (2003)
[105] OECD Science, Technology and Industry Scoreboard, 2005. Exact percentage not given, but approximately 25%.

laboratories. Women are under-represented in R&D activities across the OECD area, particularly in businesses. They are also fewer among foreign scholars in higher education.

There is a move towards the international recruitment of highly skilled people in science and technology, with the possibility of a brain drain ensuing, at least in developing countries. The UK is a major beneficiary and has one of the highest levels of highly skilled workers from non-OECD countries, together with the US, France, Portugal and Spain.

The perception of a seriously under-resourced scientific and technical workforce is augmented by the data on employment change in scientific, engineering, technician and laboratory jobs between 1996 and 2004 (Figure 15). Although the trend for scientists and engineers is upwards, when looked at as a proportion of total business employment the rise is much flatter, indicating that scientific and engineering jobs have not increased at the same rate as overall employment. It is also of concern that the employment levels of technicians, laboratory assistants and draughtsmen have decreased.

Figure 15: Employment change in scientific, technical and administrative occupations, 1996 – 2004



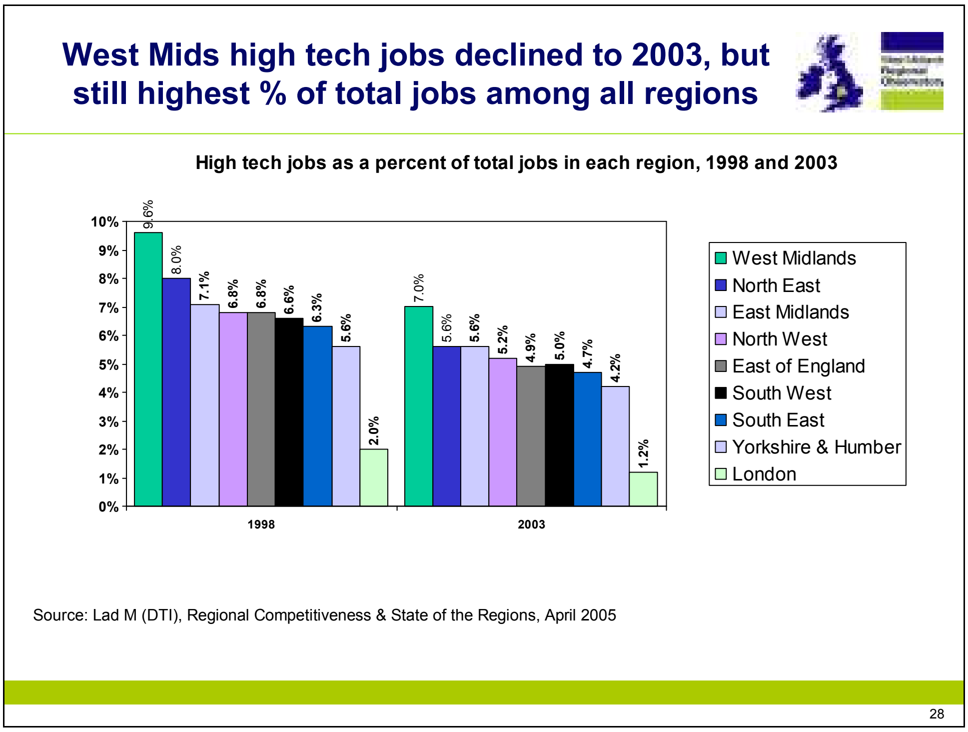
3.5.1 West Midlands employment in high and medium technology sectors

Between 1998 and 2003, West Midlands jobs in the high and medium-high technology sectors decreased from 220,039 to 162,128, representing a fall from 9.6% of total employment to 7%.

As Figure 16 shows, these jobs represented a higher proportion of all the Region's jobs in 1998 and 2003 compared to other regions.

However, it is important to note that the data do not provide a full picture of the occupations or type of work that underpin this result. Nor, without relating this to innovation indicators, can any significant correlation be assigned between high tech intensity and the Region's innovation activity level.

Figure 16: Employment in high and medium-high tech industries: regional contrasts 1998 and 2003



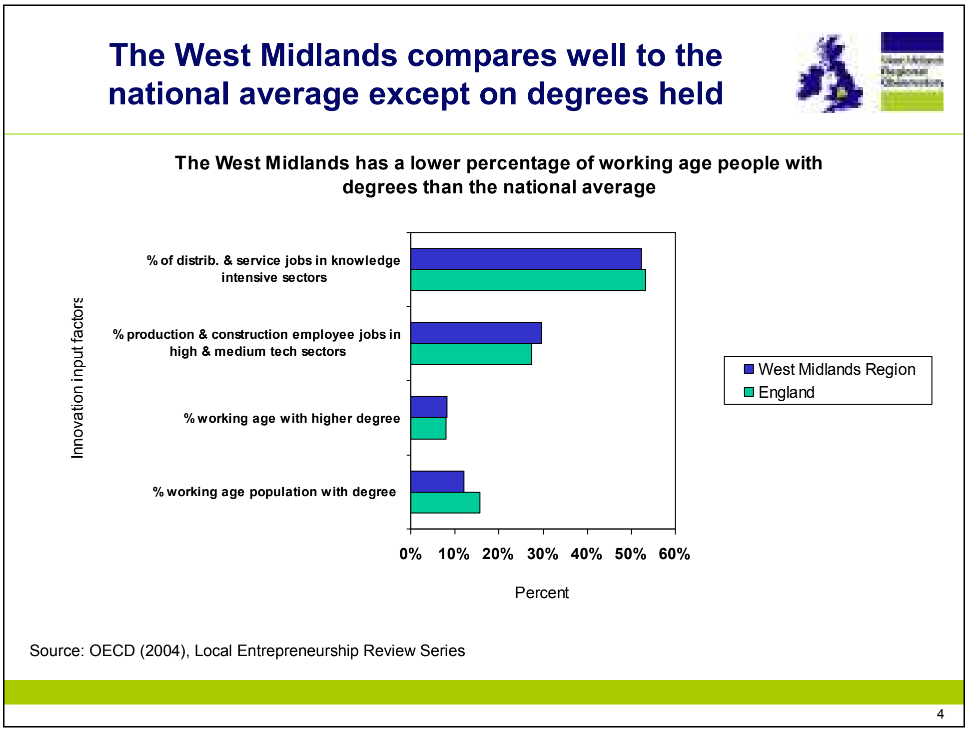
3.5.2 Graduate skills and knowledge-intensity

The OECD looked at innovation in the West Midlands, setting out the Region's performance in its inter-regional and national contexts. The data showed that the West Midlands compared well against other regions in 2003 in relation to the percentage of production and construction jobs in high and medium technology sectors, (29.6% compared to an average for the English regions of 27.3%) (see Figure 17).

The OECD observed that the lack of graduates in the West Midlands (11.9% of working age population compared to an English regional average of 15.6%) "...has an effect on the nature of innovation in firms and across the region." This is because graduates tend to drift to London and the South East, where lies the real knowledge intensive presence.[106]

It is also worth noting that the mobility of higher degrees is considered to be a feature of the UK research sector, since foreign students represent more than a quarter of all doctoral enrolments in the UK.[107] Certainly, most of this talent will depart once their studies are completed, representing a significant diminution of the nation's knowledge base and research capability across the regions, including in the West Midlands.

Figure 17: Higher qualifications held: English regional contrasts



3.6 Entrepreneurship

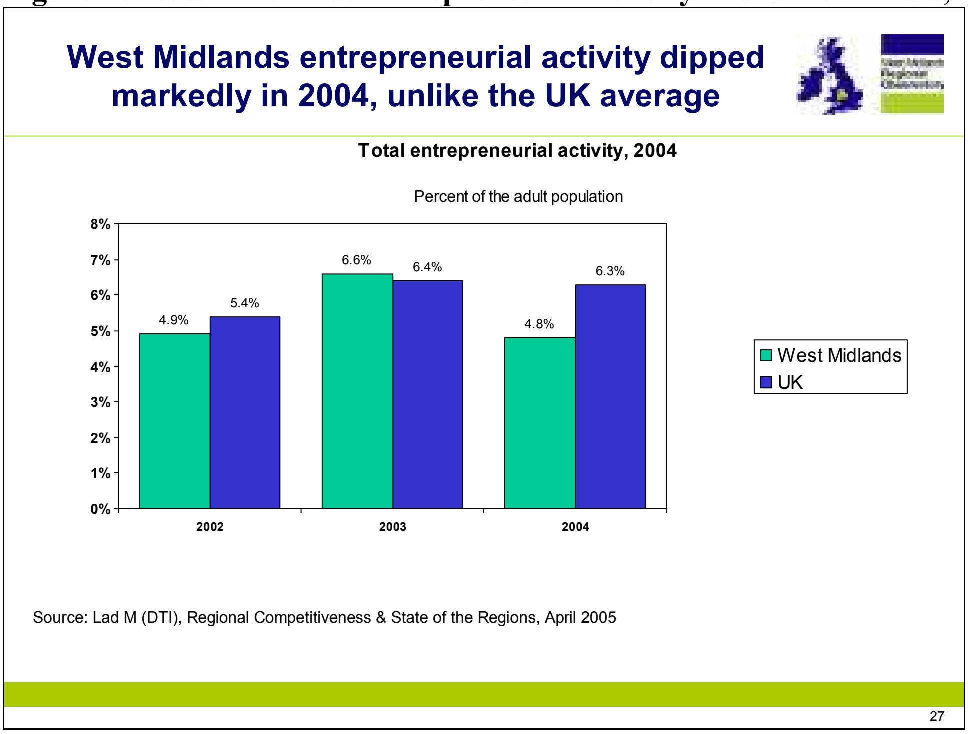
Entrepreneurship is assessed as the proportion of the labourforce actively involved in starting a business or who own or manage a business that is less than 42 months

[106] OECD defines knowledge intensity as measured by R&D ratios in service sectors, and technology intensity is measured by the R&D ratio of a manufacturing sector.
[107] OECD Science, Technology and Industry Scoreboard 2005

old.[108] The OECD looked at the West Midlands Region in the context of OECD member countries.[109] By total entrepreneurial activity, the Region emerged as an average performer in a country which is itself an average performer internationally. Although total entrepreneurial activity in the West Midlands Region was 6.6% and this was slightly above the UK average, the UK was ranked 14th out of 23 countries, and the estimated rate of total entrepreneurial activity in the UK was only 5.4 compared with an OECD average of 7.2.

This finding is borne out by the Global Entrepreneurship Monitor UK 2004, which creates even more concern due to the downturn in entrepreneurial activity recorded for the West Midlands between 2003 and 2004. In 2004, 4.8% of the Region's adult population were entrepreneurially active (against a UK average of 6.3%), compared to 6.6% in 2003 (Figure 18).

Figure 18: West Midlands Entrepreneurial activity and UK contrasts, 2002 – 4

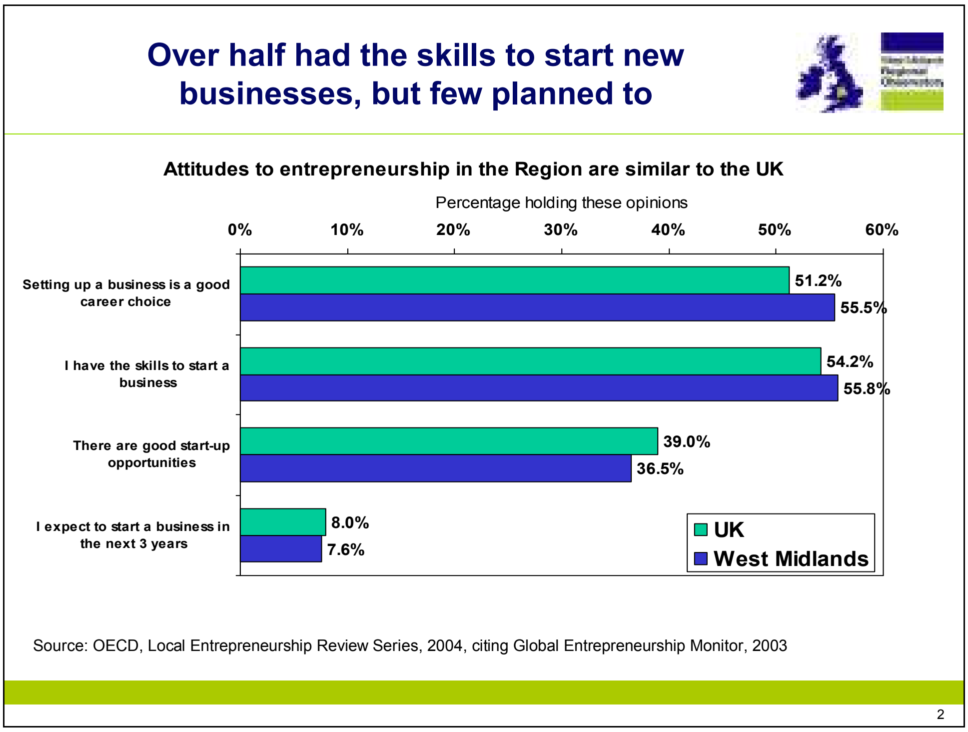


It is important to question what the underlying reasons might be. Attitudes to entrepreneurship in the West Midlands are broadly similar to the UK overall (see Figure 19).

108 OECD Local Entrepreneurship Review Series, August 2004
109 OECD: United States, Canada, Australia, New Zealand, United Kingdom, Japan, Korea, Mexico, Iceland, Ireland, Norway, Switzerland, Hungary, Denmark, Italy, Germany, Spain, Netherlands, Finland, Poland, Sweden, France, Belgium

OECD figures presented in Figure 18 show that just over half (55.8%) in the Region considered that they had the skills to start a business (54.2% in the UK), but fewer in the Region (7.6%) expected to start a business in the next 3 years than in the UK (8%), and fewer in the Region (36.5%) thought there were good start-up opportunities than did people across the nation (average 39%).

Figure 19: Attitudes to entrepreneurship: UK and West Midlands contrasts



Increasing the rate of entrepreneurial activity in the West Midlands is a major policy objective, given its importance for the: "...creation of new jobs and incomes, the adjustment to economic change, the shift towards growth activities and the stimulation of innovation and local competitiveness." [110] The policy objectives propose tackling the fragmentation and limitations of support delivery including the barriers to inter-agency collaboration. Support is undertaken by a range of public sector organisations including the RDA, Government Office and Chamber, and delivered through various initiatives targeting different groups. Stimulating entrepreneurship has a strong knowledge and skill development dimension, and includes:

- Start-ups, as well as modernising existing SMEs.
- General workforce development.

[110] OECD Local Entrepreneurship Reviews: West Midlands, UK, Executive Summary, August 2004

- Technology entrepreneurs.
- University graduates.
- Entrepreneurship in distressed localities, and in
- Social groups under-represented in business ownership: women, and black and minority ethnic groups.

As understanding grows of the characteristics of entrepreneurship and the needs of different groups it will be important to reconsider the extent to which the support and delivery framework and mechanisms meet those needs and the policy objectives. It will also be appropriate to consider the target groups themselves and how best to adapt the knowledge and skill development and support for each.

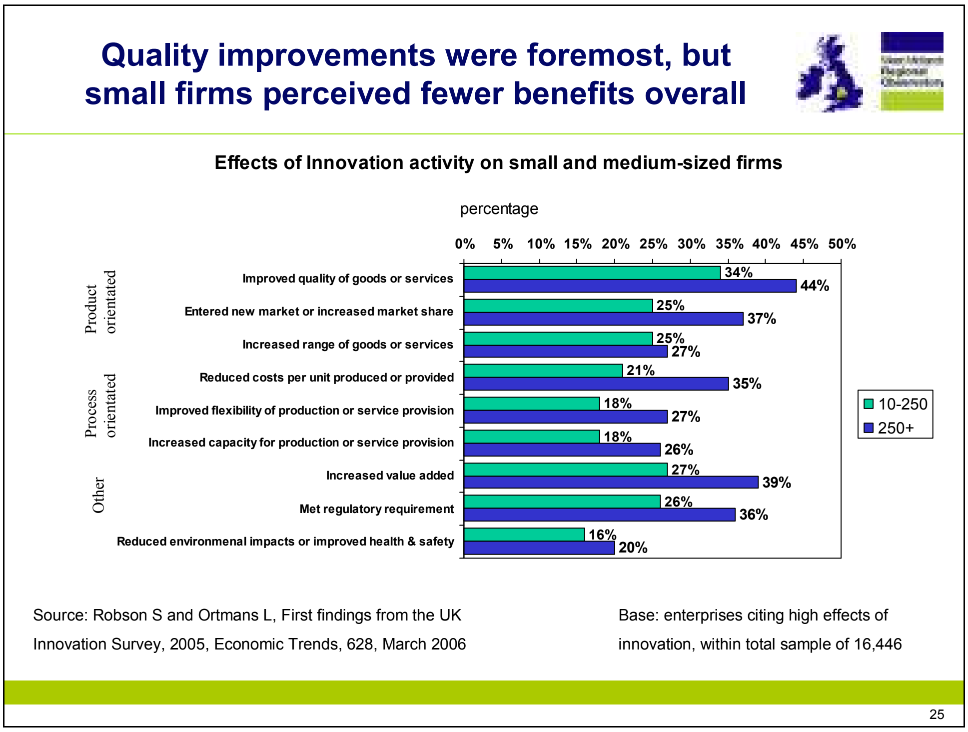
3.7 The performance effects of innovation activity

The UK Innovation Survey 2005 showed that, during 2002 – 2004, wider performance-related benefits to businesses of innovation activity were signified by one third (34%) of smaller firms, and 44% of larger ones, who improved the quality of their goods and services.

Other important effects included:

- Increased value added (27% smaller firms, 39% larger firms).
- Better ability to meet regulatory requirements (26% and 36%, respectively).
- Entered new market or increased their market share (25% and 37%).
- Increased the range of goods or services (25% and 27%).
- Reduced the costs per unit produced or provided (21% and 25%).
- Improved the flexibility of production or service provision (18% and 26%).
- Increased capacity for production or service provision (18% and 26%).
- Reduced environmental impacts or improved health and safety (16% and 20%).
- It is striking that, for all these criteria, smaller firms experienced less positive effects from their innovation activity than larger ones did (see Figure 20).

Figure 20: Effects on UK businesses from their innovation activity, 2002 – 2004



3.8 Barriers to innovation

Although smaller firms invest less on innovation-related activity, it is important to query whether there are other underlying factors at work in addition to the obvious financial limitations. Some insights are available through the UK Innovation Survey, which shows that, during 2002 - 2004:

- Smaller firms perceived UK and EU regulations as posing greater barriers to innovation activity than larger firms did.
- Smaller firms were more likely to find lack of qualified personnel was an issue.
- Smaller firms were slightly more likely to consider that the dominance of their markets by established enterprises posed a barrier to engaging in innovation.

3.8.1 Barriers to innovation in the West Midlands

The Framework for Regional Employment and Skills Action[111] set out the problems facing the West Midlands:

- The low levels of basic, intermediate and management skills.
- A workforce with below national average higher level qualifications.
- The problem of retaining graduates.
- Access to higher education in rural areas.
- Below average levels of self-employment, and
- Skills shortages in the public sector and construction industries.

A recent assessment of the challenges for the West Midlands' development of a knowledge-driven economy enabling 'smart' growth described the Region (like the North) as possessing pockets of high human capital "underdeveloped" because:

- Business drivers of the knowledge economy appear weak. Few business sectors are knowledge-intensive. High skills are concentrated in a few sectors, particularly in the public sector, like health and education.
- The graduate labour pool is relatively small, and skills poverty affects nearly 40% of the workforce.[112]

Variation does occur, though: the Birmingham-Coventry-Warwick triangle of technology-based manufacturing and knowledge-based business services contrasting with the Black Country which needs particular support in rising to the challenge of building a modern knowledge economy.

These persistent limitations severely curtail the potential for innovation and growth in the West Midlands. Policy objectives are focused on tackling these limitations on various fronts, including by workforce development, management skills, and SMEs' greater engagement with e-learning. The capacity for SMEs to manage change and the development of an integrated approach to support innovation and knowledge transfer into the business base are among key actions. Young people, women and minority ethnic communities receive particular emphasis in respect of further developing the West Midlands' enterprise culture.[113]

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[111] Advantage West Midlands, Delivering Advantage: The WM economic strategy and action plan 2004 - 2010; OECD (2004).
[112] Hepworth et al, undated report (c.2005/6) for the DTI
[113] Advantage West Midlands, Enterprise Strategy, 2003

Clearly, it is important to undertake further investigation to clarify SMEs' perceptions and experiences of, and available solutions to, barriers to innovation by obtaining more in-depth information on the innovation process, where the limitations and blocks occur, and the characteristics of these. At the same time, it would also be useful to look at what works well, and why, and how this good practice can be transferred to, and mirrored by, firms that encounter problems, either in getting started or mid-way during the process.

PART TWO: SECTOR ANALYSES

Part Two gives an overview of innovation skill needs and issues in:

- Manufacturing
- Automotive
- Medical and Healthcare Technologies
- Construction and the Built Environment, and
- Information and Communication Technologies (ICT)

The size and spectrum of the manufacturing sector is such that a single chapter cannot expect to do it justice. As the R&D and innovation skills context for manufacturing was given in chapters 2 and 3 and it is not necessary to duplicate this in chapter 4.

The automotive side of manufacturing is discussed in chapter 5, and readers will find more on performance and technological innovation in that chapter.

Transport equipment is a subsector within manufacturing, and businesses engaged in materials processing, electrical and electronic equipment production frequently have a diversified customer base which includes transport technologies. They are therefore often a part of the automotive supply chain. The issues and needs discussed in relation to manufacturing are also those which are pertinent to the automotive industry.

For a more general skills analysis of the manufacturing sector readers could refer to the Regional Skills Partnership (RSP) Manufacturing Report completed by the West Midlands Regional Observatory in 2005 (wmro.org). Also on the WMRO website is the cross-cutting issues paper on management and leadership skills, and others were in preparation by the Observatory in Spring 2006 on entrepreneurship and the knowledge sector.

A recent RSP Construction Skills Profile for the West Midlands Regional Observatory was completed by this writer. This report is available on the WMRO website. The discussion here makes substantial reference to the findings of that report.

4 MANUFACTURING

4.1 Introduction: Manufacturing

Despite its decreasing employment size, the West Midlands remains the greatest concentration of manufacturing among the English regions, with 415,799 people working in a wide spectrum of industries in 2003, representing just under 15% of the total manufacturing workforce across England. The largest manufacturing contingents on a sub-regional level are in Birmingham (72,771 employees, 17.5% of the West Midlands total) and Staffordshire (56,349/13.6%).

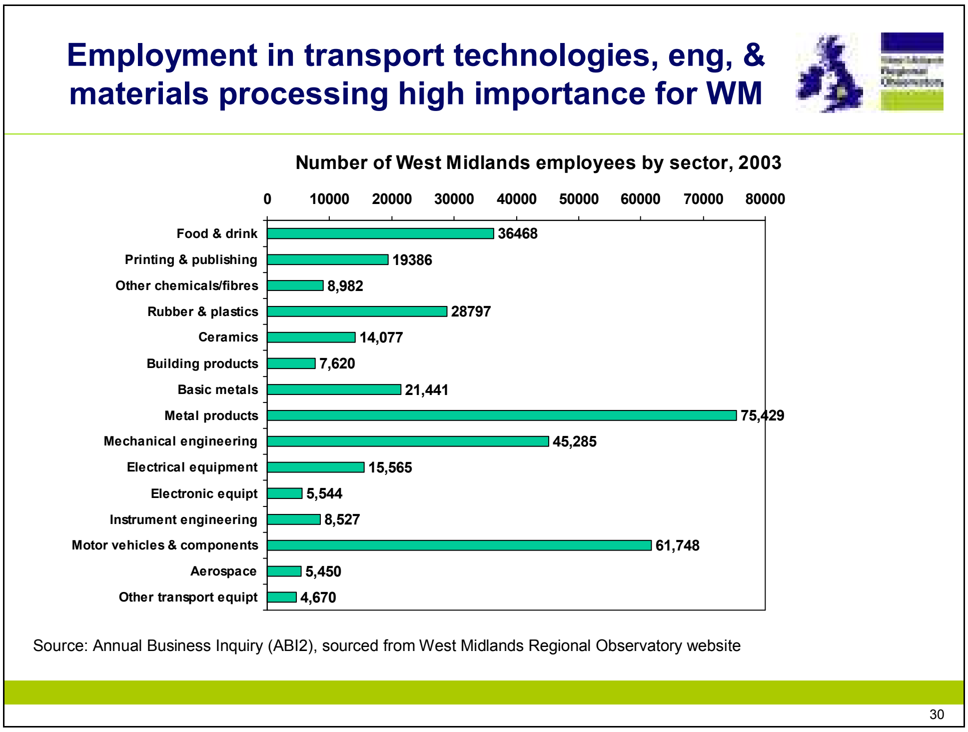
The manufacturing industries consist of:

- Food and drink
- Paper, pulp, printing and publishing
- Basic metals
- Fabricated metal products
- Rubber and plastic products
- Other non-metallic products (including ceramics)
- Transport equipment
- Electrical and optical equipment
- Machinery and equipment not elsewhere classified

The manufacturing sectors most significant to the West Midlands economy are evident in Figure 21 which shows key sectors by employment size. This confirms the primacy of motor vehicles and components and other engineering industries. Also highly important is materials processing, notably metal products and rubber and plastics. The ceramics cluster centred on Staffordshire is of international significance though shrinking in employment size. The Region also has significant levels of food and drink production, and printing and publishing. The jewellery cluster employing

2,597 people, although of international renown, is too small to feature among key sectors by employment size.

Figure 21: West Midlands manufacturing employment by sector, 2003



Note: key sectors are shown. For total sector breakdown refer to wmro.org

4.1.1 Achieving Global Competitive Advantage through Innovation

Research into successful innovation by middle market manufacturers undertaken for The Manufacturing Foundation (2003) established six Innovation Essentials:

1. Inspirational and tenacious team leadership by the whole management team, who establish a clear strategy and are able to maintain momentum. They pursue a strategy planning process, use innovative staff communication methods and key performance indicators to measure progress, and achieve buy-in to the strategic vision.

2. Collaboration on breakthrough products and processes. Enthusiastic collaboration with a wide variety of organisations for product development and/or design for manufacture, in order to compete in global markets.

3. Hard work, delivering incremental improvements. Performance improvement – continuously – by cost reduction, quality improvement, process efficiency, operational effectiveness, time compression, service improvement using tools like 6 sigma, lean manufacturing and kaizen.

4. Enthusiasm for building deep relationships. With customers, suppliers and others, through networks and co-operative structures for R&D, process and product development, improvement programmes, market development, sales etc. Early involvement and integration of suppliers in the development process.
5. Empowered and committed people. Developing people to have the authority to take decisions, so devolving decision-making. Changing the corporate culture throughout the company. Team working. Increasing workforce skills. Developing middle managers and improving health and safety.
6. Effective use of technology, not just investment in new technology and R&D. Capital equipment investment is strategic.

Improving leadership performance was identified as a crucial factor. The strong link is noted between the ability of companies to innovate and their use of business improvement techniques to raise their performance. Strategic planning, leadership style, project management and the use of key performance indicators delivered the greatest impact on performance. Benchmarking was not particularly important.

4.1.2 Achieving an Appropriate Market-led Innovation strategy

"There is no innovation strategy that is appropriate for all companies in all situations" warns a US Innovation Network paper. "Innovation effort is valuable if it is properly targeted." [114] What is needed is a method to analyse the organisation's business environment, develop a customer-focused innovation programme, that takes technological progress into account, that looks at the potential impact of competition, and assesses the company's capabilities. To determine the most appropriate innovation strategy for the company, it is recommended that the following factors must be considered (see Text Box 8).

[114] Schumann and Prestwood (undated), Innovation Network website, accessed March 2006

Text Box 8: Determining the most appropriate innovation strategy

- What is the time frame that constitutes the initial 'window of opportunity?'
- What is the market the company chooses to serve?
- What are the current and future needs of the customers in the marketplace? Is the market relatively satisfied with present products and services, or is there pent-up desire for new capabilities?
- Who are the real competitors and what are they doing? Are present competitors stressing small advances, or are they emphasising more basic changes? What competitive responses can be anticipated to meet the needs of customers? Are new and unexpected competitors emerging?
- What are the key technologies in the marketplace? Are they mature, developing, or in a state of transition? What are the underlying supportive and enabling technologies? What is their status? Are there any new technologies that could affect the marketplace?
- What resources exist for innovation efforts? What is the state of the company's personnel, facilities, funding, intellectual property, and strategic alliances?
- Who are the company's stakeholders? What are their needs, hopes and desires?
- What are the long and short-term company objectives? Does it seek to be on the forward edge of technology and organisational development, or is it more comfortable with a conservative approach?
- What is the current culture of the company? What type of change does it permit?

4.1.3 SMEs and Innovation

SMEs play an important role in innovation. The OECD[115] note that they are a constant source of renewal of technology, of technological breakthroughs and of competitive pressures for larger firms. These are compelled to innovate to maintain their technological edge, carrying out large-scale innovations and even co-ordinating smaller firms. SMEs face particular problems for innovating and adopting new technologies in accessing funds, markets and skilled labour. Public policies are often perceived as biased against SMEs.

A comparison between innovation-led companies and knowledge-driven SMEs, reinforces the synergies between their key characteristics. Both, for example, have a culture of innovation, and a worldwide focus, acquire specialised knowledge and expertise, and neither competes solely on low cost (Table 3). Indeed, it could be argued that innovation-led and knowledge-driven SMEs are virtually synonymous.

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[115] OECD, Science, Technology and Industry Scoreboard, 2005

Table 3: Characteristics of Innovation-led Firms and Knowledge-driven SMEs

Innovation-led companies... [116]	Knowledge-driven SMEs...[117]
They have a **world-wide focus**, often requiring early expansion overseas.	Are competing on an **international and global** level. Are **globally mobile**. Use local and global networks.
A balanced growth strategy, based on organic growth and targeted acquisitions to enter **new markets** or acquire **critical expertise.**	Have 20+ year development trajectories. Are highly specialised and competitive in **niche markets**. Have highly **specialised expertise** and knowledge. Are experiencing a rising demand for **knowledge and skills**.
A balanced investment strategy.	
Above average investment in market-led research and development (R&D).	Have the organisational capacity for continual and rapid **innovation.**
A focus on what really matters to the customer.	Are competing on value (knowledge) and cost, but not cost alone.
An innovation culture with corporate leadership that expects growth through **development of new products and services**.	Possess mature learning systems and a **culture of innovation.**

4.2 Research and Development

The picture of R&D investment by sector was presented in chapter 3. Figure 10 showed that certain research-intensive industries, such as pharmaceuticals, aerospace and defence, electronics and IT hardware, receive the greatest levels of investment.

UK innovation activity is highest for electrical and optical equipment, and manufacturing not elsewhere classified, followed closely by transport equipment, and fuels, chemicals, plastics, metals and minerals (Figure 7).

The West Midlands has a particularly high focus of transport equipment R&D expenditure, exceeded only by the Eastern region (Figures 12 and Appendix 5, Figure A.4). Otherwise, for manufacturing R&D the Region's record is somewhat undistinguished.

Clearly, there is considerable scope for raising the level of R&D investment in the Region, and this in itself will help to increase the competences of the Region's workforce by creating a demand for skills and augmenting the labour pool.

[116] DTI, Innovation Report, 2003
[117] Hepworth et al, Innovation in the East Midlands Knowledge Economy, 2005

4.3 Skill Issues and Needs for Innovation

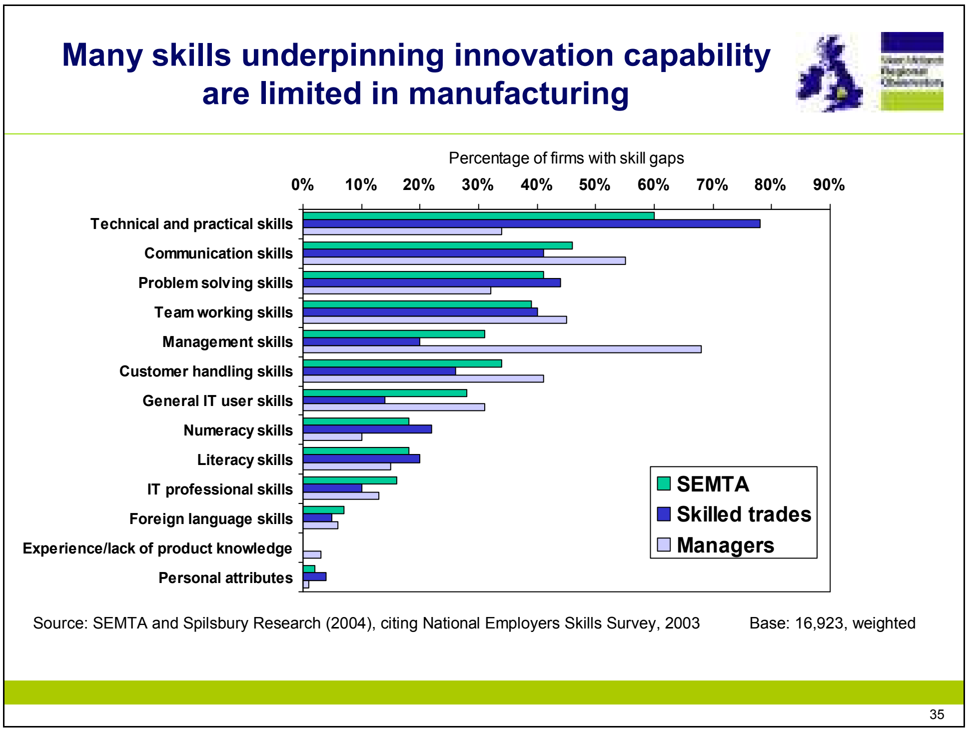
Manufacturing industries are severely hampered by skill inadequacies, both in their workforces, and in the supply of labour. In part this is due to competition from non-manufacturing industries. But it also reflects changes in manufacturing and in employers' expectations of what they want from their workforces. Globalisation has introduced a range of new skill requirements to execute everyday business transactions, as well as engaging in innovation. This means that a higher calibre of employee is needed, with a better level of basic skills, technical competences, and much more besides. We have already seen in chapter 2 that, due to greater levels of team working and multi-skilling, soft skills like communication, adaptability and relationship building are necessary. Workers are seen as key sources of ideas for innovation as well as possessors of technical prowess.

A rather bleak picture on skills is apparent both nationally and Regionally in the National Employer Skills Survey (2003). Over one quarter (28%) of West Midlands companies in manufacturing within the SEMTA remit[118] have skill gaps in their workforces, and 11% of staff within those with skill gaps are not considered proficient in their jobs.[119] The problem is even more acute for firms within the Cogent remit, which includes polymer processors and chemicals manufacturers, where nearly one half (47%) of West Midlands firms have skill gaps.[120]

Recruiting the right skills is problematic, and many of the skills that are vital to companies trying to improve their performance and innovate are in short supply. Not only technical and practical skills, but also communication skills, problem solving, management skills and customer handling skills head the list of skill gaps and shortages for companies in both the SEMTA and Cogent remit. In view of the need for shopfloor personnel to engage in innovation and to take responsibility, skill gaps such as management, communication and problem solving are a major drawback. But it is particularly hard to conceive of SEMTA managers fostering and driving innovation and change by having poor communication skills, being deficient in team working, and having inadequate managerial ability (Figure 22).

[118] Basic metals, metal products, mechanical equipment, electronics, electrical equipment, motor vehicles, ship/boat building, aerospace, other transport
[119] SEMTA and Spilsbury Research (2004)
[120] Cogent and Spilsbury Research (2004)

Figure 22: The nature of skill gaps in the SEMTA workforce, 2003



Lack of staff motivation and the inability of staff to keep up with change are among leading skill issues among workforces. Failure to train and develop their staff is a factor for one quarter of firms (24%). Delays and difficulties introducing new working practices and developing new products or services, attaining quality standards, and problems meeting customer service objectives are among the principal impacts of skill gaps. The shortage of science graduates poses a concern as it makes it difficult for firms both nationally and in the Region to recruit the skills they need.

A continuing problem nationally is the high proportion of low skills and the shortage of intermediate skilled employees in the labourforce. Particularly significant is that these intermediate skills are critical for manufacturing, and include craft positions, machine operators and technicians. Professional level skills are also in short supply, such as design and development engineers, and systems and software engineers.[121]

These drawbacks also emerged during studies of the West Midlands automotive supply chain. Among the survey samples were lower tier metal and polymer processors as well as toolmakers with a diversified customer base including not only automotive but also aerospace, marine equipment, medical devices, controls and instrumentation, electrical equipment, domestic appliances, and many others (see also chapter 5). Firms were preoccupied by skill and training issues, and raised a number of areas where their knowledge and capabilities needed to be increased, such as gaining accreditation to internationally recognised quality standards. Product

[121] Engineering Employers Federation, Bridging the Continental Divide, 2003

development and innovation capabilities, research linkages, and supply chain collaboration on innovation were uppermost. Firms were hindered by their lack of knowledge and expertise as well as limited resources for developing new products and manufacturing processes. They were also held back by the inability to purchase expensive equipment to modernise their plants.[122]

4.3.1 The product development process

Keen interest surrounds the question of what competences, working practices and procedures are best suited to the product development process, in order to give companies that competitive edge technologically, in market entry timing, and at the user interface. Mason (2005) investigated the competitive advantage achieved by certain UK-based plastics processors of packaging, medical devices, printing onto plastic film wrap, and automotive components. These firms demonstrated the positive outcomes of, firstly, R&D effort to develop new products, including improved performance products which were higher specification but also lower cost. This type of product development and worldwide patent protection helped to keep firms ahead of Asian competitors. Secondly, the acquisition of specialist expertise in high-quality and difficult techniques gave a market advantage. Thirdly, developing close relationships with customers also featured among the ingredients of competitive advantage. Fourthly, resources were committed to new product development in areas of developing market demand.[123]

Actions to complement, maximise and protect innovation therefore included:

- Worldwide patenting.
- Continued focus on improving cost-competitiveness by various means, including by location (e.g. of R&D), efficiencies, and product improvement.
- Close customer relationships.
- The acquisition of specialist expertise.
- Focus on a niche and/or emerging market.
- The commitment of extensive resources.

The question is: what impact is the digital age having on the product development process, through the use of computer-based technologies for design, simulation,

[122] Tilson, Plastic materials, processing, innovation and supply chain issues, 2002; Supplier impacts of changes in the contractual arrangements for tooling, 2004; Skill gaps in the automotive supply chain, 2005
[123] Mason, Enterprise Product Strategies... , July 2005

prototyping and testing? Internet use brings into the office the opportunity for market and competitor analysis. It also allows individuals to undertake remote teamworking to exchange ideas, specifications and designs, and to share these with customers, suppliers, users and other partners. This exerts additional skill needs in terms of managing and participating in remote teams, which may have an international composition; and in handling sophisticated software and information databases. It lends another dimension to skills such as effective team building, motivation and negotiation, effective feedback, keeping targets on track, customer relationship handling and communication.

Changes in the product development and introduction process have prompted SEMTA, the sector skills council for manufacturing, to formulate a revised set of 37 standards. It is worth listing these because they detail the individual components of the process and therefore indicate what the technical areas of expertise entail (Appendix 7). They include the full range of tasks from the initial benchmarking and product brief, through product design, pre-production trials and quality assurance to design for manufacture and assembly.

4.3.2 Issues for the inclusion of suppliers in product development

The digital age has important implications for the inclusion of suppliers in product development teams, and the development needs of those suppliers. It poses questions about suppliers' possession of the range of expertise required to participate in product development, and whether there are answers which enable effective resolution. A key issue is whether suppliers have the motivation, the resources (human and financial), and the opportunity to acquire the right technologies and skills to enable their inclusion in customer-supplier product development programmes? For instance, do they have any experience in the market, the product area or the advanced material or technology their customer is developing?

Another major issue is whether their software is compatible. Do they have expertise in using the software or equipment that their customer is using? Are they adept at simulation and computer-aided design?

Manufacturing expertise may also be an issue. Can they undertake process innovation, to enable the manufacture of the end-product or its components? Can they purchase any new equipment necessary and learn how to use it?

A further issue is supplier development. Is their customer willing to work with the supplier to help develop that supplier's expertise to ensure their competences meet the required needs? Are there other sources of help available?

4.3.3 Facilitating change and encouraging innovation

A focus on the technicalities of product development and introduction misses out the human resources element, including the softer skills needed in bringing those new products to fruition.

Advice from Skills4Business for company personnel – including team leaders - on facilitating change and encouraging innovation in their organisations, teams and individual areas of responsibility notes that the main generic skills include:

Communication	Leadership
Inspiring	Thinking strategically
Networking	Analysing
Team building	Problem solving
Reporting	Information management
Motivating	Monitoring
Decision making	Providing feedback
Learning	Reflecting
Valuing and supporting others	Involving others
Risk management	Creative thinking

Innovation leaders must be able to motivate team members and themselves to identify ideas for new products and/or services, and improvements. Leaders should respond enthusiastically to the ideas they receive, providing constructive feedback, encouraging them to make and learn from mistakes, giving ongoing support, overseeing the practical implementation, and ensuring that originators and developers of any ideas which are successfully implemented receive due credit.[124]

The behaviours which Skills4Business consider underpin effective performance are:

- Finding ways to overcome obstacles.
- Encouraging and supporting others to make the best use of their abilities.
- Making time available to support them.
- A curiosity to learn and try new things.
- Balance risk against the benefits that may arise.
- Act within the limits of individual authority.
- Constructively challenge the status quo.
- Recognise the achievements and success of others.

[124] For the full advice see Skills4Business Network, www.ukstandards.org/

4.4 New Materials and Technologies

The government sees it as key that the UK can successfully exploit the next wave of technologies.[125] Continually developing and exploiting innovation in advanced materials, technologies and manufacturing processes is a primary means to ensure a globally competitive position at the forefront of change, to capitalise on emerging industries and to update mature ones. Exploiting 'next generation' technologies is considered to require a focus on advanced materials and resource-efficient manufacturing processes; biotechnology for industrial and healthcare applications; and environmental and clean energy technologies. In the West Midlands, research and technology organisations at the leading edge of technological research and innovation include Qinetiq, RAPRA (polymers), MIRA (engineering), and Ceram Research, and universities including Warwick, Birmingham, Aston, Keele and Coventry.

An essential part of the Technology Strategy is to provide firms with the very highly skilled workforce to manage these technologies.[126] Clearly, it is also important that organisations undertaking R&D at the technological leading edge maintain that momentum, and that the knowledge and expertise they possess is diffused into the industrial base in a way that is easily and speedily accessed and effectively exploited.

4.4.1 Issues about technology and knowledge transfer mechanisms

Great interest and expectation surrounds the potential for university-industry knowledge and technology transfer as a major element in industrial innovation and the growth of spin-out firms in new and embryonic clusters. But Hepworth et al (2005) highlight findings that indicate that local universities are not always the best option for local businesses seeking knowledge transfer. Instead, they may need access to a global university network. Indeed, collaboration and licensing agreements with multinationals are considered to represent key knowledge transfer processes.[127]

Hepworth et al note North American research which describes as "overly optimistic" the expectations of universities as local knowledge producers and state that the commercialisation and spin-out agenda for regional development is "possibly unjustified." Further, the Local Futures report cautions that: "Research has shown that very few institutions make any significant money, and that even in city-regions with successful knowledge economies, universities do not always lead the charge and actually fall in place behind major private sector corporations."[128]

[125] DTI, Technology Strategy, Annual Report 2005
[126] DTI, Technology Strategy, Annual Report 2005
[127] Hepworth et al, May 2005
[128] Hepworth et al, May 2005, citing Gertler (2004)

This finding poses a question about whether research into the reasons and action to address the limitations and blocks may be needed. Could skill needs be a part of the equation? Questions have arisen about the effectiveness of some technology transfer mechanisms from universities. The 2004 A D Little report on the West Midlands highlighted the intellectual property rules and limited professional skill of some university technology transfer functions.

It is important that industrial linkages occur into the science research base, [129] for instance in relation to advanced technologies such as nanotechnology, the generation of hydrogen from biomass and other hydrogen based technologies such as fuel cells, including at Birmingham University, Keele and other West Midlands universities. There is further potential for industrial-research institution linkages for plastics innovation. For instance, research into new technologies, environmental improvements and waste reduction is led by Warwick Manufacturing Group and RAPRA Technology. Ceram Research leads R&D into new ceramics technologies and their applications. The potential for technology transfer from other industries has been identified, including environmental technologies and laboratory analysis and testing.

Concerns have also been raised about the successful transfer from Qinetiq of its vast array of technological know-how to industry.[130] Its cultural shift was thought to have some way to go from its role as a former government defence research agency (DERA) to its present role as a commercial research organisation. Issues were particularly evident in respect of cost and timescale. Its linkages with industry geared to relatively high-volume production, like automotive, were less smooth rather than with high-cost, low volume manufacture like aerospace and defence. Qinetiq, like other (unnamed) major companies, was said to be moving towards strategic relationships with a few universities rather than spreading itself too thinly. Given the conclusion of "ample potential" for Qinetiq and the skills base around it "to become key performance-enhancing assets to the region," any deficiencies in the ability of businesses to connect with its intellectual knowledge and technical expertise in advanced technologies will clearly exert a major drag on industrial innovation. This applies to direct linkages for knowledge and technology transfer, as well as indirect ones via larger collaborative industrial partners, or via university transfer mechanisms. There are also issues about multi-disciplinary linkages.

It is vital that the whole system functions optimally. It is particularly an issue when firms in embryonic, emerging and fast growing industries – like biotechnology, medical devices, ICT and nanotechnology – are likely to be small and resource-limited. What opportunity is there, for example, for SMEs to engage with the Advanced Knowledge Alliance (AKA) which brings together the knowledge

[129] Various writers have noted this point, including A D Little (2004)
[130] A D Little (2004)

providers in the A38 Technology Corridor programme – Qinetiq, and the universities of Aston, Birmingham, UCE and University College Worcester? How successful is any interaction? What skills underpin that success?

4.4.2 Issues about innovating in smart materials and technologies

The concept of the 'intelligent' home or workplace is an IT-intensive, wired up environment where internet connectivity is used for the remote control of equipment. The smart environment requires smart products. However, the Materials Foresight report on Smart Materials for the 21st Century[131] notes that there has been little action in developing smart consumer products. Instead, there is "a market largely unexploited and ripe for attack." This signals that businesses – manufacturers and design/engineering consultancies - are not grasping the product development and innovation potential. Clearly, there are issues about:

- New horizon watch.
- Market appraisal.
- Competitor analysis.
- Technology and knowledge transfer.
- Product development expertise.
- Workforce skills and resources.
- Leadership and management of innovation.

The Materials Foresight report recommends:

1. Awareness building of the new design paradigm through a smart materials outreach programme to individual designers and engineers, such as the EPSRC-funded Appliance Design Network.
2. Development of a focused programme of pre-competitive work on the benefits of smart adaptivity for improved user/product interaction, ergonomics and market segmentation.
3. The development of project teams spanning the disciplines of materials engineering, industrial design, product psychology and manufacturing which integrate all aspects of the required technologies and design.

[131] The Institute of Materials, undated (c.2003/4)

Materials Foresight concludes that companies need to be stimulated to develop such teams as there is a large barrier to the development of smart domestic products due to the near-market and short-term financial view of many companies at the commodity end of this market sector.

Smart opportunities are seen in speciality polymers, coatings, adhesives, composites, inorganic materials, metals, and biotechnologies and materials. Coming closer are new-horizon technologies, notably nanotechnology. The business climate of entrenchment around core product lines evident in the chemicals and materials supply industries, however, is not seen as conducive to mature firms taking the lead in new developments relating to smart materials. Cost and the perceived risk that smartness will affect profits, as well as the long-term horizon of commercial realisation, will be viewed negatively and impose a barrier to innovation. Potential is seen in new start-ups and spin-offs emerging to lead the drive to new products and services using smart materials and technologies.

The Manufacturing Advisory Service is noted as a key provider of advice and support. Organisations like MAS and the DTI also act as brokers and have an important role in encouraging and enabling cross-disciplinary R&D in both the research base and manufacturing industry.

4.4.3 Issues about innovating in alternative future technologies

As already noted, alternative future technologies include fuel cells and nanotechnology. It is worth looking at little closer at action and issues related to these.

Fuel cells have many potential applications where cleaner energy is required. The UK has been slow to invest substantial research and capital resources to this field and the areas of strength are limited. It is paramount that West Midlands manufacturing – such as automotive and other transport sectors, construction and the utilities – grasps the opportunities and speedily. There are issues about skills in research and development, materials science, product prototypes, testing/demonstration, and manufacture.

It is also imperative that the level of research investment, and industrial linkages to research organisations as well as research-based companies are strong. Keele and Birmingham Universities have been engaged in developing innovative processing techniques. The University of Birmingham leads both a European Commission and UK research programme on solid-state hydrogen storage. Firms with West Midlands bases which have significant activities in fuel cells include Johnson Matthey.[132]

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[132] Institute of Materials, Materials Foresight, Fuelling a greener economy, undated (c.2002/3)

Nanotechnology is an umbrella term for technologies which deal with the engineering and applications of very small particles approaching the size of small molecules and atoms. In the Innovation Report (2003) the DTI notes that there will be "exciting opportunities for micro- and nano-technological applications in most industries." Existing applications include self-cleaning glass and advanced pharmaceutical applications. The UK Microsystems and Nanotechnology Network was set up to unite businesses and assist their access to a network of facilities for research, fabrication and prototyping supported by the DTI, RDAs, and Devolved Administrations in conjunction with industry, universities and research councils.

The development of a new Nanotechnology Institute in Birmingham would strengthen the Region as a centre of this field of research[133] and help to catalyse the industrial potential. It is important that the emerging research strengths in nano- and micro-technologies are supported and matched by the development of a skill base which responds to its research, prototyping, testing and commercialisation needs, and supports its development with the range of resources and expertise which will maximise the potential. This requires close attention to identifying the nature of specific solutions and building the skill base needed.

4.4.4 The digital factory

Concern about global competitiveness is concentrating the minds of manufacturers, including those involved in transport technologies. US firms like Ford, and the large French automotive manufacturers, are setting strategic product development goals such as reduced development time in which software uses play a pivotal role. Within the premium automotive brands of Jaguar and Land Rover, UK research is ongoing through Warwick Manufacturing Group. Here, software development and applications occur within the constraints of Ford's global manufacturing strategy which precludes the premium brands taking up certain design options.[134]

Research ongoing in Germany could have relevance for increasing UK and West Midlands manufacturing competitiveness and time to market, including in the automotive sector. Led by the Fraunhofer Institut, this research is focusing on the adaptability of the manufacturing environment through the creation of the digital factory. The University of Stuttgart has established The Stuttgart Company Model, which provides ways to look at problems in the operation and planning of a company to increase its adaptability through:

- Strategies, management and controlling concepts in adaptable companies.

[133] Shields (2005)
[134] Information Iain Cameron, March 2006

- Adaptable planning of structures and adaptive assembly and processing systems.
- Adaptable processes in planning and control.
- The contribution of human resources to adaptability.
- Adaptable information system mechanism.
- Knowledge management in adaptable companies.

The concept of the digital factory denotes the integration, through the use of ICT, of existing or planned products and production, the recording, storage and use of ensuing data, as well as their digital planning and form. The first step is modern tools that solve tasks such as material flow simulation or workplace design.

The Fraunhofer Institute has mapped the higher education institutions and technical centres which offer training courses not only on advanced industrial engineering and digital technologies in manufacturing but which, more specifically, offer training related to *any* aspect of The Stuttgart Company Model. In all, the course offerings would heighten both manufacturing competitiveness skills as well as innovation skills, though none are considered to have a strong offering in terms of digital technologies in manufacturing. It could be useful to benchmark this mapping exercise, as well as to assess the training offering. In addition, the concept of the digital factory is one which merits consideration.

The mapping undertaken by Fraunhofer includes:

Production, engineering and technical training such as materials technology, micro-manufacturing, virtual engineering, simulation, advanced materials, product development, CAD, quality assurance in production, specific techniques including kanban, kaizen, and Just in Time.

Management training, such as business management, production management, human resource management, management practices and psychology, flexible use of personnel, business process design.

Training related to international business operations, such as inter-cultural communication, success-oriented procurement strategies, modern payment systems in logistics, supply chain management, international law, foreign languages and culture, marketing

Training in people skills, such as motivation, coaching, profiling, potential analysis, problem-solving, negotiation skills, team building, co-operation and life-long learning. Some of this training is aimed at team leaders, technicians and engineers.

Only one institution lists innovation management, knowledge management and collaboration, customer relationship management, risk management and business strategy, leadership, and intellectual property rights. This is the Masters programme offered by Festo AG & Co in conjunction with Aalen Technical College.[135]

4.5 Solutions to skill limitations

The barriers that detract from innovation success, or limit the ability to innovate, are significantly composed of skill-related factors. Potential solutions to enable firms, and the research base, to innovate have arisen throughout this chapter.

The Cox Review (2005) of Creativity in Business[136] noted the need for companies to draw on the talents of a flourishing creative community (including product designers and software designers) for innovation to flourish. The creative community also has a responsibility to be able to *respond* to the demands of dynamic and ambitious businesses. The review noted the crucial correlation between the survival of *manufacturing* and the survival of *creative capability* in the UK.

The Cox Review saw unrealised potential in smaller companies in particular and tried to establish what stops them from being more innovative. The findings signal the existence of profound limitations in knowledge and skills about how to access or exploit creativity, and even what it entails or how it could help them grow their business. The solutions (none easy to address) were identified as follows:

- Raising awareness and changing behaviour.
- Providing support and incentive.
- Preparing future generations of creative specialists and business leaders.
- Using the power of public procurement, and
- Creating greater visibility for the UK's creative capabilities.

In view of the poor response displayed by smaller companies to general awareness-raising programmes or business support, it was proposed to reach businesses on a local basis via the Manufacturing Advisory Service. It was also proposed to encourage medium-sized firms to get a greater diversity of skills and backgrounds into the Boardroom, and for a requirement for 'managing creativity' to be included in the Chartered Director syllabus. The Design for Business programme developed by the

[135] Fraunhofer Institut, Integrated training opportunities in knowledge transfer and skill creation in Advanced Industrial Engineering, undated. Supplied by Iain Cameron, March 2006
[136] HM Treasury (2005)

Design Council in conjunction with RDAs (which includes a Design Innovation Service element) was advocated as a tool for encouraging and enabling SMEs to take up design services. This service has a strong skills-raising component through:

- A design-matching service for clients and designers.
- Professional development for business advisors and designers to build regional skills and capacity, and
- Accreditation and training for design mentors and others who deliver the programme.

In the ceramics sector, the Ceramics Industry Forum has introduced masterclasses for ceramics manufacturers as part of the DTI's Adaptation Programme to help them to devise and implement organisational change to adopt a market-led approach which enables them to design new products and quickly bring them to market. The programme is aimed at firms of all sizes (though most are SMEs) in all subsectors including tableware, giftware, sanitaryware and tiles, as well as refractories, bricks, roof tiles, clay pipes and industrial ceramics.

Issues for the ceramics industry are seen as:

- The need to encourage companies to embrace innovation through business processes.
- Accessing design market intelligence and speedy new product development to satisfy customer service requirements.
- Tracking and sustaining manufacturing process improvement.
- Developing employee skills at all levels of the business.

The programme commenced with Design to Sell, and, in 2001, Leading by Design began. This included a range of projects enabling firms to access:

- Technical design support.
- IT capability in rapid prototyping.
- Access to market information and design consultancy.
- Innovation grants to encourage design and marketing innovation.
- A range of seminars, networking events and an international design competition.

Subsequent stages of the programme include sector workforce development plans and the formation of a human resources and training action team.

The aerospace, process, metals, automotive, oil and gas and tourism industries also receive the benefit of the Adaptation Programme, tailored to their individual needs.[137]

It is clear that awareness-raising among industry's managers is crucial to get the message through that cost reduction strategies are not enough to enable them to compete. They must appreciate that they need to innovate. But they need also to understand what innovation entails, that it is not just about developing products, processes and services. It may require them to change their organisations and their working practices and cultures if they are to achieve successful innovation outcomes.

Questions occur about the readiness and ability of mature industries to adapt to market and technological change and to innovate, particularly if narrowly focused within a 'sunset' industry and unprofitable. The skills which are needed to undertake what might be a radical change may not be in place. It might prove too unwieldy to transform existing skills speedily – the innovation leadership skills, different technical skills, nurturing the ideas culture, achieving the adaptability of the workforce and the ability to engage them in new thinking and ways of working. The premises may be unsuitable, the location poor, resources limited. Yet progress can be made if the company is financially viable, and there is the will and determination shared by managers and workforce to diversify, there is an innovation champion and change agents, and perhaps external support, mentoring and partnering. The formation of networks and specialist interest groups is important.

It places a great onus on firms themselves to be motivated and determined to succeed, and to make the necessary change and investment. The West Midlands public sector agencies and private sector organisations have established mechanisms and funding to give support, advice, information, ideas, collaboration, and appropriate training. Examples among many include the Lord Stafford Awards, and the Innovation Networks Programme.[138] Further investigation of innovation skills will indicate where additional delivery could be placed.

The West Midlands has a number of universities and high quality independent research centres and technology consultancies engaged in advanced materials and processing technologies, including RAPRA, MIRA, CERAM, Qinetiq and Ricardo. The general consensus is that considerable further scope exists in drawing on the expertise that such organisations possess, and those of businesses in high performance sectors like aerospace and motorsports, as well as extending and deepening the Region's research base.

There is also a great impetus for skill development and research and innovation activity from national sector development initiatives and research and technological

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[137] For details of other sectors, see DTI/Industry Forum, Industry Partnership, Fit for the Future, 2001.
[138] See, for example, Advantage West Midlands, Making Innovation Real, undated (2005)

innovation through programmes like those led by the DTI including Foresight, and the regional and sectoral workforce development initiatives of organisations such as the sector skills councils, the LSC, and the Regional Skills Partnership.

4.5.1 The 7th Research Framework Programme

In their 7th Research Framework Programme proposals (2007 – 2013), the European Commission notes the dynamic of cluster development, support and encouragement by regional policy and activities and its relationship to research and development at regional level.[139] The 'Regions of Knowledge' initiative is proposed to unlock and develop the research potential at regional level by involving and bringing together universities and other research centres, industry, regional development agencies and other public authorities. Measures will help to:

- Improve research networking and access to sources of research funding.
- Integrate research actors and institutions into regional economies, and
- Strengthen the capacity of researchers to successfully participate in research activities at EU level by:
- Transnational secondments and recruitments of research staff.
- The acquisition and development of research equipment.
- Enabling the full exploitation of research.
- Workshops and other ways to facilitate knowledge transfer.
- The provision of evaluation facilities for researchers requiring independent analysis of the quality of their research and infrastructures.

To ensure a strong and international science and technology policy, strategic partnerships outside the European Union will be made in selected scientific fields by engaging the best scientists to work in and with Europe, including those fields of mutual interest and benefit.

Reform of the science and technology system and improvement of knowledge and expertise entails engaging not only universities and other research institutions, but also society, policy makers, educators and the media, tackling the attitudes, inequalities and ignorance which limit interest and participation in science and technology by means of research projects, studies, networking and exchanges, public events and initiatives, prizes, surveys and data collection.

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[139] European Commission, Commission Proposal for the 7th research framework programme, 2005

Among proposed activities, the 7th Research Framework Programme aims to address:

- Questions of scientific advice and expertise, and the future of scientific publications.
- The broader engagement of both researchers and the public on science-related questions.
- The role of women in research, which has had a low emphasis.
- Creation of an environment which triggers curiosity for science in young people.
- Engage universities in the necessary reforms to face the challenges of globalisation.
- Improve communication between the scientific world and the wider audience of policy makers, the media and the general public, by helping scientists to communicate their work better and by supporting scientific information and media. [140]

[140] European Commission, Commission Proposal for the 7th research framework programme, 2005

5 AUTOMOTIVE

5.1 Introduction: Automotive Sector

For our use of the automobile, there is a growing paradox between increasing mobility and concerns about the impact on the environment of the growth of vehicle traffic and the effects of congestion and increased vehicle emissions, as well as the finiteness of natural resources. The impacts of these concerns are seen in the introduction of new legislation for the automotive industry, as well as design and technological changes - some radical - including powertrain redesign and the development of new fuels.

The principal drivers for innovation and change in the automotive industry are:

- The global market: both as opportunity and the source of fierce competition due to market overcapacity
- Legislation and regulations, e.g.on passenger safety, emissions, recycling
- Lifestyle changes; social and economic factors; end-customer expectations of certain user features and choice
- Improved profitability, performance, efficiency and cost reduction
- Procurement changes, notably online auctions (e-procurement)
- ICT – change along the whole value chain from design to delivery and end-of-life
- Materials and technology changes, including for light-weighting
- The development of new fuels
- Policies, programmes and initiatives giving strategic direction and business support, including information, brokerage, training, grants and capital investment

The West Midlands had a 33% share of the UK's vehicle output in 2004. Prior to the collapse of MG Rover there were at least 1,500 automotive suppliers in the Region, including 17 first tiers. It is estimated that productivity will increase by 31% and employment will fall by 23% for the transport technologies cluster as a whole.[141]

Issues which affect manufacturing also affect the automotive sector, though there are distinctive features present in the automotive manufacturing and supply base, not least due to the dominance of the industry by a few major international players mainly from North America, Japan, and continental Europe. The internationalisation of much of the original equipment manufacturing structure, as well as the first tier - certainly in terms of volume vehicle production, as well as many of the major niche brands - means that the location of a substantial slice of leading edge research and technical development occurs outside the UK.[142] Where decision-making occurs outside the Region, it makes it difficult for subsidiaries to take the initiative themselves to engage in the kind of innovation activity that is outside the sphere of action permitted of them. Their resources may be confined to certain operational areas. Cost-cutting to improve their global competitiveness has forced UK-owned firms to rationalise their operations, sometimes at the expense of their West Midlands R&D bases.

The UK retains a number of important automotive design, engineering and materials research centres, as well as industrial R&D and technical centres of some vehicle manufacturers and first tiers (most notably Ford), and a motorsport sector which is at the forefront of technological advances. The Motorsport Development Board was established in 2003 to oversee efforts to help the UK motorsport sector maintain its position as a world renowned centre of motorsport engineering and innovation.[143] The UK's motorsport industry has turnover of over £5 billion and supports over 3,000 jobs. Its manufacturing and supply chain is particularly focused on 'Motorsport Valley' with a large presence in the Midlands.[144]

West Midlands' strengths also include Ford's Premier Automotive Group (Jaguar, Land Rover and Aston Martin, and the Whitley product engineering centre) and universities like Warwick, Birmingham, UCE and Coventry, advanced research institutes like RAPRA and MIRA, and specialist consultancies like Ricardo. Warwick University's Warwick Manufacturing Group has established a Premium Automotive Research and Development Programme within its International Automotive Research Centre through AWM funding and has a special research relationship with Ford companies. Toyota (just beyond the Staffordshire boundary) has a small research base

[141] Advantage West Midlands, Automotive Cluster Business Plan 2005 – 2008. This estimate was prior to the Peugeot closure announcement of April 2006
[142] Tilson, Automotive industry market and sector context, 2002
[143] Motorsport Industry Association, EEMS: Energy Efficient Motorsport (2005)
[144] AWM, Automotive Cluster Business Plan: Interim Automotive Strategy 2005 – 2008 (Viv Stevens), April 2005

within MIRA. A number of first tiers have R&D facilities in the Region, including Dana, GKN, and Denso.[145]

The international ownership of vehicle manufacturing and first tier automotive suppliers perhaps makes it less easy for lower tier companies to get involved in UK-based customer-supplier R&D, though their diversified supply to other non-automotive sectors increases the potential that other avenues may be open to them for linkages to advanced research programmes if they have the will, the capability and the opportunity to engage with them. AWM asserts that industry collaboration between companies with complementary capabilities needs to be encouraged to facilitate technology exchange. It is both cost-effective and encourages new product innovation. It is also “vitally important” that the technology developed through research is spun-out to industry via technology transfer to enable automotive companies to undertake new product and process development. The Automotive Cluster Business Plan includes various mechanisms to encourage and facilitate this objective, including the Higher Performance Engineering Programme delivered by Business Links and the Technology Transfer Centres delivered by Accelerate. Accelerate also heads the Networks for Change programme. [146]

Further opportunities for suppliers could arise through changes in the design process, if they have appropriate knowledge and expertise, equipment and resources. Vehicle manufacturers are expected to relinquish to their first tiers the development of large numbers of niche products and special variants, especially for public service vehicles.[147] Accelerate advise that suppliers must have excellent Quality, Cost and Delivery performance, as well as innovation capability, if they are to take advantage of the development of new models by UK-based vehicle manufacturers like Bentley and the Ford brands – Jaguar, Land Rover and Aston Martin.[148]

A D Little note the existence in the Region of a broad and deep body of technological skills. More scope exists for a better linking of, and more responsiveness by, universities in serving industry’s needs. [149] The Foresight Vehicle programme asserts that the UK’s university research base could focus more on road transport. [150]

[145] AWM (April 2005)
[146] AWM (April 2005)
[147] Foresight Vehicle website, accessed March 2006, citing Dr Peter Davies, Innovative Manufacturing Initiative Land Transport (Road Vehicles) programme
[148] Malpass, Fighting back, Accelerator magazine, 9, Autumn 2005
[149] A D Little, Research and Innovation for the West Midlands, 2004
[150] Foresight Vehicle website, accessed March 2006, citing Dr Peter Davies

5.2 New Materials and Technologies

Foresight Vehicle is the primary knowledge transfer network for the UK's automotive industry, involving collaboration between industry, academia and government to identify and demonstrate technologies for sustainable road transport. It includes an extensive R&D programme. The Foresight Vehicle Programme's identification of future technologies [151] has 5 themes:

1. Engine Powertrain
2. Hybrid, electric, alternatively fuelled vehicles
3. Software, sensors, electronics and telematics
4. Advanced structures and materials
5. Design and manufacturing process

These technologies are expected to deliver progress towards the priority environmental, societal and economic goals (see Text Box 9, overleaf).[152]

Key technologies include engine powertrain for hybrid, electric, alternatively fuelled vehicles, the development of fuel supply systems including refuelling using hydrogen or methane; the on-vehicle reforming of methane; and power units including fuel cells, electric motors, batteries, energy storage and regeneration from braking and suspension. The fuel cell is described as "one of the most promising technologies" and hydrogen "a particularly attractive fuel in terms of reducing vehicle emissions." Alternative fuel and engine solutions are not expected to become widely available for at least 15 – 20 years. A variety of competing solutions are expected to emerge. Development must be accompanied by advances in software, sensors and electronics.

A major strand of Foresight research concerns telematics, or intelligent transport solutions. The SLIMSENS project focuses on developing low-cost vehicle-to-vehicle communications in recognition that microwave, radar and broadband technologies are transforming motoring. Satellite navigation, integrated hands-free telephones, electronic parking aids and on-board email systems are increasingly commonplace in-vehicle features. Anticipated technologies include voice recognition systems which enable a range of services including accessing traffic information to on-board shopping, as well as web browsing and video conferencing.[153]

[151] The Society of Motor Manufacturers and Traders, Foresight Vehicle website, accessed March 2006
[152] The Soc. of Motor Manufacturers and Traders, Foresight Vehicle Technology Roadmap, v2, 2004
[153] Department for Transport, ITS in the United Kingdom Today, 2004

Text Box 9: Primary goals for technological innovation

Environment
Global warming, co_2 reduction
Conservation of resources
Health, pollutant reduction
Waste, re-use and recycling

Safety
Accident prevention
Accident effect mitigation

Choice
Vehicle design
Vehicle manufacturing

Mobility
Access and use of the system
Infrastructure development

Security
Vehicle and occupant security
Prevention of vehicle use in acts of terrorism

Economics
Manufacturing cost reduction
Flexible manufacture
Cost of ownership

As diesel and alternative powertrains are growth areas, the potential for hybrid technology development in conjunction with the Japanese vehicle manufacturers is identified as a large growth area. Other opportunities exist in controls and electronics, safety systems, and software development. Rapid prototyping for both vehicle and powertrain components is flagged as "an obvious area of rapid growth." Integrated telematics and lightweight materials – aluminium, plastics and composites – and re-design for these also offer scope. [154] The contributions that are or could be made from the Midlands research and technology development base include electronics, braking systems and control systems. [155] Advanced materials research is also expanding.

To accelerate the uptake of technological innovation, a Centre of Excellence in Intelligent Transport Solutions has been established through a recommendation from the Automotive Industry and Growth Team. The objectives of the Centre include the

[154] Ricardo (2005)
[155] A D Little, Research and Innovation for the West Midlands, 2004

development of integrated solutions from products and projects sourced from the various stakeholders, and a continuing programme of innovation involving the identification of gaps as well as the initiation of new projects. Clearly, UK suppliers must develop the capacity to engage with the development of these technologies and benefit from the market opportunities that telematics growth will bring.

The EEMS (Energy Efficient Motorsport) Project Team is developing ideas for a new approach to motorsport technical regulations that will allow cars powered by different fuels and with different engine configurations to compete equally. The belief is that motorsport can help to accelerate the acceptance of these fuels and green technologies by the general public by showing that their use does not lower vehicle performance.[156]

The End of Life Vehicles directive and the sustainability agenda have introduced considerable emphasis on design for recycling and the necessity to consider the whole value chain from conception to disposal.

Key topics in the automotive sector also include advances in polyurethanes for automotive interior components; products for improving sound management and seating comfort, including further developments in the production of flexible foams for seating; and new processing technologies. The reduction of emissions of volatile organic compounds (VOCs) and other chemicals from polyurethanes is a key issue.[157]

The Foresight Vehicle roadmap does not specifically highlight skill implications of the technology roadmap, but it does state that "Greater co-operation and collaborative knowledge sharing will be required, without compromising competitive advantage."

It is clear that, even by the end of the decade, many changes will be under way which could exert supplier obsolescence if their technological adaptation and innovation is inadequate. In assessing future technological developments, the roadmap notes (among many points) [158] that:

- By 2010 design for manufacture will incorporate new technology benefits at an earlier stage of the development project; and low weight structural materials will enable cheaper manufacture; cheap, environmentally friendly systems will be developed to join steel, aluminium and magnesium without corrosion issues; design and simulation tools will be required for durability, fatigue and so on.
- By 2012 it will be possible to have one chassis with snap-on body modules.
- By 2017 there will be power options – whether combustion or fuel cell.

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156 Motorsport Industry Association (2005)
157 The Learning Grid, March UTECH Europe conference to tackle VOCs from interior materials, 8 February 2006
158 The SMMT (2004). This is a very small extract from the extensive list detailed in the roadmap

- By 2020 the paintshop will be eliminated; there will be reduced time to manufacture for novel technologies; 'low skill' joining technologies; flat pack modularity will mean the ability to make cheap, structural, sealed joints.

CAIR has proposed an alternative car production scenario for a devolved network of micro factories, comprising small local car assemblers/retailers. These would source key components globally, with tailored local sourcing to assemble vehicles attuned to local tastes and conditions. These micro factories would manufacture, sell, service, repair, modify, upgrade, sell used and deal with end of life vehicles.

5.2.1 European Commission Initiative for the Development of New Fuels

In December 2005 the European Commission published a biomass action plan whose aims include the promotion of biofuels in both the EU and developing countries. A further aim is preparation for the large-scale use of biofuels by improving their cost-competitiveness and by increasing research in this field. Biofuels – for example from forestry and cereal, sugar crops - are of interest because they can contribute to a reduction in emissions and can be used in petrol and diesel to lessen the oil (ethanol) content. Those that can be cultivated in Europe also represent an opportunity for entrepreneurial farmers for growing raw materials for biofuels.

To encourage the development of a second generation of biofuels, the EC planned to publish a report in 2006 on a possible revision to the existing biofuels directive. A Commission proposal to promote clean and efficient vehicles is being brought forward. Through its Intelligent Energy Europe Programme, the Commission proposes to support the market introduction and dissemination of proven technologies resulting from the 7th Framework Programme (see chapter 4), where a high priority for research concerns second generation biofuels and the bio-refinery concept.[159]

5.3 Skill Issues and Needs for Innovation

The automotive industry is considered to be ahead of other manufacturing sectors on the implementation of lean manufacturing approaches to embed continuous performance improvement.[160] However, the danger is that a tendency to associate lean manufacturing approaches with severe downsizing, as well as the need to slash their costs, has made firms not only leaner but "positively anorexic." [161] The effects can be felt on the diminished ability to innovate.

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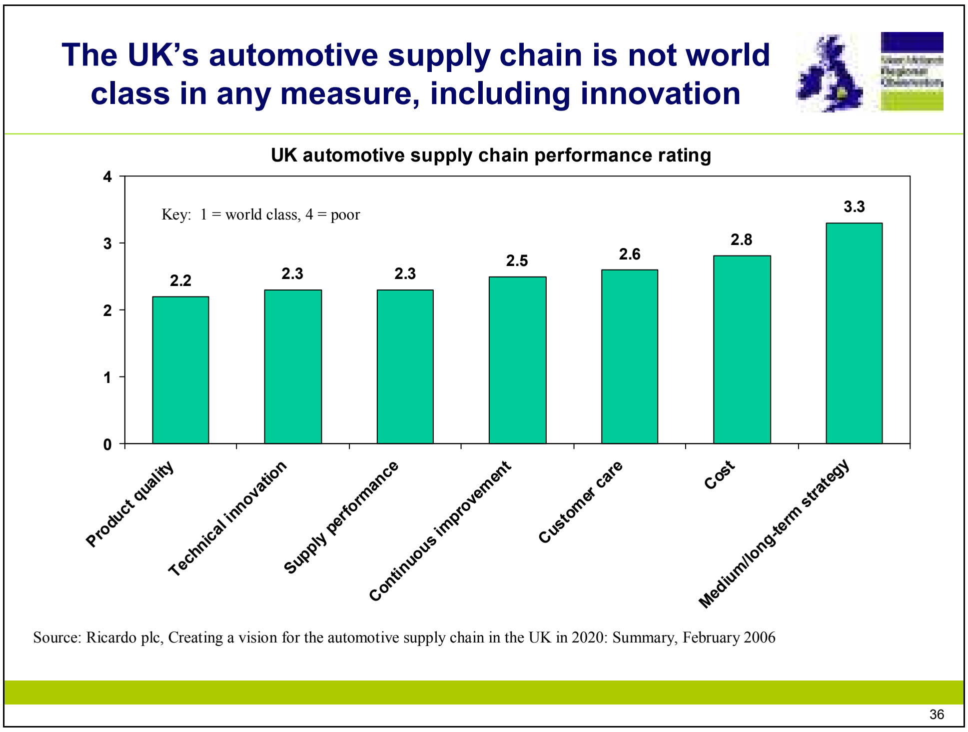
[159]The Learning Grid, EC urges new drive to boost biofuels production, The Learning Grid website
[160] SEMTA, Automotive Sector Skills Agreement: Stage 1, September 2004
[161] Consultation Ian Massey, Foresight, April 2006

Despite the automotive industry's success in implementing continuous improvement techniques, a study of the UK automotive sector and supply chain by Ricardo plc in 2005 showed that the supply chain's performance in no way reaches world class standards (Figure 23). In strategic capability the supply chain is considered particularly poor. It performs best in terms of product quality and technical innovation, though the highest ratings are in the twos, against a one for world class level. Significantly, AWM note that in the West Midlands the automotive sector's investment in plant, equipment and new product development is inadequate, and the adoption rates for the international quality standard ISO/TS 16949 are low.[162]

Comments about the transient nature of management and organisational culture, the poor strategic direction, and the way that continuous improvement is insufficiently embedded into operational practice across their companies have added significance given the identification in the present study of the ways that these can hinder or energise innovation and performance improvement. They also confirm issues raised elsewhere[163] in relation to identifying best practice. It is particularly difficult for lower tier suppliers to benchmark global best practice in their own sphere. The question is posed: "what are these firms benchmarking their performance against? Is it against firms they know rather than acknowledged exemplars?"

Figure 23: Ratings for the UK supply chain against world class performance, 2005



[162] AWM, Automotive Cluster Business Plan 2005 - 2008
[163] Tilson (2005), report for Skills4Auto

SMEs understand what they need to do to compete better, and 'being more inventive' is at the top of a broad spectrum of areas for improvement which include investing in new technology and developing new products. The whole spectrum consists of:

- Be more inventive
- Invest in new technology
- Cut waste and focus on lean manufacture
- Offer more added value to their own employees
- Offer a higher level of customer service, and give more added value to them
- Focus on getting more customer sales
- Locate funding to recruit an extra person and develop new products
- Develop their own internal information systems
- Upskill the whole workforce

The Ricardo (2005) study notes that the largely foreign ownership of the automotive supply chain (certainly at first tier level) is among major contributory factors, since it has: "no incentive to improve UK automotive performance." The lack of UK powerhouses to act as role models (except for GKN) does not compensate. In relation to product quality, this is almost entirely driven by the Japanese vehicle manufacturers. It is apposite to question whether a strong industrial impetus also exists for materials, technological, product and process innovation, since the largely foreign ownership of vehicle manufacture and the first tier means that much of the R&D base is outside the UK.

5.3.1 Engineering and Technical Skill Shortages

The Automotive Innovation and Growth Team's report of May 2002 asserts that: "if they are to be fully competitive, firms need to be able to offer innovative products and to have eliminated waste from all aspects of their operations, not just the production area." [164] Process improvement and development initiatives include SSMT/Industry Forum, Accelerate and the Manufacturing Advisory Service.

There is a perception of a risk to West Midlands automotive firms of missing out on involvement in developing leading edge technologies. [165] "Small pockets" of UK-led R&D and innovation are noted, but also "major gaps in emerging technologies where

[164] Automotive Innovation and Growth Team (AIGT) (2002), Executive Summary, DTI
[165] Ricardo (2005); Tilson, report for Birmingham & Solihull, 2002; A D Little (2004)

the UK does not have the technology, capacity or capability to compete." Ricardo (2005) point to the need for technical skills relating to emerging technologies, products and processes. Concerns have also been raised about the strong retention of the UK's skill base in more standard technologies related to fabrication, like welding (particularly programming robot welders) and machining; also in toolmaking.[166]

Both Ricardo and A D Little see further potential for the engineering industry to take a co-ordinated approach to tackle technical issues. Ricardo advocate that: "The excitement of Formula 1 and the UK's leading position in this automotive sector should be used to stimulate automotive skills development especially in engineering."

AWM has noted the recent growth in outsourcing in other manufacturing sectors that automotive companies supply to, such as aerospace.[167] This represents an opportunity for businesses which have the process quality and product development capability, as well as the resources, to increase their collaborative and supply arrangements for allied vehicle sectors.

The globalisation of automotive production is viewed as an opportunity which needs to be grasped speedily. Overseas linkages such as production alliances and outsourcing introduce technical competences and the need for information and expertise in languages, cultural knowledge, business procedures in overseas countries, regulations, and logistics. Shields (2005) advises that the automotive industry should be touting already to receive the next wave of technical centres when Indian and Chinese manufacturers are looking to establish their European bases. Indeed, the same could be said of any research, technical and production facilities. Clearly, it is crucial to get to grips with the skill implications of this objective, as well as establishing the knowledge assets and relationships which will help to see its fruition.

E-business is growing and evolving, not only for communication and information handling, but also for purchasing, marketing and selling, billing, and despatch, as well as materials resource planning, and documentation for the traceability of products and materials. E-business also has an expanding design and development facet. It is crucial for vehicle manufacturers to be able to transfer designs and other development materials to their first tiers, and that the first tiers mirror them in the technical, ICT and skill investments they make. This also poses a question for the lower tiers SMEs in paralleling these abilities. The lack of experience of SMEs in product development, as distinct from development assistance in manufacturability, further limits their competence for collaboration.[168]

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[166] Tilson, Accelerate report, 2004; Tilson, report for Skills4Auto, 2005
[167] AWM, Automotive Cluster Plan diagram, Interim Automotive Strategy, undated sheet (2006)
[168] Tilson (2005)

The Centre for Automotive Industry Research points out that the introduction of new technologies into cars also restructures the supply chain because the need for different competences brings in new companies as suppliers, such as ICT firms and logistics providers. [169] There is a skills issue for new entrants from outside the automotive industry through lacking experience of its requirements and working practices, as well as how best to market their products.

Despite being highly responsive to engineering change, and having a good understanding of engineering and manufacturing best practice, numerous issues remain. The UK automotive industry has a priority need for skills in design engineering, project engineering, specialist computer solutions for manufacturing and, increasingly, in simulation software. The importance is growing of acquiring skills in relation to changing and advanced technical knowledge through incoming products, materials and processes resulting from design and production changes and from the emerging manufacture of alternative powered vehicles. Keeping in step with advances in electronics and information technology is a constant battle. Modularisation, too, introduces fresh challenges in relation to production processes. [170]

AWM note that the West Midlands has a weakness in electronics.[171] The capability of the West Midlands to attract and retain talent is a more general cause for concern.[172] AWM note that although in the automotive industry average spend per employee is near the national average, there is confusion over qualifications, course accreditations, training provision and funding. There is also a need for combined business and automotive knowledge. [173]

Key issues concern the suitability of existing training, and the ability of suppliers to access it, whether by e-learning or traditional methods. Issues have been raised about training materials and the quality of training, for example by internal staff and external providers. For instance, trainers need to keep at the leading edge of developments themselves. Where do people acquire all the skills they need if some are in short supply in the Region, or even in the UK? The cost of training may prove problematic to bear, or located too far away to send people, perhaps for training in new equipment and processes.[174]

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[169] CAIR, Cardiff Business School, website, accessed February 2006
[170] Tilson (2002); Deloitte & Touche and BCT Research Associates, 2001
[171] AWM, Automotive Cluster Business Plan diagram, undated sheet, 2006
[172] AWM, Automotive Cluster Plan diagram, 2006; A D Little (2004)
[173] AWM, Automotive Cluster Plan diagram, 2006
[174] Tilson (2005)

5.3.2 Leadership and Management Skill Needs

A number of UK automotive studies have highlighted perceived weaknesses in leadership and management competences in the supply chain.[175] The ability of suppliers to deliver new technologies, prototypes, products and services exactly meeting their customer requirements was also criticised. Poor programme and project management were noted by Ricardo (2005): "with UK organisations overestimating their competences and under-estimating the task."

It is not only at senior management level that improved competences are needed. The Automotive Innovation and Growth Team highlights the importance of good team leaders (non-graduate engineers), with the added advantage that (in line with the Total Productive Maintenance approach of the Japanese) they can handle routine maintenance and technical problems, leaving the qualified engineers to focus their energies on project management.[176]

A 2005 report for Skills4Auto based on interviews with Midlands vehicle manufacturers and suppliers communicated numerous points made about the need for better leadership and management skills, involving not only the ability to lead, but also better technical prowess, innovative thinking, and strategic management. It is seen as crucial that people at all levels of a company develop leadership skills. Engineers are not the only group with a crucial role in innovation. The innovative input of the shopfloor (in part due to the increase in production cell working) is considered to be of growing importance, by contributing their ideas and multi-skilling. There is a need for better team working, not only among the workforce but also at director and senior management level. Senior managers are considered to have skill needs in relation to the use of ICT. A clear recognition emerged of the role of 'soft' skills like negotiation, customer-supplier relationship building, communication and networking across businesses. Leadership and soft skills are crucial in order to motivate people to perform at their best. [177]

5.4 Solutions to Skill Limitations

Firms need to capitalise on the opportunities and be more proactive in relation to innovation and product, process, and also market diversification. Diversification of products and processes places a particular value on their possession of broad-ranging expertise as well as in-depth specialist knowledge and, therefore, on the need to acquire the necessary skills.

[175] Tilson (2005); Ricardo (2005)
[176] AIGT (2002)
[177] Tilson (2005)

The various routes for in-company or external skills raising include via:

- Universities and colleges
- Collaboration or networking with industry customers and partners
- The developers and suppliers of products and equipment
- Commercial training providers
- Public or private sector support agencies such as Skills4Auto, Accelerate, the LSC, Industry Forum or the Chamber of Commerce.
- Trade associations or agencies within or *outside* the automotive industry such as Motorsport Development UK, the Engineering Employers Federation or Society of British Aerospace Companies (for technology transfer)
- Research institutions such as Ceram, RAPRA, Warwick Manufacturing Group, or the Technology Innovation Council, or
- Research programmes and initiatives led by the DTI, EC, or regional bodies.

5.4.1 Policies, Programmes and Initiatives

Programmes and initiatives targeting the development of automotive sector skills in the West Midlands cover a broad spectrum of skill areas, some directly related to innovation, such as keeping up with technology, or product development. Others are aimed at assisting businesses to improve their performance through skill raising in areas such as quality, cost and delivery (QCD). Those listed in AWM's Automotive Cluster Business Plan 2005 – 2008 include:

- The recruitment and retention of new entrants: an LSC project aimed at automotive, engineering and manufacturing, particularly graduates.
- Developing workforce skills: an LSC project for automotive and non-automotive, for improving basic skills (including ICT), business improvement and QCD, product development and introduction, and adult apprenticeships.
- Keeping pace with technology and legislation: an LSC project targeting automotive and non-automotive, to identify skill needs in emerging automotive technologies and legislative changes.
- Leadership and management development: an LSC project for automotive and non-automotive, to develop business improvement techniques to NVQ level 5.

- Skills4Auto Regional Pilot – TASK: The formation of a regional spoke of the Automotive Academy (already operational).

The formation of the Automotive Academy arose from a key recommendation of the AIGT's report (2002) that the SMMT Industry Forum should be extended to enhance the support for process improvement activities for the automotive industry via the development, testing and publishing of new curriculum and training materials on advanced techniques for supply chain management, production preparation, new product development and build-to-order capabilities, and the spread of best practice across the country.[178] AWM confirms the Automotive Academy as the focus for industry upskilling.[179] The workforce development and training spoke of the Automotive Academy is Skills4Auto.

Advantage West Midlands has provided funding of £33m over 4 years for the £60m collaborative programme between Warwick Manufacturing Group and the automotive sector, involving the Premier Automotive Group and potentially over 450 suppliers. The Premium Automotive Research and Development programme involves the take-up of new technologies, improved production processes and more craftsmanship.[180]

The DTI, through its Technology Programme,[181] is urging collaborative R&D programmes in manufacturing, including in the automotive supply chain, including:

- Materials modelling.
- Power electronics and electrical power control systems.
- Design and manufacture of sustainable products, and
- Low carbon energy technologies.

The Learning Grid is promoted and funded by the motorsport sector body, Motorsport Development UK, created to encourage young people to consider a career in engineering, spurred on by the competition wielded by the professions. The Learning Grid is designed to meet the needs of students, teachers and industry by bringing together different programmes and competitions for young people. All activities are linked to science, technology, engineering, design or mathematics. Some elements are included in the National Curriculum. Pupils from primary school onwards gain practical skills and acquire the fundamental principles of engineering through learning how to design, create, develop and race their own cars.[182]

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[178] AIGT (2002).
[179] AWM, Automotive Cluster Business Plan 2005 - 2008
[180] DTI, Innovation Report, 2003
[181] Foresight Vehicle website, accessed March 2006
[182] Motorsport Development UK, Introduction to the Learning Grid, The Learning Grid website

6 MEDICAL AND HEALTHCARE TECHNOLOGIES

6.1 Introduction: Medical and Healthcare Technologies

The healthcare sector represents roughly 8% of GDP and is the largest sector financed by the government.[183] It is one of the largest employers in the world, with a workforce of around 1.3 million in England and Wales.[184] Firms in medical and healthcare technologies are engaged in:

- Orthotics and prosthetics.
- Rehabilitation and mobility.
- Pharmaceuticals and biotechnology.
- Opthalmic goods.
- Dental and orthodontic devices.
- Electromedical equipment.
- Surgical and medical instruments, and
- Medical disposables.[185]

The nature of medical and healthcare technologies is cross-sectoral, with links to disciplines such as plant science and agriculture, environmental technologies, the retail food sector (e.g. for lifestyle and nutritional) and sports science.

UK medical device suppliers are mainly large US and German multinationals together with some innovative small suppliers in niche fields.[186] An estimated 400 – 500 West Midlands companies have some or all of their turnover derived from medical technologies, and frequently operate in one or more other sectors such as automotive,

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[183] Mai (2004)
[184] Lewis (2005)
[185] Burfitt and Gibney (2003)

engineering and plastics processing. A 2005 study indicates that another 500 – 600 have expressed an interest in the medical sector and could consider diversifying into it, either fully or in part. [187]

The healthcare sector in the West Midlands is undergoing rationalisation, with the 3 Strategic Health Authorities merging into one super SHA for the West Midlands. The 20 Hospital Trusts will eventually become Foundation Trusts. The 29 Primary Care Trusts are being restructured into fewer and larger units, which will decrease by about half the 2005 number. [188]

6.2 Research and Development

Pharmaceuticals and biotechnology was the top UK sector by R&D spend in 2005 among the 750 largest companies. It also ranks third among the 1,000 largest global companies (see Figure 12, chapter 3). Medium-sized pharmaceuticals companies (sales £25m - £500m) are also highly R&D intensive (defined as R&D as a % of sales). The majority of these pharmaceuticals firms are overseas-owned.[189]

Biopharmaceutical drugs account for 8% of the total pharmaceuticals market and are the fastest growing part of it. Bioscience is a high value added, knowledge-based industry, relating directly to the quality and quantity of the intellectual property it generates and the input from highly educated and skilled employees during research and product development. [190]

The strength of UK pharmaceuticals and health research serves to attract international R&D investment. It needs to remain strong in order to continue to pull in investment resources. Facilitating improvements to the organisational design of commercial clinical trials would help to attract further R&D activities to the UK. [191]

The government intends to ring-fence the Department of Health's R&D budget. A single health research fund would be created from DoH and DTI funds and is expected to realise £1 billion of research funds a year, delivered by a revised delivery structure to provide greater coherence.[192]

Innovation in the healthcare sector has helped to decrease the costs of treating some illnesses by replacing expensive treatments with lower cost substitutes with

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[186] A D Little, UK Sector Competitiveness, May 2005
[187] Lewis (2005)
[188] Lewis (2005)
[189] DTI, The 2005 R&D Scoreboard
[190] The Bioscience Innovation and Growth Team, Bioscience 2015
[191] A D Little, UK Sector Competitiveness, May 2005
[192] HM Treasury and DTI, Science and innovation investment framework 2004 – 2014, March 2006

comparable clinical outcomes. The treatment of coronary heart disease is a prime example of the development of new technologies with innovative outcomes.[193]

Existing medical school and hospital developments place the West Midlands potentially at the forefront of medical technologies research and development. Birmingham is a particularly strong existing focus, due in large degree to the University of Birmingham Medical School (including its joint venture with military medics to form the Centre for Defence Medicine) and Aston University's bio-product innovation centre and academy of life sciences. The University of Warwick Science Park has a small biotechnology cluster and the university's focus also includes health technologies and medical devices. Staffordshire's research focus is at Staffordshire University (including on bioengineering), and the University of Keele and its science park (e.g on orthopaedics). The NHS is also a notable source of R&D activity. [194]

6.2.1 Patenting Activity

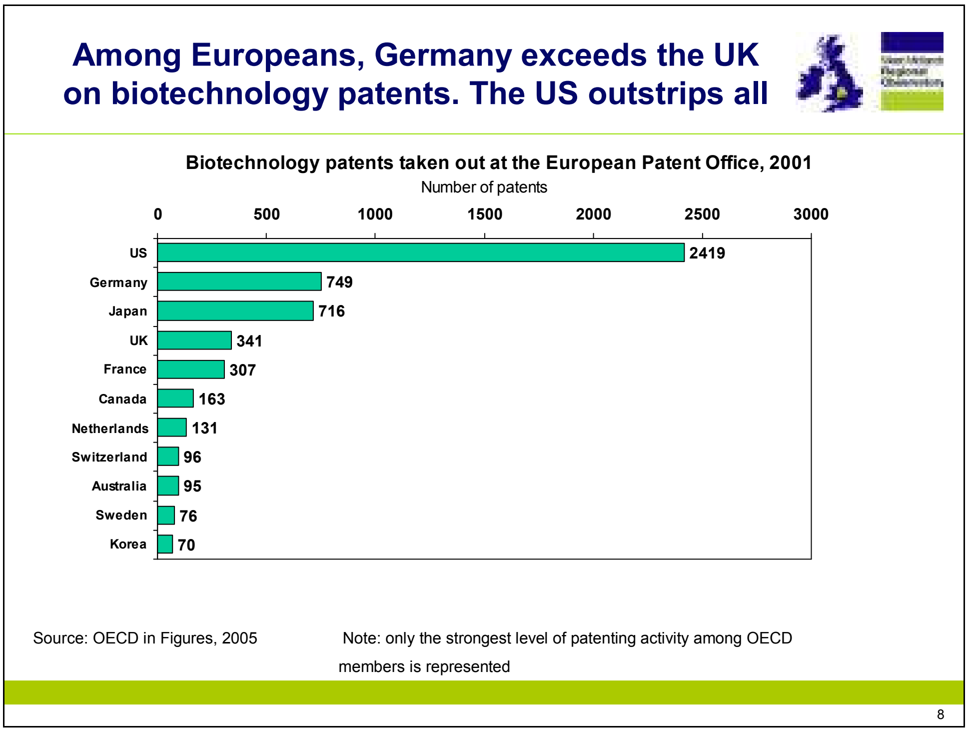
The UK is one of the stronger national performers in terms of patents taken out with the European Patent Office. OECD statistics for 2001 show that 341 biotechnology patents were taken out by UK applicants. However, this was paltry compared to those of the US (2,419) and Japan (716), well behind Germany (749) but roughly on a par with France (307) (Figure 24, overleaf).

International patent activity in the more important US context, however, is considered a more significant indicator of patenting levels. The DTI's 2005 R&D scoreboard looks at the average patent to R&D ratio (US patents granted in 2004 combined with the latest R&D investment figures from the Scoreboard) for 11 sectors, including health and pharmaceuticals/biotechnology. This shows that the ratio for pharmaceuticals and biotechnology is only 0.9 compared to the highest result – IT hardware at 7.6 – and for health the figure is 2.3.

The important point is made that pharmaceuticals and biotechnology companies have to conduct substantially more R&D investment than firms in other sectors to ensure that a patented compound is effective, is acceptable to regulatory agencies and has a low level of side effects. This point needs to be borne in mind in relation to the importance of the range of skills around research, analysis and testing as well as general laboratory work and administration, that are required, as well as the continuing support and investment required by these firms.

[193] Mai (2004)
[194] For a more comprehensive list see A D Little (2004)

Figure 24: UK Biotechnology Patent Activity in the OECD Context



6.2.2 Product development and commercialisation

A D Little (2005) note that new products arising from new knowledge are vital to position a company to differentiate itself and to enter the market via alternative technologies or other design configurations. The product development process varies according to the subsector and the maturity of the technology. However, some distinct features are observable:

- The R&D director or Chief Technology Officer manages the technology portfolio, establishing a scientific advisory board and ongoing technology scanning.
- In some sectors, like orthopaedics, the surgeon may invent or develop new product ideas on their own or in collaboration with established suppliers.
- Strong networks are usually maintained with surgeons or clinicians to ensure market knowledge and technology intelligence.
- Sub-processes include business intelligence; product development and launch, resource management (including intellectual property and partnering assessment).
- Access to scientific knowledge in academia, hospitals and public sector research labs yields knowledge on future technologies.

Faster new product development cycles and new market ideas are key to business competitiveness. Smith & Nephew is one of the largest UK firms, with its R&D base in York and Hull. The company has been able to successfully convert its R&D on new medical concepts into commercial products, and to achieve strong exports. Successful commercialisation has occurred and key factors are:

- Close internal links with customers, market/sales staff and R&D teams.
- R&D structures have been modified closer to the individual business units including some in the US so that communication links are even closer.
- Time-to-market has been improved, enabling greater competitiveness.
- Productivity has improved, and exports are high.[195]

6.2.3 The innovative role of medical and healthcare practitioners

Pioneering surgeons, clinicians and other medical practitioners have a pivotal role in medical and healthcare innovation including the development and introduction of new devices and techniques. A well documented example[196] is that of the surgeon, Gruentzig, who perfected coronary angioplasty using balloon catheters which led to the development of the field of Interventional Cardiology (see Text Box 10).

What makes the Gruentzig case pertinent is his involvement in the invention and development of devices, providing an impetus for skill and knowledge development not just among a scientific medical elite but also among a manufacturing and support structure. A 'community of interest' developed around the surgeon which acted as a knowledge hub.

Text Box 10: The Gruentzig case study of surgical product innovation

The idea for the coronary device came from the surgeon, Gruentzig, who also initiated and oversaw and advised on its prototyping and early production, which was placed with a small local company (Swiss). The growth of the technique and this field of cardiology resulted in the evolution of a medical industrial complex supplying devices, materials and drugs. This complex grew as commercialisation expanded, as this grew so did the market, and the complex formed a part of the associated medical innovation system that included other players providing service support. The field grew through the spread of creative efforts and associated investments. The few small pioneering firms there at the outset has become a larger group of players that includes imitators as well as highly innovative firms exploring new areas. This medical innovation system is an *international* one, able to internally generate novelty itself.

[195] A D Little, UK Sector Competitiveness, May 2005
[196] Mina et al (2004)

Key points about development and commercialisation of the Gruentzig device:

- Inventive activities are truly competitive, with creative teams of various sizes and institutional affiliation.
- Innovation occurs through a network mechanism which acts as a knowledge hub. It includes medical and non-medical players.
- Early innovative manufacturers are resilient. Successful ones never stop innovating.
- Where the focus shifts to final product market, scale effects are paramount, to the detriment of competition.
- Where patentees are not part of corporations, intermediate markets for knowledge flourish between inventive units and production units.
- Some firms opt not to grow beyond a certain point, following buy-out strategies and selling to larger players when they reach a certain size, often then becoming specialised units of larger firms. Others grow organically, but also consolidate their position in the market through strategic acquisitions.
- Markets are open to challenge from new technologies via aggressive pricing, acquisition strategies and continuous innovations in established products.
- Further innovation challenges can occur between outward alliances between manufacturers and pharmaceutical companies.

Research into the West Midlands medical technologies sector also confirms the importance of manufacturers having direct contact with innovative surgeons in turning new product ideas into practical devices and developing a market.[197] This point was strongly reinforced by Biocomposites, the pioneering joint replacement specialist, in a March 2006 presentation.[198] However, A D Little point out that although UK doctors have historically led advances in new surgical techniques and the design of devices, the creation of products from their ideas has been "sub-optimal. They note the scope for improving manufacturer-practitioner collaboration."[199]

6.3 New Materials and Technologies

Engineering and materials research are major strands of existing and potential research and application, including polymers, metals, advanced ceramics, composites, and nanotechnology. The Materials Foresight report highlights the potential of smart materials and technologies in the medical and healthcare sector. These include self-diagnostic materials, neurosensor prostheses, smart diagnostics, chemical and structural biomimicry, and genomic smart cards. The report concludes that there is considerable scope for further research into the fundamental, interfacial properties of existing smart materials in biosystems, for example in the use for implants. Research

[197] Tilson, Medical Technology Businesses..., two reports for AWM, 2002
[198] Bratt, Presentation to a medical technologies cluster event, AWM, Walsall, 2 March 2006
[199] A D Little, UK Sector Competitiveness, 2005

and funding needs to be multidisciplinary and target the study of the interactive behaviour of the smart material in its biological environment.[200] The absence of an EU framework on the licensing of biologics innovations is described by Smith and Nephew as "a constraint" on all firms in this field.[201]

A 2005 report on the West Midlands medical technologies sector observes that the interventional procedures programme (IPP) of the National Institute for Health and Clinical Excellence (NICE) is forcing the UK healthcare system to take greater notice of these procedures.[202] This could see greater use of innovative and rare technologies in the NHS. The report advises that: "All West Midlands medical technology companies should be examining this emerging change for relevance and insights." The Medilink and NHS Innovation Hubs are highlighted. The East Midlands is seen as having complementary strengths to those of the West Midlands in relation to biotechnology and pharmaceutical technologies. This is thought to be particularly helpful for combining strengths to tackle the major North American market.

UK based opportunities are identified in:

- Biomaterials and advanced woundcare.
- Tissue engineering.
- Structures for devices, including their control systems and software.
- Diagnostics, orthopaedics and assistive technologies.
- Telemedicine, especially monitoring and wellness and care in the community.
- ICT/e-technology.
- Infection control. [203]

The Region has particular strengths in materials technology, including nano, micro and plastics processing. A D Little (2004) consider that it is the Region's expertise in high quality engineering and high precision manufacturing in often difficult materials such as occurs in aerospace that gives the West Midlands a promising juxtaposition of capabilities due to cross-over technological potential in relation to medical and surgical devices (including dental and ophthalmic), biomaterials, assistive technologies for the elderly or disabled, and diagnostic equipment.

ICT, plastics and textiles clusters in the West Midlands have existing expertise and potential synergies with the Region's medical technology cluster:

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[200] For a full discussion see Materials Foresight, Smart Materials for the 21st century
[201] DTI, 2005 R&D Scoreboard
[202] Lewis (2005)
[203] Lewis (2005); A D Little (2005)

ICT: notably around the Warwick and Aston Science Parks. Around 50 firms exist in the Warwick area alone with an interest in medical technologies.

Plastics: More than 50 companies in the Region have an interest in medical technologies, particularly in the Telford area. RAPRA has expanded in the medical technology field, and manages the Faraday Initiative providing company assistance.

Textiles: This is not a field of proven value for medical technologies in the West Midlands, but is considered worthy of further study, e.g. for wearable devices and personalised healthcare.[204]

Marine biotechnology may also provide opportunities (see Table 4).

Table 4: Sectors in which marine biotechnology could make a contribution

Sector	Two examples[205] of potential contributions by marine biotechnology
Foods	New colourants Edible coatings
Neutraceuticals	Osteoporosis Anti-oxidants
Medicine	Pain management Anti-cancer agents
Healthcare	Biomaterials, including biopolymers and bioceramics Components of medical devices
Cosmetics	Collagens Sunscreens
Research tools	Reagents including enzymes Model organisms for safety and toxicity tests
Processing technologies	Improved bioreactor technology Improved purification methods
New energy sources	Light capture Hydrogen producers
Agricultural	Seed coatings New vaccines and disease control in aquaculture
Industrial	Ceramic materials Nanotechnological developments
Food safety	Diagnostics for toxins in seafood Materials for preserving and decontaminating foods and feeds
Environment enhancement	Pollutant and toxin detection and removal Metal removal and retrieval from soils, water and mining

Source: Foresight Marine Panel, report by Lloyd-Evans, January 2005

[204] Lewis (2005)
[205] For the complete list of potential contributions refer to the source document

Biomaterials of marine origin could be used in bioactives, adhesives, anti-adhesives, biocompatible colloids, nanostructures, porous materials, and increase the knowledge of how cells and substrates interact in fields such as cancer research. Marine-origin bioactives and biomaterials may have a role in coating devices and implants with a biocompatible and lubricated surface and cut down on cellular reactions. In the orthopaedic field, marine materials such as those derived from coral are already used for their bone-like qualities. Chitosan fibres can be turned into woven, knitted or non-woven fabrics and are already used for wound dressings and sutures. Inhalation and injectible products and oral administration are other opportunities.

The potential for marine biotechnology poses questions about how or should firms get on board, and what innovation skills might be needed. None of the UK's strength in marine biotechnology research is in the Midlands, though London, the South East and East, and North East all have some investment in this field. The Foresight Marine Panel (2005) advises that:

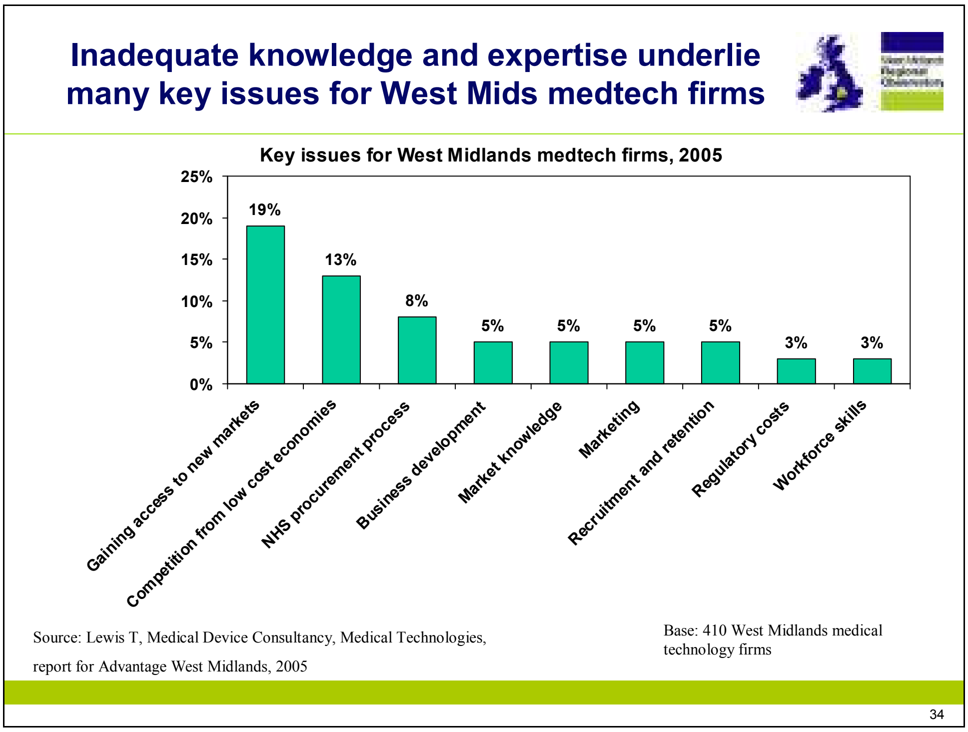
"A fairly comprehensive review of clusters in the UK could be useful in identifying regional end-user clusters that could be targets for marine biotechnology and its outputs, including regional strengths in biopharmaceuticals, chemicals, environmental industries, food, marine technology and classical pharmaceuticals."

This is just one example of a potentially advantageous linkage that could be evaluated for its innovation potential, identifying existing strengths and synergies with innovation objectives and evaluating the potential skill needs. Certainly, the Foresight Marine panel notes the need for appropriate higher education qualifications, the funding of marine biotechnology science and engineering training, and investment for the development of commercial activities.

6.4 Skill Issues and Needs for Innovation

A 2005 survey of West Midlands medical technology firms notes that most firms are SMEs. About two thirds of the 410 companies interviewed had developed their own products or services, but more than one half did not have any intellectual property protection. Key issues relate to gaining access to new markets (19% of firms), and the ability to compete with low-cost economies (13%). Workforce skill needs affect 3% of businesses, though other points indicate further limitations (Figure 25).

Figure 25: Key issues for West Midlands medical technology companies, 2005



To exploit the opportunities in medical technologies, West Midlands firms should:

- Address and improve market access, both domestically (mainly via the NHS) and in export markets notably in Europe, North America and the Pacific Rim.
- Improve their human resource capability in general and specifically in business development, marketing and regulatory affairs.
- Capture or create high value intellectual property that is well protected, provides investor confidence and is capable of ensuring a secure, sustainable profit. [206]

High value activities include R&D and sales and services. But time-to-market and the integration of technical solutions with strategic marketing are considered more important than manufacturing or technological advances alone. [207]

The development or new products or services and penetration of new markets are key features of medical technology businesses' plans over the forthcoming 5 years. They need the capability to do this. Weaknesses are noted in business strategy and sales and marketing expertise.[208] Market access is a major difficulty and the question for businesses is: "where do you start?"[209] In the UK it is more difficult than in other countries like the US, Germany and France. The UK procurement system is described

[206] Lewis (2005)
[207] A D Little, UK Sector Competitiveness, May 2005
[208] Lewis (2005)

as "risk averse", under high cost-cutting constraints, and not adapted to evaluate and acknowledge the benefits of new products. It is advised that processes need to be clear and streamlined for industry to qualify and certify new products.[210] A 2005 report on the West Midlands medical technology sector advocated the formation of an e-procurement capability and businesses learning to work with the evolving NHS procurement processes.[211]

The NHS recognises that its procurement process is not easily navigable, particularly by SMEs, and is seeking to devise a solution. For instance, the NHS Collaborative Procurement Hubs (CPHs) have been designed to ensure that clinicians have an opportunity to provide advice on purchasing decisions and suppliers are being involved in national procurement plans.[212] The NHS is keen to stimulate and support innovation within its own organisation and remit and has established Innovation Hubs.[213] In view of the wealth generating potential of getting more NHS business, West Midlands firms were urged to enter into a dialogue with the NHS to ensure that they are a part of the creation of that solution, not just passive observers to it.[214] However, a presentation to a 2006 medical technologies cluster event by a West Midlands implants manufacturer noted that it is the surgeons who *use* products, asking: "so why do we need to sell to the NHS? They don't know about (our) products and so can't make a decision."[215]

The Lewis report (2005) emphasised that there is increased interest among companies in working with design and development companies, universities, the NHS, and other organisations. However, access to venture capital and intellectual property expertise could be improved.

Firms are also interested in forming joint ventures, pursuing acquisitions and mergers, and undertaking trade fairs and missions. It is emphasised that firms need to be good at the international level and an increase in foreign direct investment is advised. Incidentally, this would help to achieve that objective through an influx of world class manufacturers.

Suppliers to West Midlands firms are mainly in the Region and rest of the UK rather than overseas-based, though there is a "significant" use of suppliers in Europe and Asia.[216] What is less clear is the mix of capabilities which they posses, where the particular knowledge, information and skill deficiencies lie, and how these affect firms in different subsectors and of varying size and profitability.

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[209] Bratt (2006).
[210] A D Little, UK Sector Competitiveness, 2005
[211] Lewis (2005)
[212] Department of Health, Government Response to the Health Committee's report... , 2005
[213] Department of Health, The Way Forward: NHS Institute for Learning, Skills and Innovation, 2005
[214] Lewis (2005)
[215] Bratt, Biocomposites, presentation to AWM medical technologies cluster event, 2 March 2006

6.4.1 Skill needs of medical device manufacturers and allied processors

A study of Coventry and Warwickshire medical device manufacturers' workforce skill needs[217] found that these are focused on technological expertise either related to manufacturing improvements or to the expectation of new processing techniques or ways of working coming in over the next few years. Skill needs include:

- More advanced quality planning, including statistical process control.
- The ability to use more sophisticated electronic equipment, including CNC.
- A knowledge of new laser products, and the acquisition of skills to make laser-powered surgical products.
- Greater knowledge on the shopfloor of polymer processing.
- Multi-skilling on the shopfloor, to achieve a more flexible workforce.
- Medical knowledge by engineers.
- Design skills to enable collaboration with the customer on product development and adaptation.
- IT skills including software systems development.
- Legal knowledge, e.g. of patenting.
- Knowledge of medical compliance/regulations.
- Management, teamworking and other people skills including motivational, customer liaison.
- Distribution and logistics skills.
- Knowledge of exporting.

A key impetus for skill changes relates to materials or technology change as well as the need to respond to customers changing requirements in relation to new product development. The use of different equipment exerts skill needs, and there are questions about the availability and accessibility of training. E-business evolution in the workplace has important skill impacts.

Issues raised about sourcing the appropriate skills and labour are shown in Text Box 11.

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216 Lewis (2005)
217 Tilson, BCTRA, The Medical Technologies Research Project, 2002

Text Box 11: Issues about sourcing appropriate skills and labour

Issues about recruitment costs
- The cost of recruiting people with experience, and specialist skills.
- The cost of using recruitment agencies.

Issues about the shortage of specialists
- The lack of knowledge by recruitment agencies of the medical sector.
- The shortage of people with specialist skills, particularly relating to niche medical products, and some scientific disciplines.
- A shortage of chemists, exacerbated by the low salaries graduates can obtain.
- A shortage of graduates in pharmacy.
- The problem of finding product design skills and the cost of employing them on a part-time basis.
- The disappearance of vocational skills from the labour pool as firms close, technology changes, and the skill base shrinks.
- Shortage of people in the labour pool with technical ceramic/engineering skills who have gone through apprenticeship training.
- Shortage of engineering and toolmaking skills in fine engineering.
- Shortage of people with multi-disciplinary skills.

Issues about low career interest in manufacturing and engineering jobs
- The transience of young people and their lack of interest in shopfloor jobs.
- Lack of interest of young people in careers in engineering.

Issues about learning and training provision
- The unavailability of specialist training across the Midlands.
- No or few courses in the West Midlands for certain biotechnology and pharmaceutical specialisms.
- The disappearance of some vocational skill training in Higher and Further Education.
- Training for dental technicians is piecemeal.
- The lack of expertise/knowledge among private training providers – notably in software programming – claiming to supply high level training.
- Lack of information about training providers and what they do.
- Limited apprenticeships.

Issues about training costs and grants
- Lack of grants available for workforce training.
- Lack of subsidies available to recruit or train people outside the Region.
- The high cost of specialist training.

6.4.2 Case Study of skill self-development of a Staffordshire start-up

It is problematic for firms in leading edge technologies to find the training and the skills in the labour pool that they need. The solution found by an implants manufacturer (Biocomposites) was to teach themselves. First they had to identify what they needed to know. The skills they developed as they evolved are shown in Text Box 12.

Perseverance is described as the biggest quality to have, in order to keep going when failures occur. Innovation, too, has to be continual. "If we don't innovate, we're nothing. We need to do it constantly, and it is difficult to be innovative *and* risk averse." Biocomposites had Brite-Euram funding for research initially.[218]

Text Box 12: Case Study of Skill Development by a Growing Medical Implants Start-up – Biocomposites, Staffordshire

- How to research.
- How to manufacture.
- How to identify and communicate with their market (current market opportunities are seen in the US and China).
- Selling skills – can be outsourced.
- Understanding procurement decision-making e.g. of NHS; understanding purchasing decisions of distributors who are likely to select from a proliferation of products on vagaries such as the packaging. Taking decision to sidestep these and to go direct to the end-users, i.e. the surgeons.
- How to communicate and manage outsourced and long-distance operations, e.g. sales subsidiaries in China and the US; testing.
- How to differentiate themselves in the market
- How to reinvent what they do, continually.
- Foresight skills.
- Collaboration skills, as it is vital to work with partners and role models and also to use these as mentors and advisors – others who have grown their business from scratch, commercial people (such as distributors, manufacturers), scientists and engineers.
- Regulatory knowledge.
- How to get from research to commercialisation, and how to sustain it.
- Locating funding, not only this, the most appropriate sources of funding. Venture capital support is said to have slowed them up by 2 years, whereas private company investment and Business Angels is described as useful.

Source: Bratt (2006)

6.4.3 *Skill needs of biotechnology firms*

Biotechnology firms in the West Midlands tend to be small start-ups or science park based university spin-outs. In the pharmaceuticals industry it is common for large established companies to outsource early stages of the discovery process to biotech firms.[219] Ambitions for the growth of the biopharmaceuticals sector in the West

[218] Bratt, op.cit., 2006
[219] Munshi et al (2005), citing Kale and Puranam (2004)

Midlands emphasise the importance of helping to ensure that the Region is an attractive location for biotech start-ups and growing firms, and that these can source the calibre of skills in the labour pool and the support that they require. Further work needs to be done to identify specific skill needs.

Existing research[220] shows that skills for biotech firms do not solely relate to scientific research and laboratory work at advanced and technician levels, but include:

- Business management and office-related skills.
- How to generate new business and investment/business development.
- Sales and marketing, as well as distribution skills. Web-based marketing.
- Operating on a sound financial footing; financial and accounting skills.
- Having the legal skills to negotiate intellectual property rights, patent filing.
- Strengthening scientific skills; but also giving research scientists business skills; chemists being more entrepreneurial; cross-disciplinary scientists.
- Bringing research to commercialisation.
- Dealing effectively with supply chains; ensuring that quality standards are met.
- Production management.
- Project management for outsourced production.
- Health and safety knowledge.
- Medical compliance/regulations in their markets, e.g. US, UK.

It is also crucial to take a broad perspective of skill needs and development issues across the supply chains of the various subsectors, as it is vital that the development and supply of materials, equipment, devices and other goods and services is optimal. It is important to bear in mind that the supply chain can include firms in sectors which may not consider themselves medical technology firms at all – metals and polymer processors, for instance. It will include businesses engaged in laboratory analysis, and the production of organically-derived chemicals including those from plants and meat products. It can also consist of large multinational distributors and manufacturing corporations who may be beyond reach. But it will also include some West Midlands and UK-based firms, as well as niche players overseas.[221]

[220] Tilson, The Medical Technology Sector in the West Midlands, 2002
[221] Tilson Medical Technology Businesses in Staffordshire, Shropshire and the Black Country, 2001

6.4.4 Diversification into the medical technology sector

The potential for cross-over technologies into medical and healthcare from other industries has already been noted. Firms in declining clusters may also be able to diversify their expertise into medical technologies. Opportunities for diversification potential involve, for example, metals and plastics processors, precision engineering, jewellery and silversmithing, and ceramics, electronics firms, automotive suppliers and other component manufacturers.[222]

Diversifying into medical technologies would require diversification skills, as well as innovation skills. The HealthTech model presents a useful schema of the additional expertise that is needed for firms diversifying into the sector, but also having to undertake product and process development (Table 5).

Table 5: Diversification and Innovation Model for Service Delivery Success of New Medical Technologies

Diversification	Innovation
Awareness Market knowledge Business strategy	Technology assessment Benchmarking Business planning
Mentoring Relevant OEMs[223] Funding	Funding Idea generation Product design Engineering Prototyping
Partnership Capability Building Credibility - branding	Licensing Manufacturing Virtual OEMs
Sales and marketing Quality, certification and validation	

Source: Lewis (2005), citing HealthTech

A recent IER study on diversification into medical technologies[224] indicates that a sizeable minority of firms (13%) stated that they needed to hire more R&D people, invest in medical related sales (18%) and hire people with regulatory knowledge (15%).

In addition to these actions, there would inevitably be a degree of organisational change and upheaval, and a reallocation of tasks, training and recruitment needs

[222] See Tilson Plastic Materials, Processing, Innovation and Supply Chain Issues, 2002 and other BCTRA medical sector reports for AWM, 2001
[223] OEM – original equipment manufacturer i.e. the company at the top end of the supply chain that supplies to the end customer
[224] Hogarth et al (2006)

associated with the acquisition of market, sector, materials, technology and product awareness.

Further points about diversification were made at a 2006 seminar on medical technologies:

- Firms in dying industries need to be aware of how their technical expertise can be used in other fields.
- Firms exiting their existing industry need to keep their eye on the core business while diversifying, because it takes years for a business diversification to grow.
- It is crucial to talk to company insiders and get their buy-in to what you are doing.
- The right people are needed in the business to enable it to adapt to change and move forward.[225]

6.5 Solutions to Skill Limitations

It is clearly important that the skill implications for businesses of improving their performance and exploiting their innovation prospects are clarified and steps taken to remedy any deficiencies. Priority support areas for West Midlands medical technology companies are considered to be:

- Skills development in marketing, regulatory affairs and business development.
- Investing in higher value added processes, as well as the use of low cost economy sourcing, where appropriate, but with intellectual property protection.
- The development of quality systems from ISO 9001 to ISO 13485: 2003.

The NHS is looking abroad to identify best practice.[226]

There are various organisations in the West Midlands that firms already engaged in, as well as those seeking to diversify into, medical technologies, could utilise for information on innovation opportunities, or to link up with for multi-partner innovation projects. Examples include Medilink, MidTech, the West Midlands NHS Innovation Hub - part of a national network whose aims include initiation of R&D, commissioning prototypes, advice on commercialisation – and CHID, the Centre for

[225] W Gray, S Bratt, presentations to AWM medical technologies cluster event, Walsall, 2 March 2006

Healthcare Innovation and Development. This is a public/private sector interchange whose aim is to exploit innovations in the West Midlands and so remove the barriers to successful commercial interactions between industry, the supply chain, investors and the NHS. It also supports a schools innovation competition. The Innovation and Technology Council and the Regional Skills Partnership, too, have an important role in Regional innovation and skills development.

In the private sector organisations with a business interchange and support remit include RAPRA, private healthcare providers such as Amicus Healthcare (or BMI), BUPA and Nuffield, and in the public sector various university and science park initiatives including those at Keele, Aston, Birmingham and Warwick. Providing financial and advisory support is Mustard at Birmingham & Solihull Chamber of Commerce. The Medical Technologies COG and the LSC both have a business/workforce development role. The importance of the possession of *specialist* expertise in medical technologies is noted for Business Link in order for BL consultants to support businesses in the way they require.

It is crucial that like minded people are in the West Midlands, and all pull together.[227]

Questions do arise:

- Are there any voids or shortfalls in the innovation remit of the various organisations and initiatives, such as deficiencies in the resources available?
- To what extent can or will organisations such as these have in their remit the upskilling or reskilling of medical technology firms to enable them to maximise the innovation potential?
- How successfully will the various innovation-related organisations and initiatives liaise and/or be co-ordinated to provide seamless and easily accessible sources of innovation information, advice and support for medical technology businesses?
- How well equipped is the training infrastructure to meet the various needs of innovation stakeholders and to monitor and adapt to change itself, as well as modifying its training delivery?
- To what extent are these organisations and initiatives, and the training they provide or will provide, able to assist firms that must or wish to operate international innovation projects either with customers, suppliers or other partners?

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[226] Lewis (2005)
[227] Bratt (2006)

6.5.1 *Collaboration, knowledge and technology transfer*

The absence of large pharmaceutical firms in the West Midlands, indeed, the scarcity of larger players in other disciplines, makes it imperative to provide support to growing smaller and medium-sized firms that they might otherwise obtain by a proximity to and networking links with bigger players.[228] The scarcity of larger firms and the relatively small size of the cluster also has other disadvantages for the medical and healthcare technologies sector:

- Fewer people receive training outside of the formal education sector.
- The leakage of expertise into the labour pool is less.
- There is less demand for skills, so training provision is more limited.
- Support services are less well developed.
- The potential Regional linkages which firms can form for innovation are fewer.
- The formation of R&D links elsewhere in the UK and overseas makes it more likely that firms will manufacture elsewhere, and that they will move away.
- The cross-fertilisation of ideas and know-how between sectors is more limited.

Enormous scope is seen in developing the linkages across the industrial base throughout the West Midlands within and outside medical and healthcare, and in further developing the linkages for this sector into and out of the university research institutions, the medical science parks and hospitals.[229] In view of the potential for the cross-fertilisation of ideas and expertise from the NHS into the private sector and vice versa, NHS Trust-university collaboration was already under way in 2003. This included MIDTECH, one of the NHS Regional Innovation Hubs which (like the Centre for Healthcare Innovation and Development – CHID) supports business development and provides an innovation management service. Its services include the evaluation of intellectual property, commissioning the production of prototypes, and advising on the setting up of spin-out companies. Other collaborative projects include those of Medilink (e.g. the Technology Translator project), Warwick Manufacturing Group and NHS Trusts, and the Medici programme which promotes the exploitation of knowledge from that sector.[230]

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[228] A D Little (2004)
[229] Shields (2005)
[230] A D Little (2004)

6.5.2 Increasing the Bioscience Workforce: lessons from North Carolina

Problems are encountered by biopharmaceutical companies in recruiting the right skills in the West Midlands as well as in the right numbers.[231] Experience from the US state of North Carolina[232] on growing their bioscience workforce may hold some useful insights in how to increase the labour pool for expanding firms to draw upon. The state – which has its own State Bioscience Association - in 2003 launched the North Carolina Biomanufacturing and Pharmaceutical Training Consortium (BPTC), designed to create a vertically integrated life science training network to meet post-secondary training needs.

The consortium has the following components:

1) The North Carolina Community College System BioNetwork. This is a programme spanning the college system. It overlays existing biotechnology training programmes with a "**readily deployable training capability**" aimed at meeting the workforce development needs of existing and new bioscience firms. It has a central planning unit operating state-wide as well as 5 spokes.

The programme also **ensures that the training provision itself moves on**, for it includes **funding for equipment acquisition and facility uplifts** at community colleges that provide training to biomanufacturing and pharmaceutical firms.

2) A Biomanufacturing Training and Education Centre (BTEC). This $35million commercial-scale biomanufacturing unit is operated by North Carolina State University. It enables students in the university and community college system to gain **hands-on experience of commercial-scale biomanufacturing equipment and facilities**, including cell-culture, fermentation, purification, sterile fill, quality control, and support operations.

There were plans to equip BTEC with distance learning facilities capable of bringing real-time operational data and educational content to community colleges and other satellite locations state-wide.

There were also plans for BTEC to provide **continuing education and shutdown training for biomanufacturing and pharmaceutical workers.**

3) Biomanufacturing Research and Training Enterprise. A $19million facility at North Carolina Central University, offering undergraduate students in the state's universities **laboratory experience in key biopharmaceutical disciplines** such as virology, microbiology, analytical chemistry, fermentation and purification. The

[231] Tilson, The Medical Technology Sector in the West Midlands, 2002
[232] Battelle Technology Partnership Practice and SSTI, Laboratories of Innovation, 2004

facility is also intended to **support graduate-level research and education in life science disciplines.**

4) In the school curriculum, the North Carolina State School of Sciences and Mathematics is a two-year “residential magnet school” for talented students. The school offers **mini grants for K-12 curricular development in the biosciences**.

7 CONSTRUCTION AND THE BUILT ENVIRONMENT

7.1 Introduction: Construction and the Built Environment

The construction sector includes not only building but also infrastructural and structural engineering as well as architectural consultancy, building services such as electrical wiring, plumbing, and heating and air conditioning, and gas services. It also encompasses the production and manufacture of materials for the building industry, including polymers and timber.[233]

Drivers for innovation and change in the construction and built environment sector include:

- Globalisation, and the need to keep abreast of international innovation in order to compete successfully on overseas building and civil engineering projects and to ensure competitiveness against rivals bidding for UK projects.
- Major building programmes. Currently the Olympics and completion of the Wembley Stadium are hot topics. There are also major programmes in the West Midlands associated with public sector, commercial and infrastructure works.
- Building regulations and environmental legislation. Examples include the climate change levy (2000); building regulations (2002) on energy efficiency and gas, refrigeration and boilers (2005 – 7), as well as regulations on chemicals and aggregates. In prospect, there is also a potential cut in buildings' carbon emissions.
- Rising costs of materials, fuels. Also the rising cost of house prices.
- The multi-facetted sustainability agenda which includes recycling, energy efficiency, modern construction methods and affordable housing.

[233] Much of this chapter is based on Tilson, RSP Construction Sector Profile, WMRO, 2005; Tilson, Innovation and change in construction and the built environment: the skill implications, WMRO presentation, 2006. See wmro.org

- The development of new materials, technologies and processes, including those which are environmentally sound.
- The determination to improve performance through organisational change, supply chain collaboration, and better project management.
- The use of ICT across the value chain, including for design and simulation, databases, communication, tracking, project management, logistics.

7.1.1 The Sustainability Agenda

The Sustainability Agenda is an important impetus for innovation and change, stemming in great measure from the 1998 influential Egan report, Rethinking Construction, and a number of follow-ups for and by the Office of the Deputy Prime Minister, such as Skills for Sustainable Communities (2004) and Sustainable Communities: Building for the Future (2003). These put forward strong arguments for the modernisation of the construction and built environment sector not only in terms of its development and use of new building techniques but also in relation to the wider social and environmental context.

'Sustainability' has strong community regeneration and social inclusion relevance through the objective of providing high quality living at affordable cost and ensuring the regeneration of residential districts. The ODPM has established a £38 billion Communities Programme. Plans include a National Centre for Sustainable Community Skills. A further £10 billion has been put forward by the European Commission.

The ODPM has also asked the construction industry to find ways to build low cost homes, in view of the difficulties people face in getting into the property market. There are two main facets:

1. By the industry improving its performance – avoiding cost-over-runs, less delays, less rework, achieving the reliable delivery of supplies on-site, better project management, better supply chain management and so on.
2. To bring down building costs by using innovative construction techniques. This has brought into focus the potential of off-site manufacture, or pre-fabrication. To drive forward the programme targeting the modernisation of the industry and instil a more innovative approach, the Constructing Excellence initiative has been established nationwide.

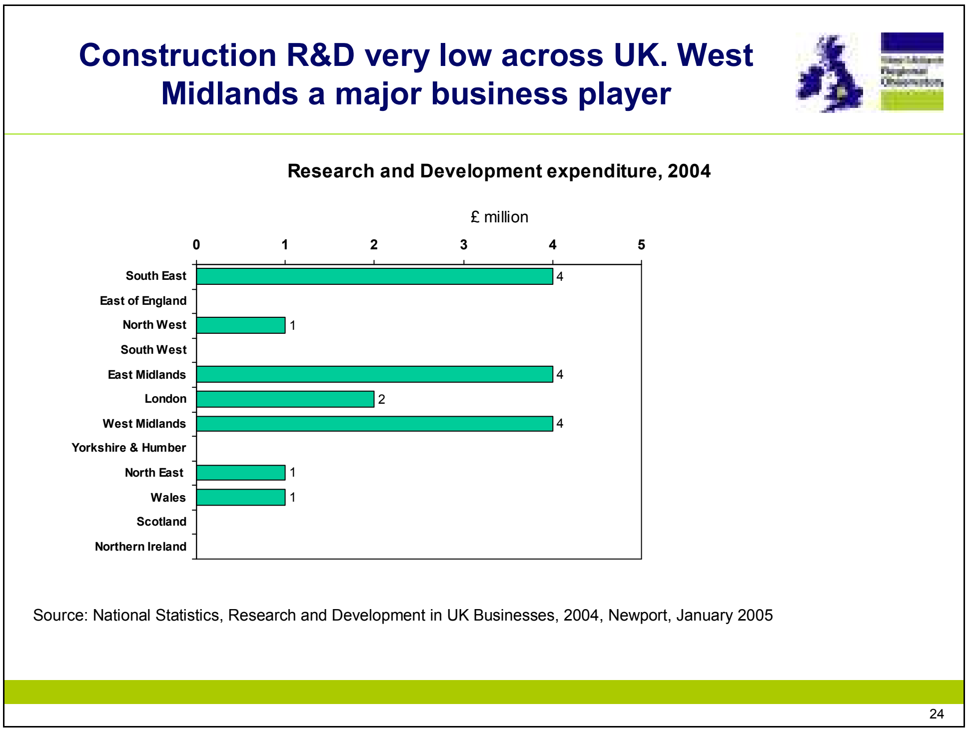
The West Midlands has been given the lead on innovative construction techniques.

7.2 Research and Development

The innovation picture for the West Midlands is a confusing one because, by some measures, its record is abysmal, while, for others, it is much more positive. The overall impression, though, is that the construction industry could do far more innovation activity, not only in terms of R&D investment but also in commercialising the results of that research.

Expenditure on R&D by the construction industry in 2004 was £40 million across the whole of the UK, the lowest of the broad industry sectors covered by the Standard Industrial Classification. Only the electricity, gas and water supply sector, at £43 million, recorded a figure in double digits. Contrast this with the lowest industry sector in manufacturing – transport equipment – which recorded £998 million on R&D spend. Nevertheless, the West Midlands is one of the more significant regional players in construction R&D. Like the East Midlands and South East, the Region's construction businesses spent £4 million on R&D in 2004 (Figure 26).

Figure 26: R&D Expenditure by Region in the Construction sector, 2004



Contrary indications are given by the regional record of construction business turnover attributed to new, improved or novel products. This has historically been rather low, particularly in the West Midlands – only 1% compared to 11% UK-wide (see Figure 4, chapter 3). The 2005 UK Innovation Survey showed that, nationally, the construction sector's innovation activity – at 44% - was still among the lowest of all the broad industry groups (see Figure 7, chapter 3).

The perception of an entrenched conservatism in the sector is reinforced by international comparisons which show that the adoption of new technologies is tardier in the UK than elsewhere. For instance:

- A Building Research Establishment exhibition on new construction methods showcased the German PassivHaus concept, which consumes 25% less energy than a standard UK home.
- In 2005, the share of housing sales represented by pre-fabricated construction was 1% in Britain, compared to 15% in Germany.
- Glued brickwork, which had been used in the Netherlands and Belgium for 10 years by 2002, was then being trialled in the UK for the first time, at the University of the West of England, Bristol.
- There is little interest in the UK in bendable concrete, though substantial interest in Japan due to their earthquake problem.
- Underfloor domestic heating is standard in some countries, but hardly used here.
- The development of fuel cells for building applications mainly occurs in the US.

There is little indication of the participation of West Midlands higher education institutions in international research partnerships. This is undoubtedly due to the prominence of research activity devoted to other sectors. That the Building Research Establishment is based in Watford rather than the Midlands may also be a contributory factor in the lack of stimulus for West Midlands research into new technologies.

The DTI report A Strategy for New Materials (2006) emphasises the need to optimise the research base not just for construction-related activity but for materials research more generally. Indeed, the technological cross-over and multi-disciplinary nature of materials development and applications makes a strong case for linking construction research to research in other fields.

7.3 New Materials and Technologies

Modern methods of construction and new and alternative materials are inherent in the concept of sustainability. Modern construction methods are designed to:

- Speed up the construction process significantly.

- Reduce energy and water consumption during a building's construction and occupation, and
- Reduce waste, eliminate defects, and decrease building expenditure.[234]

Elements classed as off-site include the whole range of building components, such as:

- Precast or preassembled inspection substructure chambers.
- Precast building foundations, including steel piles.
- Structural precast concrete frames and beams, including steel and timber.
- Utilities pods, preassembled service and distribution units and modular wiring.
- Large panel systems for walls and doors.
- Preassembled modular or flat pack buildings.
- Preassembled bridges and other large civil engineering structures.[235]

New materials for construction applications include composites and new types of concrete and joining methods. 'Smart' technologies are a major impetus for innovations including the 'intelligent home' which is digitally controlled, such as by switching appliances off or on to adjust to temperature or to suit the resident's lifestyle, as well as recording data. Fuel cells offer prospects as power sources.

Nanotechnology has a future in construction, its potential already foreseen in cement and coatings.

Sensors are already in early adoption, for instance in bridges to monitor structural changes.[236] The DTI's Materials Strategy (2006) points out that *materials* for sensors in construction applications await further innovation for use in measuring the lifetime of structural materials, concrete ageing in functional materials, monitoring structural health and diagnostics in multifunctional materials, and the microbial hazards in biomaterials. Structural materials represent an opportunity for the construction sector in terms of advanced steels and light alloys and composites, as well as through incremental improvements in materials development.

Green concepts have much significance in construction and the built environment, not least due to concern about protecting the natural environment, ensuring that the urban setting is constructed of environmentally sound materials and building techniques that help to conserve natural resources by using alternative or regenerating sources. This

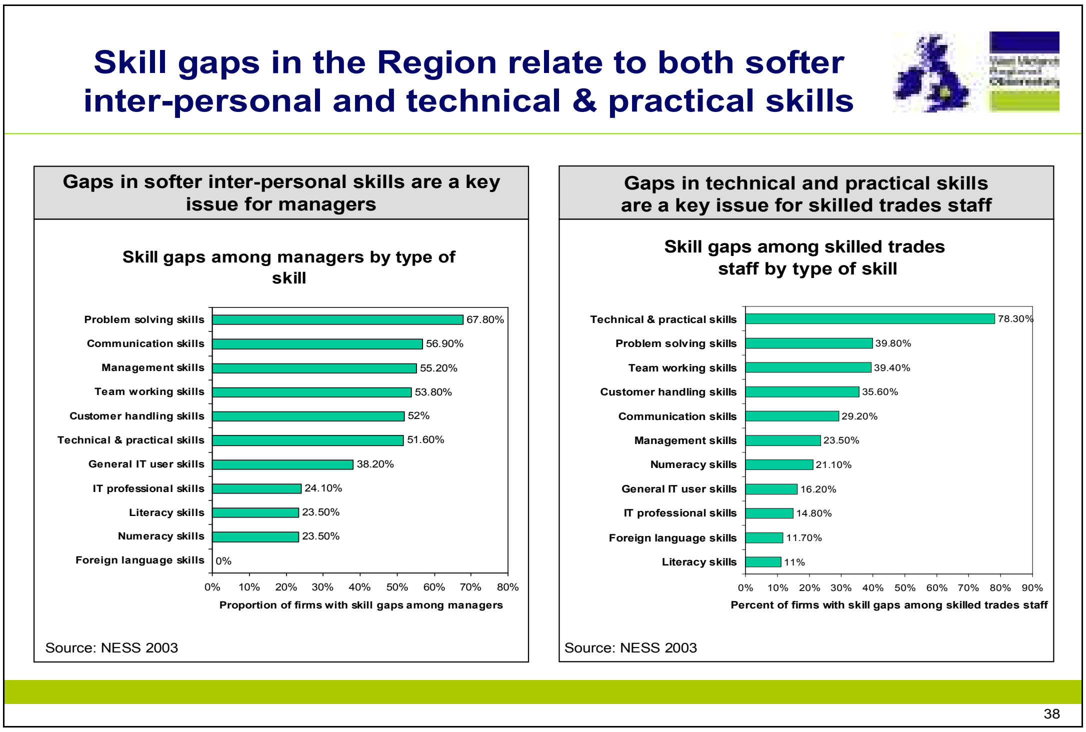
[234] Materials World, July 2005
[235] Goodier and Gibb, undated (2004/5)
[236] Tilson (2005); ibid (2006)

has kindled interest in the use of timber, as well as other materials which can be grown and harvested. The use of recycled materials is already a part of the construction value chain through such means as the use of waste aggregates in road construction, and the re-use of reclaimed building materials.[237]

7.4 Skill Issues and Needs for Innovation

Performance improvement among West Midlands construction businesses is severely curtailed by skill deficiencies across the spectrum of competences among the range of occupations from managers to skilled trades. Results from the National Employer Skills Survey (2003) demonstrate that many of the skills for successful supply chain collaboration to improve performance, as well as engaging in innovation activity, are in short supply, including inter-personal skills like team working, customer handling, and communication skills. Technical and practical skills are deficient. Managers are severely lacking in the ability to manage effectively (Figure 27).

Figure 27: Skill gaps in West Midlands construction workforces, 2003

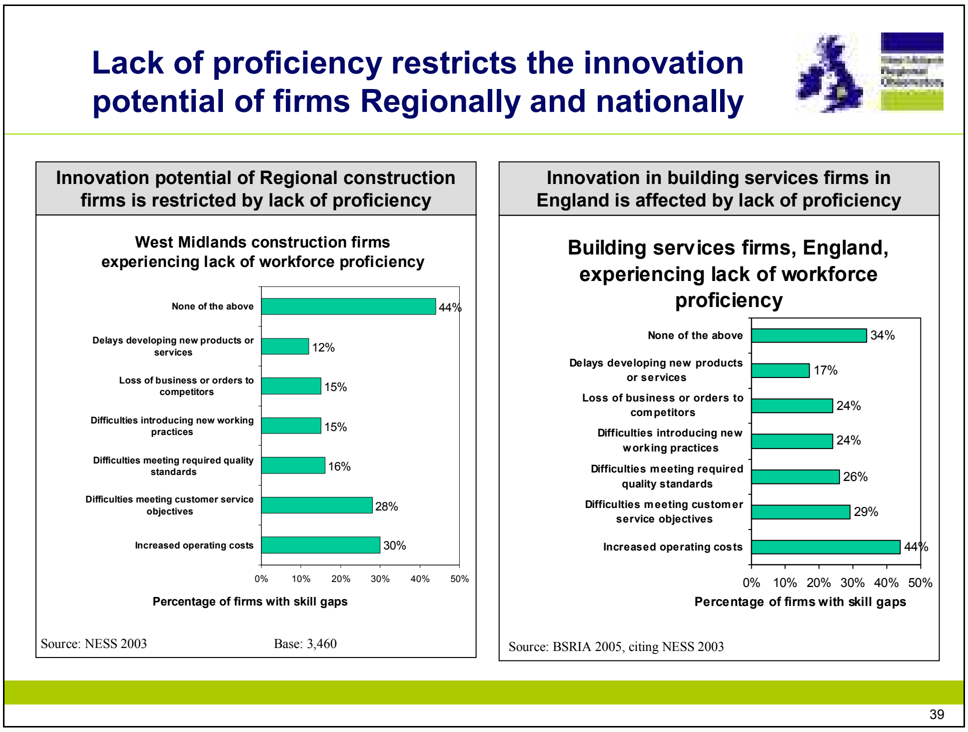


Apart from the major effect of lack of proficiency on increased business operating costs, it is also noteworthy that this restricts the *innovation* potential of firms both in the West Midlands as well as nationally. It creates problems for the introduction of new working practices, as well as new product or service development. It also

[237] Tilson (2005); ibid (2006)

prevents the achievement of efficiencies which would bring down operating costs, improve performance and help meet customer targets (Figure 28).

Figure 28: Impacts of lack of proficiency in construction and building services



7.4.1 Skill needs for ICT

The use of more sophisticated information and communication technologies, and ICT use across all functions, exerts skill needs in terms of:

- Internet-based communication methods and knowledge and data transfer.
- Procurement and logistics.
- Supply chain management and partnership.
- The development and use of smart technologies, robotics, and
- The construction and fitting out of 'intelligent' buildings.

CITB-Construction Skills points out that preparing construction workforces for the greater use of ICT systems entails the development of appropriate qualifications and training. Business leaders and managers also need to gain the skills to successfully manage ICT as a strategic resource. They identify a role for the sector skills agency in encouraging industry bodies and employers to work with ICT suppliers to develop systems relevant to the construction sector, and to maximise the quality of computer learning that is available to construction managers and workforces.[238]

7.4.2 Pre-fabrication and modern manufacturing methods

The emergence of innovative building techniques and the growth of novel and alternative materials relies on the willingness of contractors to adopt them. A key issue is the lack of familiarity of contractors in new techniques, including installation skills. This places an onus on the availability of appropriate training and support, as well as a marketing campaign to enthuse them out of any conservative tendencies.

The take-up of modern methods of construction involving pre-fabrication such as wall systems and doors, preassembled bridges and precast building foundations[239] promises to revolutionise the construction and building services industries, certainly for new build and perhaps for a degree of repair work. However, off-site manufacture is not expected to reach significant levels until about 2020 – although who can say for sure, given the current policy, economic and competitive forces for change – and even thereafter the traditional skills are still expected to be in demand.[240]

As much of the work will be done in the factory, there will be less call for the on-site employment of many of the traditional trades associated with construction sites like plasterers, electricians and even bricklayers. They will need to be trained to enable their adaptation to new working environments and practices which could include modular wiring in preassembled service and distribution pods and dealing with flat pack buildings. The *supply* of training itself will need to adjust. Clearly, it is imperative to initiate the necessary adaptive mechanisms and structures.

7.4.3 Innovation and skill issues for building services

Manufacturing innovation in products relevant to building services engineering has clear skill impacts for installation and maintenance. SummitSkills notes ongoing issues in terms of:

- System design and pumping.
- Water treatment.
- Power flushing.
- Building regulations.

[238] CITB-Construction Skills, The business case for IT, 2005
[239] Goodier and Gibb, Build Offsite, undated (2004/5), report for DTI

- Energy efficiency, and
- Sustainability.

Emerging issues are noted for evolving technologies like:

- Photovoltaic energy sources, and
- Environmental technologies.

In August 2005 SummitSkills launched a group consisting of product manufacturers and trade associations whose remit is to monitor technological change and to determine the skill impacts.[241]

7.5 Solutions to Skill Limitations

It is important to motivate and enable firms in all facets of construction and the built environment, both large and small, to learn about and utilise new materials and techniques. Management and leadership need to understand and drive change, and be responsive to changing technologies, processes, and the possibilities within the greater use of ICT.

To manage supply chains better – which may involve several hundred small subcontractors on large construction projects - requires better skills in supply chain management. There are issues about acquiring greater expertise in the use of project management software, undertaking analytical processes such as value engineering to evaluate each stage of construction projects from design conception to delivery and finalisation, optimising design build, and simplifying site inventory and installation. The construction and built environment sector has a benchmark in the automotive and engineering sector for the adoption of performance improvement and lean manufacturing techniques. Only by taking a proactive approach to self-improvement can firms make the efficiencies that the Deputy Prime Minister has called for.

Engaging employers in training initiatives is vital - encouraging them to train their staff, and devising solutions to issues which hinder training action (such as the high mobility and transience of labour) by being innovative in the way that training is delivered. It is important that trainers themselves keep at the forefront of technological advances. How can this be ensured?

While training in traditional building techniques and building services trades will continue to be important over the next decades, it is crucial that training – and the

[240] Tilson, Construction skills profile, 2005

qualifications base – adapts to technological advances. It was noted above that the projected increase in pre-fabrication will mean less work done on building sites, both in bricklaying and other skills such as plastering and electrical wiring. Instead, more pre-installation work will occur in the factory. The question is – where will that manufacture take place? Will the UK – and the Region – grasp the opportunities that the growth of pre-fabrication offers for developing and producing innovative building solutions? Will the knowledge and expertise, as well as the networks and information exchange mechanisms to engage in R&D programmes and to see these into commercialisation become more fully evolved in the Region, not only for pre-fabrication but for advanced and new technologies and systems more generally?

It is crucial to increase the numbers of graduates and research students in disciplines like materials science and civil engineering. Certainly, the lack of a sufficient level of demand from employers needs to be resolved in order to expand course provision at higher education level. The use of overseas talent, made possible through the online transfer of engineering designs, is an issue which needs to be taken up. Bringing on the next generation of mechanical and electrical engineers, and solving these skill shortages, are also high priorities. A key solution is seen in employers taking the initiative and filling HNC and HND courses with their own employees.[242]

It is also important to increase the numbers and calibre of young people in further education, and to improve the participation rates among women and minority ethnic groups. Although there are initiatives under way, it is worth addressing whether these are adequately targeted and resourced to make a large enough difference, and sufficiently speedily. The industry itself, as well as public sector agencies, are well aware that an image-raising exercise for the construction and built environment sector can increase the appeal of construction careers to potential recruits and increase the diversity of its labourforce.

7.5.1 Policies, Programmes and Initiatives

A number of programmes and initiatives have innovation and performance improvement objectives. These include government programmes with regional delivery, as well as those which are initiated and led by West Midlands-based institutions and organisations like the regional development agency and local LSCs.

Constructing Excellence is a government initiative which has a regional delivery structure. The objective is the construction sector's increased productivity and performance improvement. Constructing Excellence is a prime focus of the West Midlands Building Technologies Cluster Opportunities Group's activity.

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[241] SummitSkills, information release, 17 August 2005, SummitSkills website
[242] Construction News, 4 August 2005

AWM's project to encourage the development of materials and products to create modern building solutions identifies major areas including:

- Active support for innovation in West Midlands companies.
- Construction waste, linking with the Environmental Technologies cluster and the Waste Resources Action Programme (WRAP) to develop a strong regional market for recycled building materials, and
- Smart materials and technologies in ceramics, plastics and metals.[243]

The Technology Innovation Council has included construction within its remit.

Under the Sustainable Public Buildings Initiative the West Midlands has been given the national lead for off-site manufacture. The objective is to encourage research, to develop training packages, and to provide information.

There are also various other programmes which have a sustainability and regeneration theme, including New Deal for Communities, and the Housing Market Pathfinders. The latter was established by the government in conjunction with the Housing Corporation. There are 3 Pathfinder projects in the West Midlands, in Birmingham, Sandwell and North Staffordshire.

Coventry and Warwickshire's stAR Group has an ongoing Sustainable Training for Sustainable Communities demonstration project, run by the Whitefriars Housing Association with other partners, notably the LSC.

Coventry and Warwickshire LSC, with other partners, has put forward an ACT-UK proposal to establish a national centre for advanced construction technologies, including a training centre for the latest building processes and materials.

It is important to note that some key West Midlands initiatives were 'virtual', or still remained in the planning or early stages in 2005/6. This raises questions about the speed with which innovation can occur. Is the level of funding adequate, the involvement of stakeholders sufficient? Are the links to other fields of research and innovation – like materials, engineering, ICT and electronics - being strongly forged in order to maximise the potential from cross-disciplinary expertise? How can greater industry participation be encouraged?

There is also potential for greater engagement in various UK and international collaborative research, including via the recently formed Materials Innovation and Growth Team (MIGT). The MIGT's Science and Technology task group is led by Birmingham University's Professor Graham Davies, head of the School of

[243] AWM, Building Technologies Cluster 3-year plan 2005 - 2008

Engineering. The structural materials strand is led by Rolls-Royce at Derby. A Multifunctional Materials strand is led by Dr Alan Hooper of Qinetiq. The EPSRC has a construction research strand, though involvement appears to be mainly outside the Region. Other research groups include SUMACON (concrete) and NANOCEM. [244]

[244] Tilson, Construction Skills Profile, 2005

8 INFORMATION AND COMMUNICATION TECHNOLOGIES

8.1 Introduction: Information and Communication Technologies

The expansion of the global economy has increased the need for industries to compete strongly against international competitors. ICT is pivotal to any strategic action taking on the challenge of globalisation, as it has a growing role in the convergence of technologies and the emergence of new markets and business models.

ICT is a basic skill of modern business - indeed, a business enabler - ranking highly alongside literacy and numeracy. It also possesses cross-sectoral importance for innovation. Increases in software expenditure have been the major source of investment in knowledge among the majority of OECD countries including the UK.[245] ICT software, systems and hardware expertise is fundamental to most other sectors including manufacturing, automotive and other transport technologies, medical and biotechnology. Not only does this underpin organisational and supply chain management, but it also provides the means for firms to unite globally for innovation through internet communications, to design and develop products and systems and send these electronically to partners, customers and suppliers, and to employ automation to manufacture these. It is also employed to document and to record electronically, and to exploit internet-based information for market, competitor and supplier analysis, as well as for marketing, selling, and procurement.

Broadband subscription is growing, similarly internet sales – though issues exist about the unsuitability of products for sale via the internet, and there are security and legal concerns about transactions and information. Demand for the internet has substantially driven the increase in home computer use.[246] Between 2000 and 2004,

[245] OECD Science, Technology and Industry Scoreboard, 2005. Investment in knowledge here defined as spend on software, higher education and R&D.
[246] OECD Science, Technology and Industry Scoreboard, 2005

the UK, France, Austria and Spain saw an increase of over 70% in the share of households with access to a computer at home. In most European countries the volume of internet and other e-commerce transactions (including electronic data interchange) has increased as a percentage of total turnover. In 2004, the UK, Ireland, Denmark and Germany reported the largest share. The UK was also among OECD countries with the largest share of businesses purchasing via the internet, as well as selling. During these years, home internet access grew fastest in the UK, Germany, Portugal and Austria. China is expected shortly to become the country with the largest number of internet users. [247]

Use of the internet has become standard for businesses with 10 or more employees, with broadband access used increasingly for internet connection. The rise in broadband access has coincided with a rise in the use of internet telephony, such as Skype, and mobile internet use. Technologies such as these are disruptive ICT technologies whose use can radically change the ways that businesses operate.

ICT manufacturing includes computer and office equipment, software, instruments for measuring, checking and testing, industrial process control equipment, as well as electronic, television, video, recording and telecommunications equipment. Asian economies, including China and Taiwan, but also the US and Germany among OECD members, are the main exporters of ICT technologies. However, the UK has a "vibrant ICT industry with many of the critical conditions to be a world leader." [248]

Around 12 million people work in ICT-related jobs in the UK. Over 580,000 people work within the ICT industry, and an additional 590,000 work as ICT professionals in other sectors. This rate is expected to grow between 1.5% and 2.2% every year for the next decade, particularly areas such as consulting and outsourcing. The UK has a relatively large share of ICT specialists and broadly defined ICT-related employment, compared with most other OECD members, as well as having the largest share of broadly defined ICT-skilled employment in the EU in 2003. ICT specialists and users accounted for 20% - 30% of total employment in most OECD countries in 2003.

The West Midlands ICT cluster sits within a group of subsectors which form the creative industries. These include design, film, media and advertising. The Region is considered to have a developing strength in software, interactive leisure software (screen, games and new media) and hardware consultancy.[249] The Region ranks 5th among the English regions for the size of its ICT workforce, totalling 87,777 people. Over half of these (53%) work in the ICT industries, the remainder as ICT professionals working in other industries, principally as computer software consultants, as is the UK norm.

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[247] OECD Science, Technology and Industry Scoreboard, 2005
[248] Birmingham and Solihull LSC, Review of Education and Training within the ICT Sector, 2005
[249] Advantage West Midlands, Digital West Midlands – The Regional ICT Strategy, 2005/6

8.1.1 Defining ICT Uses and Skills

The OECD asserts[250] that there is no commonly adopted definition of ICT skills and no internationally agreed list of ICT-related occupations. ICT skills are described as "difficult to measure" and proxies tend to be used such as educational level or occupation. ICT skills cover both ICT *specialists* and ICT *users*:

- ICT specialists have the ability to develop, operate and maintain ICT systems. ICT is their main job.
- Advanced ICT users are competent in advanced, often sector-specific, software tools. ICT is not their main job, but a tool.
- Basic ICT users are competent users of generic tools, such as Word, Excel, Outlook and Powerpoint, needed to function in the information society, e-government and working life. ICT here is also a tool, not the main job.

Business uses of ICT include:

- The employment of e-commerce for buying and selling products and services, internet auctions (e-procurement), technologies used to sell products, for market/supplier research, and for marketing/advertising through websites.
- Links between e-commerce and in-house systems, e.g. for customer/supplier documentation,
- Customer relationship functions e.g. orders, warehousing, databases.
- Dealing with government.
- Computer networks in business functions like logistics, finance and human resources.
- Design and engineering; production control; testing.

8.1.2 The Link between ICT Use and Increased Productivity

The link between ICT use and increased business productivity was recognised in the 1990s, when over 40% of labour productivity growth in UK business was said to be due to the diffusion of ICT. [251] This correlation is still confirmed, both between the use of e-procurement and higher productivity levels, and by firms employing a high proportion of labour with frequent access to ICT. Productivity gains are as follows:

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[250] OECD Science, Technology and Industry Scoreboard, 2005
[251] HM Treasury, Lisbon Strategy for Jobs and Growth, October 2005, citing EU and OECD research

- For every additional 10% of employees ICT enabled in manufacturing industries, productivity is increased by 2.2%. For younger firms it is 4.4%.
- For every additional 10% of employees internet enabled, productivity is increased by 2.9%. For younger firms it is 3.4%.[252]

Manufacturing firms are more likely to use ICT to optimise their value chains and operations. This gives them a degree of flexibility to respond to fast changes in their business environment and helps to improve their productivity. It is particularly useful for mature firms, whereas younger firms are generally more flexible in adopting and employing new technologies, allowing them to experiment more. In services, productivity gains via the use of ICT tend to come from channelling improved supply chain models and inventory management, especially in distribution services. Among manufacturing industries, the substitution of low-cost labour by ICT is evidently well advanced. Employees that remain tend to be highly skilled ICT users. [253]

Although there is growing evidence of a relationship between ICT investment, ICT use and skills, what is not entirely clear is the *balance* of the contribution to higher productivity made by ICT skills, compared to work organisation and management practices that may be more, or as, conducive to a productive environment. Indications are that the level of ICT investment plays a strong part, based on evidence from the effects of US takeovers of UK firms, for where a US firm takes over a UK firm the US purchaser makes a higher level of ICT investment than occurs in a UK takeover. Neither is the role of ICT in knowledge management well understand for its enabling of networked, information sharing individuals, both for its use by 'virtual' firms and also for businesses' use of electronic networks for innovation. [254]

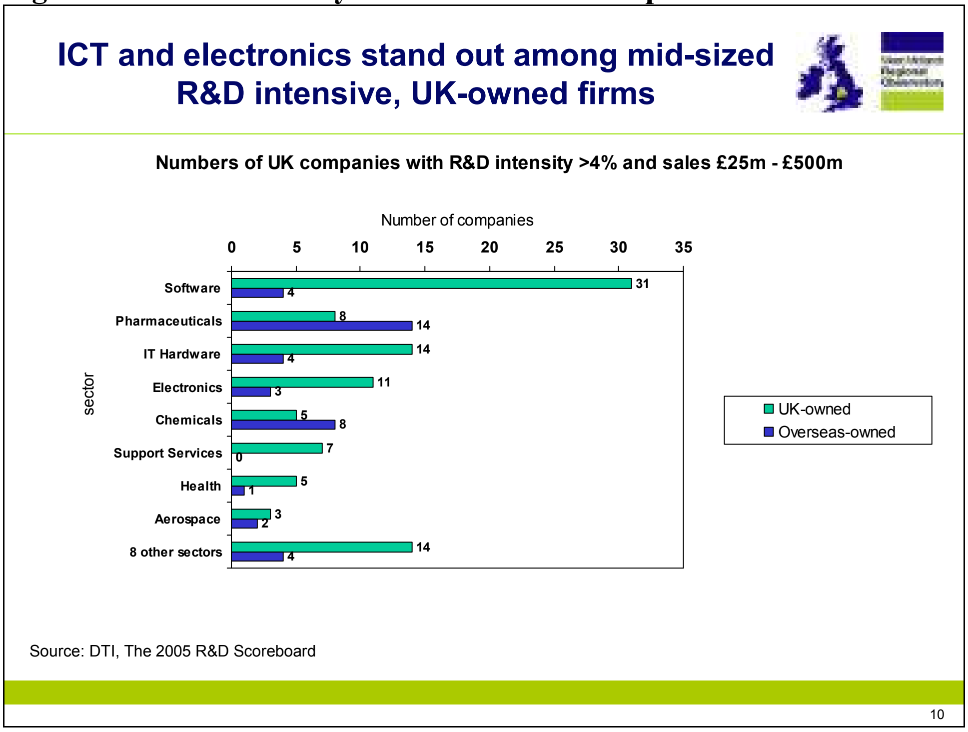
8.2 Research and Development

The UK is a strong base for ICT innovation. Firms in the ICT sector invest heavily in R&D. In 2005, the Treasury noted that a growing number of research intensive SMEs exist in ICT where the UK has performed less well in the past. [255] Software, electronics and IT hardware are distinguished by their largely UK-owned medium sized R&D intensive companies, unlike most other sectors where companies are predominantly overseas-owned (Figure 29). R&D intensity for these companies

[252] Clayton (2005); Farooqui (2005)
[253] Clayton (2005); Farooqui (2005)
[254] Clayton (2005); Farooqui (2005)
[255] HM Treasury, Lisbon Strategy for Jobs and Growth, October 2005, citing EU and OECD research

is at least 4%, measuring R&D as a percentage of sales. Among OECD countries (which include the UK), ICT manufacturing industries accounted for more than a quarter of total business R&D in 2002 in most members.[256]

Figure 29: R&D intensity of mid-sized UK companies in ICT: sector contrasts



Note: in the 8 other sectors, UK-owned firms include 4 household and 3 engineering; 3 automotive firms are among the 4 overseas-owned.

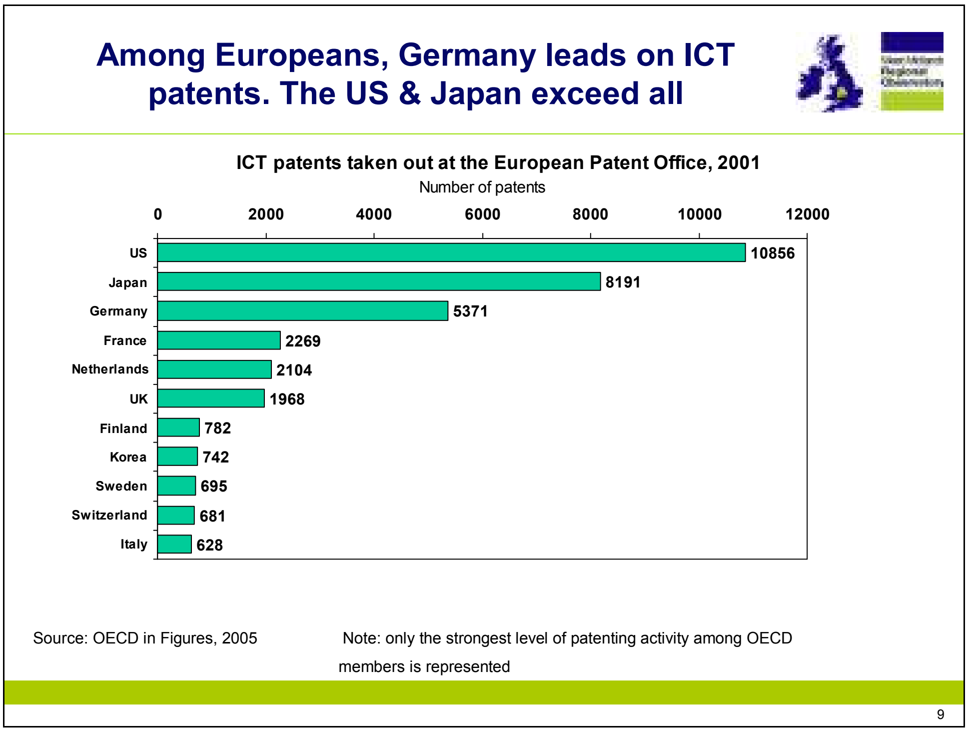
In software and computer services, the 2005 Scoreboard shows that UK firms in the Financial Times 750 index increased both the proportion of total UK R&D, as well as their R&D intensity since 2004 (5.2% compared to 4.5%). For IT hardware, telecoms services, and electronic and electrical equipment, however, the pattern is reversed.

Among OECD members the UK displays among the strongest levels of patenting activity, though well behind the US and Japan. Across Europe, the UK is roughly on a par with France and the Netherlands, but trails Germany (Figure 30).

However, the patent level for ICT is not a sound reflection of the strength of R&D activity in the sector, since software development is one case where protection is made by UK firms using mechanisms such as copyright and trademarks.[257]

[256] OECD Science, Technology and Industry Scoreboard, 2005
[257] DTI, The 2005 R&D Scoreboard

Figure 30: UK patent activity for ICT in the OECD context, 2001



8.2.1 The Software Development Process

Silicon Valley is probably the most significant – certainly the most famous - cluster of software expertise in the world and, for this reason, it is of value for benchmarking. From the point of view of developing the ICT cluster in the West Midlands, it is interesting to note that a Silicon Valley Product Group exists for software developers. Sharing knowledge is a prominent aspect of the group's culture. This includes publication of a regular online newsletter as well as 'how to do it' – or, in fact 'how *not* to do it' - papers on developing software products. These share some useful insights into the range of expertise and processes involved – whether variants of the Waterfall process, different types of Agile process, or the Rational Unified Process. The point is made that: "After 30 years of trying there is still no perfect product development process...the determining factor is usually the quality and experience of the team members rather than the process or tools." [258]

Issues raised by the Silicon Valley Product Group include:

- The question of what constitutes 'best practice'. Which method to use, and variants. Issues also of quality assurance.
- The problem of achieving user-ready products which work well, even for methods that are light on documentation.

[258] Cagan, The product manager and the product development process, 2005

- The need for collaboration between business people/customers and product developers during the development process.
- The need for real user feedback to ensure the software will be robust enough to operate across the spectrum of user environments.
- The importance of effective teams for partnered or group development during the design process, to share ideas and review each others' work.
- The importance of product/project management expertise.

8.2.2 Case study of a software developer's expansion

Firms in the vanguard of research and development often have little choice but to develop what they need themselves both in terms of hardware and expertise. Later, mature innovative firms can find it a challenge to keep at the forefront of a developing market, particularly when their product portfolio is more complex and their operations are sizeable. The case of AVEVA, an innovative UK software solutions provider for the design of complex, large-scale process and marine facilities, [259] illustrates the key strategic decisions and competency needs of an expanding firm (Text Box 13).

AVEVA note that, in the engineering software business, finding engineers to produce specifications is the most difficult task facing employers in Western Europe. The problem is exacerbated by the decline and transfer of industries like shipbuilding to Asian economies. The company emphasised their continuing need to recruit experienced talent in software applications. An effective way to do this was seen as establishing development centres where the skills are located, in Asia and east Europe.

The decision to establish overseas development centres introduces fresh challenges in relation to export controls and intellectual property ownership, though having R&D centres abroad means that they will still be able to keep this function in-house and so help to safeguard their IP security.

Communication in teamwork is named as the key competence after software engineering skills. Video conferencing facilities were in use, but were not seen as an effective substitute for face-to-face meetings.

[259] DTI, The 2005 R&D Scoreboard

Text Box 13: Case study of AVEVA's expansion

- Developed what was needed themselves in the early days when software industry was embryonic.
- Keeping products at the forefront of a developing market is a constant challenge.
- Nearly 20% of sales are invested in R&D. Operating profit just over 10% of sales.
- Core (in-house) teams develop strategic features, while non-core coding, testing and localisation are outsourced.
- Functionality development is split between in-house specialist engineering teams and outsourced partners.
- Software development takes place at the home site and across Europe and beyond. The spread occurred for 2 reasons: to access precious skills and diversify the portfolio, and to broaden market access.
- The firm is working more closely with Asian customers.
- Multicultural development teams are seen as the way forward. For example, a team in India has been employed for a specific project. Indian and Romanian centres are being brought into the development programme.

8.3 Skill Issues and Needs for Innovation

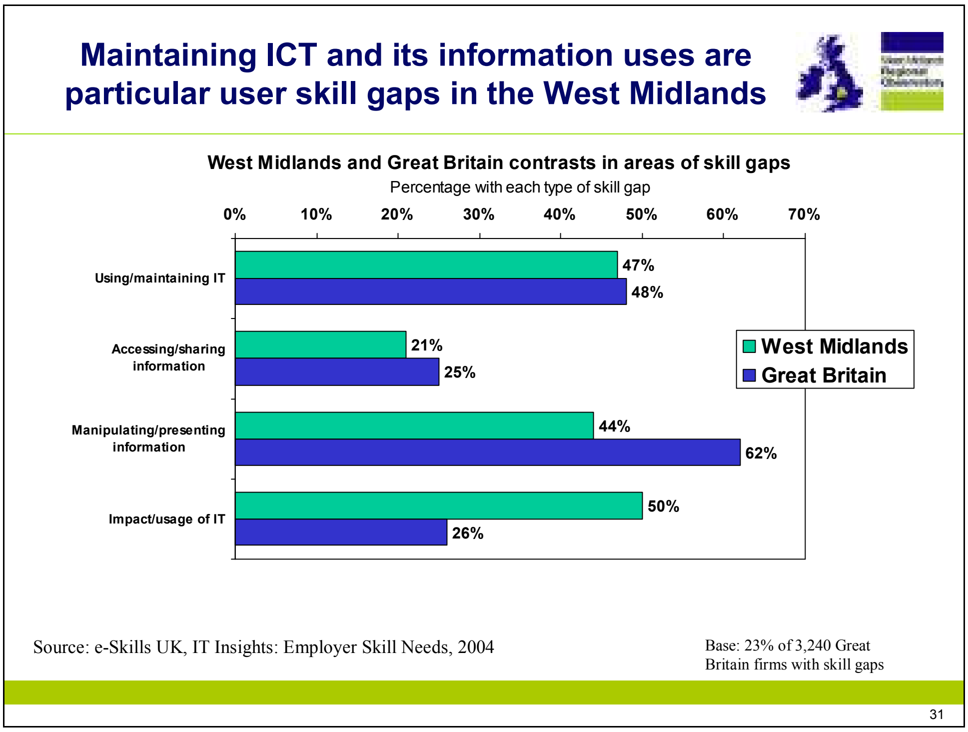
The sector skills agency, e-skills, confirms that skill shortages are one of the major limiting factors in enterprise growth. Certainly, this is an issue not only for media-related ICT, but also across the spectrum of medium to high performance applications in other industries, including in manufacturing and design engineering. Indeed, e-skills asserts that in 2004 recruitment problems relating to ICT were having a major effect on the operation of two out of every 5 of the one third of 51,000 companies they surveyed that encountered recruitment problems, and, in particular, was affecting their development of new products and services.[260]

The West Midlands has high levels of skill gaps among ICT users (Figure 31). Although slightly less seriously affected than the national average, cross-regional contrasts undertaken by e-skills UK show the Region more severely affected than many regions.

Keeping up with ICT-driven change is a challenge, particularly for smaller firms. The A D Little report (2004) on Research and Innovation for the West Midlands notes that these firms need a constant influx of financial and professional support. Concern is aired about the quality of graduates in the West Midlands labour pool, and the suitability of course content to local industry.

[260] E-skills UK, IT Insights: employer skills needs, 2004

Figure 31: User Skill Gaps for ICT, 2004: West Midlands and Great Britain



8.3.1 Customer relationship management

Internet-based ICT is increasingly an enabling factor for businesses in terms of their customer relationship management, to enable managers and sales people to record, organise, source and supply information, services and products. The market expanded by 10% in 2004. [261] Consequently it has a strong strategic function. Mobiles and personal digital organisers that have network functions increase the possibilities for data management and knowledge sharing 'on the ground', enabling sales to communicate directly with, for example, the shop floor. Crossover from other technologies like these is expected to continue to boost the ways that customer relationship management is performed. It enables the business community to analyse every aspect of its customer interface. It is important that businesses are able to put this information to good use and this makes it crucial that they invest in technology and skills to enable them to exploit their opportunities. However, there are major question marks about this, as the National Employer Skills Survey 2003 showed that inadequate ICT skills affected 26% of cases where staff lacked proficiency in their jobs. Skill gaps affected 46% of administrative staff, and one in 3 professional and associate professional staff.

[261] E-skills UK, IT user digest, 2, October 2005

8.3.2 Professional ICT skill gaps

Specialist software is utilised by businesses for applications such as:

- Design and engineering.
- Project portfolio management.
- Supply chain management.
- Enterprise resource planning.
- Customer relationship management.
- Financial systems.
- Web/multimedia.

The uptake of these is much greater among medium-sized and larger firms than among micro and small firms. Not surprisingly, due to its concentration of manufacturing, the use of software for design and engineering is highest in the West Midlands (20%) than nationally (9% in Great Britain), and the use of computer aided design (CAD) is also particularly high in the Region.

The 2004 e-Skills UK survey found that, nationally, 6% of firms using specialist software reported issues about training and skills for design and engineering, and 8% for project portfolio management, though less for other applications.[262] ICT professional skill gaps were estimated to be an issue for 84,000 enterprises across Great Britain in 2004. In the West Midlands, firms were more severely affected than most other regions by skill gaps (14% compared to 9% nationally), and skill gaps were more frequently cited among ICT professionals in West Midlands firms than nationally (41% compared to 36%) (Figure 32, overleaf).

About one third of firms in Birmingham and Solihull had vacancies for professionals in 2005, needing skills in Java, Action Script and broadband specialisms, in particular.[263] The most significant skill gap in the sub-region is the development and implementation of ICT systems and services. It is important to note that this is not only a sub-regional issue, since the e-Skills UK survey noted a problem nationally, particularly in relation to systems integration (Figure 33).

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[262] E-skills UK, IT Insights: employer skills needs, 2004
[263] Birmingham and Solihull LSC, Review of education and training within the ICT sector, 2005

Figure 32: The Incidence of Professional ICT Skill Gaps: West Midlands and Great Britain, 2004

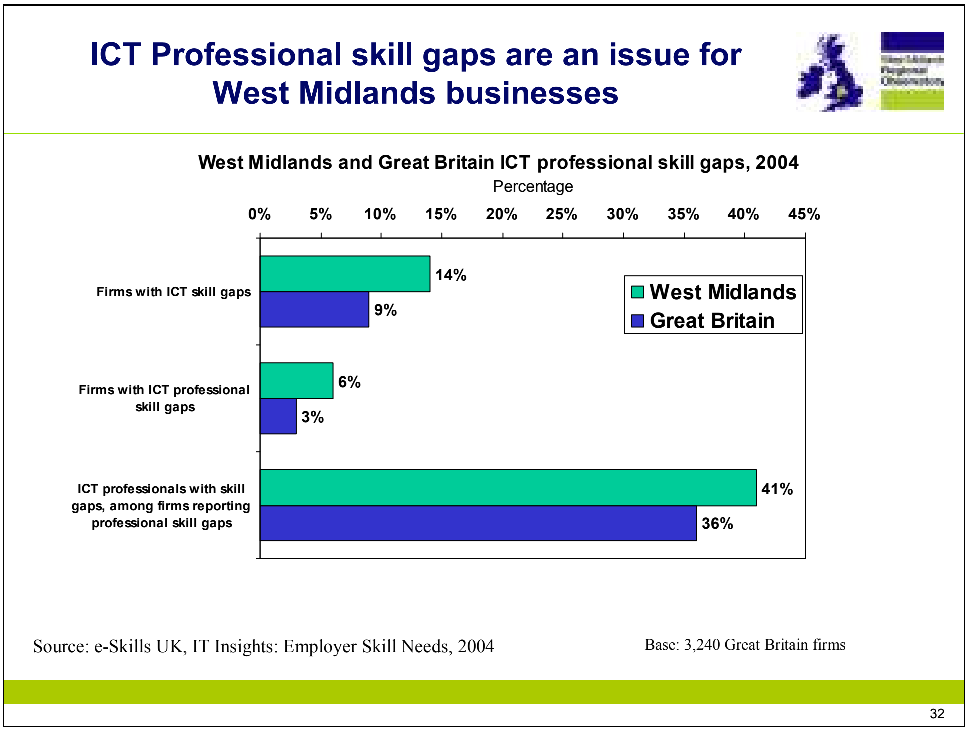
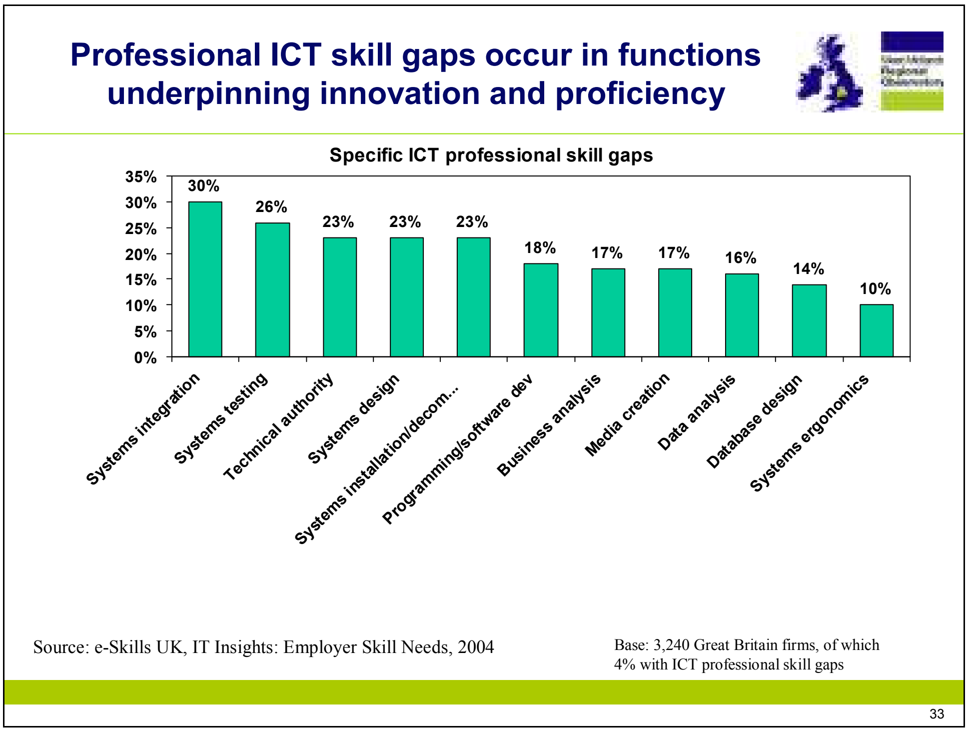


Figure 33: Skill gaps in development and implementation skills among ICT professionals, Great Britain, 2004



Limitations in the development and implementation of ICT systems and services are a most pressing concern due to the pivotal role of ICT in enabling firms in all sectors to compete strongly in the global business environment. It is projected that the role of

ICT professionals will change from that of technology support to business application. These professionals will be part of the business and improvement team with a much broader remit for processes and procedures than simply automating them using ICT systems.[264] ICT professionals with expertise in systems architecture and integration, networking, web design, and security will be in continued demand. Those with systems expertise and who can work in [international] teams to design business-relevant systems and services are expected to command the highest financial rewards. It is crucial to ensure that ICT professionals have business competences as well as ICT knowledge. Their continuous professional development is a key area for urgent and ongoing attention.[265]

Managers, too, are increasingly dependent on a knowledge of ICT, and specifically, it is crucial that they understand the technological opportunities inherent in ICT and how these could be used to maximise business performance. It is believed that 58,840 managers needed improved ICT professional skills in 2005, with 40% increased to level 2 and 60% to level 3+.[266] Managers often lack the skills they need to exploit ICT in this way and to operate in the e-economy, though ICT skills are expected to be an increasingly important tool for managing change. There is a major issue about providing managers of small businesses, in particular, with the vital ICT skills they need if they lack in-house professional staff because there is little skill development in place to address this, either Regionally or nationally. There is also a lack of accessible diagnostic and support tools for SMEs wishing to make strategic use of ICT.[267]

Although the West Midlands has one ICT professional for every 33 employees, against a UK average of 36, it is noticeable that the English regions which are highly innovation-successful and R&D intensive are among those with a better ratio of ICT professionals to employees. The East of England, for instance, has one ICT professional for every 25 workers, the South East has one for every 20 (see Figure 34).[268] It is essential for the West Midlands to improve its own ratio substantially.

Operations technician skills are also in relatively short supply in the West Midlands compared to the UK overall – 14% of the Region's firms having technician vacancies and schools and the public sector reporting recruitment problems.[269] It is crucial that their numbers and levels of expertise are increased.

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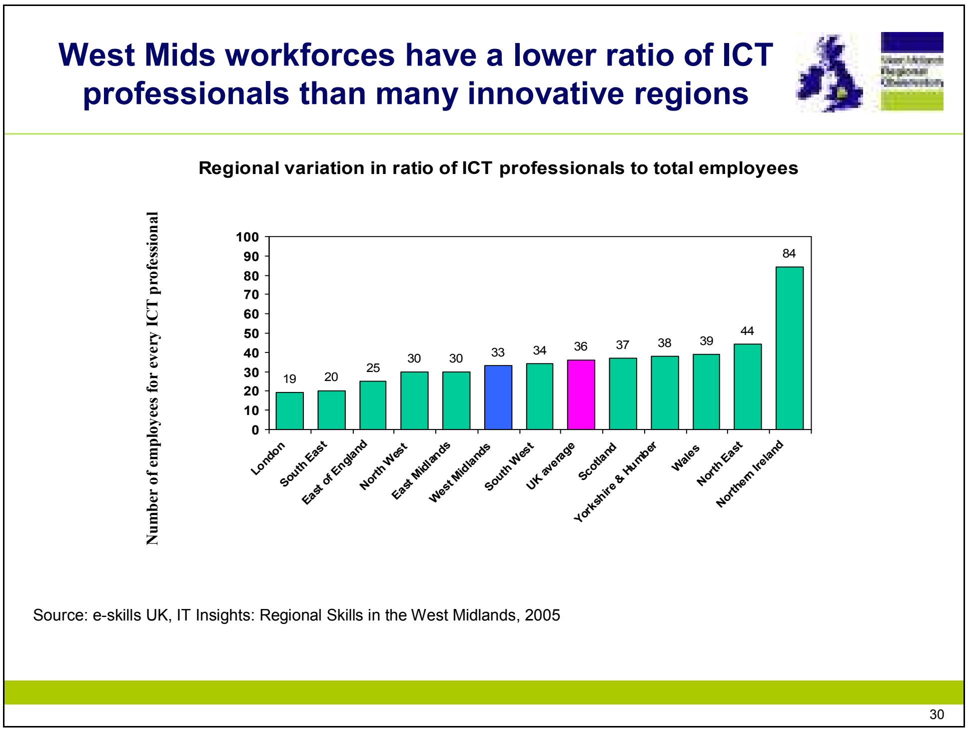
[264] E-Skills UK, It Insights: drivers of demand for skills, 2004
[265] E-Skills UK, IT Insights: regional skills in the West Midlands, 2005; E-Skills UK, Level 3 Trials, 2005
[266] Birmingham and Solihull LSC, Review of education and training within the ICT sector, 2005
[267] Sector Skills Development Agency, Exploitation of IT, ssda.org.uk/, accessed February 2006
[268] E-skills UK, IT Insights: regional skills in the West Midlands, 2005
[269] Birmingham and Solihull LSC (2005)

Figure 34: The ratio of ICT professionals to employees: regional contrasts



Broadly, the concerns that employers raised for the 2005 Review of Education and Training within the Birmingham and Solihull ICT Sector are also held nationally. The Review found that nearly all employers felt that current training provision lacks relevance to what is happening in the ICT sector. How do you ensure that ICT training provision is up-to-date? Also, students are rarely taught the importance of business, or about the life cycle of product development, the interdependencies of ICT with other operations, and the use of project management techniques. Further points were raised about the need for collaboration skills to work with other disciplines; adaptability to change; and the ability to transfer skills to others.

Wider skill limitations were also noted in ICT recruits outside their specialisms, mainly in ‘soft’ skills. These are certainly skill needs which are generic to business operations, but are also highly important for people engaging in innovative activity:

- Customer service
- Communication
- Social skills including reliability
- Team working and collaboration
- Taking initiative
- Confidence and assertiveness
- Risk assessment, and

- Business awareness

8.3.3 ICT skills and the knowledge society

The geographical clustering of high-tech industries will exert added demand for ICT expertise, not least through the business growth in the Technology Corridors, R&D undertaken at public and private sector research institutes, and activities relating to the commercialisation of R&D as well as knowledge and technology transfer. Indeed, the West Midlands ICT Strategy notes that: "The knowledge capital developed and exploited within the High Technology Corridors will be vital to achieve the objectives of Digital West Midlands." [270] Some of the demand for skills – certainly at lower and intermediate levels - will be fairly localised. There is also a question mark about the availability of higher level skills in sufficient numbers and with the specific required expertise, given the skill shortages that have already been identified. These shortages will limit the growth potential of new and growing firms. It is also important that firms – including small firms - are able to establish knowledge and technology transfer links with advanced research institutes, such as Qinetiq, RAPRA, the Warwick Manufacturing Group, Birmingham University's engineering and medical strengths, that will enable ICT specialists – not just scientists and engineers - to develop and maintain leading edge capability in their individual disciplines.

All sections of the labourforce must have the skills to operate in a modern business setting. Any inadequacies will hamper businesses' innovation potential. Operating in the global information society means that ICT users at all levels need to be able to access, analyse and share information, and employers increasingly need people to acquire more advanced skills in data management and retrieval. The projection is that 403,298 people in the West Midlands workforce need to be upskilled in ICT, 52% to level 2 and 48% to level 3+.[271] Growth in the employment of ICT expertise is expected to be highest in the West Midlands Region and the North East.[272]

8.4 Solutions to Skill Limitations

ICT has a pivotal role in transforming education and learning, but growth has been generally haphazard across the country. Problems occur because:

- Systems are often incompatible with each other.

[270] Advantage West Midlands, Digital West Midlands – The regional ICT strategy, undated (2006)
[271] E-skills UK, IT Insights: Regional Skills in the West Midlands, 2005
[272] E-skills UK, IT Insights: Employer Skill Needs, 2004

- Each institution can buy its own system and support services, so these tend to be unnecessarily expensive, and consequently
- There are no economies of scale.

A more strategic approach is intended to further develop ICT in education and learning. The objectives include the encouragement of all organisations to support a personal learning space for their learners to develop eventually into an electronic portfolio for lifelong learning.[273]

Clearly, it is imperative to determine and address employers' needs for continuous professional development in managers, professionals and other occupations, and to monitor technological and business change so as to identify and respond to additional ICT needs. It is also vital to identify and address the particular CPD needs of the ICT professionals themselves operating in, and supporting, the key business sectors of the West Midlands economy, as well as those with embryonic and growth potential. This will require not only an understanding of the evolution of the ICT sector and technological and occupational change, but also how other industries it serves are being transformed technologically and in the ways they conduct business. The trick will be to marry these three professional competency needs – ICT specialist expertise, specific industry expertise (e.g. automotive, aerospace, medical technology, construction), and business acumen. Strategic competences, as well as customer/partner relationship management skills will be essential. Teamworking and personal relationship skills will also be invaluable for engaging in multi-disciplinary innovation-oriented activity with colleagues and externals. It is also crucial that ICT professionals as well as support staff are more plentiful.

Given the link between e-business and performance, it is a concern that West Midlands firms are slow in adopting e-business. The OECD recommends that smaller firms need targeted programmes relating to:

- R&D incentives.
- Frameworks for standards.
- Skills formation.
- Information and demonstrations of best practice and the benefits of using ICT.

They also advocate that intellectual property protection of ICT innovations and digital products is necessary to build confidence among SMEs, if they are to take advantage of UK and cross-border online activities.[274]

[273] Cabinet Office, Connecting the UK: the Digital Strategy, April 2005
[274] OECD Information technology outlook 2004

8.4.1 West Midlands strategic priorities

The mission of the West Midlands ICT Cluster Opportunities Group is to develop a cluster of ICT businesses and partners in order to bring competitive advantage to the Region. Innovation has a central position within this mission, whose three strategic directions are:

1. Developing networks.
2. Growing sub-clusters, and
3. Exploiting innovation.

The exploitation of innovation is targeted via well-disseminated ICT research; effective collaboration and spin-out activities to create leading edge knowledge based ICT firms; and to develop management competence in ICT.[275]

Skills and education are notable among the strategic enablers. The range of skills needed to achieve a successful ICT industry in the West Midlands includes business, technical, managerial and commercial expertise. It is also important to identify new skills to support future needs.

Strategic objectives established by Advantage West Midlands and its partners for the digital economy include:

- The encouragement of personal creativity in order to stimulate skill needs relevant to future knowledge-based industries. This point is of particular interest given the ability of ICT to act as a disruptive technology, and also for its knowledge-enhancing role. Collaborative knowledge working is viewed as a key means to improve public sector efficiency.
- Achieving a step change in the adoption of e-business by industry. Exploitation of ICT is linked to the growth of entrepreneurship and commercial advantage.
- Increasing the generation, development, dissemination and take-up of e-learning opportunities. The connection with innovation is noted, and action in tandem will occur to identify and establish potential growth areas and new market applications. It is also necessary to address the teaching and mentoring of ICT.[276]

The public sector agencies are also assessing the extent to which training serves industry's needs, and whether training/education of business owners/partners acts as a

[275] AWM, The West Midlands ICT cluster strategy 2005
[276] AWM, Digital West Midlands – the regional ICT strategy, 2005/6

barrier to growing their businesses is also a concern, similarly whether the available support is appropriate.[277] In addition to these issues, Advantage West Midlands' ICT Cluster Opportunities Group is also focusing on ways to retain graduates in the regional economy (stemming the brain drain to London) and creating access and career progression routes for ICT personnel.[278]

AWM fund the following projects which are expected to eventually become businesses in their own right:

- West Midlands Information Technology Association.
- Icentrum – a tighter market, innovation, new technology and loaning kit.
- Cercia – Birmingham University, high end research, and data mining techniques.
- Photonics – sub-regional, measurement, lazerlight and high end skills.
- ICT Futures (a subsidiary of Wolverhampton University) – ICT solutions into
- SMEs.
- NCC Supplier standard.
- Mobile Phone and Wireless.
- ICT Directory – survey and continuing research into the industry.[279]

Birmingham and Solihull LSC's proposals include the need to:

- Encourage collaboration between secondary schools, further and higher education, and develop strong Lifelong Learning Partnerships in ICT.
- Increase the take-up of ITQ and ICT Apprenticeships by strategic marketing of these.
- Encourage participation of under-represented groups, through role models and developing appropriate materials.
- Target the recruitment and upskilling of ICT trainers, to deliver training to level 3+. [280]

[277] AWM and Coventry & Warwickshire LSC, data and intelligence project, typescript, undated (2006)
[278] Birmingham and Solihull LSC, Review of education and training within the ICT sector, 2005
[279] Birmingham and Solihull LSC (2005)
[280] LSC, Information and communications technology (ICT) Review Launch, 8 November 2005

8.4.2 Issues for nurturing ICT-based creative industries

The plethora of ICT disciplines and uses lends an added degree of difficulty to understanding and solving skill issues and needs, and where to place the focus of attention. Combined with this, there is a distinct danger that the more glamorous facet of ICT – film, video, the media and other creative industries – where potential is foreseen could exacerbate skill shortages in other embryonic and emerging as well as mature industries which require high-quality specialist ICT input. Indeed, the A D Little report (2004) indicates that much of the strength in research and new technology development in the West Midlands is in film and other audio production, media, art and design. Increased collaboration between firms and with higher education institutions was advocated for new media companies, together with an increase in work placements for graduates. This advice could also apply to the furtherance of advanced ICT skills in other sectors. Furthermore, lack of access to high quality and impartial information on how to use and manage ICT within their businesses is a particular issue for SMEs.[281]

The government is working in partnership with firms from the creative industries, and more widely, to examine developing business models in the digital environment, to see how awareness of the benefits of a robust and fair intellectual property enforcement regime can be raised.[282]

[281] HM Treasury, Lisbon strategy for jobs and growth, October 2005
[282] HM Treasury (October 2005), citing EU and OECD research

PART THREE: CROSS CUTTING ISSUES AND RECOMMENDATIONS

9 SKILL AND WORKFORCE DEVELOPMENT ISSUES AND OPPORTUNITIES

9.1 Introduction: Improving the Innovation Ecostructure

In July 2004, the government published a 10-year Science and Investment Framework which set an ambition for the UK's public and private investment to reach 2.5% of GDP by 2014, from its current level of 1.9%. Increased investment in R&D by the business sector, its creation of better links to the science base, and improved collaborative working are seen as vital factors in ensuring the delivery of the government's science and innovation goals as laid out in its 2004 Technology Strategy.

An equally crucial objective is to raise the level of supply and demand in science, technology, engineering, and mathematics (STEM) skills.[283] The promotion of best practice in industry through Innovation and Growth Teams and the Manufacturing Advisory Service is also a core objective. Proposed reforms are intended to help employers make effective use of workforce skills, advise businesses on technological change, and assist them in moving to high-skilled, high value added products and services.

Concerned about the relatively low investment in R&D in the UK than across Europe, and the under-performance in translating R&D effort into products and processes, the government proposes a 3-pronged attack to create an effective infrastructure for innovation, by:

1. Improving the strategic management of investment in science and innovation, to ensure that the UK's science and innovation system is more responsive to economic and public priorities, as well as co-ordinating the various funding streams more effectively. This is expected to enhance business confidence in engaging with the science base.

[283] HM Treasury, Lisbon Strategy for Jobs and Growth, 2005

2. Ensuring the right skills and brokering mechanisms are in place to encourage greater collaboration between industry and the research base, enabling firms and the science base to interact in various ways to suit their needs.
3. Making science, technology, engineering and mathematics subjects more attractive to students, to ensure a highly skilled and diverse workforce to drive future innovation and growth.[284]

The role of RDAs is viewed as central to achieving the government's strategic objectives on innovation and technology.[285]

9.1.1 The West Midlands Innovation Programme

Advantage West Midlands' action plan for its innovation programme states: "It is people that will drive our innovation programme and their creativity and commitment are key to its success." [286] The action plan has four themes: People, Resources, Knowledge Transfer, and Vision and Context (see Text Box 14).

The specific disciplines for which advice and support for businesses is available from initiatives and university innovation centres[287] include:

- Encouraging entrepreneurship.
- Change management.
- Creativity and design.
- Prototyping.
- Protection of intellectual property, including in-company audits of intellectual property and the identification of opportunities, advice on exploitation, patenting.
- Management of innovation for high-technology companies such as biotechnology, medical technology, materials science and ICT; interim Managing Directors.
- Business planning and accessing finance.
- Forming networks.
- Developing people's skills, and

[284] HM Treasury and DTI, Science and Innovation Investment Framework 2004 – 2014, March 2006
[285] DfES, Skills: Getting on in business, getting on at work, March 2005
[286] Advantage West Midlands, Making innovation real, undated (2005)
[287] AWM, The West Midlands Regional Innovation Strategy action plan 2004 – 2010.

- Accessing resources; knowledge and technology transfer.

Text Box 14: West Midlands Innovation Action Plan

1) People

- Entrepreneurship.
- The development of innovation leadership skills.
- The encouragement of graduate employment opportunities.
- The development of networking and mentoring between people and organisations so as to share skills as widely as possible.

2) Resources

- Access to finance.
- Science park accommodation, incubation and specialist technology centres.
- Sources of specialist equipment for the business clusters.

3) Knowledge Transfer

- R&D investments.
- New product development support.
- Links to specialist university departments, using their intellectual property.
- Knowledge transfer of business skills, marketing and best practice.
- Innovation audits.

4) Vision and Context

- Monitoring progress and achievements.
- Scanning the horizon for new developments with capitalisation potential.
- Further development of regional Foresight and innovation awareness programmes.

Initiatives include the West Midlands Intellectual Assets Management Programme; Spinner; and support and resources provided by universities such as Keele, UCE and Aston. Warwick Manufacturing Group, Coventry and Birmingham Universities are among those providing advanced engineering expertise and technology transfer.

It is seen as crucial that businesses use design more effectively; introduce new services and products; that they increase productivity through process improvements; and collaborate in business networks, sharing resources and expertise. Various initiatives operate to stimulate and support innovation in the West Midlands and develop the necessary skills in businesses:

- An Innovation Networks Programme has been established to assist firms to collaborate, pooling their skills and resources to launch a new product or service.

- The Lord Stafford Awards help to stimulate innovative collaboration between businesses and university research departments.

- Coventry Technocentre has the Region's only Creativity lab, inspired by the DTI project, Future Focus. This is available for organisations to use for strategic planning, electronic facilitation of meetings, video facilities and training.
- The Foresight programme helps to encourage firms to develop creative solutions and ideas with a view to generating business growth, developing new strategies and forming business networks.
- The knowledge, innovation and technology transfer scheme (KITTS) assists small businesses to employ a university graduate for a programme of development.
- A Promoting Innovation Programme has commenced, giving tips on creative problem solving through workshops.
- Technology Opportunity Study funding enables smaller companies or divisions to tap into the technological expertise of the Defence Diversification Agency.
- An Entrepreneurship Innovation Fund and Early Growth Fund have been established to support new ventures in the West Midlands.
- The three High Technology Corridors have been established to foster and support enterprise and innovation, contributing to a diversification of the business base through a partnership approach. Skill development is at the heart of this programme.

9.2 Skills for modern business

Skills and learning are an essential component of businesses' innovation capability. Innovation is not solely concerned with R&D and product development, for the ability to innovate requires a large bundle of competences. Skill deficiencies of any type can therefore limit the potential for individuals and businesses both to innovate and to perform highly.

In March 2003 the government published its skills strategy, 21st Century Skills.[288] This established a number of key problems needing to be resolved, notably:

- Employers perceive a shortage of suitable recruits.

[288] DfES, July 2003, Cm 5810

- Skill gaps exist in basic skills, including language, numeracy and computer skills; intermediate level skills including associate professional, apprenticeship, technician and skilled craft level; leadership and management; and mathematics.
- Courses and qualifications often do not fulfil what employers want.
- Many private and public sector organisations show a limited grasp of how a better skilled, trained and qualified workforce could improve their performance.
- Many individuals do not realise how better skills, training and qualifications could help them towards their personal, financial and career goals.
- Employers and learners do not understand what support is available from the government and its agencies, nor how to access it, and
- The roles and responsibilities of government, employers and individuals in terms of paying for and organising training and qualifications remain unclear.

These problems are not confined to any particular sector or industry, as this review of innovation skills has confirmed. SEMTA (2004) has singled out the priority cross-sectoral issues, which include entry level skills, management and leadership, and ICT skills. Since manufacturing companies increasingly operate globally, service-type functions are rising in importance and so the softer skills are crucial. Generic skills include problem solving, project management and operational management. Given the essential possession by employees and managers of communication and team working skills, it is significant that the Skills Strategy consultation highlighted these deficiencies among young people. Similarly, the relationship of entrepreneurship to innovation places a great emphasis on nurturing an enterprising approach among potential entrepreneurs.

9.2.1 The West Midlands Skills Picture

We now understand what kinds of characteristics and expertise are needed in managers and workforce for businesses to be innovative. But can the educational and workforce training systems create the calibre of labour supply possessing the attitudes and skills that are essential? A 2006 West Midlands Regional Skills workshop showed that a wide gap exists between what employers need and what is available.[289]

In relation to higher value added products and services, for instance, issues concern:

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[289] West Midlands Regional Skills Partnership, Skills Summit 3 February 2006

- The gap between the provision of higher level skills and the needs of the economy, which is perceived to be widening. Too many students possess skills not required in the workplace, such as sports science and media studies.
- Generic 'soft' skills like customer care and communication skills are required in modern business, yet this message has apparently not reached training providers.
- The possession of business skills among graduates needs to be greater.
- Issues about the skills and training of young people include:
- Concerns over their possession of basic skills and attitudes to work. Good quality young people are in short supply.
- College courses are not putting on courses in response to employers' needs but tend to provide training they are willing to deliver.
- Similar points are made about leadership, management and entrepreneurship skills:
- Employers want more work based learning. Higher and Further Education providers do not see a sufficient demand from employers to stimulate a radical change in the way that training is delivered.
- Employees want recognition of their learning through gaining a qualification.
- Managing Directors in businesses need support in identifying their needs in relation to leadership and management development.
- On the need to communicate the message about labour market changes and employment needs:
- Labour market information on the changing needs of the market and the jobs of tomorrow is needed in an accessible format for pupils, teachers, advisors, brokers and parents. It needs to be tailored for different groups.
- Communicating with employers is problematic, particularly SMEs. The integrated business support service provides a communication channel. Skills foresighting is a useful mechanism to communicate changing skill needs to employers.

9.2.2 Issues for tackling innovation skill needs

The government's Skills Strategy (2003) observes that many employers are national and international and identify with their sectors and their supply chains (rather than the locality in which they are based) particularly in keeping up with leading edge techniques, product or service innovation, and knowledge transfer from new research. This has implications for understanding where each sector is going, and what has to be done through regional *and* sectoral support to match and exceed the highest international productivity performance. Without this understanding, they concluded: "We will not pitch our skills ambition at the right level."

This gives SEMTA's (2004) identification of pan-industrial skill needs added significance, because these needs span a wide spectrum of workforce development requirements. SEMTA warns that a one-size-fits-all approach to cross sectoral skills development will perpetuate the low skills equilibrium which characterises much manufacturing industry. "Many firms...need to raise their skill achievement to levels already surpassed by automotive." Lean manufacturing approaches used in the automotive sector are applauded as eminently applicable to other sectors like aerospace, electronics, the food industry and construction. Fast new product development techniques are mandatory to enable businesses to get ideas quickly into production and out into the market. These were pioneered in the electronics industry and are now moving into other sectors including automotive, clothing and textiles.[290]

The DTI's Innovation Report points to the need to ensure that business support for innovation is relevant and accessible, and is tailored to the individual needs of local, innovative businesses.[291] This places importance on the flexibility and suitability of the business support structure and tools. It is crucial to address speedily and continually where and how the system works well or not, and to adapt it where necessary. It also requires that the appropriate type and level of resources is available.

"The challenge facing the Regional Skills Partnerships," notes a Local Futures report, "is the low business demand for skills in many sectors." [292] It is seen as crucial to work on both the demand and the supply sides of the labour market, particularly in the Midlands and the North, regions which have ambitious objectives for 'smart' growth, but lack sufficient knowledge capital to carry these out fully.

The flow of human and creative capital (i.e. the brain drain) is a key indicator of the health of regional and local knowledge economies, and their labour markets. Gathering data on this flow is considered crucial. Retaining more human capital in regions like the West Midlands and offsetting the lure of London and the South East places a great onus on those regions to provide more high quality knowledge-intensive jobs.

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[290] SEMTA, Automotive sector skills agreement: stage 1, September 2004
[291] DTI, Innovation report action plan update, 2005
[292] Hepworth et al (c.2005/6)

The need for the *diffusion* of innovation in the business and service communities is highlighted, the recommendation being for the development of knowledge management systems, led by RDAs, for use in the capture of learning outcomes from successful innovation projects.

The A D Little report on innovation also notes the need to encourage wider engagement from businesses exploiting the linkages with the Region's knowledge base. Particular attention is drawn to the development of the technology corridor programmes. They also observe that many firms need to better understand research and development opportunities, secure the necessary inputs and apply them for sustainable commercial advantage.[293] The requirement is therefore not just related to specific skills, but in awareness raising, motivating, providing effective linkages for businesses to knowledge and resource providers, and guiding the whole sequence of activities from ideas generation through prototyping products through their development to readiness for robust commercial manufacture.

The A D Little report advocates that the Region's knowledge providers (universities and specialist research institutes) should benchmark - i.e. compare best practice among - themselves and to emulate best practices within the Region. Particularly advised is making higher education expertise readily accessible to business.

They also note that the technology consultancies have significant influence on regional innovation and technology transfer. They are a repository of technological expertise; draw into the Region skilled technologists for all sectors; and through their work are exposed to global innovation and ideas. It is worth questioning whether Regional innovation initiatives maximise the potential that these organisations have for contributing to the improvement of businesses' innovation skills, and to what extent they are networked with other programmes of support and resource provision. Indeed, the West Midlands is considered to have potential not yet fully exploited.

9.2.3 Leadership and management skills development

A CMI study of management training and development in the UK, France, Germany, Spain, Denmark, Norway and Romania[294] confirms that management development leads to superior organisational performance. The study notes that, since the early 1990s, there has been a pronounced increase in reported management development activities, both internal and external, in most countries, with the annual increase rising from 5.4 to 9.3 days on average a year. But less is spent on management development in the UK than the European average of 2,513 euros per manager a year. A

[293] A D Little, Research and Innovation for the West Midlands, report for AWM, 2004
[294] Mabey and Ramirez, Chartered Management Institute, 2004

government report on productivity and competitiveness[295] also asserts: "We appear to suffer from a management quality deficit with respect to our main competitors."

Most training in the UK is external, tending to lead towards formal qualifications. Appraisals are little used. Line managers in UK businesses are less likely to be involved in career planning than these other nations. "There are comparatively weak career structures", notes the CMI report.

There is also less appreciation in the UK that Human Resources Management has a strategic contribution to make to the business. More scope is seen in HR Managers doing more to ensure that improvements in motivation, performance and productivity are reported to the Board to maximise the chances of receiving increased resourcing.

When line managers see senior managers giving management development a sustained priority, and see it linked to organisational skills and competences, this helps to enhance performance and productivity. But the challenge for the UK is: "Lack of continuity in national policy frameworks. (The) Employer approach to development (is) often short-term, tokenistic and non-strategic."

9.2.4 Work organisation and change

There is a clear correlation between businesses' capacity to be innovative and their achievement of high performance working conditions where employees are respected, motivated to improve, involved, take decisions, and are loyal. Sissons (2005/6) asserts that this is not achieved through skills enhancement alone. It has to be achieved through a change in the organisation of work, and/or in the relationships within the working environment, and initiated via awareness that deficiencies or problems exist, followed by analysis to understand what they are, and a determination to remove any barriers to improvement. Such changes can help to bring about a working culture where innovation approaches can flourish.

Sissons also points out that the need for reorganisation of work structures, practices and cultures is something that managers in SMEs, in particular, may not understand or address without external help, either through public sector support, and/or from larger firms in their upstream supply chains. He sees a central role for the regional development agencies and their partners in the regions to promote the concept of workforce development - taking their lead from the German, Scandinavian and Netherlands experience - to take both an information-raising and communication role, as well as a business support one. A carrot and stick approach is advocated for SMEs – changes in work organisation leading to the award of grant funding, for example.

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[295] HM Treasury and DTI, The 2005 productivity and competitiveness indicators.

Certainly, acting on this advice necessitates the possession of a clearer understanding of the workplace from the vantage point of employment and working conditions, the management of work, the strategic and structural context in which work occurs, how that work correlates with individual and business performance, employees' engagement in innovation, the variation that occurs across the spectrum of industries and according to different business models and objectives.

9.2.5 Stimulating entrepreneurship potential

In its Action Plan on The European Agenda for Entrepreneurship, the European Commission recommends that entrepreneurs should receive management training, irrespective of their backgrounds, but especially for women and ethnic minorities. Networks and strategic partnerships between entrepreneurs on a cross-border basis are also viewed as a major route for the transfer of knowledge and best practice.[296]

The significance of entrepreneurship training is particularly important given the urgency to increase the percentage of businesses with managers possessing high educational qualifications. The Lambert Review compares British managers poorly with those in the US, and even in France, in terms of their educational profile, with qualifications in science and business administration rarely held among British managers. This raises questions about the capacity of British managers to absorb science and innovation into their operations. It also helps to explain why large numbers of medium sized companies have no contact with universities.

There is growing consensus that entrepreneurship must also be nurtured in schools and colleges. In its February 2004 Action Plan on Entrepreneurship, the European Commission highlights the need to promote entrepreneurial mindsets in young people by presenting best practice models and creating the awareness of and ability in entrepreneurship.[297] Long-term policy objectives to achieve this aim include:

- Introducing entrepreneurship into the educational curriculum, followed up by supporting initiatives.
- Training and motivating teachers.
- Promoting entrepreneurship through 'learning by doing' e.g. by means of project work, mini companies and virtual firms.
- Involving entrepreneurs and local companies in the design and running of entrepreneurship courses and activities, promoting links between schools and enterprises.

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[296] Reported in Euractiv, 31 January 2006
[297] Euractiv, 31 January 2006

- Increasing the teaching of entrepreneurship in higher education in subjects outside economics and business, notably at scientific and technical faculties.

- Within business courses, placing a greater emphasis on creating enterprises and managing the growth phase of these.[298]

Entrepreneurship training for students gives them the entrepreneurial skills to exploit their innovations and develop the commercial potential of their work. The Lambert Review welcomed the formation of the government-funded Science Enterprise Centres, noting their aim for skill development for both students *and* staff. Also approved is the intention to establish a Council for Graduate Entrepreneurship to encourage and support more students to set up their own businesses.

It is also seen as crucial to stimulate entrepreneurship in schools so that, when pupils leave, they will be better motivated and equipped to start up and run their own businesses, and to take an innovative approach to working. The ICE programme[299] has been established by the DTI to nurture innovation, creativity and entrepreneurial skills in young people. The initial delivery of the programme is based on the e-skills method employed successfully by the CC4G (Computer Clubs for Girls) programme. It will therefore involve self-managed learning, with course materials designed to appeal to young people and motivate them to develop themselves and increase their understanding of what entrepreneurship involves and how to do it.

9.2.6 The Potential Impact of Off-shoring on Innovation

The transfer of work to off-shore locations must be considered for its impact on innovation strategy and capacity. It is particularly crucial since the West Midlands is one of two UK regions outside London (the other the South East) thought to have lost the most jobs off-shore. *Manufacturing* jobs are particularly likely to go off-shore, as are those of *smaller* companies. Most of these jobs have gone to China and India, or to central and east Europe. Fewer than one in 10 go to the Americas, Africa and Australasia. UK businesses are also considering more off-shoring closer to home. [300]

Aside from the main objective to exploit lower costs overseas, proximity to customers is a major driver for off-shoring. Continual advances in technology make it possible to consider off-shoring functions that would once have been inconceivable. IT support and development, as well as R&D and design functions, are among the preferred off-shorable activities. This raises some pertinent questions about what impact this does

[298] Weinberger, Update on the Green Paper on Entrepreneurship 2003, European Commission, 2004
[299] Cantelo (DTI), ICE Clubs information sheet, June 2005
[300] MORI, Off-shoring survey 2004

and could have on how firms engage in innovation, the skills they need, and the most appropriate support (see Text Box 15).

A key question is whether off-shoring means less innovative activity conducted in the UK. To what extent will UK-based enterprises be the beneficiaries of innovations developed at their off-shore plants either solo or in collaboration with overseas partners or customers? Where will any products be commercialised and produced? Will any innovations in customer service, organisational structures and production processes also be implemented at UK plants? Is the UK more likely to benefit if this is written into any arrangements established for business support and intellectual property relating to off-shored innovation? Would transnational networks and collaborative partnerships mean manufacturers taking a more active role in off-shoring innovation than might otherwise occur?

Text Box15: Issues about Off-shoring Innovation

- Will less innovation occur in the UK if more occurs overseas, or could it provide a stimulus to UK plants?
- Do firms need incentives to keep innovating in the UK?
- Will innovations in customer service developed abroad be transferred to the UK?
- Where will products designed and developed off-shore be manufactured?
- What issues need to be resolved about intellectual property and commercialisation to enable the UK to have some benefit from off-shored innovation?
- How can the use of the internet, software development and utilisation, video conferencing and other digital technologies be utilised to keep R&D and design here, and/or used for aiding transnational innovation partnerships? What skills and resources are required?
- Skills are needed in managing transnational networks and collaboration.
- Language/translation issues, cultural differences, understanding overseas regulatory contexts and requirements.
- There are issues for the support and facilitation of firms innovating off-shore.
- Are there any opportunities? For example, is there a potential role for specialists and managers overseas, including project managers for innovation networks?

9.2.7 Skills for international trade

Foreign language ability is a crucial component of conducting international business, for locating partners, collaborators, distributors, customers and suppliers; for marketing and negotiating business deals; for dealing with long-distance day-to-day operations and problems; for working abroad; and for understanding, preparing and adhering to export, regulatory and commercial documentation.

The general consensus is that British companies, certainly among SMEs, generally lack the language skills needed to win and conduct business overseas. The potential for establishing links with overseas innovators to develop, trial and commercialise new products and processes, and the drift of manufacture off-shore, lends even greater urgency to acquiring and improving the skills needed to do business overseas.

Advantage West Midlands and Trade Partners UK have identified a number of priority sectors which possess key potential in the international trade arena.[301] These are:

- High performance engineering.
- IT and software.
- The creative industries.
- Food and food processing, and (prospectively)
- Environmental products and services.

Other priority sectors are expected to emerge over time. Certainly, research shows that medical/healthcare technologies and biotechnology, advanced processing materials and technologies (including nanotechnology), alternative power, advanced construction materials and building techniques possess emerging potential.[302]

Training must be tailored to the specific characteristics of the overseas activity where expertise is required, and to individual countries where business is conducted. Translation services need to be responsive to businesses' specific and evolving requirements. The trade strategy also notes the importance of developing international supply chains.

9.3 Addressing research and technical skill needs

The DTI report, A Materials Strategy (2006), identifies five themes to address in order to enhance the prospects for the successful development and exploitation of materials and their product applications:

1. Knowledge transfer.
2. Raising awareness.
3. Accelerating innovation.
4. Improving skills and knowledge.

[301] AWM and Trade Partners UK, International Trade Strategy, undated (c.2003/4).
[302] Research by Tilson, BCTRA, inc. medical technologies, automotive, and the construction sector.

5. A better business environment.

These themes are significant across the innovation and technological spectrum. Indeed, the Materials Strategy highlights transport technologies, construction, aerospace, and other manufacturing sectors. Businesses need to be more aware of design and how it can be used. The subject of sustainable development and consumption is raised in terms of its potential, but also its significance for selecting the right materials, as well as the need for understanding what sustainability entails. Opportunities are highlighted in eco-design. Greater interaction is advised between engineers and scientists, including production engineering, and the design community to enable information exchanges which could lead to innovations.

The Materials Strategy observes that the demands on the technical community are changing. They now need to be able to: "monitor, assess and improve environmental performance across the life cycle." Performance monitoring, product labelling and supply chain management are highlighted. The skill and training implications of change cover the production, processing, safe use, re-use, recycling and assessment of the whole product life cycle. Identifying and benchmarking best practice is advocated.

The matter of financial incentives to support innovating businesses is also topical. The Lambert Review's (2004) discussion of R&D incentives for UK businesses raises the issue of the right type and level of incentives and support, particularly for small innovators, and especially at the mid and final stages of the often long and tortuous path to commercialisation. This introduces the need for further monitoring and analysis of progress along that route.

9.3.1 Links for business with universities and other research institutions

Business support for innovation is particularly difficult to manage in relation to the research institutes, universities and commercial R&D organisations that the government wishes to ensure are more easily accessed by businesses. It is crucial that these organisations have the skill mix, resources and systems necessary to maximise their support of business innovation.

The DTI report, A Materials Strategy (2006), notes the need to optimise the research base, views business access to laboratory equipment as imperative, and advises that mechanisms are needed to facilitate access to this equipment in university, government and business laboratories. This raises a question as to the skill-related implications for users if such mechanisms were devised, and what would work best.

The Lambert Review[303] identifies areas of concern relating to the identification and resolution of industry's skill needs by universities. The Review asserts that universities are doing a good job in meeting the needs of businesses for skilled graduates and postgraduates in most areas, but are less successful for IT and creative courses, as well as some science, engineering and technology specialisms. It is advised that Sector Skills Councils should have real influence over university courses and curricula: "Otherwise they will fail to have an impact on addressing employers' needs for undergraduates and postgraduates." Whereas the SSCs need to have a dialogue with universities about the future skill needs of employers, the report noted that: "It is not clear that a mechanism exists for this to happen." Indeed, some SSCs are not able to get universities to listen to employers' needs for graduate skills.

Businesses in disciplines like medicine, engineering and architecture express their skill needs through professional bodies which define the academic requirements of courses. Indications are that these mechanisms for accreditation, particularly in engineering, could constrain innovation and also slow universities' responses to business needs.

The Review asserts: "More needs to be done by both universities and business to work together to meet the continuing demands of the economy. The Government also needs to ensure that the structures within which universities operate are sufficiently responsive to encourage these collaborations to occur." They note that university-business links tend to be with *larger* businesses. Only about 20% of medium-sized companies have any interaction with universities.

The Local Futures report[304] stresses the importance of increasing the *demand* for skills. A pivotal role is seen for the Regional Skills Partnerships in helping to develop more effective regional innovation systems in which universities and Higher/Further Education partnerships provide the basis for increasing that demand. Also advised is the development by RDAs and RSPs of *global* dimensions to the new regional skills strategies. Recommended, too, is a review of the funding of university courses in order to take account of the views of organisations that benefit from skilled graduates, such as employer-led bodies, to ensure that the system is responsive to their needs.

The Lambert Review notes that an expansion of student work placements is needed because some skill deficiencies mentioned by employers relate to skills best acquired on-the-job. They advise that initiatives would be best targeted at SMEs since they have fewer resources to devote to schemes such as internships and links with careers services and may not recognise as well as larger companies the benefits of employing graduates. Also recommended as useful to employers as well as students are schemes like CASE, for Collaborative Awards in Science and Engineering, where PhD students

[303] HM Treasury, Lambert review of business-university collaboration, December 2003
[304] Hepworth at al (c.2005/6)

undertake industry study placements. This gives employers access not only to highly skilled people but also a route to academic contacts and knowledge.

It is important to bear in mind, too, that smaller firms can be well aware of the benefits of employing graduates and postgraduates, but may not be able to afford to employ them, or give them the kind of salary, conditions or prospects for advancement that will attract or retain them.

As the Lambert Review points out, students can bring in: "...fresh, highly motivated minds, to tackle their business problems at low cost." It is important to consider the stimulus to innovation that work placements offer to businesses. Indeed, the Review notes that Shell, through its Technology Enterprise Programme (STEP) has been piloting methods of tailoring the basic scheme (aimed at SMEs) to meet specific regional or sector needs. Shell has established the Micro-STEP scheme in conjunction with the East Midlands Development Agency to encourage recent start-ups and small businesses to take on graduates.

The review also recommends that the flow of business people *into* universities should be greater as these are frequently the starting point of successful university-industry collaborations. Such contact has a two-way skill and knowledge development impact. A pivotal role is noted for regional development agencies in encouraging university-business collaboration.

9.3.2 Issues about the Contraction of the Research Base

Any contraction of the UK's research base has an impact on the innovation potential of firms. The Lambert Review (2003) notes that British companies are doing more of their research work outside Britain, pointing to large defence and aerospace companies like BAe Systems and Rolls-Royce. Consolidation in the pharmaceutical and health sectors, too, is forcing their consideration of other parts of the world to invest in R&D. The trend is for multinationals to locate their research centres in their most important markets: "...especially if those markets happen to contain centres of outstanding research." This has benefited the US particularly, which has received an increased volume of business R&D investment from other parts of the world.

The Review underscores the "fragility" of the UK business research base, undermined by overseas acquisitions and the sale of businesses' unwanted assets to overseas buyers with their decision-making headquarters and R&D facilities overseas. This has a crucial impact on the research base and associated skills and interactions. The Review quotes Arthur D. Little, saying: "Trends such as these have reduced business awareness of the research base, and individuals with a thorough and expert knowledge of the research base and how to get the best out of it are few and far between."

It is also pertinent to note that if British companies expand their research overseas at the expense of their British research base this affects their demand for specialist and advanced skills, as well as all skills associated with research activities, not just at high level but also at technician standard. It means less innovation occurs, less interaction with universities and other research institutions, lower levels of research activity at research institutions, fewer partnerships with other UK companies, and less diffusion of research knowledge and expertise into the economy and labour pool.

9.3.3 Addressing the Region's shortage of scientific and technical skills

It is important to consider what an outward facing stance towards global opportunities entails and how to exploit the Region's skill assets. The 'Science City' initiative, for example, is viewed as a "real opportunity for Birmingham and the region...(by)... having the potential to change the image of the area, to act as a rallying point, bringing partners closer together through a common set of objectives and to genuinely add value."[305] The initiative could help to develop the links between the three High Technology Corridors (Table 6) and between these and the skills agenda, giving further emphasis to developing the potential of existing and new SMEs. Significantly, it also represents an opportunity for Birmingham - and the Region - to promote its innovative and creative skills worldwide, an opportunity which: "Birmingham and the West Midlands must be seen to grasp and implement decisively."

[305] Shields (2005)

Table 6: High technology sectors

Sector	SIC92
High technology	
Pharmaceuticals	24.4
Office machinery and computers	30.0
Aerospace	35.3
Electronics communications	32.0
Medium-high technology	
Scientific instruments	33.0
Motor vehicles	34.0
Electrical machinery	31.0
Chemicals	24/0 (excluding 24.4)
Other transport equipment	35.2, 35.4, 35.5
Non-electrical machinery	29.0

Source: Lad M (DTI), Regional Competitiveness & State of the Regions, April 2005

A D Little (2004) assert that the continued growth of high technology sectors in the West Midlands stresses the significance of solving any skills issues. This growth will exert a greater need for specialist services, engineering skills, and patent agents. The Science City initiative is considered helpful in driving the knowledge economy through the innovative application of the science and technology base in support of the Region's target sectors. It would foster knowledge creation and its transfer, and make better use of knowledge, as well as providing a focus for a better relationship between the demand for and supply of knowledge in the West Midlands. But the point is also made that, although some companies require and can benefit from leading edge technological development, "the vast majority need to apply *established* technology (my italics) much more effectively" in order to improve their competitiveness.[306]

More scope exists in using the Region's business schools and further education colleges to drive the development of the learning economy and (for the former) in providing a greater focus for management and leadership training. The problem is highlighted of finding qualified school teachers in Physics, Maths and Chemistry and the need to take action quickly to change the perceptions of young people, fire their enthusiasm and attract them into these fields. This echoes the government's 10-year Science and Innovation Investment Framework (2004), which asserts that a vibrant innovation system relies on a strong supply of specialists in science, technology, engineering and mathematics, and identifies shortages of specialist science and maths specialists nationwide. Enhancing the learning and teaching of these STEM subjects at all educational levels is crucial, and improving the incentives to recruit and retain

[306] Shields (2005)

science teachers and professional researchers. A 2005 progress review noted slow progress towards improving the study of these subjects at A-level and university. [307]

A primary role is identified for the Regional Skills Partnership in the demand-led evidence-based approach which assesses:

- Gross Value Added.
- Employment and worklessness levels.
- Qualifications and skill levels.
- Wage levels.
- Employers engaged in skills assessment.
- Increase of employment in the knowledge economy.
- The number of organisations employing graduates, and
- The level of entrepreneurial activity.

These success measures used by the RSP are considered directly relevant to the Science City approach.

Developing and utilising the entire cross-section of potential skills is vital, including from groups who tend to be under-represented in science, engineering and technology, like women and minority ethnic groups. It is also important to consider the contribution that the mature workforce could make and any special requirements that any group might have for training and development. Furthermore, giving graduates and others a quality of life that will help to retain their talents in the Region is seen as key to a successful knowledge economy.[308]

[307] HM Treasury, Lisbon strategy for jobs and growth, October 2005
[308] Shields (2005)

10 RESEARCH AND INTELLIGENCE GAPS

10.1 General Points on Research and Intelligence Gaps

This review of innovation skills has indicated numerous areas where knowledge and information are limited of the processes, skills, and learning relating to innovation. This section commences by making some general points on research and intelligence gaps, before highlighting some specific issues for each sector.

10.1.1 Benchmarking innovation

- A comprehensive range of appropriate skills and related indicators could be developed to benchmark innovation activity. What should these consist of? Existing benchmarks focus mainly on research, science personnel, science, engineering and mathematics training, and qualifications (degrees/postgraduates). But, as this review has shown, there are many other potential benchmarks which relate to developing and operating innovative environments.
- Companies undertake their own benchmarking to evaluate their own business against competitors and exemplars. How do companies benchmark, who do they benchmark, how often, what criteria do they use? How do they use the information they unearth?

10.1.2 Policy questions on innovation processes and performance

- The Commission of the European Communities states how important it is to understand the full scope of innovation and its mechanisms in order to recognise where the weaknesses are that public policy could address. The CEC recommends that questions should be asked to determine why innovation performance does not match that of the world leaders such as the US and Japan. Are European Framework conditions hindering the conversion of skills and knowledge into innovation? Is the process of innovation in the European context properly understood? What would prove effective in increasing Europe's innovation performance?[309] There would also be value in posing these questions on a [cross-]regional basis, and for regions to locate and benchmark international best practice for particular sectors, industries and working practices.

- There is a strong relationship between entrepreneurship and innovation. The European Commission[310] advise that policy should help to promote entrepreneurial behaviour by pointing to role models and by offering specific forms of training.

10.1.3 How firms innovate, and innovation enablers and barriers

- The DTI's Innovation Report (2003) states that: "The ability of firms to absorb new ideas and turn them into action is critical to a high innovation performance." Do we know enough about how firms *absorb* new ideas? How best they can be assisted to absorb new ideas?

- We do not know enough about how firms (especially SMEs) innovate. There are many sides to this question: what makes them innovate, or prevents them, and under what conditions can innovation occur? Do they change their organisational structure and methods? To what extent does independence of firms or their subsidiary status affect their innovative capability? What innovation links do they form, and are these sufficient? What is their access to new technology and their use of technology transfer? What investment do they make in innovation, and how do they manage risk? Is the right support available and are there issues about its take-up? What do firms see ahead in terms of opportunities, issues and barriers to innovation?

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[309] CEC, Innovation Policy, Brussels, 2003
[310] CEC (2003)

- Companies may have intangible assets, i.e. unidentified core competences that are not recognised as such.[311] It is pertinent to evaluate what these are and how they might be used by firms to innovate. For instance, a core task in servicing customers' equipment might disguise an expertise in logistics which could be utilised in innovation collaboration or market entry.
- It is apposite to look at the potential impetus for innovation from other industries and what opportunities these could give to mature, embryonic and growing industries/sectors. There is also the issue to consider of growing sub-clusters, which ones are relevant, and are there different issues for these?
- This review has highlighted the breadth of expertise necessary in research. The importance of this subject merits a more focused evaluation of research environments and organisations to assess strengths and weaknesses and to identify good practice.
- ICT is an innovation enabler. It has a fundamental role in innovation outside its own sector through basic and specialist uses as well as software development. It is necessary to understand this, keep monitoring it as it changes so quickly, and understand how to ensure that the right skill base and support is in place.
- Enablers and barriers to innovation need to be examined more generally.[312]

10.1.4 The product development and commercialisation process

- What does the product development process comprise, and how does it vary for different sizes and types of company, in different industries? Detailed analysis should include a focus on skills assessment of the route from invention to commercially realisable products/processes, and routes to market. It is important to clarify SMEs' perceptions and experiences of, and available solutions to, barriers encountered to innovation by obtaining more in-depth information on the innovation process, where the limitations and blocks occur, and the characteristics of these. What are the issues and solutions for the mid and later stages towards commercialisation? At the same time, it would also be useful to look at what works well, and why, and how this good practice can be transferred to, and mirrored by, firms that encounter problems, either in getting started or mid-way during the process.

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[311] Consultation Ian Massey, Foresight, April 2006, citing Institute of Manufacturing, Cambridge Univ.
[312] Munshi et al, Advanced Institute of Management Research, 2005

- There are associated issues about market development for innovators. How do firms learn how to negotiate their route to market when that market may be an entirely new one? What happens when their market takes off, or indeed, does not take off? How do they respond quickly? And how do they acquire skills and manufacturing, management and services resources quickly if market opportunity suddenly expands?
- How do customer procurement practices inhibit or stimulate innovation?
- Mason (2005) points out that very little research has been conducted into the form that value added production (based on more complex product specifications, less likely to depend solely on low prices for competitive success) takes in different industries, or the associated skills that companies need in those industries in order to succeed in producing high value added goods and services.
- Mason (2005) advises that to obtain meaningful data from research into product [development] strategy must focus on this subject rather than being an add-on to research questions on other (unrelated) topics. Instead, he observes: "The key issues surrounding enterprise product strategies, high value added production and employer demand for skills are likely to be more fruitfully explored through new special surveys on product strategies and skills." [313] Furthermore, survey research questions should vary for different sectors.
- A better understanding is required of the role of patenting/copyrighting in relation to the impetus for and protection of innovation.

10.1.5 The use of creativity techniques

- Creativity techniques are well known, but how useful are they? What evidence is there that they do lead to innovations? Are there other techniques that must be used at a later stage in order to ensure that ideas generated are successfully implemented? What is the fit with innovation management and performance improvement techniques like benchmarking, business process re-engineering and total quality management and their variants? Do creativity techniques have limited applications? To what extent do, or would, these creativity techniques help in a manufacturing or high-tech research environment? Are there newer techniques now used in the business environment, though not yet widely known, which await identification and dissemination?

[313] Mason, Enterprise product strategies... , report for DfES, 2005

- Is there a knowledge gap among some industries or types of business about creativity techniques and their employment? Does their use rely on external facilitators (consultants) – and therefore represent a business cost and, because they do, they are employed infrequently? Does the demand for facilitators exceed the supply? Do managers and team leaders need to be more aware of the available techniques? Is there sufficient use of, and provision of training in, creativity techniques? How appropriate is it? What training is there in *computer-based* techniques? How good is the software?

- Innovation value analysis is seen as a variant on creativity techniques.[314] Undertaking value analysis specifically of their own innovation competences and actions gives companies the means to assess where to strengthen or add to their existing portfolio. Its importance merits examination of what innovation value analysis should entail, how firms use it, and issues for taking adaptive action.

10.1.6 Collaboration, networks, and knowledge transfer

- The DTI's Innovation Report (2003) notes that firms need to collaborate with many different organisations and to draw ideas from many different places, asserting: "This is an area where we have the opportunity to improve." It is pertinent to ask: what kinds of networks and collaborative partnerships work best for different sectors/groups. What exists in the West Midlands/Midlands/UK? Are there gaps or weaknesses? What are the strengths and how can they be protected/augmented? What else could be done to support these? Do firms need training to enable them to form innovative partnerships. How do supply chain groups work in relation to innovation?

- The DTI's Innovation Report (2003) notes that the UK has a strong science, engineering and technology base, but: "...the UK record of knowledge transfer and exploitation by business has been generally weak." Do we understand why? Is our understanding too general, not specific to SMEs, or to firms in particular sectors? How do firms find out about developments outside their sector that might help them? What stages do they go through to turn awareness into action then into innovation?

- The significance of strong knowledge and technology transfer links between businesses implies that further analysis would be beneficial of the skills that research organisations require to enable their successful knowledge and technology transfer.

[314] Consultation with Ian Massey, Foresight, April 2006

- One solution to difficulties in the knowledge/technology transfer mechanism is seen in firms moving individual employees to where the most suitable expertise exists in universities, to undertake research alongside those university specialists. It is thought that this might work well for smaller firms.[315] There may be issues about differences in cultures, backgrounds, and understanding. It is important to look at this potential and to assess where the inhibitors lie.

10.1.7 Managing innovation

- This review raised important issues about off-shoring production and its impacts on innovation management, capability and processes. These need to be evaluated.
- The impact of outsourcing needs to be examined in terms of innovation management. It is important to ascertain whether firms that are potential beneficiaries of outsourcing have the competences to exploit the opportunities. It is also important that firms do not outsource the competences that are vital to their innovative capacity, nor fail to establish the relationships with those outsourced firms (i.e. their suppliers) that enable them to innovate.
- A CRIC report (2005)[316] on innovation and skills is among studies to assert that leadership and management skills at all levels of an organisation are fundamentally important to innovation. They advise that these skills "may be imperfectly measured in a variety of ways." The Advanced Institute of Management Research[317] also concludes that the role of leadership in the innovation process is not well understood, describing research in this field as: "in its infancy." Clearly, there is more to be learnt about what innovation management and leadership skills require; the variation in skill profiles and needs according to, say, different sectors, firm size, product mix, strategies, forms of organisation, location, the economic and competitive context; and how best to instil or improve on the requisite skills.

[315] Consultation Ian Massey, Foresight, April 2006
[316] Tether et al (September 2005)
[317] Munshi et al (2005)

- The CMI assert[318] that little is known about good workplace practices in relation to management development and training as research focuses on the quantity and type of training, rather than the quality and effects of that training and development. Insufficient is known about the most effective training interventions by training providers in different sector and cultural settings. Furthermore, a government report[319] notes that on management skills there is a lack of robust internationally comparable data, not aided by differences between nations in the definitions of management and managers. But it is considered that UK managers lag those in the US, Germany and France in terms of competence and experience.

- It is necessary to consider how to communicate the messages to employers about achieving innovation through job [re]design, getting employee commitment, engaging/motivating/rewarding them, being approachable, respecting and listening to them and so on.

- The role of Human Resource Management in innovation is growing in importance, for example in relation to achieving the kind of organisational culture and employee motivation and engagement conducive to innovation. How well is their role understood? How are they equipped for this role?

10.1.8 Employee-centred innovation and learning

- It is seen as crucial that managers have the technological and managerial skills to innovate. The concept of continuous learning in managers and workforces is rising in importance. Do we understand what this entails? Do we understand how they can develop technological and management skills? Does the right training exist?

- The DTI's Innovation Report notes the need for injecting more resources into technician and intermediate skills where international comparisons show the UK's record is poor. There are a host of relevant issues. For instance, how do people learn, say, on the shopfloor? How appropriate is training? Are there gaps in training? How can the supply of training be tailored to meet employer needs? How are people on the shopfloor motivated to be innovative? How does it differ for sectors and occupations?

- Studies of high performance working could investigate job quality from the employee's perspective, as well as analysis of the processes of organisational change and workforce learning and development, would yield useful insights into how innovation occurs and how it could be improved.

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[318] Mabey and Ramirez, Chartered Management Institute, 2004

- The role of multi-skilling in innovation and learning is worthy of research focus. This literature review indicates that multi-skilling provides a means for internal knowledge transfer and can generate ideas for performance improvement and innovation.

- There are issues about training provision for trainers, both in-company and external. How are they kept up-to-date?

- More generally, it is pertinent to assess where the gaps are in training provision and ways to fill any gaps.

- The DTI notes the need for research to map the innovation, creativity and entrepreneurship skills that need to be delivered to young people in the ICE programme. The intention is to deliver this via self-managed e-learning. Questions exist about how best the development modules could be tailored to enthuse school pupils about being entrepreneurs, and to instil an awareness of what is involved. The DTI considers it necessary to undertake research to identify the subject areas that are likely to do this, and how employers can also be engaged to work with schools on the programme. Are there any gaps in the research currently under way that might be undertaken at regional level?

- What training is available on entrepreneurship? What groups and industries does it target? What is the take-up? How could it be improved?

10.2 Research and Intelligence Gaps: Manufacturing

- Developing an appropriate customer-focused innovation strategy is identified as vital for companies. The question is: how should this be determined and what factors need to be considered (see Text Box 9, above)? It could prove useful to devote further attention to this question.

- There is considerable scope for raising the level of business R&D. Ways need to be found to enable firms to do this, including by appraisal of skill issues and resources.

- Skill gaps detract from manufacturing industry's ability to innovate. Further investigation is warranted of cross-workforce skill issues and needs, the accessibility of knowledge resources, and the supply and delivery of training and workforce development.

[319] HM Treasury and DTI, The 2005 productivity and competitiveness indicators 2005

- The issue was raised about limitations in capital equipment to enable firms to develop new manufacturing processes and products. Further investigation is needed.

- Customer-supplier collaboration on product development is important. It would prove helpful to develop these links more strongly. Suppliers can be hampered by lack of experience in innovation and they need help to overcome this problem. Is that help available, to the right level, and sufficiently speedily?

- Issues about generating creativity are prominent in terms of how this ability can be encouraged and strengthened, particularly in smaller firms.

- Companies need to manage change, not just at top level but throughout their workforces. Do firms understand what is involved (see section 4.3.3)? Change management may need facilitation. Is it available?

- It is crucial that firms keep a horizon watch and grasp the potential of new wave technologies and materials. How adept are they at doing this? Where do they get information from? How can they be helped to undertake this more successfully?

- Product development and process changes can relate to new horizon and alternative technologies, e.g. nano, alternative fuels/power, advanced materials, environmental, recycled materials. Much of our knowledge on manufacturing skill needs relates to existing business conditions rather than evolving manufacturing and research environments. We do not know enough about the specialist skills which relate to new horizon and early commercial production. These skills may be digital/ICT, or they might involve skills for revised manufacturing processes using new materials and technologies. Much research about ICT skills is limited in geographical scope or is generalist.

- Do we understand what skill needs underlie the use of nanotechnology in manufacturing as well as in research environments? Have we identified what other new horizon areas exist? What skills will be obsolete? How will they need to change? How should training and workforce development best meet those changing skill needs? What needs to happen?

- The concept of the digital factory is occupying minds in Europe as it offers the prospect of radically bringing down costs and speeding up product development. What issues are there for introducing this innovation into UK companies? Could a mapping exercise of existing relevant competences be undertaken in the way that the Fraunhofer Institut has done?

10.3 Research and Intelligence Gaps: Automotive

- There is an issue about firms' access to the technical skills they need to innovate. Do we understand enough about those needs, or how firms can access these? A particular issue concerns emerging technologies.
- Growth fields include alternative powertrains, fuels, advanced and new materials and technologies, and telematics. What connection do automotive suppliers have with R&D programmes in such fields that might trigger subsequent production and supply contracts? If the research facilities of their customer base is outside the Midlands, indeed outside the UK, are there ways to establish innovation linkages with these, or to attract some of these research activities to the UK/Region, or to compensate by establishing quasi automotive industry customer-supplier R&D programmes such as by using firms in related sectors, linking firms better to universities and other research institutions, or establishing independent facilities?
- It is considered vital that knowledge sharing occurs. This does not solely relate to intellectual property protection, but also indicates the lack of a collaboration culture which it is important to overcome. How? More understanding is needed of this question.
- There is an issue for smaller firms in engaging in innovation if the focus of industrial linkages formed by universities and other research organisations targets medium to large-sized firms. This needs evaluation and resolution.
- The emergence of new technologies brings in different types of automotive suppliers that may not have prior experience of this sector. What issues are there for familiarisation with automotive industry practices? Might this also be an opportunity for existing suppliers to acquire new skills?
- Overseas sourcing and production exerts additional skill needs. Are firms able to obtain the information and support they need?
- Qualifications, course accreditations, training provision and funding need to be rationalised. One example is the electronics sector.
- Questions have been raised about the appropriateness of e-learning and training materials, and the extent that suppliers can access these.
- Leadership and management competences need to be improved. What issues are there about the supply and delivery of this kind of training, and the take-up by individuals at all workforce levels, including team leaders?

- Firms benchmark other companies. Who and what are they benchmarking themselves against? Are they able to *directly* access information about world class performance and innovation capability?
- What is the role of ICT in automotive industry innovation, including customer-supplier and other collaborative product development programmes? What ICT software and skills are needed and are there training and resources issues for smaller firms in particular?

10.4 Research and Intelligence Gaps: Medical/Healthcare

- There is an incomplete understanding of the knowledge processes involved in medical innovation. Firms in different sectors have varying skills portfolios and needs. The details remains to be clarified of the mix of capabilities which they possess, where the particular knowledge, information and skill deficiencies lie, and how these affect firms in different subsectors and of varying size and profitability. The same applies to the supply chain.
- Improvements are considered necessary to the organisational design of clinical trials. This merits further evaluation.
- The issue has been raised of the ability of smaller firms, particularly, to qualify for NHS procurement. There is probably more scope in further investigating this matter and its impact on innovation.
- The role of medical practitioners in innovation is fundamental. Firms need to establish collaborative links with medical practitioners including surgeons. How can they be helped to form these? Who with? For what outcomes? What competences do they need to acquire or improve to enable their successful collaboration?
- Businesses in transition from research teams to manufacturing enterprises – such as biotechnology start-ups and spin-outs - need to acquire a swathe of new competences and resources, many of which might be unfamiliar. There is merit in deducing what these are, and how businesses can access and utilise them.
- It is worth investigating specialist fields like marine biotechnology, evaluating this for its innovation potential, identifying existing strengths and synergies with innovation objectives, and devising a skills matrix to help build the capacity. There would be merit in conducting a parallel exercise for other business and technological opportunities.

- Case studies of firms that have successfully negotiated the route from product development to commercial production need to be benchmarked as role models.

- It is important that innovative firms have an international perspective of market opportunities, competition, regulations, and business procedures. Is the information base sufficiently resourced to supply the range of needs? Is the training infrastructure able to supply courses and a pool of labour of the right calibre and in sufficient numbers?

10.5 Research and Intelligence Gaps: Construction

- Performance improvement is imperative for firms in construction and the built environment in order to increase their efficiency and bring down costs. Due to the nature of construction projects, improving performance also necessitates sound project management and supply chain collaboration. It is important to address the various facets of performance improvement, and this obviously provides a means to introduce new working practices. But it is also vital that the effort to improve their day-to-day operations does not detract from the capacity to undertake innovation in new technologies and materials. It would be helpful to investigate further how this might be achieved.

- UK innovation in new technologies appears to lag international advances. It is important to address this issue and to determine what can be done, both nationally and in the Region, to ensure that firms are encouraged and able to exploit the opportunities. These include pre-fabrication and other novel and advanced technologies and materials.

- To what extent do firms possess the ability to form collaborative partnerships for innovation?

- ICT is fundamental to successful project management and improved supply chain collaboration. What technology is relevant to the construction sector and are firms able to source the skills and training they need?

- Issues have been raised about training. How does training provision keep abreast of the latest thinking and technologies? Are there gaps and how should these best be resolved?

- What issues are there for encouraging employers to invest more in training and to populate further education courses with their own employees?

- What can be done to increase the demand for training courses at higher education level, including civil engineering and materials science?

10.6 Research and Intelligence Gaps: ICT

- The analysis of skills issues and needs for the West Midlands ICT sector indicates that further information is required on the ways that ICT is used, or could be used, strategically by companies to improve their competitiveness in the global business environment. A more complete understanding is also needed of ICT diagnostic and support tools, what these are, how they are used (or could potentially be used) and the skill issues relating to their use by managers and others.
- A greater *appreciation* of the strategic uses of ICT, and of the specific ways that their own skills could be improved, needs to be instilled in managers and leaders *in all industries*. It is a particular issue for smaller firms.
- Greater understanding is needed of ICT specialist expertise employed by, and required by, non-ICT industries. A particular emphasis should be given to the picture of the specialist ICT expertise within major West Midlands sectors like automotive, aerospace, and target sectors like medical technologies/biotechnology, construction and environmental technologies.
- Ways to increase the numbers of ICT graduates and postgraduates need to be addressed. These people also need to be equipped to operate internationally and in multi-disciplinary teams. Soft skills are also needed as ICT personnel are increasingly called upon to project manage. This signifies a much broader skill base. More detail would be useful about the specific competences required.
- It is important to assess the training and continuous professional development needs of professionals and technicians within the ICT sector as these occupations have a pivotal role to play in innovation.
- Problems encountered by schools in getting ICT technicians need to be addressed. In addition, it is important to ensure that ICT teachers and technicians in schools and further/higher education possess the skills to equip students with the knowledge and expertise required to operate in the modern business setting.

- Farooqui (2005) points to the E-commerce Inquiry, an annual survey of ICT use and electronic trade. Limitations in the knowledge of ICT use and skills are highlighted, specifically in terms of looking at the adoption, usage and impact of broadband technologies, as well as building up measures of ICT skills, and looking at the correlation between skills and ICT investment and use.
- The software development process is evidently full of potential pitfalls. Is further understanding needed of this process and how it might be adapted for different outcomes? What companies should be benchmarked for good practice? Indeed, what does best practice entail?
- The potential of cross-over technologies (broadband is an example) as disruptive technologies warrants a very close 'new horizon' watch for potential opportunities and obsolescence threats.
- The Innovation and Technology Council has identified serious digital games for business, health, defence training purposes as a subsector for strategic intervention.[320] More information is needed about this field and the specific technological and communication features of it, as well as the skill needs.

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12 Appendices

Appendix 1: Human Resources Management policies linked to commitment and those which damage commitment

Positive HR Policies	Negative HR Policies
<u>Professionals</u> Communication Reward and recognition Appraisal Effort Relationship with managers Career opportunity	 Poor management leadership Lack of job challenge Unsatisfactory work life balance No pay/performance link Poor climate of employee relations
<u>Front line managers</u> Relationship with manager Career opportunities Work life balance Openness Job security	 Low job satisfaction Dissatisfaction with training Lack of openness
<u>Workers</u> Communication Rewards and recognition Openness	 Dissatisfaction with career opportunities Poor job security Low job satisfaction (job challenge and job influence)

Source: Purcell (2004).

Appendix 2: Creativity and Ideas Generation Techniques

1. Brainstorming

The objective is to obtain as many ideas as possible in a large group situation. The technique can also be conducted by electronic means. A variant is to focus on plus points, minus points and interesting points.

2. Story Boarding

Used for strategic and scenario planning, using a white board to brainstorm ideas, and allowing the interconnection between ideas. It can be used to identify issues, solve complex problems and determine ways to implement solutions. The four phases are a) planning, b) ideas, c) organisation, d) communication. A variant is the Lotus Blossom Technique, a hybrid between this and brainstorming and useful for forecasting strategic scenarios.

3. Checklists

Used mainly for product improvement or modification, using words from a checklist to describe products' attributes. A variant is Morphological Analysis which also employs a matrix of words for in-depth analysis of products or services.

4. Mapping processes

Many forms of mapping include computer based support tools. Mapping is useful in strategic management thinking, enabling a spatial representation of a situation and solving discontinuities, contradictions and confusion and bringing logic and order.

5. The Excursion Technique

A facilitated exercise which commences with participants taking an imaginary visit to a physical location and writing down what they see. Five stages include problem identification and solution.

6. Computer techniques

Their uses include research planning, product design, knowledge acquisition, decision-making, motivation exercises. Techniques include:

- Artificial Intelligence models
- Idea processors software.
- Visualisation and graphical systems
- Spatial representation tools, and
- Spatial information systems.

Source: Sefertzi (2000).

Appendix 3: Input Factors and Innovation in UK Regions

UK Regions	Average hourly earnings (£ per hour – 2001)	Population of working age by highest qualification (%)		% of total production & construction employee jobs in high & medium technology sectors	% of total distribution & service employee jobs in knowledge intensive sectors	Expenditure on R&D performed within UK business by region (£ per head of population 2000)
		Degree	Higher			
UK	10.6	15.2	8.3	27.0	52.6	193
England	10.8	15.6	7.9	27.3	53.1	218
West Midlands	9.9	11.9	8.2	29.6	52.3	1.8
East Midlands	9.4	12.6	7.5	27.3	50.0	223
London	14.6	25.0	6.0	19.8	56.0	111
South East	11.3	17.8	8.1	33.3	55.4	367
South West	9.8	15.5	9.2	29.6	49.6	176
Eastern	10.4	14.4	7.7	27.9	51.8	509
Yorkshire & Humber	9.3	Not given	Not given	20.1	51.9	60
North East	9.1	10.4	7.9	29.9	50.6	64
North West	9.8	12.9	8.9	28.8	52.7	265
Northern Ireland	9.0	12.8	6.2	22.6	48.7	82
Scotland	9.7	14.1	12.5	24.5	49.2	78
Wales	9.2	12.3	9.2	29.1	51.9	49

Source: OECD, Local Entrepreneurship Review Series: case study of the West Midlands, United Kingdom, 2004

Appendix 4: Innovation Performance Measures in the UK by Regions

Regions	Innovation activity of SMEs by region (% of SMEs)		Novel product innovation by region (% of SMEs)	Novel process innovation by region (% of SMEs)	Mean % turnover from products new to firm or significantly improved (mean % over all respondents)
	Production and construction	Distribution and services			
UK	47	44	7	4	35
England	47	45	7	4	35
West Midlands	50	52	7	5	31
East Midlands	49	43	10	5	31
London	42	46	7	4	34
South East	47	43	7	4	44
South West	52	49	9	4	39
Eastern	47	43	7	4	35
Yorkshire & Humber	53	43	6	3	34
North East	44	43	5	4	27
North West	46	38	5	4	34
Northern Ireland	52	37	3	3	34
Scotland	42	42	8	5	30
Wales	47	44	8	6	29

Source: Source: OECD, Local Entrepreneurship Review Series: case study of the West Midlands, United Kingdom, 2004, citing DTI Innovation Review, 2001 and ONS

Appendix 5: R&D Expenditure by Region in broad product groups, 2004

Figure A.1: R&D Expenditure by Region: Chemicals

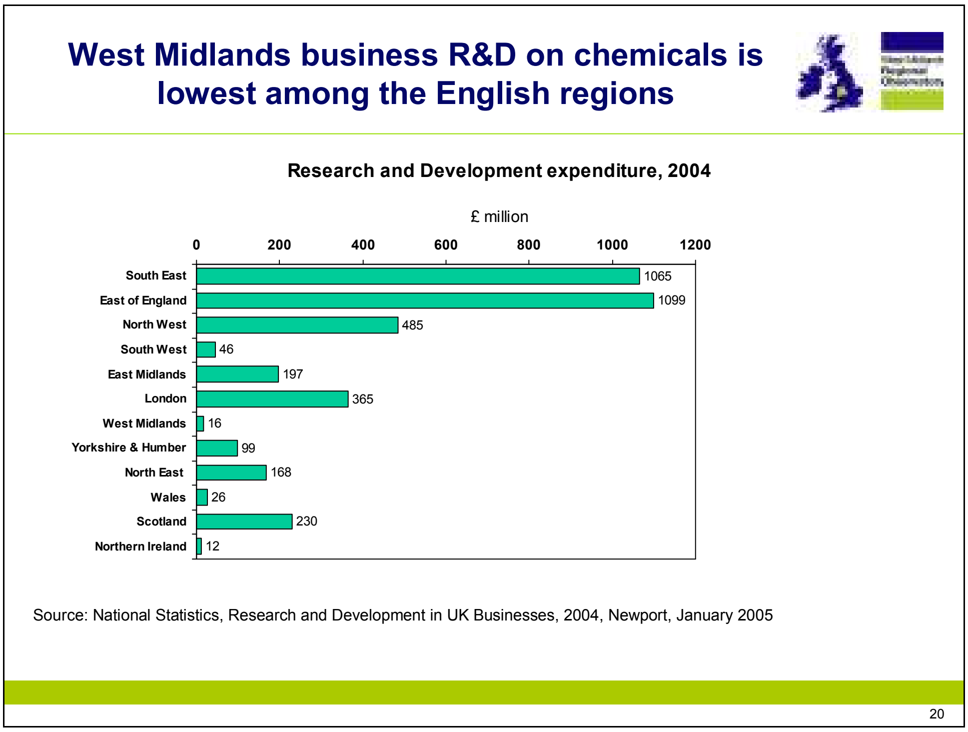


Figure A.2: R&D Expenditure by Region: Mechanical Engineering

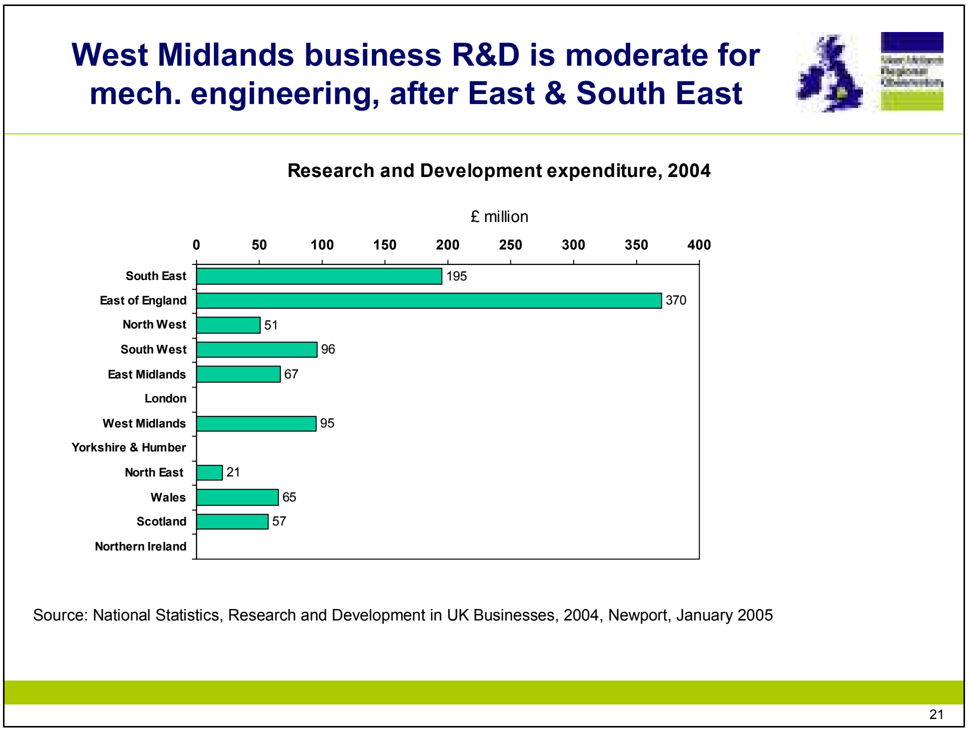


Figure A.3: R&D Expenditure by Region: Electrical Machinery

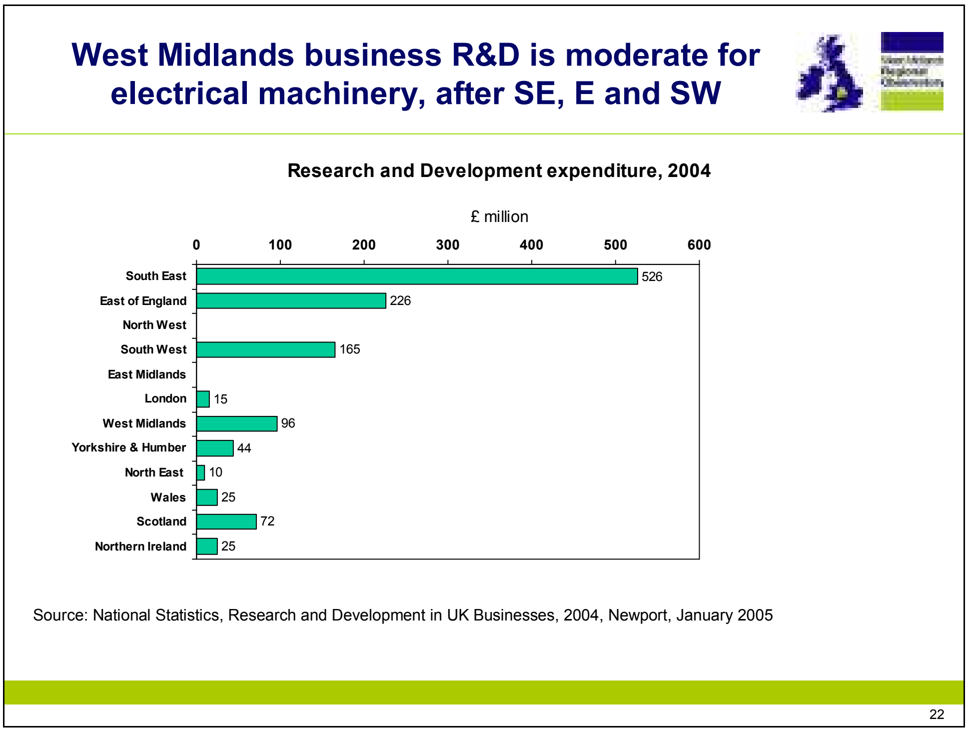


Figure A.4: R&D Expenditure by Region: Transport equipment

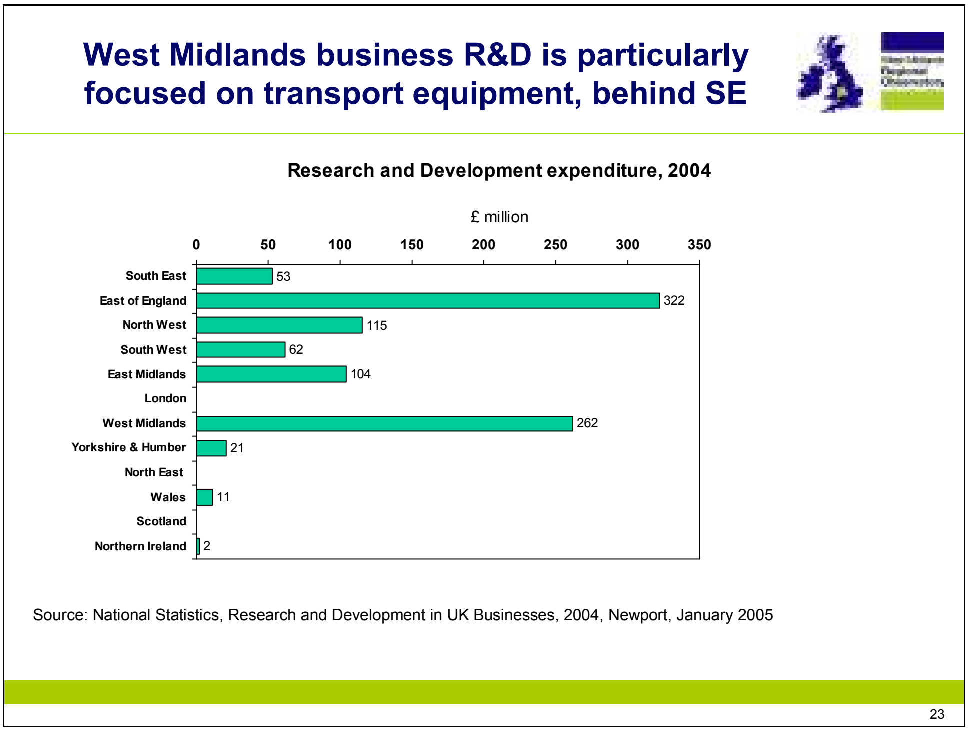


Figure A.5: R&D Expenditure by Region: Aerospace and Other Manufacturing

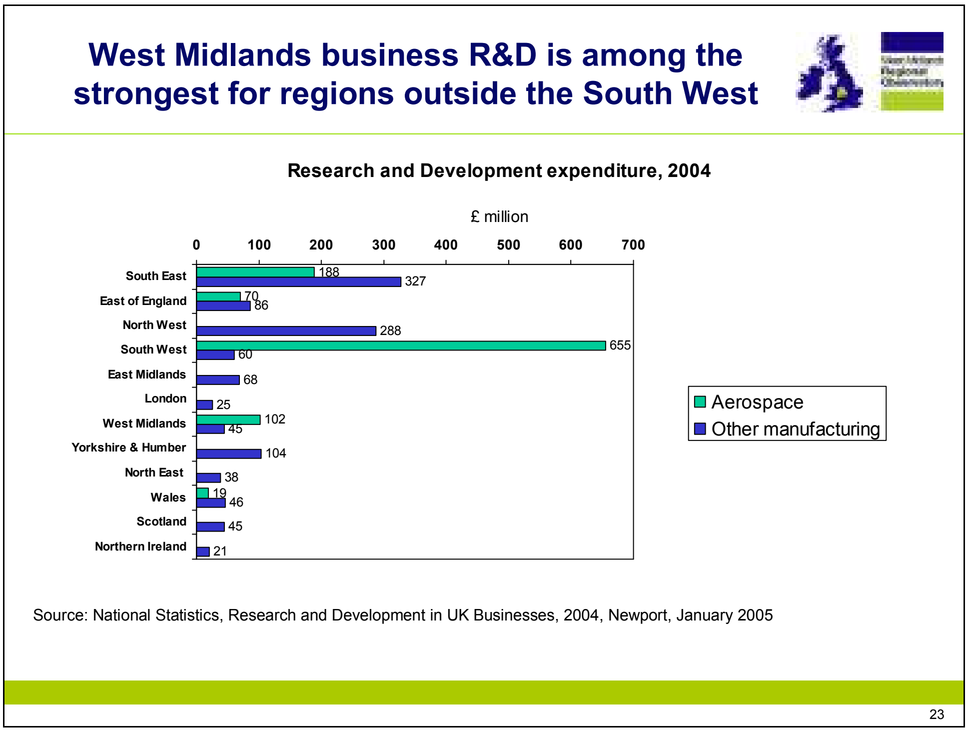
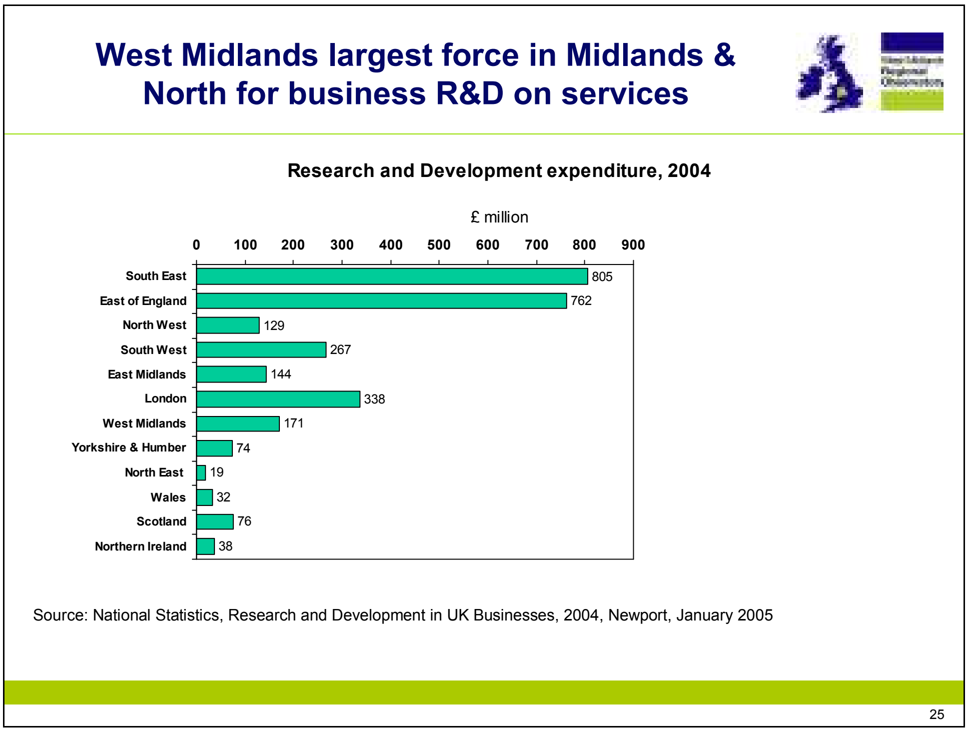


Figure A.6: R&D Expenditure by Region: Services



Note: for construction sector see chapter 7.

Appendix 6: Patenting activity, 2001, by OECD members

Number of patents taken out by nation

Nation	Patenting Activity				
	Patents taken out in US, Europe, Japan	Applications to the European Patent Office			
		Total	*Of which* : % of foreign co-inventors	ICT	Biotech-nology
Australia	374	924	19.6	301	95
Austria	281	1,169	27.8	228	53
Belgium	433	1,167	34.7	276	81
Canada	638	1,586	31.2	582	163
Czech Republic	12	70	45.8	14	3
Denmark	222	868	21.1	221	86
Finland	511	1,344	15.1	782	31
France	2,455	7,175	15.9	2,269	307
Germany	7,466	21,310	11.4	5,371	749
Greece	7	71	27.1	20	4
Hungary	28	96	36.7	30	9
Iceland	6	19	37.5	11	3
Ireland	74	239	31.3	101	22
Italy	857	3,906	10.0	628	59
Japan	11,751	18,844	2.8	8,191	716
Korea	503	1,518	4.6	742	70
Luxembourg	21	72	46.9	10	0
Mexico	15	42	50.0	8	2
Netherlands	993	3,808	13.5	2,104	131
New Zealand	37	140	20.6	27	17
Norway	108	346	21.7	105	15
Poland	7	53	46.6	8	4
Portugal	6	40	35.3	7	2
Slovak Republic	4	12	55.6	5	2
Spain	118	851	21.2	169	37
Sweden	817	2,042	17.1	695	76
Switzerland	861	2,716	30.1	681	96
Turkey	7	43	41.9	2	1
United Kingdom	2,168	5,342	23.3	1,968	341
United States	16,469	28,515	12.1	10,856	2,419

Source: OECD in Figures, 2005

Appendix 7: SEMTA's New Product Development and Introduction (NPDI) Standards: draft, March 2006

	Standard
1	Plan and control benchmark activities
2	Establish new product development and introduction (NPDI) brief
3	Solve NPDI problems
4	Produce and evaluate conceptual design problems
5	Verify the design using a computer model
6	Verify the design using a physical model
7	Produce product designs for manufacture and assembly
8	Control the design change process
9	Develop and implement product design verification tests
10	Plan and control process benchmarking activities
11	Establish process brief for new product introduction
12	Develop process design strategy
13	Contribute to a team feasibility review of product
14	Develop and implement product design validation tests
15	Develop process flow and floor plan layout
16	Produce a plan for the installation of the new process
17	Produce mechanical engineering drawing using computer-aided techniques
18	Produce electrical engineering drawing using computer-aided techniques
19	Produce electronic engineering drawing using computer-aided techniques
20	Produce fabrication/structural engineering drawing using c-a-t
21	Produce fluid engineering drawing using c-a-t
22	Manage the installation of the new process
23	Commission the new process
24	Run pre-production trials and fine tune the process
25	Write process instructions/standard operating procedures
26	Develop and implement quality plans
27	Produce functional quality assurance plans
28	Manage the implementation of the functional quality assurance plans
29	Manage the outcome of the functional quality assurance plans
30	Identify and solve process and product quality assurance plans
31	Develop systems and procedures to assess the readiness of the manufacturing process for production
32	Obtain customer approval to commence production
33	Manage and implement quality planning processes
34	Provide data and information to support risk management
35	Create visual management systems
36	Manage the design and process change approval procedure/process
37	Contribute to design for manufacturing and assembly

Source: SEMTA, March 2006

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Document contact:	Andy Phillips, Head of Skills Research, Skills Research Team, West Midlands Regional Observatory Tel. 0121 202 3251 E-mail: andy.phillips@wmro.org

West Midlands Regional Observatory
Level L1
Millennium Point
Curzon Street
Birmingham B4 7XG

Telephone: 0121 202 3250
Fax: 0121 202 3240
E-mail: enquiries@wmro.org
www.wmro.org

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European Social Fund