Government Office for Science

Foresight

What type of future workforce will the UK need?

Future of Manufacturing Project: Evidence Paper 36

Foresight, Government Office for Science

What type of future workforce will the UK need?

By

Professor Rob Wilson & Terence Hogarth

Warwick Institute for Employment Research

October 2013

This review has been commissioned as part of the UK Government's Foresight Future of Manufacturing Project. The views expressed do not represent policy of any government or organisation.

Contents

Executive summary

The current and future importance of manufacturing

Manufacturing employs around 2.6m people which accounts for approximately 10 per cent of the UK workforce. But this underestimates the true importance of the industry with many jobs in other sectors being dependent upon the supply of goods and services to manufacturing. This is will continue to be the case in to the future.

The UK has longstanding strengths in several advanced manufacturing sectors such as pharmaceuticals and aerospace. And the process of technical change – linked to developments in, for example, nanotechnology, new materials, and biotechnology - provides the UK with the opportunity to further enhance its advanced manufacturing base. But for this to be realised the skills supply will need to keep pace with skill demand. Increasingly it will be the quality of their respective workforces upon which advanced economies will compete with one another.

The scale of future skill demand

Future skill demand will be dependent upon a number of factors including: technical change; regulation, the ongoing process of globalisation; demographic change, and the strategic choices made by multinational companies relating to where they decide to locate different parts of the manufacturing process (such as R&D, design, manufacture and assembly).

By incorporating, as far as possible, these types of skill drivers within forecasting models, projections of future skill demand suggest the following:

- a continuing decline in the overall number of people employed over the medium-term as a consequence of productivity gains. By 2020 there will be 170,000 fewer people employed in the UK's manufacturing industry;
- reflecting the fact that manufacturing will be increasingly concentrated in advanced manufacturing activities, the share of overall employment accounted for by managers, professionals, and associate professional employees will increase;
- because the workforce of the industry is relatively aged, there will be a large number of people retiring from workforce over the medium-term. This will result in nearly 800,000 jobs needing to be filled by 2020 many of which will be in skilled trades jobs. Even though overall employment levels are falling, the scale of expected retirement will result in many job openings.

The projected pattern of skill change projected to take place in the UK over the medium-term is one which will be observed across many other European countries with a relatively advanced manufacturing sector. It is notable that the UK sector is less dependent upon skilled trade workers than in countries such as Germany and Switzerland which are acknowledged as possessing relatively strong manufacturing sectors.

More detailed insights into future skill demand

The industry will need to be able to attract people who are at the cutting-edge of technological developments germane to manufacturing. These skills may be required in small volume but are of critical importance to the future development of the industry. The relative scarcity of these skills often results in employers searching for them in international labour markets rather than national ones. More generally, future skill demand will be:

- in activities increasingly concentrated in high-skill activities such as R&D, design for manufacture, production of prototypes, and low-volume manufacture of complex / high value products;
- for people employed in managerial and professional occupations who are capable of managing the R&D process and bringing new products to market. They will also be expected to have the capability to work in networks of organisations which are likely to be spread across several countries;
- for people working in associate professional and skilled trades jobs. The role of the technician – which straddles the associate professional and skilled trade occupational groups - has been highlighted as one which may well become increasingly important in the workplace. This reflects the changing nature of production processes and employer preferences for people who have undertaken their initial vocational preparation within the workplace.

Where people are required in the above occupational roles they will be, in many instances, qualified in Science, Technology, Engineering and Mathematical (STEM) disciplines.

The future supply of skills

Given the pace of technical change in manufacturing there is the risk that the supply of skills is always trying to catch up with emerging demand. That said there is a well developed training infrastructure in place at both further education (FE) and higher education (HE) levels capable of producing the skills – especially STEM skills – which the industry will increasingly need in the future. But two issues will need to be tackled:

- the relatively small share of those graduating from HE in STEM subjects who enter the manufacturing sector;
- the relatively small share of employers providing the Apprenticeships which will produce the next generation of technicians.

A failure to tackle these issues runs the risk of failing to sufficiently satisfy future skill demand such that future development of the industry will be less than it might be.

The future development of the industry is also dependent, at least in part, on effective collaboration between industry and the HE sector. This can be difficult to achieve, especially so in relation to Small-Medium Enterprises (SMEs), but it provides the means of ensuring that the knowledge extant in universities and research institutes stimulates growth in the manufacturing sector. This points to the importance of those policies and programmes which facilitate collaboration and knowledge transfer between HE and industry.

1. Introduction

1.1 The importance of manufacturing

Any history of employment in the UK labour market over the latter part of the 20th century will emphasise the increasing dominance of the service sector as a source of employment (Lindley, 1981). It will also draw attention to the decline in manufacturing employment with reference to either the total number of people it employs or its percentage of overall employment. But any such history would be wrong to infer the demise of the manufacturing sector as a source of either employment or economic growth. There are at least three principal reasons for this.

1. Manufacturing provides important inputs to other sectors of the economy because it satisfies a range of final and intermediate demands. The OECD illustrates this by examining the share of manufacturing in overall total demand (intermediate and final demand). Data from the mid-1990s for the UK suggest that this was around 35 per cent which is much higher than indicators such as employment or value-added would suggest (OECD, 2006).

2. Manufacturing is a source of productivity growth, driven by investments and new technologies in products and processes, which drives overall economic growth (c.f. Baumol and Bowen, 1966).[1]

3. The UK has a strong global position in high technology manufacturing sectors (OECD, 2006). These are sectors which are characterised by relatively high levels of investment in research and development (R&D), have considerable growth potential, and are export orientated.

Public policy has increasingly focussed on how the manufacturing sector, especially the more capital and knowledge intensive parts, can be supported in order to boost economic growth (HM Treasury / BIS, 2010). There are resonances with the past here. Writing in the 1970s Bacon and Eltis (1975, 1976) suggested, somewhat contentiously, that the UK's relatively weak economic performance and the decline of the manufacturing industry stemmed from the expansion of the public sector. Whilst the precise mechanisms through which the expansion of the public sector might have affected economic performance in the 1960s and 1970s are likely to be different from those nowadays – there are, for example, no nationalised industries today – there are similarities between the exposition of Bacon and Eltis and current policy. This is seen with reference to the aim of rebalancing the economy by reducing its reliance upon public sector investment and encouraging private sector activity, across a range of key sectors, including manufacturing (HM Treasury / BIS, 2010).

Another resonance with the past is the importance given to the role of vocational preparation in bringing about relatively good economic performance. It is apparent that Government has sought over many decades to reform the vocational education and training (VET) system to ensure that it responds more readily to employer skill demand

---

[1] The OECD (2006) suggests that this may be less true of the UK than in countries such as the USA though the data are now rather dated.

(both current and expected future demand). For instance, the Leitch Review in 2006 - which provided the justification for the present organisation of the VET system in the UK - was just the latest in a series of reviews dating back to the Royal Commission on Technical Instruction in 1881. The importance, however, of being able to meet the manufacturing industry's skill needs should not be underestimated. It is apparent that large parts of the manufacturing sector are dependent upon highly skilled people qualified at higher and intermediate levels in science, technology, engineering and mathematics (STEM) subjects. Increasingly the future of the sector is seen to rest upon a number of mutually reinforcing factors: highly qualified and skilled employees are required to support relatively high levels of investment in R&D which, in turn, are needed to design the new products and processes capable of capturing a significant share of the high-value added segment of the global market which will generate the funds for further investments in capital and labour (Davis, *et al.*, 2012). Clearly, skills are central to the manufacturing industry's future success.

1.2 Manufacturing in the UK

As a single sector the industry accounts for around 12 per cent of total output and 10 per cent of employment (2010). Only the financial services sector produces a larger share of output and employment (SEMTA, 2012). Over the ten years between 2000 and 2010 output volumes have not kept pace with those in the economy as a whole and employment has declined by nearly one and a half million. But these data refer to the manufacturing sector as a whole which encompasses a wide range of economic activities.

Table 1.1: Output and Employment in Manufacturing, 2000 - 2010

	2010 level	Growth rate: 2000-2010 (% p.a.)	Changes (absolute)
Output (£2006m)	130,435	-1.2	-17,459
			-
Employment	2,638,037	-4.3	1,448,350
Part time employment	196,518	-4.3	-108,560
Full time employment	2,239,433	-4.5	1,294,141
Self employment	202,086	-2.0	-45,649
Male employment	1,988,851	-4.0	-989,125
Female employment	649,186	-5.2	-459,225

Source: Labour Force Survey / Working Futures Database

In many respects discussion of the manufacturing sector as a whole can be misleading especially so when the focus of the discussion is upon skills. A cursory glance at the major groups which comprise the manufacturing sector in the Standard Industrial Classification (2007) reveals the mix of high and low-value added activities:

- 10 Manufacture of food products
- 11 Manufacture of beverages
- 12 Manufacture of tobacco products
- 13 Manufacture of textiles
- 14 Manufacture of wearing apparel
- 15 Manufacture of leather and related products
- 16 Manufacture of wood and of products of wood and cork, except furniture
- 17 Manufacture of paper and paper products
- 18 Printing and reproduction of recorded media
- 19 Manufacture of coke and refined petroleum products
- 20 Manufacture of chemicals and chemical products
- 21 Manufacture of basic pharmaceutical products and pharmaceutical preparations
- 22 Manufacture of rubber and plastic products
- 23 Manufacture of other non-metallic mineral products
- 24 Manufacture of basic metals
- 25 Manufacture of fabricated metal products, except machinery and equipment
- 26 Manufacture of computer, electronic and optical products
- 27 Manufacture of electrical equipment
- 28 Manufacture of machinery and equipment not elsewhere classified
- 29 Manufacture of motor vehicles, trailers and semi-trailers
- 30 Manufacture of other transport equipment
- 31 Manufacture of furniture
- 32 Other manufacturing

Several of the sectors listed above are relatively low value-added ones - such as food and drink manufacture, manufacture of wood products, *etc.* Mason (2005, 2011) points out that enterprises with low value-added strategies tend to more reliant upon local and regional markets, are not subject to export competition, and make relatively modest investments in the skills of their workforces. In contrast, enterprises which pursue high value product market strategies are more likely to consider their current and future skill needs and engage in updating the skills of their existing employees.

In looking at how the economy might be rebalanced BIS makes references to the advanced manufacturing sector (HM Treasury / BIS, 2010) which is classifies as that part of the manufacturing sector which is characterised by:

- intensive use of capital and knowledge;
- long term investment decisions to develop processes and buy equipment (that can take more than a year to manufacture);
- high levels of technology utilisation and R&D and intangible investments (training, improvements to business process) to support innovation;
- a flexible workforce with strong specialist skills in the areas of science, technology, engineering and mathematics and design;
- competing in international and domestic markets.

In many respects the concepts of high value product strategies and advanced manufacturing are synonymous and both concepts emphasize the role of skills development. Davis et al. (2002) also draw attention to the fact these are dynamic concepts. Being a high value producer or advanced manufacturer requires on-going investments in product design and production processes alongside investments in skills in order sustain that denomination because, eventually, nearly all products are subject to becoming low-value added ones because they become outdated or become mass market commodities.

At the time of writing the UK's strengths in advanced manufacturing include:[2]

- Aerospace;
- Plastic / silicon electronics;
- Bio-medical / pharmaceuticals;
- Composites / new materials;
- Nanotechnology.

It is also evident that the country's automotive industry is also performing well especially so in export markets.

1.3 Is UK manufacturing different from its international competitors?

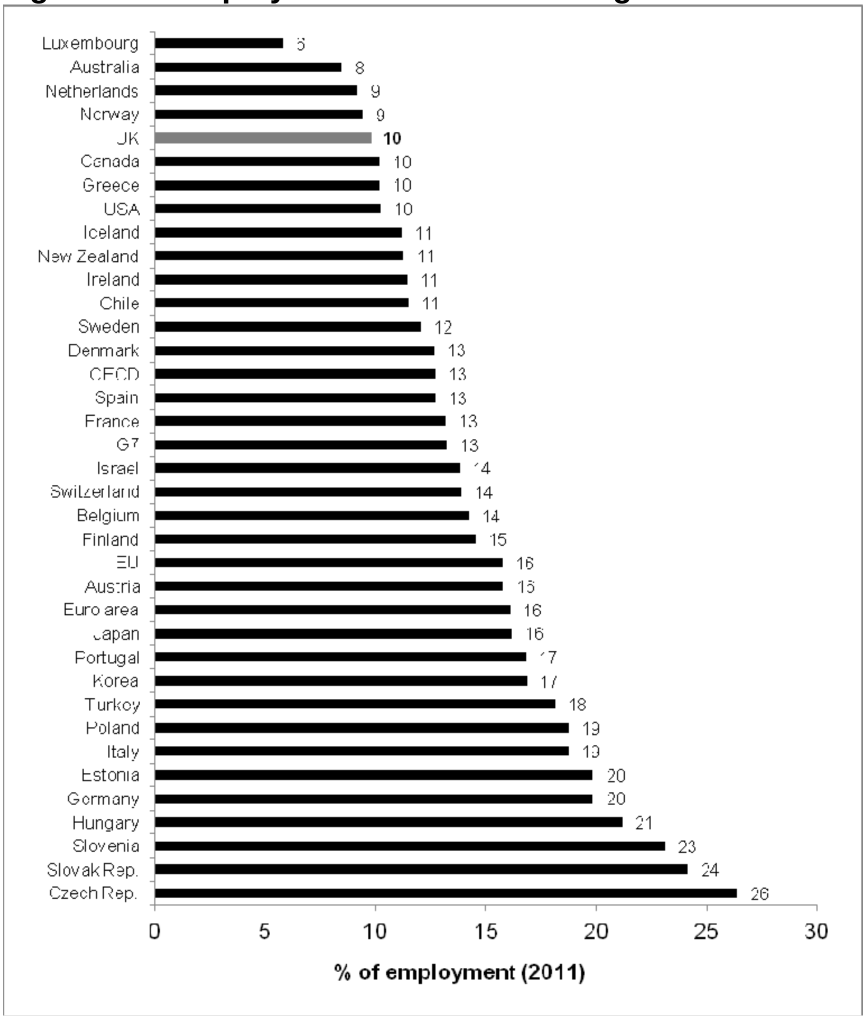
In the 1970s, Kaldor suggested that UK's economic development was more advanced than those of other countries and the decline of manufacturing was something which other countries would eventually experience too (Kaldor, 1975). Why employment levels should fall in industries such as manufacturing, other things being equal, was outlined by Baumol and Bowen (1966). Potentially employers in the manufacturing sector have more scope to increase labour productivity by substituting labour with machinery and by outsourcing various activities including low-value elements of the production process. Parts of the service sector, such as the education and the arts, cannot achieve these types of productivity gain or at least not to the same extent (for example, an orchestra cannot increase its productivity by playing faster or by, for instance, outsourcing the string section to a lower-cost ensemble). But these sectors are in competition, with the ones realising productivity gains, for labour (and skills) and, accordingly, pay wages at least equal to them.[3] Manufacturing is able to offset the potential for wage-push inflation by continually raising its productivity levels (and, consequently, reducing the size of its workforce). As will be described later this also has important consequences for the manufacturing sector's skill needs.

It is readily apparent that the manufacturing sector has accounted for an increasingly smaller share of employment in advanced industrial nations. By 2011, employment in manufacturing in the UK was, as percentage of overall employment, not much different from that in Western Europe and North America (see Figure 1.1). The only countries with levels of GDP per capita comparable with the UK's and where manufacturing accounts for a relatively high share of employment are Germany, Italy and Japan.

---

[2] Based on SEMTA's analysis of the future of manufacturing employment (SEMTA, 2009)
[3] Clearly parts of the service sector have through the introduction of information and communication technologies have been able to realise substantial labour productivity improvements over recent years.

Figure 1.1: Employment in manufacturing as a share of total employment



Source: OECD

Like many other countries in the western world, the UK has developed its niches in advanced manufacturing.

1.4 Aims of the study

If the education and training market is to respond to the needs of the industry it is desirable to have an indication of the scale and nature of future skill needs. This is the purpose of this short paper is as follows:

- What is the current skills mix of the UK's manufacturing workforce (including qualifications (academic and vocational), apprenticeships, and graduates)?
- What are the recent employment trends in manufacturing, together with medium-term employment projections, and what do they suggest to us about what the UK's future manufacturing workforce will look like (in 2020, and as far as possible thereafter, at intervals to 2050) the future?
- How is the supply of skills developing and how well placed is it to supply the skills required by manufacturing in the future?
- Are there particular skill shortages on the horizon we should be aware of, particularly with regards to increasing internationalisation and specialisation of manufacturing?

The study will provide medium-term estimates to 2020 but will also consider possible longer-term issues up to 2050.

1.5 Structure of report

The report is structured as follows. Chapter 2 looks at medium-term trends in the demand for skills based primarily quantitative evidence. In Chapter 3, provides a view of future skill demand based on a wider variety of data than supplied by quantitative projections. Chapter 4 looks at the supply of skills and identifies skill shortages. Finally, Chapter 5 provides a conclusion and outlines how policy can support manufacturing.

2. A quantitative assessment of skills demand over the medium-term

2.1 Introduction

This chapter looks at changes in the demand for skills over the recent past and the implications of these changes for the future of employment in the manufacturing industry. It draws upon quantitative projections of likely skill demand before, in the next chapter, considering some of the longer-term trends to 2050 based on wider range of evidence about how the industry is likely to develop.

This chapter is based on the projections of skill demand derived from Working Futures for the UK (see Wilson *et al.,* 2012), and Cedefop's pan European projections which give an indication of skill demand across Member States of the EU (see Wilson *et al*., 2010). Both the Working Futures and Cedefop projections of skill demand use occupation as a proxy measure of skill. Skill is a multifaceted concept and occupation provides an imperfect measure (Green, 2012), but occupation is one of the few indicators of skill available on a consistent basis over time. Accordingly, the projections of skill demand presented below provide an all important context for the analysis in the following chapters which address the demand for, and supply of, skills in more detail.

2.2 Drivers of skill demand

The demand for skills in the manufacturing industry in the UK will be shaped by changes which will affect:

- the structure of the industry (that is, the type of goods which are produced and assembled);
- the way the products are produced (including both the use of process technologies and the organisation of work around the use of those technologies).

Both of the above will determine the content of jobs and thereby the skills the industry needs. A number of factors can be identified which are likely to drive change in products and processes and consequently skill demand, including:

- technical change;
- competition and globalisation;
- environmental change;
- regulation;
- consumer demand;
- firms' product market strategies and strategic choices;
- demographic change;
- skills supply.

The characteristics of these drivers have been explored in a number of reports (for example, SEMTA, 2012; Davis *et al*., 2012). In summary the evidence points to innovation leading to the development of new products and production processes, including the automation of production systems that were previously relatively labour intensive. In a global economy which has seen many trade barriers lowered if not removed, firms have an increased degree of choice regarding the location of production. With the development of ICT technologies it makes it increasingly possible for a producer to control a system which has design and final assembly located in country *x*, whilst having the components and sub-assemblies produced in countries *a*, *b*, and *c*. Where companies decide to locate various elements of the production process – such as, research and development, product design, assembly, sales and marketing – is likely to be determined by a range of factors relating to the regulatory environment. It is this environment which will affect production costs (such as labour costs and environmental regulations) but there is also evidence that companies are also sensitive to the issue of maintaining their intellectual property which is better protected in some parts of the world than others. Employers will also choose where to locate different elements of the production process as a result of corporate strategic choice. Where a company is looking to develop its products in a given market it is likely that they will locate at least some of the more high value-added elements of the production process in that country as a sign of a willingness to do business with that country (Hogarth et al., 2010).

Skills supply will also affect which goods are produced where, and the nature of production systems. A shortage of skilled labour is potentially a major constraint on a firm's productive capacity. This is particularly important in a sector such as manufacturing where a large part of the workforce is relatively aged and likely to retire over the medium-term. It is also apparent that the nature of skills supply – such as the balance between intermediate and higher level skills supply – will affect how employers choose to organise work on the production line. In the USA the relatively large supply of graduate engineers – alongside other factors too – has allowed employers there to develop production processes which rely more upon first line managers (that is, quasi-professional roles) who supervise assembly workers (typically semi-skilled workers) working on automated production processes (Mason and Finegold, 1999). In contrast those parts of Europe which have a stronger supply of skilled trade workers stemming from their strong apprenticeship programmes tend to rely more upon skilled trade workers in the production process. This, it has been suggested, has given them a better base upon which to develop small-scale batch production of relatively complex, high value-added goods.

The strategic choices made by manufacturing employers regarding the organisation of work can be divided into two following broad categories:

1. The decisions of multinational organisations about where they locate certain activities. For instance, the relatively high share of manufacturing companies owned by companies with headquarters outside of the UK is suggested as one reason by R&D as a share of GDP is relatively low in the UK compared with countries such as Germany (PWC, 2009);

2. Where supply-chain relationships see certain production activities once undertaken in-house being increasingly located in other firms often located in other countries. For instance, the manufacture of relatively simple, low cost components; and

3. The outsourcing of a range of business services - such as catering, human resources, legal services, and IT – to other specialist companies.

All of the above have a marked impact on the occupational structure of employment in manufacturing. Over the recent past the UK has seen a large segment of that part of its manufacturing industry engaged in the mass production of relatively low cost goods being transferred to low labour cost countries. No matter what productivity gains could be realised within the UK they were nowhere near sufficient to offset the labour cost advantage which countries such as China possessed. At the same time there is evidence that the country has increasingly specialised in: (a) the high value added elements of the production process such as research, development, and design; and (b) high value, high skill sub-sectors (such as pharmaceuticals, plastics, and aerospace). In other words, it has specialised in those elements of the manufacturing process which can afford to pay the wages which the industry needs to pay in order to attract employees – often highly skilled ones – who would otherwise be attracted to work elsewhere.

In summary, the drivers of change are likely, others things being equal, to increasingly push manufacturing towards the production of relatively high value goods which are produced by an increasingly skill intensive workforce. Parts of the industry are likely to remain engaged in either relatively low value goods (for example, food manufacturing) or medium value-added goods (for instance, motor vehicles) either because production needs to be close to the point of consumption or because firms see strategic advantage in being located in one of their main markets or in a particular country. But the general trend is towards activities being concentrated in those which generate relatively high value-added or, have the capacity to become so where the activity is a new one resulting from the innovation process. This creates a substantial demand for highly skilled labour often qualified in STEM subjects.

2.3 Working futures projections of employment demand

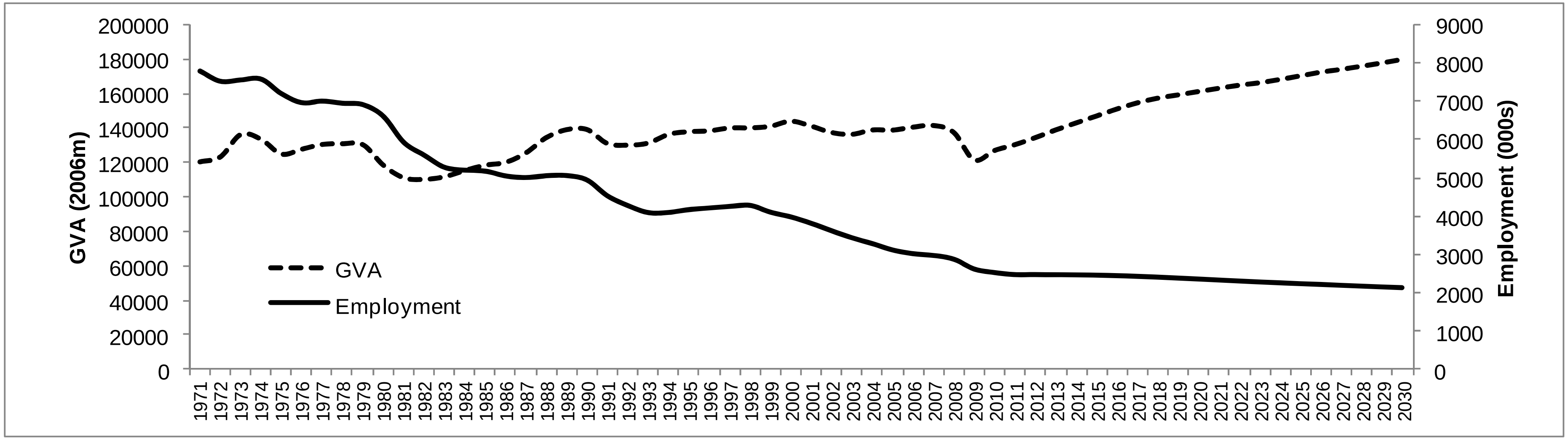
It should be stated at the outset that the Working Futures projections are based on a relatively optimistic outlook for the UK economy over the medium-term. But it needs to borne in mind that as medium-term projections they reflect long-term historical trends in both the national and global economies such that shorter-term fluctuations from the longer-term trend are expected to balance out. The projections assume that GVA grows at around 2 per cent a year over the period 2010 to 2015 with this growth supported by relatively strong output growth in manufacturing over the period as a result of policies designed to rebalance the economy. Growth is expected to be slower over the period 2015 to 2020 which suggests that the rebalancing observed over the period 2010 to 2015 will be reversed. Given the performance of the UK economy over recent years it would now appear more likely that manufacturing output growth will be weaker over the 2010 - 2015 period and stronger over the 2015 - 2020 one. From a medium-term perspective, the outcomes for employment and skill demand will be more or less the same.

It is apparent that the Working Futures projections of employment are dependent upon a renaissance in the UK's manufacturing sector. This is not reflected in employment levels which are expected to continue to fall in line with their long-term trend. But the sector will continue to make a major contribution to GDP both directly through the value of its output, and indirectly, given that the sector is a major consumer of products and services from other industries, especially business services. Figure 2.1 shows the long-term trend in output and employment in the UK's manufacturing industry and Figure 2.2 the trend in manufacturing employment compared with overall employment.

The historical data reveal the cyclical nature of employment in manufacturing and the relatively steep decline in employment between 1970 and 2010. Looking to the future, employment is expected to continue to fall but not at the pace observed in the historical data in large part because of a projected pick up in output over the period to 2030. Should this not materialise then it is likely that employment will fall more quickly.

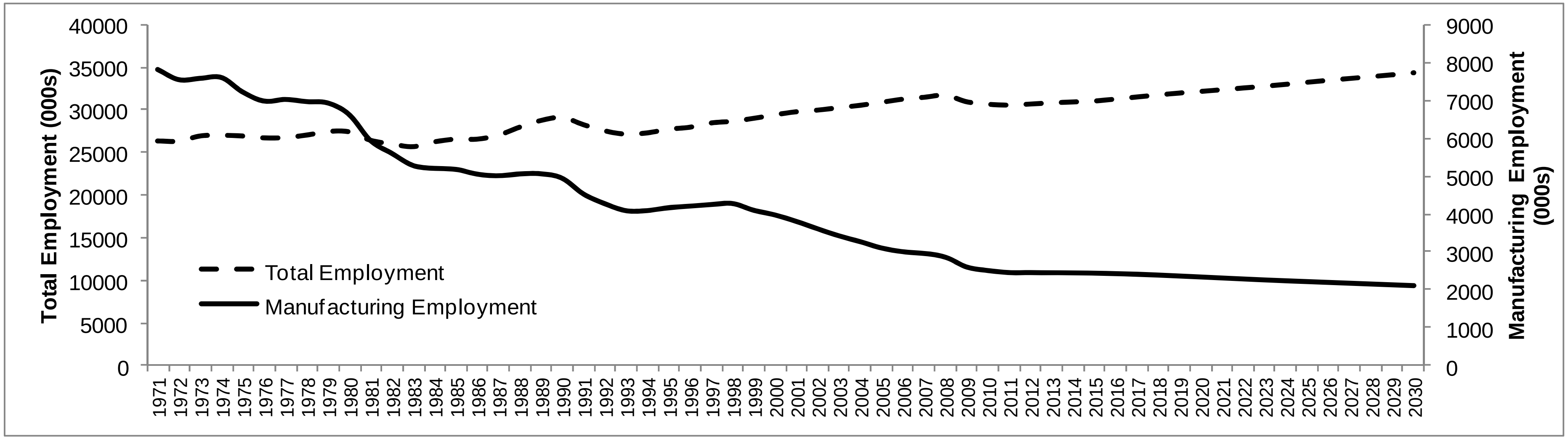
The cyclical nature of employment in manufacturing has implications for skill demand. Blake *et al*. (2000) in their analysis of skill shortages over the 1960s and 1970s revealed that redundancies during recession resulted in employers losing skilled personnel which they then struggled to recruit during the recovery phase. This occurred in part because employees were unwilling to return to an employer or industry in which they had lost their jobs – especially so when job opportunities were emerging in the service sector – and due to the signal it sent to would-be apprentices and trainees about long-term job security in industries such as manufacturing. Consequently, growth was constrained and skill shortages contributed to future slowdowns.

Figure 2.1: Output and Employment in Manufacturing: historical and projected trends 1970 to 2030



Source: Cambridge Econometrics MDM

Figure 2.2: Employment in Manufacturing and the Overall Economy: historical and projected trends 1970 to 2030



Source: Cambridge Econometrics MDM

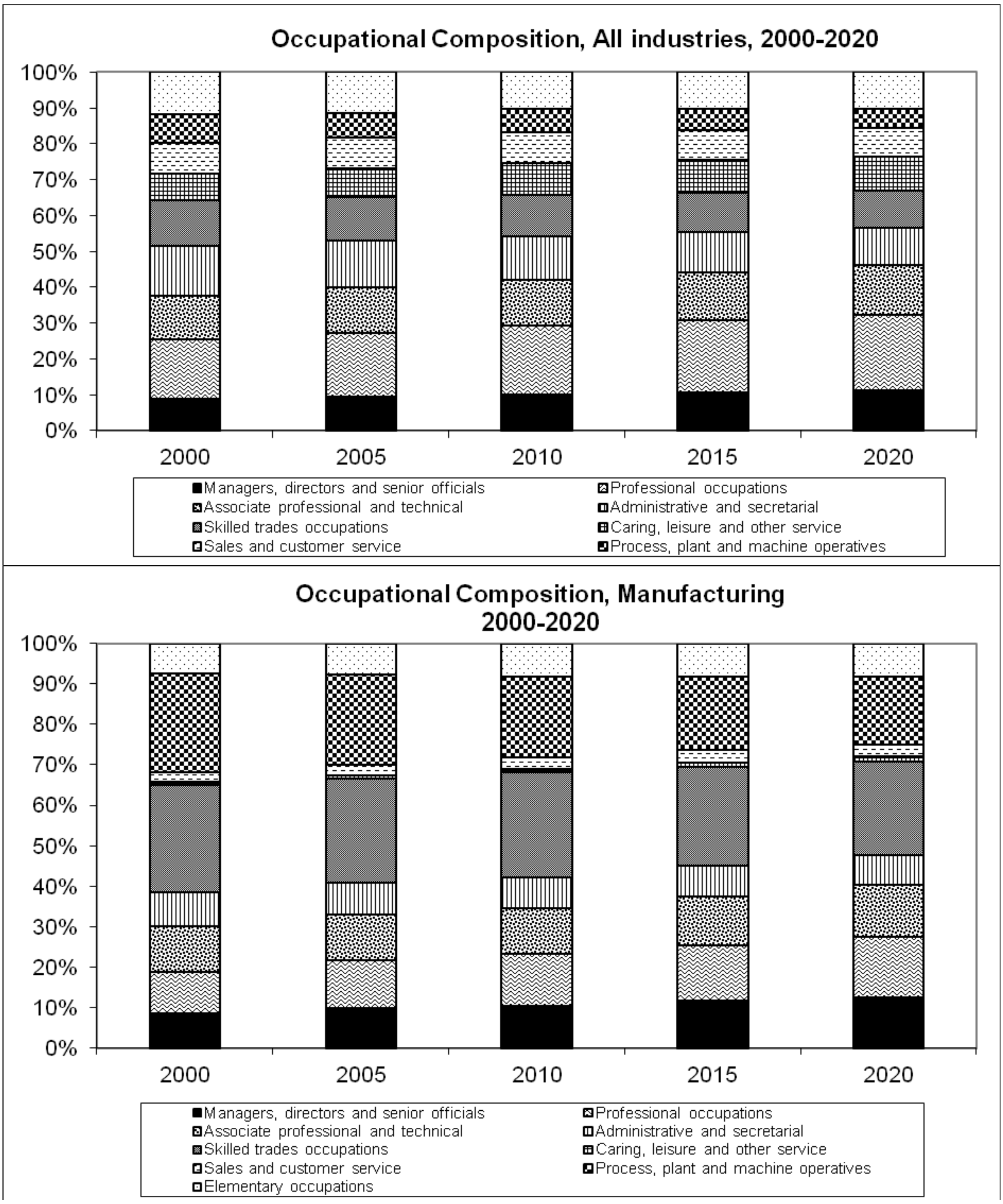
2.4 Working futures projections of skill demand

Section 2.2 summarised the factors which are driving changes in the demand for skills. These factors will result in manufacturing, by 2020, becoming increasingly highly skilled with an increased dependence upon people employed in managerial, professional, and associate professional roles (higher level occupations), with a fall in the number of people employed in skilled trades jobs (those to which entry has been traditionally been through an Apprenticeship) and those in process, plant and machinery operative jobs and elementary occupations (see Figure 2.3). The manufacturing sector is not unique in this development with a similar pattern of change being observed across all sectors: that is, an increase in the percentage of people working in higher level occupations (those in managerial, professional, and associate professional jobs). The sector will, however, continue employ a relatively large number of people in skilled trades occupations (that is, intermediate level skilled jobs).

Table 2.1 presents more detail about projected skill change over the period to 2020. It also includes information about replacement demands. Although employment is projected to decline in several occupations and the industry overall, there will also be retirements such that people need to be replaced. Taking replacement demands into consideration, even though the industry is in employment decline, reveals that for most occupations there will be a significant additional demand for labour. So, for example, by 2020 the number of skill trades jobs is projected to fall by 118,000 but replacement demands are likely to be around 245,000 such that there will be 136,000 new job openings which will need filling. This is principally due to the number of people who are expected to retire from the industry in the period to 2020.

It is apparent from Table 2.3 that the key challenge facing the industry is being able to attract relatively skilled people – or those with the potential to become highly skilled – to work in an industry which is projected to show employment decline. This can be formidable challenge where other industries are projected to show overall employment growth and thereby signal a more confident message about future job security.

Figure 2.3: Occupational Change in the Overall Economy and Manufacturing, 2000 - 2020



Source: Working Futures

Table 2.1: Employment and Replacement Demands by Occupation, 2000 - 2020

(000s)	2000	2010	2020	Change 2010 2020		
				Net Change	Replacement Demands	Total Requirement
1. Managers, *etc.*	337	267	297	30	111	141
2. Professionals	432	319	349	30	113	143
3. Associate professionals	462	288	305	17	104	121
4. Administrative and secretarial	416	191	173	-19	85	66
5. Skilled trades occupations	1437	651	543	-108	245	136
6. Caring , leisure and other service	30	20	25	5	8	13
7. Sales and customer service	100	76	74	-3	25	22
8. Process, plant and machine operatives	1338	503	389	-114	199	85
9. Elementary occupations	393	202	193	-9	75	66
Total	4944	2518	2347	-170	965	795

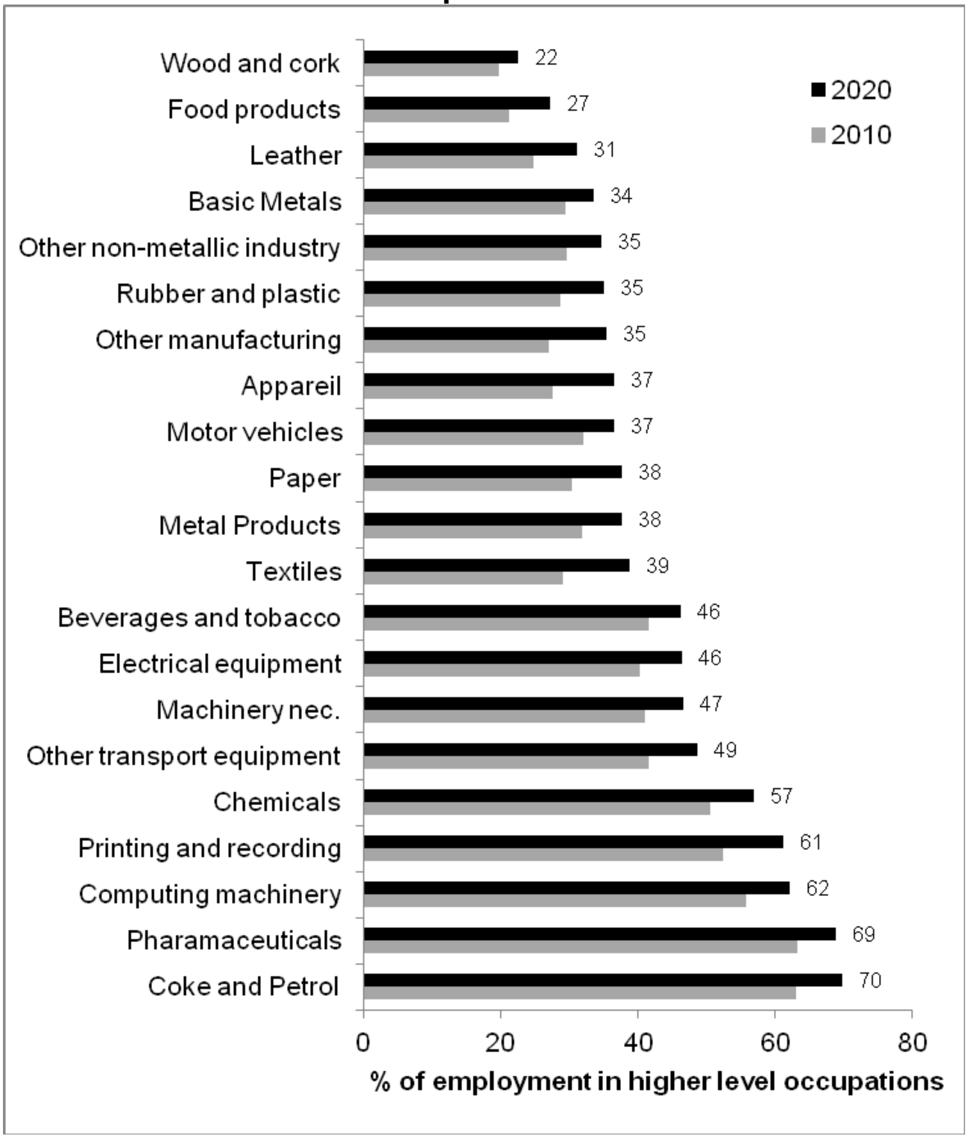
Percentage shares				Percentage Change 2010 2020		
				Net Change	Replacement Demands	Total Requirement
1. Managers, *etc.*	7	11	13	11	42	53
2. Professionals	9	13	15	9	35	45
3. Associate professionals	9	11	13	6	36	42
4. Administrative and secretarial	8	8	7	-10	45	35
5. Skilled trades occupations	29	26	23	-17	38	21
6. Caring, leisure and other service	1	1	1	23	41	64
7. Sales and customer service	2	3	3	-4	33	29
8. Process, plant and machine operatives	27	20	17	-23	40	17
9. Elementary occupations	8	8	8	-4	37	33
Total	100	100	100	-7	38	32

Source: Working Futures

2.5 A more disaggregated view of skill change

There is a tendency to see the future of the manufacturing sector as a high technology, high skill one when, in reality, manufacturing in the UK comprises a wide range of different activities the skill needs of which vary substantially. Figure 2.4 shows the percentage of people employed in higher level occupations across a range of manufacturing sub-sectors. It ranges from around a quarter in sectors such as wood, food, and leather products, but rises to around two thirds in process sectors such as chemicals and pharmaceuticals and in the computing machinery sector.

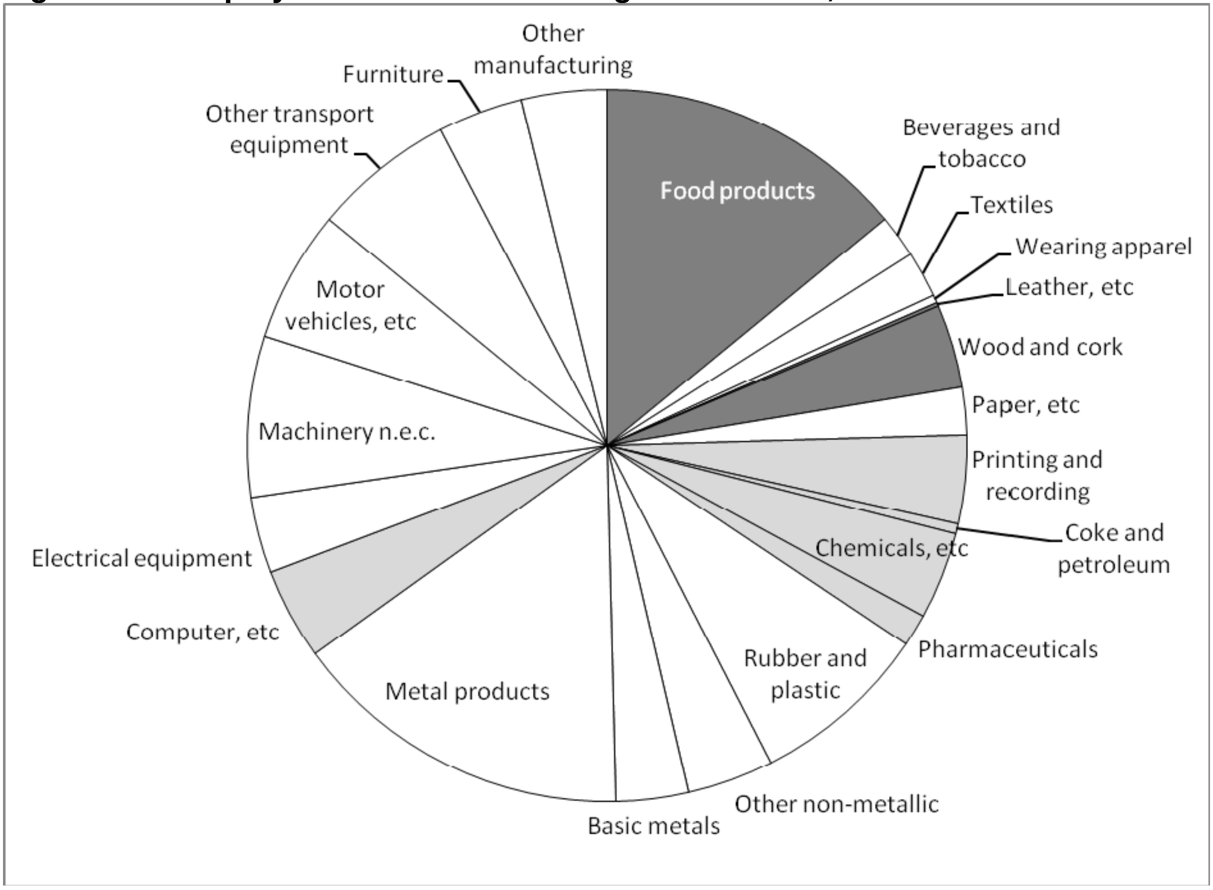
Figure 2.4: Percentage of people employed in Managerial, Professional, and Associate Professional Occupations in 2010 and 2020



Source: Working Futures

Figure 2.5 indicates that overall around 15 per cent of manufacturing employment is concentrated in those sub-sectors where more than 50 per cent of the workforce is employed in higher level occupations (shaded in light grey in the chart). Conversely, there is a substantial share of employment in sub-sectors where relatively small shares of the workforce are employed in higher level occupations (shaded dark grey in the chart). The skill structure of the sector does not necessarily reflect the relative technological advancement of different sub-sectors. The food processing industry, whilst producing relatively less complex products, often uses sophisticated production technologies in its manufacturing process. A key issue is the extent to which these will become increasingly automated over the longer-term such that the skill structure in the sector comes to match in other parts of the industry.

Figure 2.5: Employment in Manufacturing Sub-sectors, 2010



Source: Working Futures

2.6 International comparisons

Across Europe as a whole employment in manufacturing has declined over the past and is projected to do so over the medium-term (see Figure 2.6). The Cedefop projections of skill demand suggest that employment decline between 2010 and 2020 will be around 3 per cent, compared with 6 per cent in GB.[4] Rather than provide a comparison with every European country the analysis is limited to that of Germany and Switzerland. Both have relatively strong manufacturing sectors: Germany with its strong machine tools and car manufacturing sub-sectors; and Switzerland with its instrument engineering sub-sector. In both these countries the manufacturing sector accounts for a relatively high share of overall employment – 20 per cent in Germany and 14 per cent in Switzerland compared with 10 per cent in the UK – and both show lower rates of employment decline in their respective manufacturing industries. In Switzerland, for instance, there is projected to be a slight increase in manufacturing employment.
If the occupational structures are compared it is immediately apparent that the UK is characterised by a higher percentage of people in higher level occupations, and in

[4] The Cedefop projections are for GB and not the UK.

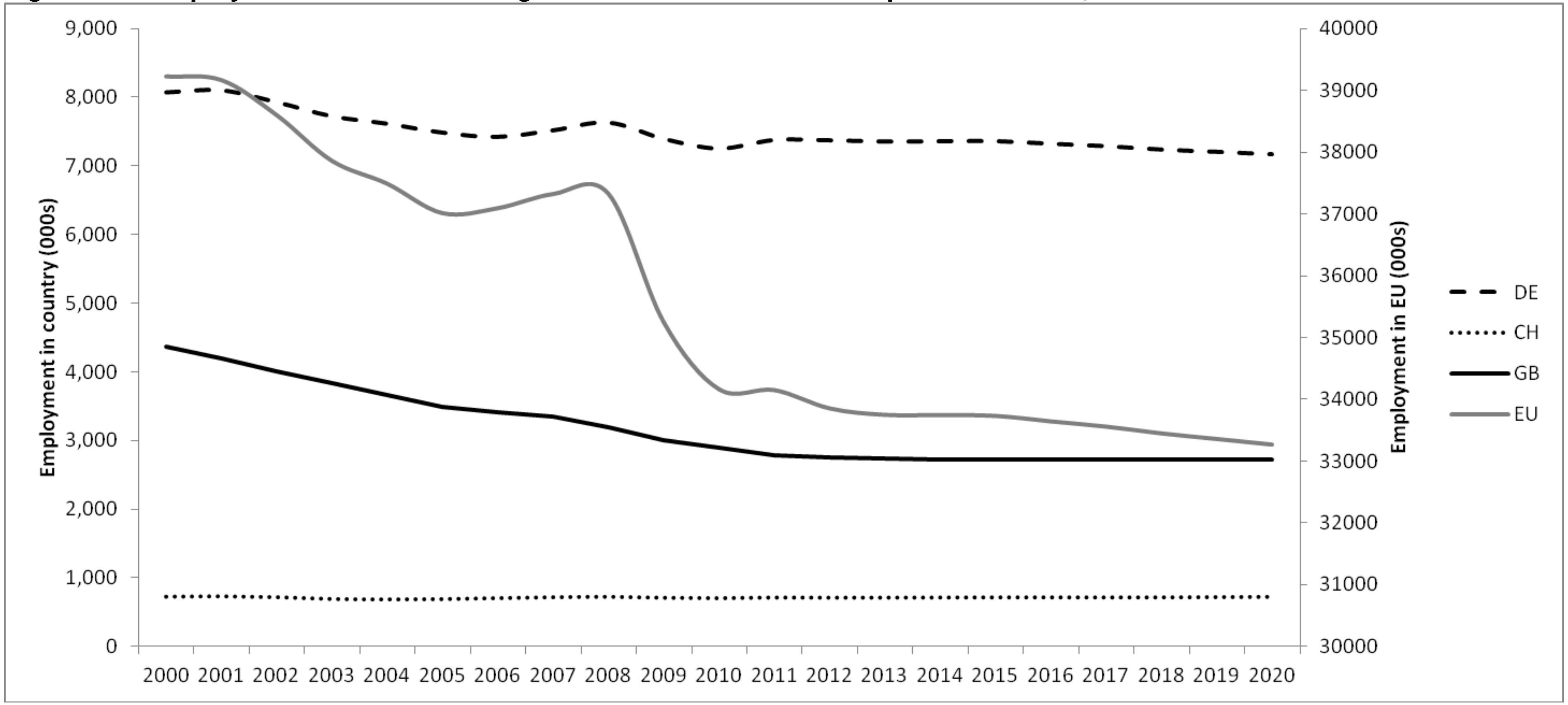
Switzerland and Germany a higher percentage employed in skilled trade occupations (see Table 2.2). Mason (2002) has drawn attention to the fact that in countries such as the UK and USA there is more activity which requires large production runs such that there is less demand for people trained at an intermediate level who might operate in the role of a supervisor or foreman. In contrast, in countries such as Germany workplaces are often engaged more in batch production which requires a cadre of intermediate skilled employees who can, for example, regularly change settings / tools on production systems. This is also allied to the production of relatively high value products, produced more efficiently, than is the case in the UK. In the future, however, production in the UK may well become increasingly smaller-scale, engaged in the production of relatively complex products. Accordingly, there is likely to be an increased demand for people in technician roles – an occupation which overlaps both associate professional and skilled trades occupations in the projections of future skill demand presented above.

2.7 Conclusion

The evidence on the future demand for skills in manufacturing suggests that over the period to 2020 more people, proportionately, will be employed in jobs where typically a degree is required to gain entry (c.f. the proportionate increase in the number of people employed in higher level occupations). These jobs are likely to require in many instances people qualified in STEM subjects. At the same time, there will continue to be relatively strong demand for people employed in skilled trades and operative occupations given the level of replacement demands. In particular, there will be strong replacement demands for skilled trades workers which may well be at a technician level.

Over the longer-term – stretching to 2050 – one can speculate about future skill demand. On the one hand, in various manufacturing sub-sectors, the competitive advantage of the UK will rest in product design and development and, allied to this, the production of prototypes and low volume, high value products. This is already apparent in sub-sectors such as, for example, pharmaceuticals, aerospace, and plastics. The demand here will be increasingly for people to work in professional and associate professional occupations, though there will remain a strong demand for people to work in skilled trades occupations – especially in technician roles - needed to engage in small-scale batch manufacture and routine maintenance.

Figure 2.6: Employment in Manufacturing Industries in Selected European Countries, 2000 to 2020



Source: Cedefop Occupational Forecasts

Table 2.2: Occupational Structure of Manufacturing Industries in Selected European Countries, 2000, 2010, and 2020

	EU-27			Switzerland			Germany			Great Britain		
	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020
Legislators, senior officials and managers	7	7	8	2	2	2	5	6	6	16	20	21
Professionals	6	9	12	14	16	19	8	10	13	8	11	12
Technicians and associate professionals	11	14	15	14	16	17	14	15	15	8	9	11
All higher level occupations	*25*	*30*	*35*	*30*	*35*	*38*	*27*	*31*	*35*	*32*	*40*	*44*
Clerks	8	8	7	13	8	6	10	11	11	10	8	6
Service workers and shop and market sales workers	2	2	3	3	4	5	3	4	5	1	1	2
Skilled agricultural and fishery workers	0	0	0	1	1	1	0	0	0	0	0	0
Craft and related trades workers	33	30	25	37	35	31	36	31	27	24	20	17
Plant and machine operators and assemblers	23	22	22	13	12	12	15	14	14	24	21	19
Elementary occupations	8	8	8	3	5	6	8	9	9	9	10	12
Total	100	100	100	100	100	100	100	100	100	100	100	100
Base (000s)	39230	34167	33271	729	702	727	8070	7249	7166	4366	2897	2715

Source: Cedefop Occupational Forecasts

On the other hand, there are lower-value sectors such as food processing where larger manufacturers utilise sophisticated production technologies which are, currently, dependent upon people employed in higher level occupations and operatives who work on production lines. It is likely that in this sub-sector of the industry, increased automation will reduce and proportionately, the number of operatives needed. There are, however, a relatively large number of employers – many of them SMEs - operating in relatively low value sectors of the market which are dependent upon labour intensive production processes. It is likely that unless the cost of automated production processes falls considerably they will remain dependent upon labour intensive production processes with a strong demand for people to work as operatives.

3. Emerging skill needs over the longer term

3.1 Introduction

The previous chapter, based on Working Futures, provided a quantitative overview of how skill needs are likely to develop over the medium-term. This chapter uses a wider variety of evidence to indicate how skill needs are likely to develop paying particular attention to the types of skill demands which are likely to arise. The manufacturing plant of the future is likely to be much more engaged in R&D, design, production of prototypes and small-scale manufacture of complex high-value added goods. Whilst UK employers may be engaged in mass production, it is likely that that part of the production process will have been increasingly transferred to lower labour cost countries. This is essentially a continuation of the trends which have been observed over the recent past. It is also likely that the employer will be operating in networks of organisations, which are spread out across the world, who are engaged in different elements of the R&D, design, and production processes. The manufacturing sector of the future is also likely to be a dynamic environment where the pace of product and process innovation in critical sub-sectors is relatively fast which means that employers will need to adapt quickly to being able to successfully bring to market new products made possible by technological advances. This applies to the production of goods for both intermediate and final consumption. This all has implications for the types of skill required to (a) manage the process and (b) produce the next generation of high value-added goods. Critical to this process will be the acquisition and utilisation of STEM skills.

In summary, it is likely that manufacturing output will be increasingly concentrated in those parts of the sector which correspond with advanced manufacturing. As noted in the earlier chapter, advanced manufacturing is a dynamic concept since the pace of change is sometimes so fast in key parts of the manufacturing sector that what was considered advanced a few years ago is no longer considered as such. This raises issues in itself about the capacity of employers to manage the process of change.

3.2 Product market strategies, the product lifecycle and skills

The longer-term skill needs of the manufacturing sector will be determined by the capacity of:

1. UK employers being able to develop or maintain the high-value product market strategies which will allow them to capture a significant share of high value-added markets and manage the process of change which will allow them to maintain a leading position in those markets;
2. the UK being selected as a location where employers with high value-added product market strategies want to develop their businesses. This relates to a wide range of factors which persuade employers to base their activities in country *x* rather than *y* – most of which are outside the scope of this paper – but skills supply is one key factor.

There is an important caveat to the above synopsis. There remain segments of manufacturing industry which have been less sensitive to the globalisation process than others. There are manufacturing sectors which, for one reason or another, tend to be located near to their main markets. Mason (2005) has pointed out that those manufacturing firms which are dependent principally upon local and regional markets tend to operate in lower value-added markets and are less subject to competition from imports. Other evidence suggests that their position is sometimes precarious, with their markets ultimately being susceptible to takeover by lower cost producers (Wilson and Hogarth, 2003). The productivity gains they require to keep their businesses strong are sometimes inhibited by both a lack of capital to invest in new plant, machinery and equipment, and the skills which would allow them to capitalise upon any investments.

If manufacturing activity becomes increasingly concentrated in the design of products, the production of prototypes, and manufacture on a batch-scale, then there is a need to recognise the skills needs which arise in relation to the product lifecycle. In their review of the product lifecycle in manufacturing, Davis *et al*. (2002) outlined how many products have a tendency to migrate towards being commodities over time (see Table 3.1). The example provided by Davis to indicate the pace with which products could migrate from one product market position to another was mobile phones. Over the course of a few years went from being expensive items (super-value goods) to must-have commodities (though still technically complex products).

Table 3.1: Product lifecycles

		Product complexity	
Market Demand	Uncertain	**Super-value goods** (e.g. aerospace)	**Fashion products** (requiring fast response to capture market)
	Certain – predictable	**Consumer durables** (e.g. cars)	**Commodities**

Source: Davis *et al.* (2002)

Davis *et al.* explained how skill needs at all levels of the organisation changed as products shifted their position over the lifecycle – from the emphasis upon design and development and small-volume production of super-value goods (such as aeroplanes) to the need to be able to manage mass production systems in the case of commodities (see Table 3.2). Manufacturers may choose to remain with a given product, in which case they need to adapt their production processes and deployment of skills as it changes its product market position, or look to develop the next range of higher value-added products.

Table 3.2: Product lifecycles and skill needs

		Product complexity	
Market Demand	Uncertain	Project management Research & development Product design skills Craft production skills	Marketing Logistics Craft production skills
	Certain – predictable	Team working Manufacturing system design Cell manufacturing	Cost control Manufacturing system design Plant maintenance Logistics Operatives

Source: Davis *et al*. (2002)

The fast pace of change and the development of new vintages of product also created its own skill demands. This tends to create a demand for agility within the workplace to:

- adapt to the changing product market position of any good (for example, the capacity to develop systems which can accommodate mass production if a product shifts to becoming a commodity including transferring production abroad);
- to develop the next range of products to replace those which in becoming commodities become reduced in value.

These are often formidable challenges for an employer to manage but one view of the future of manufacturing suggests that employers will increasingly need to acquire the skills which will allow them to become agile. This relates in many respects to the quality of management skills and, in particular, the ability to be able to read a market.

3.2 Emerging skill needs and occupational profiles

Given the future direction of manufacturing it is possible to identify emerging skill needs and changing occupational profiles. The previous section indicates that one of the principal skill needs relates to that of management being able to manage change as products move through their lifecycle. The other particular skill sets and occupational profiles which are prominent in the research literature relate to the demand for:

1. STEM skills at intermediate and higher levels which are increasingly required in a manufacturing environment which is engaged more in R&D, design, manufacturing of prototypes and small-scale production runs of complex products;
2. hybrid skills which relate to (a) workers possessing knowledge of different vintages of a product or technology and (b) workers possessing a combination of technical competence and a range of generic skills in order to make the production process run efficiently;
3. people able to both manage networks and supply chains which are often complex in character and spread across, in some instances, multiple organisations sometimes located in several different countries;
4. technician level skills where individuals are increasingly required to possess skills which lie between that of a professional engineer / technologist and a skilled trades worker.

Each of these are considered in turn below.

STEM Skills

STEM skills are seen as vitally important to the manufacturing sector given that many manufacturing firms require technologists, engineers and scientists to manage the production process, design new production systems, and design new products. Research suggests that employers which are intensive in their use of people qualified in STEM skills are relatively productive and more likely to be engaged in exporting (UKCES, 2011). It is estimated that around 3.9 million people are employed in STEM occupations of which 2.4 million are in graduate level jobs.

Wilson (2009) estimates that around 15 per cent of the workforce in manufacturing is qualified at degree level or equivalent (at NQF 4 and 5 combined). Around two thirds of this group are qualified at NQF4 and these are evenly split between those qualified in

STEM subjects and other subjects. Projections of future skill demand suggest substantial growth amongst those qualified at NQF 4 (equivalent to first degree level). Table 3.3 provides an indication of the scale of demand required over the period 2007 – 2017 including an indication of the total requirement taking into account that people will have retired or left the industry for one reason or another and will need replacing.

The data indicates that over a ten year period the industry will need around a half a million more people with around 300,000 at NQF levels 4 and 5. Table 3.4 provides an indication of the STEM qualifications which the manufacturing sector will require. Overall it suggests that of the quarter of a million more people required at NQF 4 by 2017, around half will need to be qualified in the specific STEM subjects included in Table 3.3. So overall, around 20 per cent of the future total requirement for employment in manufacturing will be made of people qualified in biological, physical, mathematical, and engineering subjects. If this were applied to the total future requirement projected to 2020 this would suggest that an additional 160,000 people will be needed who are qualified in these subjects.

Table 3.3: Projected Future Demand by Qualifications in Manufacturing, 2007 - 2017

	2007 % share	2007-2017	2017 % share	Total Requirement 2007 - 2017 (000s)
NQF 5	4	3	5	50
NQF 4	20	8	25	268
NQF 3	22	-25	19	66
NQF 2	23	-23	21	85
NQF 1	20	-11	22	148
NQF 0	11	-23	10	41
Total	100	-14	100	660

Source: Wilson (2009)

Table 3.4: Projected future demand for people with Selected NQF 4 STEM Qualifications in Manufacturing, 2007 - 2017

	2007 (000s)	2017 (000s)	Total requirement 2007 – 2017 (000s)
Biological Sciences	33	49	28
Physical sciences	34	43	21
Mathematics and computing	30	54	34
Engineering	73	80	32
Technology	12	20	12

Source: Wilson (2009)

Whilst the projections in Tables 3.3 and 3.4 were conducted at a time when growth in the economy was still relatively strong, over the longer-term there is every reason to regard the projections as providing a robust indication of the future direction of change. This would suggest, given the nature of changes in the demand for labour in manufacturing, it is likely to be the case that the demand for people with STEM skills will increase. Whilst manufacturing was once the principal destination of people with STEM degrees, the data above indicates that their destinations are much more varied currently and this is likely to remain so principally because of the demand in many sectors to process large amounts of information relating to the operation of their production processes and their customer base. Given this situation, the projections of likely future demand for people with STEM skills suggests that demand will outstrip supply principally as a consequence of the increase in STEM graduates being gradual whereas the demand for STEM graduates has been much more substantial (Wilson, 2009).

Hybrid skills

With respect to managing products over the lifecycle and being able to flexibly shift to the development of the next generation of products, Hendry (2002) has drawn attention to the need for hybrid skills: where people within the organisation have knowledge of different vintages of products. This was first observed in the computer software sector where the rapid take-up of new programming languages required people to be skilled in using the latest languages but also in older languages in order to service older products (this was most pronounced in relation to Y2K where many of the older programmes which were thought to be in danger of crashing at the start of the new millennium had been programmed in Cobalt). In a sector where there is a relatively aged workforce this potentially poses problems over the longer-term unless organisations are able to retain knowledge within the organisation (c.f. the knowledge management factor – see Scarborough *et al*., 1999).

Hendry (2002) also drew attention for the need for people to have both technical competence and the capacity to utilise those skills in a commercial environment. This required people, for example, to have the ability to lead teams, work effectively in networks, and such like. This is of critical importance in the manufacturing sector. As SEMTA (2009) point out there is a need for people to have ‘expertise beyond an adequate supply of technical skills’ if new inventions are to be turned into marketable products.

Skills related to working across networks

Manufacturing processes tend to spread across several organisations. The challenge is to manage the supply chain or collaborative working. There is evidence of manufacturers engaging in this type of activity and developing training networks which spread across the supply-chain (Brown, 2004). There is evidence from countries such as Belgium and the Netherlands of companies in a geographical cluster working closely together in collaborative networks to develop, amongst other things, a collective approach to skills development (Bosworth et al., 2011). Whilst managing supply-chain networks is well established in UK manufacturing there is evidence emerging that these networks are developing beyond a supply-chain relationships to work more collaboratively on new projects and new product innovations. More collaborative working has a skills dimension to it insofar as it requires people to work within different organisational contexts.

Working in networks imposes risks on all those engaged in them. But there are specific risks which attach themselves to SMEs. There is evidence that in some manufacturing sub-sectors of SMEs – especially new ventures – taking the risk associated with the development of new products and working with larger partners to further develop and market those products. This has been observed in pharmaceuticals for example where smaller firms often take the lead in the initial development of a new medicine before

working in partnership with a larger partner, perhaps even being taken over eventually if the new product proves successful (Davis et al., 2012).
This means that SMEs need to be able to:

- ensure that they are able to recover their investments in a new product or technology and that the expertise they develop can be transferred into new projects;
- possessing the managerial and communication skills to hold their own in working within a network especially where large partners are involved;
- being able to effectively market their expertise and products to a wide variety of potential networks including those overseas. By being able to develop language skills they are likely to be less dependent upon agents.

These are potentially formidable challenges for SMEs and their larger partners if, as is expected, the future of manufacturing is based around the development of SMEs.

Technician skills

If changes in the structure of global manufacturing result in activity in the UK being increasingly focused on the production of high value-added goods, then this potentially increases the demand for skilled trades workers operating as technicians often in a supervisory capacity. Smaller scale production tends to place more emphasis on supervisors and first line management to reset machine tools and make suitable amendment to work organisation. Mason’s research suggests that countries such as Germany with a mass Apprenticeship system tend to be relatively well placed to fill these types of job with suitably skilled people. For countries such as the UK, there would appear to be more of a requirement to get higher education graduates to fill these jobs given the structure of the supply-side which has been, over recent years, increasingly skewed towards the production of graduates (Mason 2005, 2011).

In the past Apprenticeships provided an entry point for people to enter both skilled trades and professional / managerial occupations. Typically completion of an Apprenticeship in, for instance, an engineering discipline provided the base upon which individuals could further develop their skills and acquire further qualifications which would grant entry to being a professional engineer. During the Apprenticeship individuals would be singled out on the basis of their potential for promotion within the company. Those who took up engineering Apprenticeships in manufacturing were sometimes placed in to two groups: (a) those destined to work in skilled trades jobs (for example, as fitters, machine setters, *etc*.); and (b) those who were considered to have the potential to fill technician level jobs (that is, those jobs which sat between the professional engineers and the skilled trades workers, such as draughtsmen, production engineers, junior design engineers, and such like). Technician level jobs are usually defined as being associate professional jobs in occupational classifications. Based on evidence collected during the 1990s, Hogarth et al. (1996) reported how during the second year of the Apprenticeship, manufacturing employers would select those apprentices considered to have potential to become technicians. They would then undertake a separate programme of training from that of the other apprentices. The technicians’ training took longer to complete and often led to a higher level qualification. It was this group which would have the opportunity to progress into professional and managerial jobs within the workplace which had initially trained them.
As participation rates in higher education increased over the 1990s and 2000s, the evidence points to employers increasingly using graduates to fill the associate

professional jobs which had been traditionally filled by technicians graduating from Apprenticeship programmes (Jagger, *et al*., 2010; Mason, 2012). Whether these jobs when filled by university graduates had the same skill content as when filled by the technicians, or whether the university graduates were able to transform these jobs in to higher level ones, is a moot point. The case study evidence presented by Lewis (2012a, 2012b) suggests that some employers may have become dissatisfied with the performance of graduates in associate professional level jobs because the training they had received at university lacked the combination of theory and practice which Apprenticeships provided and which the employers found to be so beneficial to their businesses. Accordingly, employers were once again looking to Apprenticeships to provide them with the technicians who could fill the types of occupations which fell between skilled trades and professional engineers.

Both Mason (2012) and Jagger *et al*. (2010) demonstrate that those employed in skilled trades and associate professional jobs are relatively old - often in their mid 50s – with the result that many employers are currently, or will be shortly, faced with a pressing need to replace those who are close to retirement. In aggregate, employers cannot resort to the external labour market to recruit experienced skilled trades workers or associate professional staff since the pool from which they are likely to be recruiting has been getting older and smaller as people retire. The alternative is for employers to provide initial vocational education and training either through Apprenticeships or graduate traineeships. With increases in university tuition fees there is a degree of uncertainty attached to the future supply of graduates from higher education. It should be noted that manufacturing employers, in any case, are able to recruit only around a quarter of those graduating in STEM subjects (SEMTA, 2009). Apprenticeships which provide the apprentice with the opportunity to earn whilst learning may become an increasingly attractive option to young people - especially where there is the potential to progress on to Higher Apprenticeships - who might have otherwise been tempted to enrol at a university (Mason, 2012; Hogarth *et al*., 2012). Accordingly, employers may well increasingly look to Apprenticeships to meet their demand for skills at the technician / associate professional level if the supply of university graduates begins to dwindle.

3.4 Emerging skill needs within advanced manufacturing sub-sectors

The discussion so far has been about the demand for skills in a generic sense. It is important to consider the specific types of skills which will be needed. SEMTA (2009) identified several advanced manufacturing sub-sectors / technologies which they considered to be of critical importance to the future of the manufacturing sector in the UK. These were:

- Aerospace;
- Plastic / silicon electronics;
- Bio-medical / pharmaceuticals;
- Composites / new materials;
- Nanotechnologies.

Based on that report Table 3.5 below summarises the emerging skills with reference to occupational demand. It is apparent across all sub-sectors and technologies that there will be considerable pressures on management and professional scientists, engineers and technologists to turn breakthroughs in science and engineering into viable products,

and then to manage the process of shifting from prototyping to manufacturing in greater volumes. In some respects this corresponds with the hybrid skills mentioned above (a combination of high technical competence allied to commercial competence).
It is also apparent that at both the development stage and in the process of moving from prototyping to greater volume production, managers, professional scientists, and engineers are working in teams – often multi-disciplinary teams – which are spread across multiple organisations sometimes located in different countries. This creates a demand for people to be able to manage these networks and work effectively in teams.

Table 3.5: Future skill demands in selected manufacturing sub-sectors and technologies

	Management Skills	Professional Skills	Technical Skills
Aerospace	Capacity to negotiate complex global markets	Mix of technical and business skills required to manage complex projects and international supply chains involved in design and R&D	Engineering (electrical and mechanical) / software (modelling and simulation); knowledge of advanced materials
Plastic and silicon electronics	Ability to bring new products to market and manage the transition from producing prototypes to higher volume production		Testing, prototyping and being able to implement new designs. Skills related to using plastic electronics
Biotechnology / Pharmaceuticals	Management of new product development	Need for scientists capable of working across boundaries of biology / genetics / chemistry / chemical engineering *etc*.	Technicians capable of working with the new production systems required to produce biotechnology products
New materials / composites	Skills related to the commercialisation of new materials	Scientists and technologists are required to develop new composites applicable to sectors such as automotive, aerospace,	Technicians will need to acquire the skills required to work with new materials in their manufacture
Nanotechnology	As a new embryonic technology there is a need for managers and professionals (especially scientists) across the manufacturing sector to identify how nanotechnologies can be incorporated in to products and processes		Higher level skilled technicians will be required in relation to the handling and use of nanotechnologies.

Source: derived from information provided in SEMTA (2009)

3.5 Conclusion

This chapter has sought to indicate the principal types of skill which will be increasingly required by the manufacturing sector over the medium- to long-term. There are three broad, inter-related skill needs:

- management skills required to chart a sustainable product market strategy with the emphasis upon operating in the high value segment of the market;
- the professional skills required in R&D and product and process design; and
- the technical skills required to support employers maintain a high value added product market strategy. These will be demanded of managers, professionals, associate professionals and technicians, and skilled trade workers.

It is apparent that as manufacturing employers increasingly make use of emerging technologies such as biotechnology and nanotechnologies there are, to some extent, brand new skill needs arising. In some areas there are likely to be relatively few people within the global labour market who have the skills industry requires. This is especially true with respect to R&D. There are also likely that the existing workforce may need to acquire new skills as, for example, biotechnologies and nanotechnologies become increasing incorporated in to manufactured products. This potentially places a considerable pressure on the industry to develop the new skills it needs. Supply side issues are turned to in the next chapter.

4. Meeting skill demand

4.1 Introduction

The projections of future employment demand presented in the previous chapter are dependent upon the supply side keeping pace with demand. Since the 1970s at least, Government has sought to boost skills supply to all industries: first through the Manpower Service Commission's attempts to create vocational pathways through further education other than through Apprenticeship; and then, later, by increasing the percentage of young people entering higher education. The manufacturing industry has always been relatively more dependent upon the vocational education and training (VET) system to supply it with the skills it needs. Whether or not the VET system has been successful in doing so is a moot point, but it is clear in looking to the future that the sector will become increasingly skill intensive. Therefore the supply of skills has the capacity to be either a facilitator or inhibitor of growth and the development of high-skill, high-value segments of the industry.

For reasons of brevity the discussion is limited to initial vocational education and training (IVET) delivered in the further education (FE) and higher education (HE) sectors, along with the continuing vocational training and education (CVET) provided by employers, together with some insights into the role of migration as a source of skills supply.

4.2 Initial vocational education and training: apprenticeships

Historically Apprenticeship has been a principal point of entry for young people wanting to enter skilled employment in the manufacturing sector. Apprenticeship across much of the EU is regarded as conferring benefits on both the employer and the apprentices over and above that which is delivered through school-based vocational learning (Vogler-Ludwig *et al*., 2012; Beicht *et al*., 2004; Müehlemann *et al.,* 2007). As noted above, the manufacturing workforces in countries such as Germany and Switzerland comprise proportionately more people who would have been trained *via* their respective Apprenticeship / dual-training systems.

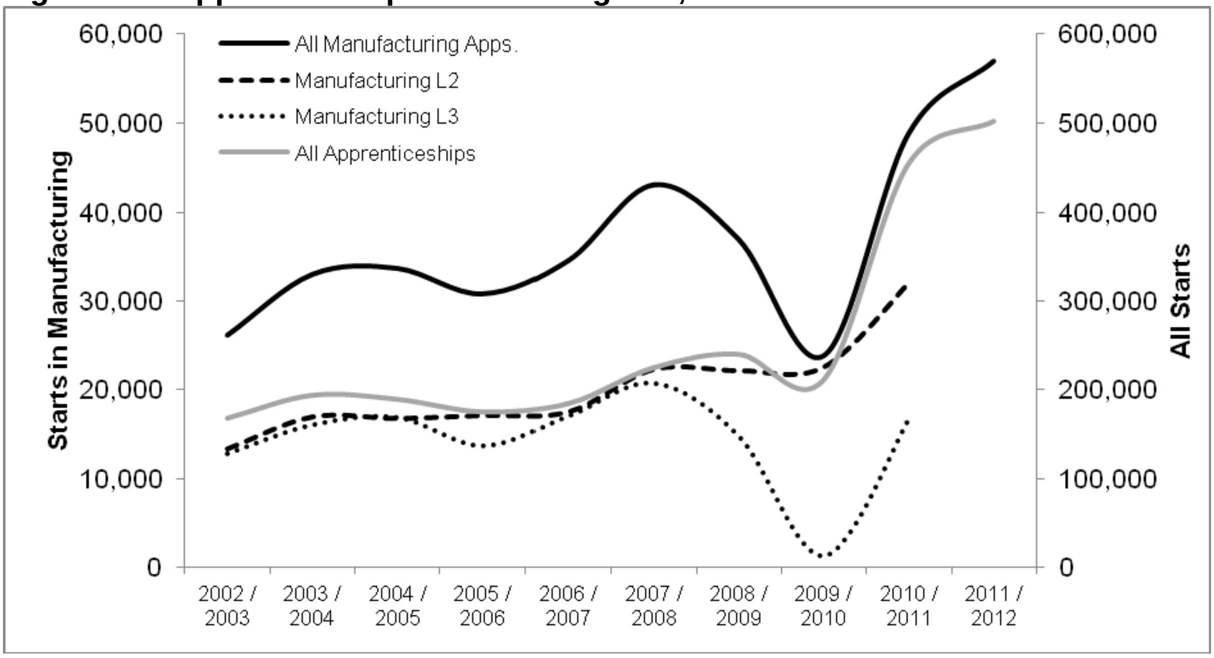
The evidence from the UK engineering sector indicates that employers recurrently invest in Apprenticeships because they see little alternative to doing so. Apprenticeships are seen as delivering the skills employers need and delivering to learners a rigorous, practical and theoretical understanding of the trade they have chosen to pursue (Hogarth *et al*., 2012). Apprenticeships would appear to deliver a win-win insofar as employers obtain the skills they need, and the apprentice obtains relatively good returns with respect to wages and being in employment (London Economics, 2011; Greenwood *et al*., 2011).

The problem is that participation levels in Apprenticeship are relatively modest in the economy overall and in the manufacturing sector. Across the economy as a whole, 4 per cent of employers provide Apprenticeships and 5 per cent of employers in manufacturing do so (Davies, *et al*, 2010). This is a problem which has long beset the manufacturing sector. The reason why the MSC promoted vocational alternatives to Apprenticeship in the 1970s was due to concerns over the low levels of participation in this form of training which was, at the time, concentrated in sectors such as engineering and construction

(Haxby, 1989). The problem endures with a relatively small share of the cohort leaving the compulsory school system each year entering into an Apprenticeship when compared to countries such as Germany (Steedman, 2011). Supporting this view the 2011 Employers Skills Survey revealed that manufacturing was one of the sectors where employers were less likely to take on young people straight from education: 19 percent of establishments in manufacturing having done so in the 12 months prior to the survey compared with 23 percent across all sectors.

Apprenticeship starts are sensitive to the economic cycle and Government attempts to boost their number (see Figure 4.1). Recent data suggests that though a large part of the recent growth in apprentices has been due to existing employees, often aged over 24 years, being trained via the programme rather than new recruits taken on exit from school or college, this is not true of the manufacturing sector. In manufacturing Apprenticeships at both Level 2 (L2) and Level 3 (L3) are delivered to young people entering the labour market for the first time (Winterbotham *et al*., 2012; Hogarth *et al*., 2012). They receive structured training over a two to four-year period involving a substantial amount of off-the-job training usually through block- or day-release to a local FE college. The problem remains, however, that participation rates are relatively low compared with other countries.

Figure 4.1: Apprenticeship Starts in England, 2002 - 2012



Source: Data Service Statistical First Releases March and October 2012

Other evidence which has looked more specifically at Apprenticeships in STEM subjects shows some increase in STEM Apprenticeship starts at Level 3 over recent years (Royal Academy of Engineering, 2012).

The key issue, given the aims of this paper, is what will happen to apprenticeship numbers in the future. The increase in university tuition fees may well increase the attractiveness of Apprenticeships to young people who, in previous years, might not have considered pursuing the form of IVET. Similarly, if there are fewer higher education graduates of a type manufacturing wants to recruit then they may be tempted to take on more apprentices as a substitute (Hogarth *et al*., 2011). As noted in the previous chapters some firms are looking to reinvigorate their technician training programmes which may well stimulate the demand for Apprenticeships from employers. It may also be the case, given changes in the higher education sector, that both employers and apprentices look to gain their Level 4 qualifications through Higher Apprenticeships rather than entering university. So over the medium there are signs that the demand for manufacturing / STEM related Apprenticeships might increase thereby increasing the supply of skilled personnel through this training pathway.

4.3 Initial vocational education and training: higher education

With regard to higher education the evidence reveals that there has been an increase over recent years in the number of students studying science, technology, engineering and mathematics (STEM). These are the subjects which are particularly in demand by manufacturing companies. Table 4.1 shows the change in the stock of full-time undergraduate students in 2011/12 and 2002/3 which shows that there has been a 9 per cent increase in the number of STEM students.

Table 4.1: Supply of people studying for a first degree in STEM subjects (000s)

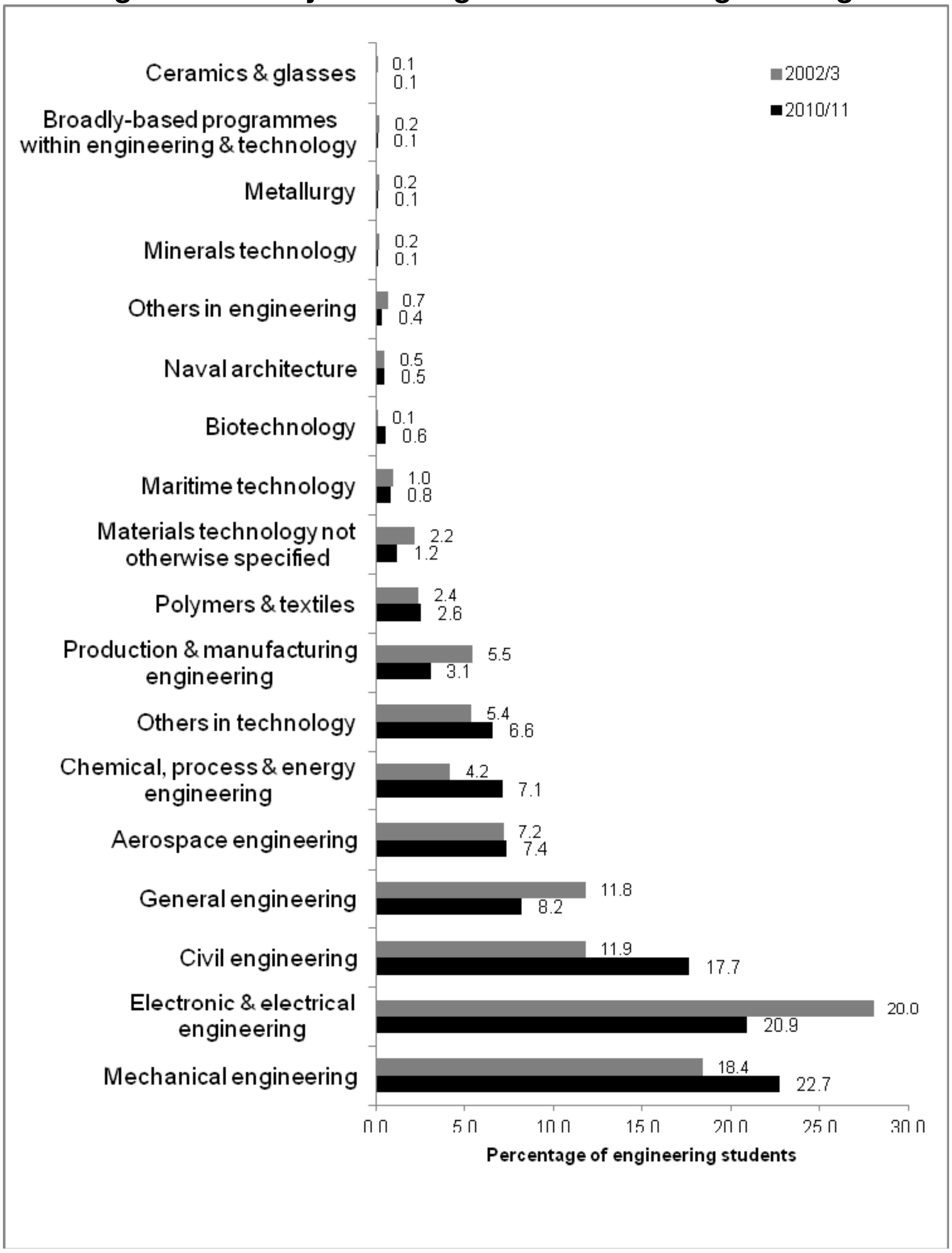
Current stock of students (000s) F/T Undergraduates	2011/12	2003/04	% change
Biology	123	92	34
Physical Sciences	58	48	23
Computer Science	56	86	-35
Mathematical Sciences	27	19	41
Engineering	86	77	11
All STEM	351	322	9

Source: HESA

Alongside the increase in the stock of students studying towards STEM degrees there has also been a change in the subjects being studied. Figure 4.2 shows the change in the subjects being studied which fall under the engineering and technology category. The principal findings from Figure 4.2 indicate that proportionately fewer people are studying towards obtaining electrical engineering degrees and more are now working towards mechanical and civil engineering degrees respectively. The latter degree is one which is likely to be of more relevance to construction than manufacturing and, importantly, this is the degree subject which accounts for much of the growth in the number of people working towards engineering degrees.

Overall the stock of people in the labour market with STEM degrees has increased over time: from 1.7 million in 1997, to 2.1 million in 2004, to 3.7 million in 2009 (DTI, 2006). In part, the growth in the number of STEM graduates has been supported by an increase in the number of school pupils studying STEM subjects at A-level. Still there remain concerns about whether the supply of people with higher level STEM qualifications will be sufficient to meet demand from the manufacturing sector given that people who are qualified in these subjects are much in demand in other sectors too (Purcell et al., 2007).

Figure 4.2: Change in the subjects being studied with Engineering and Technology



Source: HESA

Some of the new technologies which are being developed often require research scientists and engineers who are working at the cutting edge in the chosen discipline. Sometimes there are relatively few people who possess the skills required to develop new technologies. This is a potential supply side constraint on the development of technologies such as biotechnology and nanotechnology (SEMTA, 2009). It also points to the importance of collaborative relationships being developed with higher education institutions in order that the knowledge base in higher education is suitably exploited to the benefit of the economy. The Lambert Report indicated that there are sometimes barriers to effective university-business collaboration taking place, but in the future the development of new technologies and the capacity to take a lead in the development and commercial application of those technologies is likely to require more HE-business collaboration.

4.4 The employment destination of students and apprentices

Evidence about the employment destination of apprentices tends to be piecemeal, but the information available suggests that upon completion of their training, most apprentices working towards manufacturing and engineering Apprenticeships stay with the company which trained them (Hogarth *et al*., 2012; Winterbotham *et al*., 2012). The evidence indicates that a strong bond is developed between apprentices and their employers in many instances which ensures that the apprentices remain with the company which trained them.

In relation to higher education, HESA statistics indicate that around a quarter of engineering and technology graduates, six months after completing their degrees, are working in the manufacturing sector (see Table 4.2). Table 4.3 provides a summary of the evidence in Table 4.2 to show that engineering and technology graduates, and STEM graduates generally, have a high likelihood of working in distribution and financial and business services. These are all sectors which are likely to grow in employment over the medium-term. The implications of this are considered below.

People who study STEM subjects reveal a preference for working in areas which will make use of their STEM skills (Connor *et al*., 2011) and the evidence suggests that where they do so their wage levels are relatively high (Greenwood *et al*., 2011). Whilst once this would have resulted in many of them moving into manufacturing there are now jobs across a range of sectors which make use of the STEM skills. Therefore a critical issue for the manufacturing industry over the medium-term is for it to become the preferred destination for those who have the higher level STEM skills the industry needs. This is not just about wage levels, but the wider set of terms and conditions of work which allow people to derive satisfaction from their work, develop their careers, and balance their lives inside and outside of work (work-life balance). The industry will need to increasingly provide an employment offer which compares favourably with that in other sectors if it is to recruit the skills it needs and, in doing so, encourage a wider cross-section of the population to work in the industry.

Table 4.2: Employment Destinations of STEM Graduates (2010/11)

Sector of destination	All science - inc medicine (%)	ALL STEM (%)	Engineering (%)	All Graduates (%)
Agriculture, forestry and fishing	0	0	0	0
Mining and quarrying	1	1	3	0
Manufacturing	6	9	23	5
Electricity, gas and water supply	1	1	2	1
Construction	1	2	7	1
Wholesale and retail trade/repair(2)	14	17	14	17
Hotels and restaurants	5	7	4	7
Transport, storage and communication	7	11	10	7
Financial activities	4	6	3	5
Property development, renting, business and research activities	12	16	21	16
Public administration and defence/social security	3	4	4	4
Education	8	11	3	11
Health and social work	35	9	2	18
Other community, social and personal service activities	5	7	3	7
Private households with employed persons	0	0	0	0
International organisations and bodies	0	0	0	0
Not known	0	0	0	0
Total	100	100	100	100

Source: HESA Destinations Data SFR Table 4b

Table 4.3: Summary of Employment Destinations of STEM Graduates (2010/11)

Sector of destination	All science (inc medicine)	ALL STEM	Engineering	All Graduates
Primary	1	1	4	1
Manufacturing and utilities	7	10	25	5
Construction	1	2	7	1
Distribution, hospitality and transport	25	34	27	31
Financial and business services	16	22	24	22
Non-marketed services	47	26	8	36
Other	3	4	4	4
Total	100	100	100	100

Source: HESA Destinations Data SFR Table 4b

4.5 Continuing vocational education and training

Employers need to invest in the skills of their workforce simply to ensure that their skills are up to date. Moreover, with people expected to remain economically active until an older age, the skills they obtained in their initial training is unlikely to last them a lifetime. Employees who completed their Apprenticeships at, say, 21 years of age, are likely to need their skills updating over an expected fifty-year career (based on people retiring at 68 years). The industry itself is likely to be the principal means through which people in employment refresh their skills.

Data show that employees in manufacturing are less likely to report being in receipt of training than people in the labour market generally. 18 per cent of employees reported being in receipt of job related training compared with 25 per cent in the economy generally (see Table 4.4). The Employers Skills Survey revealed that 56 per cent of employers in the manufacturing sector reported providing their staff with training compared with 59 per cent in the economy generally. The amount of money expended on training per employee is relatively low at £1,425 in 2011 compared with £1,775 for the economy as a whole.

Table 4.4: Number of employees in receipt of work-related training over the past 13 weeks (2010)

	Manufacturing		Whole Economy	
Occupations (SOC Major Groups)	**Number**	**% of workforce**	**Number**	**% of workforce**
1 Managers and senior officials	108,563	19	1,008,425	23
2 Professional	95,312	28	1,588,563	39
3 Associate professional and technical	70,808	26	1,505,022	35
4 Administrative and secretarial	31,669	14	670,009	21
5 Skilled trades	94,578	15	476,943	16
6 Personal service	473	9	927,704	36
7 Sales and customer service	10,257	17	416,531	19
8 Process, plant and machine operatives	92,754	15	288,954	15
9 Elementary	30,325	11	470,477	14
All	534,739	18	7,352,628	25
Women	119,579	17	3,868,241	29
Men	415,160	18	3,484,387	23
People aged under 25	74,409	29	1,091,698	29

Source: LFS 2010Q4

The data indicates that whilst considered a relatively skilled industry the evidence reveals that at best, when it comes to training its own employees, manufacturing employers are less likely to provide training compared with the average of all employers across all sectors. This is potentially important since, in future, it is likely that employers will need to increasingly meet more of the costs of vocational education and training. Since the industry is likely to face substantial skill needs over the medium-term related to recruiting new employees and retraining existing employees, the supply of training provided by employers may be a constraint on future demands being met. Evidence suggests that the increasing use of new materials and new technologies in manufacturing processes will place a demand on the need for the skills of the existing workforce to be updated (SEMTA, 2009). If external training suppliers are not equipped to supply the skills required by these new technologies, then this place increasing pressures on employers to develop the skills in-house.

4.6 Migration as a source of skills supply

Migration is a potential source of labour for the advanced manufacturing sector. It is notable that the Ministerial Advisory Committee (MAC, 2011) advised that restrictions on entry to the UK should be relaxed in relation to a range of engineering skills such as those in aerospace. The evidence indicates that there are manufacturing sectors which are relatively dependent upon employees who were not born in the UK. Food manufacturing, for example, had the highest share of migrants in employment in 2010 – 34 per cent – followed by the manufacture of apparel at 31 per cent (The Migration Observatory, 2010). These are sectors which are relatively less well paid than other parts of the manufacturing industry which suggests that these sectors have sought migrant labour because of labour shortages rather than skill shortages.

In relation to some of the more highly skilled manufacturing sectors, the issue is less about the number of migrants and more about being able to attract people from abroad with the critical, cutting edge scientific and engineering skills the sector requires to develop new products and processes. The key issue here is being able to attract people with skills which are relatively scarce in the global labour market to work in the UK.

4.7 Skills Supply: International Comparisons

New growth theory suggests that countries increasingly compete on the basis of their human capital stock. Accordingly there is considerable interest in comparing the educational attainment of the labour force in different countries. By way of context Table 4.5 shows how levels of educational attainment vary across both developed and emerging economies.

A number of points emerge from Table 4.5:

1. the emerging economies such as China, Brazil, Argentina have relatively large shares of their workforces who are qualified at a low level (though both South American counties have relatively high shares at qualified at upper secondary level), So these countries still have some way to travel before the quality of their human capital catches up with that of western economies, though levels of educational attainment in these countries are increasing;
2. more developed economies have relatively high shares qualified at tertiary levels;
3. Switzerland and Germany stand out in having relatively high shares of people whose highest level of qualification is a vocational one at upper secondary level (reflecting the large percentage of people who enter the dual system).

But the discussion is not just about the levels of educational attainment. Increasingly attention has been focussed on the extent to which national education systems can deliver the skills in demand from the labour market – especially STEM skills – and have mechanisms in place which allow the vocational education and training system at both upper secondary and tertiary levels respond to changing labour demand.

Table 4.5: Educational attainment: Adult population (2010)

	Pre-primary and primary education	Lower secondary education		Upper secondary education		Post-secondary non-tertiary education	Tertiary education			All levels of education
			Short courses	Vocational	Academic		Vocational	Academic	Advanced research programmes	
OECD										
France	11	18		30	11		12	17	1	100
Germany	3	11		49	3	8	10	16	1	100
Ireland	11	15			24	12	16	21	1	100
Italy	12	33	1	7	32	1	n	14		100
Japan					55		19	25		100
Korea	9	11		20	21		12	24	3	100
Mexico	42	22		6	13		1	16		100
Netherlands	8	19		15	23	3	3	29	1	100
Poland		11		31	31	4		23		100
Spain	19	28		8	14		9	21	1	100
Switzerland	3	9		40	5	6	11	21	3	100
Turkey	58	11		8	10			13		100
United Kingdom		**11**	**14**	**30**	**7**		**10**	**27**	**1**	**100**
United States	4	7			47		10	30	1	100

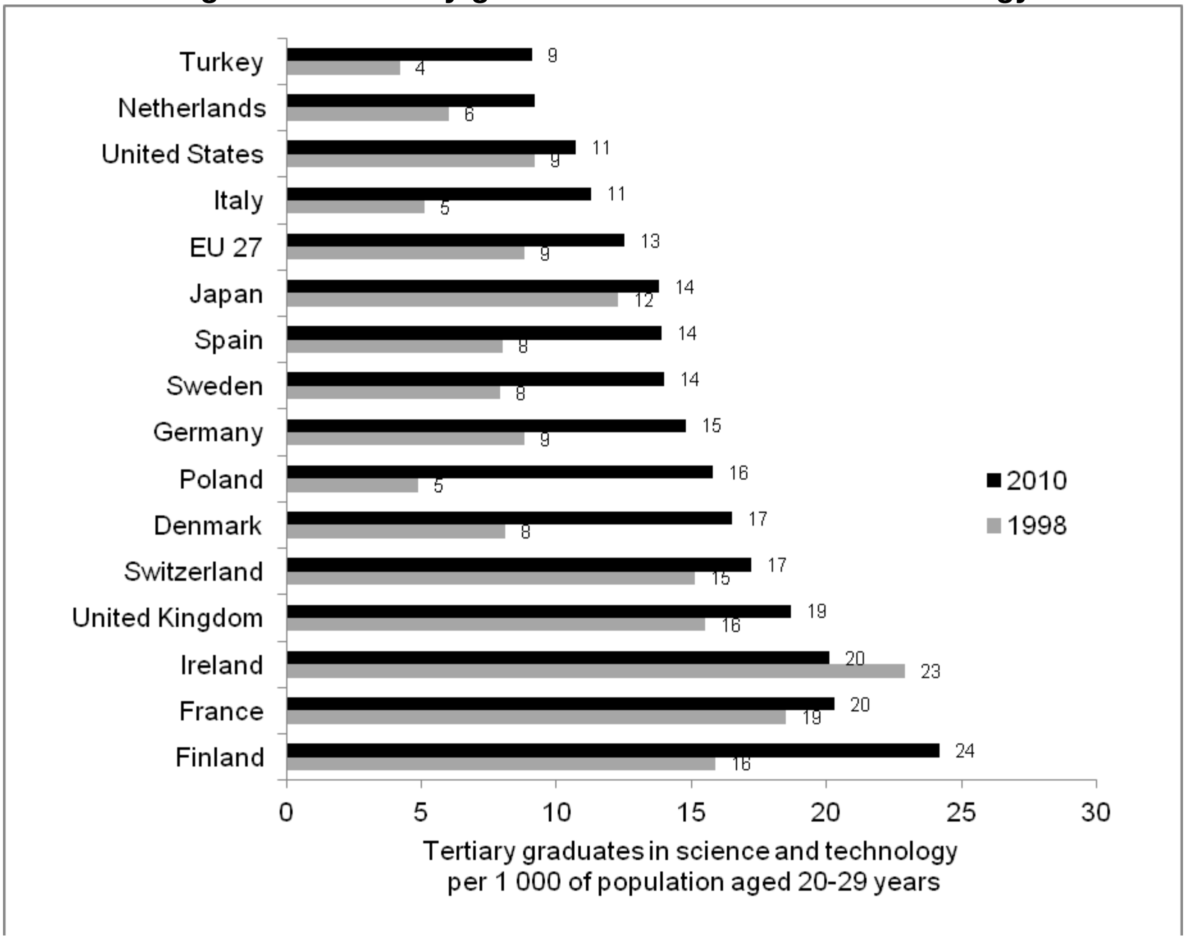
Source: OECD Education at a Glance Table 1A

	Below upper secondary education			Upper secondary level of education			Tertiary level of education			
OECD average		26			44			30		
EU21 average		25			48			28		
Argentina	44	14		28				14		100
Brazil	45	14			30			11		100
China	42	40		3	10		3	1		100
Indonesia	61	15		19				5		100
Russian Federation	3	8		16	18		34	20		100
G20 average		41			33			26		

Table 4.5 (continued): Educational attainment: Adult population (2010)
Source: OECD Education at a Glance Table 1A

Figure 4.3 provides a comparison of the extent to which people are qualified in STEM skills and reveals that in many countries this has doubled over the past ten years or so. It is also apparent that the UK stands out relatively strongly in this regard. The World Bank has pointed out that in many of the emerging economies in East Asia there are relatively small proportions of people working towards STEM qualifications in either upper secondary or tertiary levels and this is a potential constraint of their economic growth (World Bank, 2012).

Figure 4.3: Tertiary graduates in science and technology



Source: OECD

It is further apparent that many countries are in a process of reviewing and reforming the way in which their education and training systems are able to articulate employer demand. A number of features are apparent from a review of selected countries:

Germany and Switzerland at least at the upper secondary level in relation to the dual system have developed a high degree of consensus between all social partners regarding the operation and content of that system. Employers are generally of the view that they have a high degree of ownership of the vocational education and training system and recognise the high value attached to individuals spending time in the workplace and in the classroom whilst training.

In Japan there is less tradition of engaging employers in the education and training system. Historically, in the context of the lifelong employment relationship between employees and their employers, much training was carried out within the company. This now changing with the emergence of vocational colleges (senmon gakka) which aim to directly meet skill needs in the labour market and which have been relatively more successful in getting people into work compared with those who choose to go onto university. The Government is also ensuring that universities and employers collaborate more in the innovation process through its Basic Technology Plans.

Similarly, in Korea the Government is trying to ensure that the education and training system is more responsive to the needs of the labour market. Employers complain that university graduates have too few practical skills because their education concentrates on theoretical aspects of their chosen subject. And like Japan there are problems in persuading graduates to enter many areas of manufacturing because they regard these jobs as being dirty, dangerous and difficult (3-D jobs as they are known in both Korea and Japan). The Government is trying to improve the employability skills of graduates by persuading companies to provide internships, persuading industry to become involved in the design of skill programmes, *etc.*

In Singapore, there is a co-ordinated system where the various Government ministries work in an integrated fashion to ensure that the education and training system – for both IVET and CVET – delivers the skills the Singapore economy needs. The Government, for example, through the Ministry of Manpower has developed a range of programmes to ensure that the workforce engages in lifelong learning. Singapore is a relatively small economy and it may be that this type of coordinated approach is less applicable to a much larger economy where there are very many more actors to coordinate.

The challenge for the UK over the period to 2050 is to ensure that the education and training system is organised in such a way that it is able to meet both current and future and employer demand. In many respects the German and Swiss VET systems, which are characterised by high levels of voluntary engagement between the social partners, have served their respective manufacturing sectors well in this respect. If the UK's manufacturing industry is to increasingly rely upon technician grade staff, typically trained through the Apprenticeship system, then it will need to increase employer engagement with the VET system. Otherwise it is difficult to see how an increase in employer participation in the Apprenticeship will be realised.

4.8 Skill imbalances

The incidence of hard-to-fill vacancies and skill-shortage vacancies

Relative wage growth gives an indication of the extent to which there are imbalances between the demand for, and supply of, skills. In the manufacturing sector it tends to be the following manufacturing sub-sectors which record the highest year-on-year increases in wages:

- Manufacture of computer, electronic and optical products;
- Manufacture of machinery and equipment;
- Manufacture of motor vehicles, trailers and semi-trailers.

Other evidence suggest that the level of skill shortages is the same in manufacturing compared with other industries and that the level of skill-shortages has been more or less stable over time (see Table 4.6). Where manufacturing encounters a relatively high level of skill deficiency is with reference to skill gaps (the extent to which employees are fully competent at their existing job). This is an interesting finding given the evidence above which suggests that employees in the industry are relatively less likely to be in receipt of training.

Table 4.6: Skill Deficiencies in Manufacturing (2011)

	Whole economy	Manufacturing
Vacancies (total)	635,906	40,252
Vacancies / 1,000 employees	23.1	15.8
HtFVs (total)	143,564	11,834
HtFVs / 1,000 employees	5.2	4.7
SSVs (total)	103,453	9,711
SSVs / 1,000 employees	3.8	3.8
Skill gaps	1,489,540	148,007
Skill gaps / 1,000 employees	54.1	58.2

Source: ESS2011

Where skill shortages emerge is often in relation to the quality of applicants to fill jobs. Employers often want applicants who possess the technical skills they require and a range of generic / soft skills (that is, hybrid skill sets).

The overall picture in relation to skill deficiencies includes many workplaces which have a relatively low-value / low-skill product market trajectory. Where employers have adopted a more dynamic product market strategy their skill needs are often more demanding and, consequently, skill shortages and skill gaps are more likely to emerge (Davis, et al., 2002). As noted above, the three sub-sectors which have recorded relatively high wage growth includes many employers who have adopted a high value, high skill product market strategy based around using the latest technologies in both products and processes.

Looking to the future skill shortages may emerge from the following factors:

1. a relatively aged workforce in some manufacturing sectors which will result in skilled workers leaving the industry which may be difficult to replace;
2. skill shortages emerging in some EU Member States as a result of demographic trends which may result in UK based workers taking jobs abroad or skilled foreign workers who may have been drawn to the UK settling elsewhere in the EU;
3. difficulties encountered by manufacturing employers in attracting people to work in the sector especially where their skills are sought by other industries.

To date, the evidence suggests that manufacturers have been successful in meeting their skill needs given the data on the volume of skill shortages. But it is where employers are engaged in relatively advanced activities that skill shortages are most likely to be experienced. This arises for two reasons: (i) because the skills supply system struggles to keep pace with their skill demands; and (ii) because the skills sought by these employers are in much demand by other employers (sometimes on a global scale).

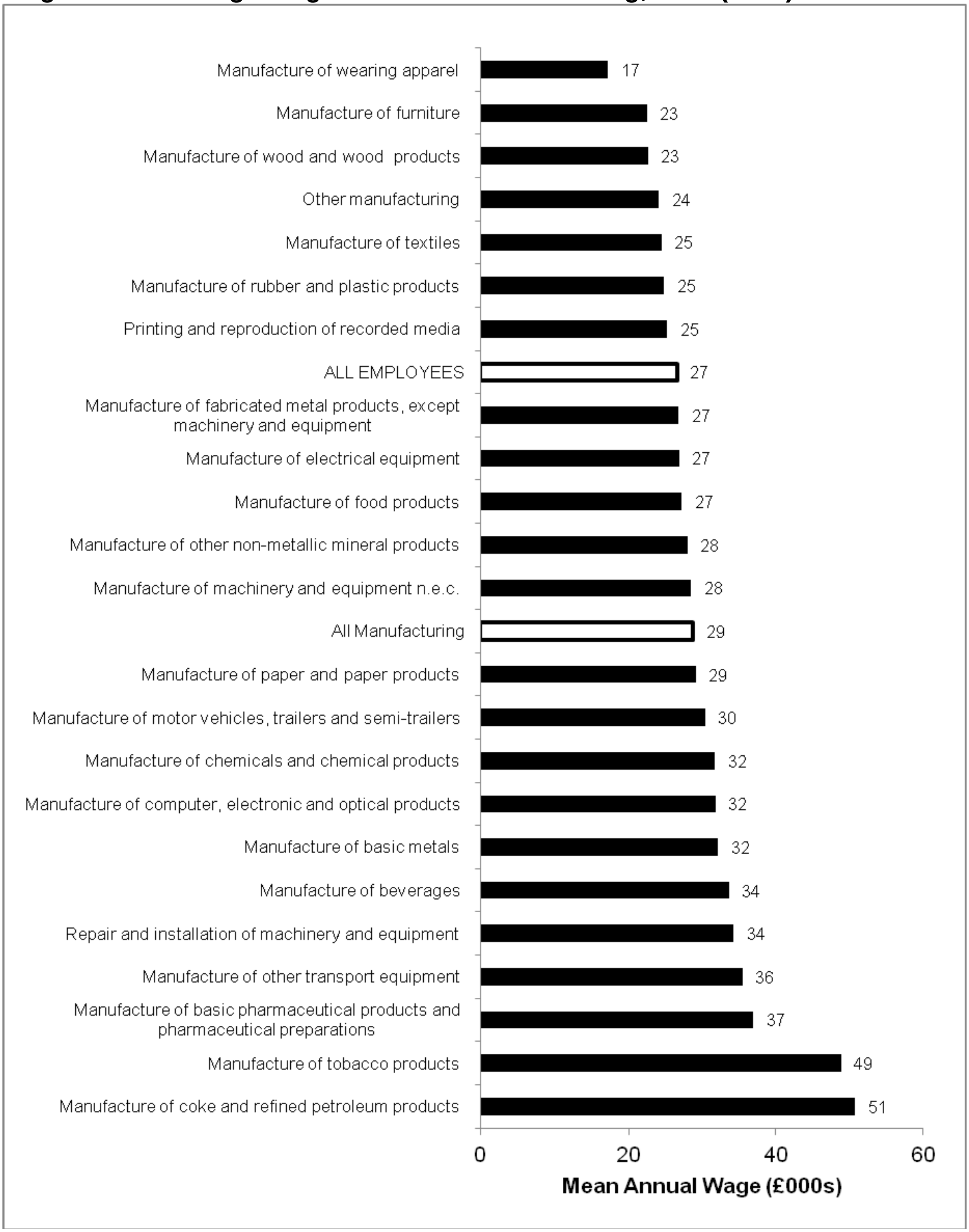
Offsetting skill imbalances

In order to attract the skills the industry needs there is a need for it to offer the terms and conditions of employment which are likely to attract people to work in it. A critical factor here is relative wages. But there are also a range of other issues which will affect whether people choose to enter the manufacturing industry or choose to remain employed within it. Important here are issues relating to job satisfaction and work-life balance. As noted in the previous section, manufacturing captures a relatively modest share of the number of STEM graduates (around one quarter). If the industry wants to recruit staff who are likely to be in strong demand by other sectors then at the very least it needs to offer working conditions which are a match with those other sectors. Analysis of the Work-Life Balance Survey of Employees reveals that employees in manufacturing are no more likely to report being able to achieve a work-life balance compared with other private sector industries.

Relative wage levels are one factor which might affect the propensity for people to enter the industry. Figure 4.4 shows average wage levels in various manufacturing sub-sectors compared with the average for all employees. In general, it reveals that employees in the manufacturing sector are relatively well paid with most sub-sectors paying above the average for the economy as a whole. Average hours, however, are slightly higher at 38 hours a week compared with the overall average of 37.5 hours across all industries.

The general picture to emerge is that it is a sector where working conditions are on par or better than elsewhere in the economy. But there tends to be a perception across many countries that the industry, or at least parts of it, is one of those considered dangerous, dirty and difficult (3-D jobs as they are referred to in Japan). Davis et al. (2012) suggests that one of the problems the sector faces is persuading people that it is a clean, safe industry in which to work and that the historic image of factory work being no longer applicable to many of the industry’s sub-sectors.

Figure 4.4: Average Wage Levels in Manufacturing, 2010 (£000)



Source: ASHE 2010

4.9 Conclusion: future trends

The estimates of replacement demand presented in earlier chapters indicate a strong demand for people working in skilled trade occupations. Typically these people are trained through the Apprenticeship system. Unless the supply of Apprenticeships can be further increased under the various manufacturing frameworks there is a danger that the sector will experience increased skill shortages for technician grade jobs. In many respects the solution rests with employers insofar as they will need to increase the number of Apprenticeship places they provide. If Apprenticeship starts cannot be increased then there will increasingly be a need to consider whether there are alternative means of supplying technician level skills to the industry. Otherwise UK manufacturing industry will be disadvantaged relative to countries with stronger intermediate levels skills supply such as Germany and Switzerland.

There is uncertainty attached to future levels of participation in higher education given recent funding changes. But if one assumes that the current provision of supply of STEM graduates stabilises at its current level and there continues to be strong demand for STEM graduates from other sectors, then the manufacturing industry may well struggle to capture both the quality and quantity of STEM graduates it requires in future years. Whilst employment levels in manufacturing are likely to continue to decline, the industry is likely to become increasingly dependent upon people employed in professional and associate professional occupations, entry to which often requires a degree, often in a STEM subject.
Even if the scale of shortages is relatively small, they often relate to critical functions within a business. Skill shortages in these critical functions, such as R&D and design, have been demonstrated to have a number of impacts on business performance including the delays in developing new products and processes. The relative strength of UK manufacturing will increasingly lie in its ability to develop new products and processes and engage in relatively small-scale, labour intensive production activity. These are the very activities which may be constrained by skill shortages.

In looking to the longer-term the development of skill needs in the manufacturing sector the most likely outcome will be as follows.

1. A continuation of the medium-term trends in the manufacturing sector outlined in Chapter 2 with the industry continuing to make an important contribution to economic output but with a continued decline in the number of people employed (at a rate more or less the same as projected in the 2010 to 2020 period).
2. Pressures on training supply to meet the skill needs of the sector. There is a well developed training infrastructure to supply the skills the industry needs both at further and higher education levels. But there are constant pressures on the supply-side to acquire the new skills the manufacturing sector needs. This pressure is likely to increase as new technologies are developed and become more commonly used in products and processes.
3. Skilled trade workers (including technicians) may well re-establish their importance in the industry given that production may well become more batch / niche oriented in the future. This will place pressures on the UK skills system at least over the medium-term to increase the number of Apprenticeships.
4. There will be an increasing demand for people qualified at further and higher education level in STEM skills. To date, the manufacturing sector has provided employment to around a quarter of all STEM graduates. Unless the supply of STEM

graduates increases then the manufacturing sector will need to increase its attractiveness to STEM graduates if it is to meet its skill needs.
5. The UK will continue to compete with countries in the world to recruit the most highly skilled staff with highly specialist skills.

There are a number of challenges to the above scenario being realised. From a skills perspective the challenges relate very much to the following.

1. The industry not being able to present itself as an ‘employer of choice’ for young people graduating from the further and higher education systems. Over the medium-term the level of replacement skill demand the industry faces at professional, associate professional and skilled trades levels is quite high. Even if the skills supply system is able to generate a high volume of people with the skills the industry needs they may well be attracted to work in other industries where terms and conditions of employment are considered better.
2. If skills shortages emerge in critical skills – that is those related to the development of new products and processes – then the growth of the industry in those sectors which have most growth potential will be constrained. The industry’s critical skill needs are at professional, associate professional, and skill trades levels. Management skills – which combine business acumen coupled with detailed product knowledge – will be in strong demand in order that the industry increasingly moves into high-value product markets.
3. It is clear that for skills at the very highest levels there is an international market and these skills are often central the innovation process and the development of new products and processes. These are the very activities on which the future of manufacturing is dependent if it to become a high value / high skill industry. The UK needs to be able to attract talent at the very highest technical levels to increasingly propel the manufacturing sector into high value added markets with substantial potential for growth.
4. The future of the industry is also dependent upon strategic alliances across the supply chain with employers increasingly working in a networked way with other employers (not just those based in the UK) in order to produce cutting edge product and process developments. There is a risk that SMEs in particular fail to learn the skills which allow them to flourish in such an environment.
5. One of the strategic alliances the industry needs to foster further is with the higher education sector. In this way, the strengths of the UK higher education sector can be better deployed to the benefit of UK industry.

Perhaps the biggest challenge for the industry over the medium to long-term is to ensure that the skills supply system is able to support emerging new technologies. There has been, over recent years, substantial public investment in developing the research and development base to assist companies exploit technological breakthroughs and bring new products to market. There are clearly a range of business skills which are needed here, but there are also likely to be a range of new technical skills which will need to be acquired too. This potentially places considerable pressures of the further and higher education sectors to be able to supply the skills manufacturing industry needs, but also places an onus on manufacturing firms to be able to articulate their emerging skill needs and to invest in the on-going development of their employees. Hence the increased importance in the future which will be attached to hybrid skills, technician level jobs, professional level science engineering and technology skills, and being able to work within networks of organisations.

There are three principal areas where policy is needed to support the future development of the manufacturing industry's skills base:

- ensuring that there are sufficient people graduating from the Apprenticeship system to satisfy the sector's future demand for technicians;
- maintaining a sufficient supply of STEM skills from the further and higher education sectors, especially in relation to satisfying the demand for professional engineers and technologists;
- making certain that there is sufficient collaboration between the higher education sector and manufacturing firms to ensure that the skills extant in the HE sector can assist the manufacturing industry.

The evidence suggests that most employers in manufacturing do not participate in Apprenticeship training. There have been various initiatives which have looked at how employers can be collectively persuaded to invest more in programmes such as Apprenticeship. The wealth of evidence on the benefits which both employers and individuals accrue from investing in Apprenticeships, especially STEM Apprenticeships, has helped increase the number of Apprenticeship starts. But there remain concerns, given the projected level of future replacement demands, that the number of people entering Apprenticeships in STEM subjects may not be sufficient to satisfy future demand. If that is the case then consideration needs to be given to identifying how public funding can further increase participation levels, or whether there needs to be some alternative to Apprenticeship which is able to deliver the same type of benefits which Apprenticeships deliver to both employers and individuals but which is able to support a larger number of learners. In the Netherlands, there has been some difficulty in finding a sufficient number of employers willing to provide Apprenticeships and so they have developed a programme of training through vocational schools which provides a substantial element of work experience (Vogler-Ludwig et al., 2012). This type of approach may need to be considered if participation in Apprenticeships is insufficient to deliver the cadre of technicians the industry needs.

With increases in tuition fees in higher education – plus the costs of students supporting themselves whilst studying – there are questions about whether participation levels in higher education will remain at their current historically high level. The risk is that the supply of people graduating in STEM subjects declines during a period when the manufacturing sector has a relatively high demand for people graduating in these subjects. There may be, therefore, a need to consider at some point in the future, depending upon how participation levels develop, how more people might be persuaded to study towards completing a degree in a STEM subject by, for example, providing them with the financial support to do so. People qualifying in STEM subjects are also needed in teaching and training occupations in order to ensure that the next generation of scientists, technologists, engineers, and mathematicians are produced.

There are a number of initiatives which facilitate collaboration between the HE sector and manufacturing firms. Collaboration between the HE sector and employers is likely to be of critical importance especially in the development of new products and processes and in developing prototypes. As the Lambert Review indicated this type of collaboration is not always the easiest feat to facilitate but the Government over recent years has invested in various centres of excellence and knowledge transfer so that employers can obtain the technical assistance to help develop their products and processes. This is likely to be of critical importance in assisting UK manufacturing firms, especially SMEs, capture a share of the new market opportunities potentially resulting from the exploitation of new technologies and materials.

References

Bacon, R.W., and Eltis, W. (1975) "The Implications for Inflation, Employment, and Growth of a Fall in the Share of Output that is Marketed." *Oxford Bulletin of E*conomics and. Statistics. Vol. 37 (4), 269-295, Nov. 1975.

Bacon, R.W., and Eltis, W. (1976) *Britain's Economic Problem: Too Few Producers*. London: Macmillan; New York: St. Martin's Press, 1976.

Baumol, W.J. and Bowen, W.G.(1966), *Performing Arts: The Economic Dilemma*, The Twentieth Century Fund: New York

Beicht, U., Walden, G., and H. Herget. (2004). *Cost and Benefits of In-Company Vocational Education and Training in Germany*, Federal Institute for Vocational Training, Bielefeld

Blake, N. J. Dods, and S. Griffiths (2000) *Employers Skill Survey: Existing Evidence and its Use in the Analysis of Skill Deficiencies*, National Skills Task Force / DfEE, Research Report SKT30

Bosworth, D.L., Giernalczyk, H., Hogarth, T. and Vogler Ludwig, K. (2011) *The Wider Benefits of VET in the Workplace*, Cedefop, Thessaloniki

Brown, A., Rhodes, E. and Carter, R. (2004). 'Supporting learning in advanced supply systems in the automotive and aerospace industries', in H. Rainbird, A. Fuller and A. Munro (Eds.) *Workplace Learning in Context*. London: Routledge (pp 166 - 182)

Brown, P., Ashton, D. and Lauder, H. (2009) *Skills Are Not Enough*, UK CES Praxis Paper

Connor, H., R. Mellors-Bourne, and C. Jackson (2011) *STEM Graduates in Non-STEM Jobs*, BIS Research Paper 31

Davis *et al*. (2012) *Advanced Manufacturing Sector*, UK CES Sector Insights

Davis, C. *et al*. (2002) *Employers Skills Survey: Engineering*. Report to National Skills Task Force.

Davies. B., Gore, K., Shury, J., Vivian, D. and Winterbotham, M. (2010) *Employers Skills Survey 2009:* UK Commission for Employment and Skills, Wath-Upon-Dearne

DTI (2006) Science, Engineering and Technology Skills in the UK, DTI Economics Paper No.16

Finegold, D. and Soskice, D. (1988) 'The Failure of Training in Britain: Analysis and Prescription' *Oxford Review of Economic Policy*, Vol. 22

Green, F. (2012) *What is Skill? An Inter-Disciplinary Synthesis*, LLAKES Research Paper No. 20 http://www.llakes.org/wp-content/uploads/2011/02/Green-What-is-Skill-reduced.pdf

Greenwood, C., Harrison, M. and Vignoles, A. (2011). *The labour market value of STEM qualifications and occupations,* Institute of Education / Royal Academy of Engineering http://tinyurl.com/ambfecp

Haxby, P. (1989) ‘Apprenticeship in the United Kingdom: From ITBs to YTS’. *European Journal of Education*, Vol. 24, No. 2, pp. 167-181

Hendry. C. *et al*. (2002) *Employers Skills Survey: Telecommunications*. Report to National Skills Task Force

Hogarth, T., Gambin, L., Winterbotham, M., Baldauf, B., Briscoe, G., Gunstone, B., Hasluck, C., Koerbitz, C. and Taylor, C.(2012). *Employer Investment in Apprenticeships and Workplace Learning: The Fifth Net Benefits of Training to Employers Study*, BIS Research Paper Number 67, London: Department for Business, Innovation and Skills.

Hogarth, T., Gambin, L. and Hasluck, C. (2011) “*Apprenticeships in England : What next?”* Journal of Vocational Education and Training, Vol.64 (No.1). pp. 41-55

Hogarth, T. et al. (2010) *Strategic skills needs in the bio-medical sector: a report for the National Strategic Skills Audit for England 2010, UK CES, Wath-upon-Dearne*

Hogarth, T. and C. Hasluck, C. Davis and G. McGivern (2006) 'Medical Technologies in the West Midlands: Skills and the prospects for growing new medical technology business', Coventry: Warwick IER and Coventry and Warwickshire LSC and the ESF

Hogarth, T. (1992). ‘Worker Support for Organisational and Technical Change: Workplace Industrial Relations in UK Manufacturing - The Case Study Evidence’ *Work, Employment & Society; vol. 7: pp. 189 – 212*

Jagger, N., Sigala, M., and Sumption, F. (2010) *SET Based Technicians: Lessons for the UK and European Labour Force Surveys*, Institute for Employment Studies Report No.475

Kaldor, N. (1975) *Causes of the Slow Rate of Growth of the UK Economy, An Inaugural Lecture*. Cambridge, England: Cambridge University Press

Lewis, P. (2012a) *Flying High: A Study of Technician Duties, Skills and Training in the UK Aerospace Industry,* Gatsby Trust, London

Lewis, P. (2012a) Space for Technicians? An Analysis of Technician Duties, Skills and Training in the UK Space Industry, Gatsby Trust, London

Lindley, R.M. (1981) *Economic Change and Employment Policy* , London: Macmillan

London Economics (2011) *Returns to Intermediate and Low Level Vocational Qualifications* BIS Research Paper 53, London

MAC (2011) Skill Shortage Sensible

Mason, G. (2012) *Science, Engineering and Technology Technicians in the UK Economy*, Gatsby Trust, London

Mason, G. (2011) *Product Market Strategies, Skill Shortages and Skill Updating Needs in England: New Evidence from the National Employers Skill Survey 2009*, UK CES Evidence Report No. 2011

Mason, G. (2005) *In Search of High Value Added Production: How Important are Skills?* Department for Education and Skills Research Report

Mason, G. (2002) "Production Supervisors in Germany, the UK, and United States: Back from the Dead Again?", *Work Employment and Society*, Vol.14, No.4

Mason, G. and Finegold, D. (1996) "Productivity, Machinery and Skills in the United States and Western Europe: Precision Engineering", *Management Research News*, Vol. 19 Iss: 4 pp. 42 – 43

The Migration Observatory (2010) *Migrants in the UK Labour Market: An Overview* http://migrationobservatory.ox.ac.uk/sites/files/migobs/Migrants%20in%20the%20UK%20Labour%20Market%20v2_0.pdf

Müehlemann, S., Schweri, J.,Winkelmann, R. &Wolter, S. C. (2007). 'An Empirical Analysis of the Decision to Train Apprentices'. Labour 21 (3), 419-441.

OECD (2006) *The Changing Nature of Manufacturing in OECD Economies*, STI Working Paper 2006/9

Purcell, K., P. Elias, R. Davies, and N. Wilton (2005) *Class of '99, study of the early labour market experience of recent graduates*. Department for Education and Skills, Nottingham

PWC (2009) *The Future of UK Manufacturing: Reports of its death are greatly exaggerated*, Price Waterhouse Coopers: London

Royal Academy of Engineering (2012) Jobs and Growth: the importance of engineering skills to the UK economy, Royal Academy of Engineering: London

Scarbrough, H., *et al*. (1999). *Knowledge Management: A literature review*. London, Institute of Personnel and Development

SEMTA (2012) *Sector Skills Assessment: UK Manufacturing*, UK CES: Wath-upon-Dearne

SEMTA (2009) *Skills and the Future of Advanced Manufacturing: A Summary Skills Assessment for the SSC Advanced Manufacturing Cluster*, SEMTA: Watford

Skills Commission (2012) *Technicians and Progression*, Skills Commission: London http://www.policyconnect.org.uk/sites/default/files/Technicians%20and%20Progression%20-colour%20final(2).pdf

Steedman, H. (2011) *The State of Apprenticeship in 2010 – International Comparisons: Australia, Aus*tria, *England, France, Germany, Ireland, Sweden, Switzerland*, CEP and the Apprenticeship Ambassadors Network.

HM Treasury / BIS (2010) *Plan for Growth*, Stationery Office, London

UK CES (2011) *The Supply and Demand for High Level STEM Skills*, UK CES Briefing Paper, December 2011

Vogler-Ludwig, K., Giernalczyk, H., Hogarth,T. and Stock,:. (2012) Best practice approaches to the development of intermediate levels skills and the role of apprenticeship, UK Commission for Employment and Skills, Wath-upon-Dearne

Wilson, R. A., Homendou, K. and Livonos, I. (2012) *Working Futures 2010-2012*, UK Commission for Employment and Skills, Wath-upon-Dearne

Wilson, R. A.(2010) *Medium-term forecast of skill supply in Europe: overview and synthesis*, Cedefop project on forecasting skill supply and demand in Europe

Wilson, R. A. (2009) *The demand for STEM graduates: some benchmark projections* London: Council for Industry and Higher Education

Wilson, R.A. and Hogarth, T. (2003). *Tackling the Low Skills Equilibrium*. London: DTI

Winterbotham, M., Vivian, D., Huckle, C., James, A.S., Hogarth, T., Gambin, L., Hasluck, C.(2012) *Evaluation of Apprenticeships: Employers*, BIS Research Paper Number 77, London: Department for Business, Innovation and Skills.

World Bank (2012) *Putting Higher Education to Work Skills and Research for Growth in East Asia*, The International Bank for Reconstruction and Development / The World Bank, Washington

Foresight
1 Victoria Street
London SW1H 0ET
www.bis.gov.uk/foresight
URN 13/846