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European Commission

ANALYTICAL HIGHLIGHT

FOCUS ON

Advanced manufacturing

- Although the manufacturing sector is expected to continue to decrease in size over the next decade, **advanced manufacturing is expected to grow significantly**, with the global market expected to double in size up to 2020.
- The growth in advanced manufacturing is forecast to lead to an **increase in the number of high-skilled jobs in the sector**. Growth in Research and Development (R&D) investment will increase demand for engineering jobs at graduate and intermediate levels.
- The introduction of new technology and the growing automation of manufacturing processes will also require all industry workers to have **increased technical skills**. In particular, it is expected that workers will require skills in **digital techniques, computing, analytical thinking, machine ergonomics and manufacturing methodologies**.

Europe is a world leader in developing advanced manufacturing techniques

Advanced manufacturing is the use of cutting edge skills or technologies to generate efficiencies and improvements to production processes. These techniques include the use of advanced robotics and 3D printing[1]. Advanced manufacturing increases competitiveness by improving the speed and quality of production, as well as supporting the EU to achieve its carbon reduction targets by reducing waste, pollution and energy consumption.

New technologies that underpin advanced manufacturing are known as 'key enabling technologies' because of their potentially wide-ranging application to support increased competitiveness and environmental sustainability:

- The development of advanced materials technologies has potential application in the areas of energy (e.g. catalysts and batteries), environment (e.g. smart packaging), health (e.g. tissue engineering), transport (e.g. lightweight materials) and ICT (e.g. optical fibres).
- Nanotechnology is already being used for medical implants and in the energy field (for energy conversion, storage and saving).
- Micro- and nano-electronics supports the development of clean motor vehicles by improving fuel efficiency.
- Industrial biotechnology has established application in the food, feed and detergent sectors.
- Photonics (the science and technology of light) is a relatively untapped technology, although the application of 'green photonics' (e.g. solar/photovoltaic power) is a rapidly-growing market[2].

Advanced manufacturing techniques can be applied across all parts of the manufacturing sector. It is not, therefore, a discrete element of manufacturing. It is, however, more concentrated in particular industries. High-technology industries are defined[3] to include the manufacture of pharmaceuticals, computers, electronics and aerospace. Medium-high technology industries include the manufacture of chemicals, motor vehicles, electrical equipment and armaments.

Europe is a world leader in advanced manufacturing. It has a global market share of over 35% and a patent share of over 50%[4]. Over 40% of EU private sector investment in R&D relates to advanced manufacturing[5].

The leading exporters of high-technology manufacturing in 2012 were:

- Germany – €153 billion (responsible for around a third of exports from EU national markets in scientific instruments, electrical machinery and non-electrical machinery, and around a quarter of chemicals and electronics exports; as well as being the leading exporter of pharmaceutical products)
- The Netherlands – £94 billion (responsible for 40% of EU computer/office machine exports and 23% of electronics exports)
- France – £89 billion (responsible for 43% of aerospace exports)
- United Kingdom – £63 billion (responsible for 23% of armament exports)
- Italy – £25 billion[6].

In 17 EU countries, the largest high-technology sector[7] in 2012 was electronics. The largest sector in 7 countries was pharmaceuticals (Belgium; Cyprus; Denmark; Ireland; Italy; Slovenia; Spain). In the remaining countries, the largest sector was variously aerospace (France and the United Kingdom), chemical products (Lithuania) and computers/office machines (Czech Republic)[8].

Advanced manufacturing is expected to grow significantly in the coming years, leading to an increase in high-skilled jobs

In 2013, it was estimated that over 32 million people were employed in the manufacturing sector as a whole across the EU-28[9]. The cross-cutting nature of advanced manufacturing makes it difficult to relate overall manufacturing employment to advanced technologies and skills. A European Commission estimate published in 2009 stated that the supply chain of key enabling technologies ('advanced manufacturing systems') provided 'some 2.2 million jobs'[10]. Employment in 'high-technology manufacturing' in 2011 was estimated by Eurostat to be just under 2.4 million people[11], which is less than 10% of overall manufacturing employment.

Employment across the manufacturing sector as a whole is expected to decrease by 4% to 2025[12]. However, employment in the high-technology manufacturing sectors for which data is available, namely electronics and pharmaceuticals, is forecast to only decline by 2%, remaining at around 2 million people employed across both industries[13]. Employment levels in the medium-high technology manufacturing industries are forecast to remain similarly stable and, in the case of motor vehicle manufacture, are expected to grow slightly.

While overall employment levels will remain fairly constant, the pattern of employment will change as the market for advanced manufacturing products grows. One estimate suggested that the EU advanced manufacturing market would grow by a third from 2008 to 2015[14]. Note that growth in the market for advanced manufacturing products does not necessarily lead to a similar increase in employment levels. This is partly because growth is driven by increased efficiency from the application of new technology and partly a function of the market being serviced by the existing manufacturing workforce adapting to supply new products.

The global market is forecast to be worth over €750 billion by 2020[15]. This is driven by particularly strong growth in:

- 3-D printing, which expected to grow globally by 13.5% from 2012 to 2017; and
- Robots and robot related products, which is expected to grow by 36.4% from 2011 to 2016[16].

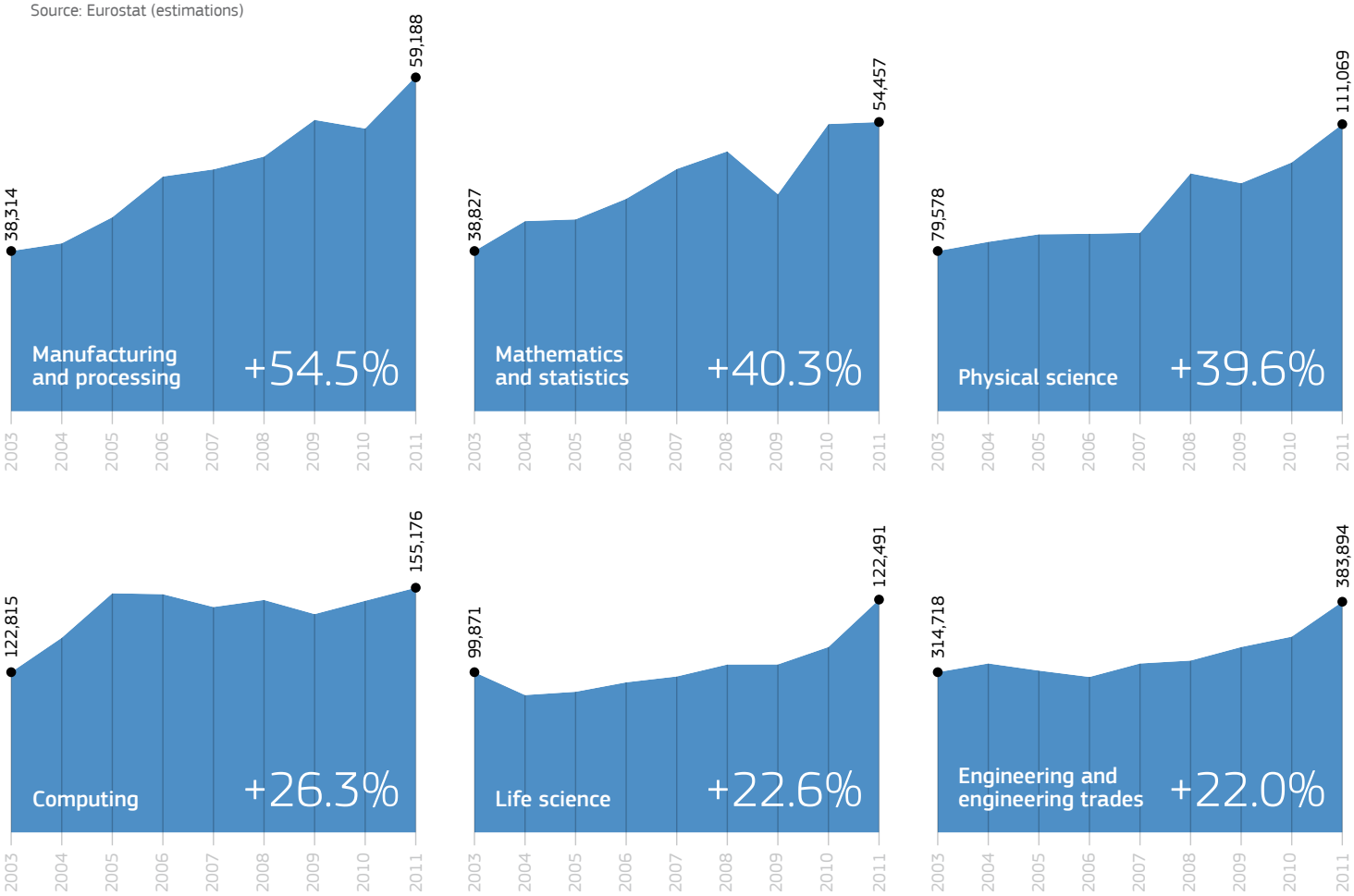
The growth in advanced manufacturing techniques will lead to an increase in high-skilled jobs. In particular, there will be demand for R&D jobs, which is the key driver for innovation in this area[17]. This is expected to create increased demand for highly-skilled engineers at graduate and intermediate levels[18]. In all of the advanced manufacturing industries for which data is available[19], there is a substantial increase in the number of professional jobs forecast to 2025; which generally sits alongside a decline in craft, plant and elementary occupations. The number of managers is generally forecast to grow as well; while the number of technicians and associate professionals will grow in some sectors (chemicals; electrical equipment; motor vehicles) and decline in others (electronics).

Most of the growth in advanced manufacturing is likely to be in western European countries

The predicted growth in advanced manufacturing is most likely to be felt in western European countries, and particularly Germany. Almost half of new patents are from Germany, followed by France (14%) and the United Kingdom (10%). These countries also have the largest manufacturing sectors and a high proportion of their manufacturing sector is knowledge-intensive. Advanced manufacturing jobs are associated with high-value and capital-intensive industries in industries such as aerospace, in which a range of manufacturing technologies are used throughout the design and production process and are central to the entire manufacturing supply chain.

Figure 1 – Graduations in ISCED level 5 and 6 (first and second stage of tertiary education) by field of study, EU-27

Source: Eurostat (estimations)



National research in the United Kingdom indicates that the greatest potential for growth in advanced manufacturing is likely to be in aerospace, defence, bio-pharmaceuticals, microelectronics and chemicals and low carbon vehicle technologies, as these are industries where there is a strong research and skills base to build on and where advanced manufacturing can provide employers with a significant competitive advantage[20]. In Germany, the growth in manufacturing is expected to be in new technologies and R&D[21].

The growth in advanced manufacturing will require an increased supply of new entrants with skills in the latest technologies

The coming years are also likely to see rapid advances in science and technology, particularly in the fields of nanotechnologies, materials science, electronics, ICT and biotechnology[22]. This is likely to lead to new manufacturing methods which will require workers to develop skills that are primarily ICT-based in:

- digital techniques;
- computing;
- analytical thinking;
- machine ergonomics;
- understanding manufacturing methodologies (including design for manufacture, design for assembly and design for automation)[2324].

The number of jobs in manufacturing as a whole requiring high-level qualifications is projected to rise by 1.6 million (21%) by 2025, whereas the growing automation of production processes will see the number of low- and medium-skilled jobs decrease by over 2.8 million[25]. A similar pattern is forecast for the high- and high-medium technology industries within manufacturing, although the shifts are less pronounced at the high-technology end of the scale. This reflects that industries such as pharmaceuticals and electronics (which are forecast to experience an 11% increase the number of jobs requiring high-level qualifications) are relatively professionalised already.

The number of science and engineering graduates is rising, but skills shortages remain

In overall terms, the number of new science and technology graduates has grown substantially over the last decade in line with the increasing demand for high-level skills. There were 16.8 science and technology graduates per 1,000 inhabitants aged 20-29 across the EU-27 in 2011, compared to 11.1 in 2001[26]. All EU-27 countries have experienced an increase in the proportion of science and technology graduates from 2001 to 2011 except for Ireland and the UK, both of which have seen increases in the most recent years. Growth in the supply of science and technology graduates tends in be associated with the countries that have a relatively stable or growing manufacturing sector – such as Austria, Germany, Poland, Portugal Romania, Slovakia and Slovenia.

Figure 1 shows that, from 2003 to 2011, growth in the supply of manufacturing and processing graduates (+54%) outstripped growth in engineering graduates (+22%), although it also shows a substantial increase in engineering graduates across the EU-27 in absolute terms. Similar growth has been experienced in the science, maths and computing-relating subjects that also supply the advanced manufacturing sector.

Almost all EU countries have seen an increasing number of engineering graduates from 2003 to 2011. In the case of Cyprus, Malta, Germany and Austria, the number of graduates has more than doubled. In Slovakia, Portugal, Romania, Latvia, the Czech Republic, Slovenia and Belgium the number of engineering graduates has increased by more than half. The trend has been flat in Denmark and Spain; while only Italy (-3%) and the Netherlands (-6%) have experienced a decline over this period[27].

The estimated number of graduations in engineering and engineering trades at post-secondary non-tertiary education (level 4) has also been slowly rising, increasing by 13% from 2005 to 2013. The number of graduations at upper secondary level (level 3) has declined over the same period by -20%[28].

Employers do, however, experience skills shortages related to increasing specialisation associated with advanced manufacturing. The fairly widespread growth in the number of engineering graduates over the last decade is not necessarily evenly distributed across engineering subjects. For example, in the United Kingdom, from 2003/04 to 2011/12, there has been a substantial rise in the number of graduates in civil engineering, chemical, process and energy engineering, mechanic engineering and, to a lesser extent, aerospace engineering[29]. Over the same period, the number of production and manufacturing engineering graduates has halved, the number of electronic and electrical engineering graduates has fallen by a quarter, and the number of general engineering graduates has also gone down.

Advanced manufacturing employers are also competing for talent with employers in other sectors. Graduates with, for example, an engineering degree are attractive to a wide cross-section of employers. An estimated 28% of employed engineering graduates across the EU are not working in the engineering profession[30].

Furthermore, education curricula have not, in the past, kept pace with the growing technological developments in the sector[31], compounding the incidence of skills shortages. The growth in advanced manufacturing will require workers to both sustain a good understanding of the skills required to utilise new ICT equipment and manufacturing techniques, as well as knowledge management skills. This will require broader training programmes, which integrate research with technology and manufacturing, from school level to graduate and post-graduate levels[32]. ■

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5 ibid. 2
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7 Measured according to the value of exports
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9 Cedefop (2014)
10 ibid. 2
11 Eurostat (2013), Science, technology and innovation in Europe
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13 ibid.
14 European Commission (2013), European competitiveness report – Towards knowledge-driven reindustrialisation
15 ibid. 1
16 ibid. 14
17 ibid. 1
18 UK Commission for Employment and Skills (2012), Sector skills insights – Advanced manufacturing
19 Cedefop (2014) – Note that data is not available at this level for the 'other transport equipment' and 'pharmaceuticals' sectors
20 ibid. 18
21 Kurt Vogler-Ludwig, Nicola Düll (2012) The German labour market in the year 2030 – A strategic view on demography, employment and education (2013)
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27 ibid.
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