ROYAL
ACADEMY OF
ENGINEERING

Jobs and growth: the importance of engineering skills to the UK economy

Royal Academy of Engineering econometrics of engineering skills project

Final Report, September 2012

Jobs and growth: the importance of engineering skills to the UK economy

Royal Academy of Engineering econometrics of engineering skills project

Final Report, September 2012

Author: **Matthew Harrison**, Director, Education,
The Royal Academy of Engineering

ISBN: 1-903496-92-6

Available to download from:
www.raeng.org.uk/jobsandgrowth

Acknowledgements

The contributions made by those attending a seminar held on the 27th June 2012 are acknowledged with particular thanks to:

Helen Atkinson FREng, Liz Bell (Universities UK),
Peter Glover (UKCES), David Grant FREng,
Sarah Hall (University of Nottingham),
Martin Houghton (TBR),
Charles Levy (Big Innovation Centre),
Stephen Rosevear (Cogent SSC),
Anna Vignoles (Institute of Education)

Table of contents

> "I have travelled around in business and seen how other nations organise themselves and tilt policy in favour of their industrial base. At the highest level, an industrial strategy in my view is about giving the right signals to society that industrial activity is very important"
>
> **Sir John Parker, President of the Royal Academy of Engineering**
>
> The Daily Telegraph, 29th July 2012

Executive summary

This report was commissioned by the Royal Academy of Engineering (the Academy) to provide evidence of the value of engineering skills to the economy and to examine analytically the concerns expressed by leaders in business and industry about the shortage of such skills.

The report provides clear evidence, based on econometric research, that the demand for people in Science, Engineering and Technology (SET) occupations exceeds supply and, because the demand is pervasive across the economy, it persists even in the current recessionary period[1,2]. As economic growth returns, demand for engineers and many other SET occupations is likely to intensify[3].

The Academy has as its number one strategic priority "To drive faster and more balanced economic growth". To achieve this, the provision of engineering skills should be a key focus of the government's industrial strategy.

As part of a strategic review in January 2011, the Academy's Standing Committee for Education and Training identified a list of priorities including:

- Building an evidence base for the economic value obtained from the supply of engineering skills to the labour market.
- Compiling evidence on the demand for engineers and technicians in the UK workforce, today and into the future.
- Compiling evidence on sectors of the economy where engineering skills contribute to a world-leading advantage.
- Compiling evidence on where engineering skills can be applied to promote new sources of economic growth.

1 The Purchasing Manager's Index for manufacturing (PMI) has been at or below the 50 level (that separates expansion from contraction) for most of 2012. Source: Markit/CIPS News Release, 3rd September 2012

2 The PMI for construction has been fluctuating in the 50-55 mark for 24 months, dipping to 49.0 in August 2012 – the second lowest value since February 2010. Source: Markit /CIPS News Release, 4th September 2012

3 UKCES Working futures 2010–20, UKCES, December 2011

These were built into an 18-month programme econometric research in five areas:

- The number of working-age people self-declaring in the Labour Force Survey (LFS) as working in SET occupations.
- An analysis of 20 broad economic sectors to identify the concentration of SET occupations in each.
- An analysis of the labour market returns to SET occupations and Science, Technology, Engineering and Mathematics (STEM) qualifications.
- An analysis of the signals of demand for SET occupations in the economy and forecasts of future demand for engineering skills in particular.
- An analysis of the supply of STEM qualified people in England and the UK more widely.

The research inspects the structure of the UK economy and compares this to competitor nations. It identifies significant deficiencies in the terminology used in economic analysis and forecasting, particularly when it comes to activity related to engineering. **These deficiencies are at least unhelpful and at worst could be hampering public policy making by obscuring the contribution made by engineering activity in inappropriately broad classifications and by promoting an impoverished definition of engineering.**

The research presented here inspects the evidence for links between education, skills, productivity and growth. It looks at how the UK school system performs against international competitors and compares the outputs from higher education with that of key nations. It presents new analysis of the structure of the SET workforce, identifying the pervasive way in which SET skills are distributed throughout the economy.

The research brings together evidence on the labour market returns from SET occupations and STEM qualifications. It inspects signals of expansion and replacement demand for SET occupations and compares these with rates of supply to answer some important questions and in particular:

- **Is there a link between STEM education, training, qualifications (or all three) and valuable economic activity?**
- **Is there a link between STEM education, training, qualifications (or all three) and economic growth?**

The principal findings of the research are:

1. Key conclusion: **There is good econometric evidence that the demand for graduate engineers exceeds supply and the demand is pervasive across all sectors of the economy**. The implication of this is that the economy needs more graduate engineers for both engineering and non-engineering jobs. The evidence can be seen in a persistent, sizeable wage premium for people holding engineering degrees and this premium has grown over the last 20 years. There are also wage premia offered for other (but not all) STEM graduates but the size of the premium varies.

2. There is evidence that the demand for people in non-graduate SET occupations exceeds supply because wage premia are also offered for many of these occupations.

3. There is good evidence that wage premia exist for many, but by no means all STEM qualifications. This is indicative of positive impact on productivity[4].

4. Independent models of future skills demand are predicting shortages of STEM qualified people for all occupational levels in SET (particularly professional and skilled trade levels). The models agree that much of this is replacement demand due to skilled people leaving the labour market but there are areas (nuclear new build, tunnelling, premium vehicle manufacture, banking and finance were some examples given by participants in the research) where demand is driven by expansion.

5. Surveys of the supply of STEM qualified people through the UK education and training systems when compared with models of demand suggest that that demand for STEM skills will exceed supply into the foreseeable future. Many employers also recruit experienced people from the international labour market of course but visa restrictions can make this complicated and in certain sectors (such as defence) this is not an option.

6. Independent mappings of the deployment of engineering (and STEM more generally) qualified people in the economy show STEM qualified people to be widely distributed through the economy (with varying concentration in different sectors). Engineers and SET workers more generally are also widely distributed. This is a signal of the marketability of STEM qualifications and SET workers. Concerns may arise however if there is insufficient supply of STEM qualified people or SET workers to meet the needs in all sectors – noting that some sectors have inherently higher profitability and hence can offer higher wages than others.

7. The under-representation of women, those from certain ethnic minority groups and people with disabilities in SET occupations is well known[5]. There is also evidence of under-representation of people from lower socio-economic groups amongst those applying for STEM degrees[6] although more research is

---

4 Increasing productivity is one component of the simplest model for growth – the other being an increase in employment (the number of people working and the number of hours worked). Example source: BIS (2010), Economics Paper No 4: Supporting analysis for 'Skills for Growth' – the national skills strategy

5 UKRC (2010), Women and men in science engineering and technology: the UK statistics guide 2010, UK Resource Centre for Women in SET, 2010 (pages 81, 94, 103)

6 Engineering UK (2012), Engineering UK 2012: the state of engineering, Engineering UK, 2012 (page 166)

required to understand the impact of sequential subject decisions made prior to applying to university[7]. These under-representations provide justification for successive governments' focus on participation in and access to STEM qualifications. When considering government support for STEM, a narrative around the **strategic value** of STEM qualifications and SET occupations should also be explored with reference to innovation, international competitiveness and security of vital supplies and services (communication and IT, water, energy, food all rely on SET occupations). Case studies would be helpful. In addition, more work is required to understand the balance between the returns received from STEM qualifications and SET occupations by *the individual* and the *wider returns* received by the employer, the economy, society and so on.

Starting from the clear need to stimulate economic growth and jobs in the UK, the key messages from this research are:

- **An industrial strategy, being greater explicit support and orientation towards areas of production in the UK economy including IT, infrastructure, construction, manufacturing and other elements of a widely-drawn 21st Century industrial base requires investment in particular types of human and other capital. A focus on UK skills in areas of existing and potential strength such as Computing & Telecommunications, Manufacturing and Construction could help deliver the objectives of and industrial strategy in the short to medium term.**
- **SET occupations, and STEM qualifications can have significant value to the individual and the demand for them is pervasive across the economy signifying that they have wide value.**
- **There is high demand for STEM graduates, and for certain disciplines the evidence is that demand exceeds supply.**

7 There are known links between household income and participation in higher education (Source: Jake Anders (2012), The link between household income, university applications and university attendance, FISCAL STUDIES, vol. 33, no. 2, pp. 185–210 ,2012) and the gap in participation between richer and poorer young people largely emerges before the point of application. The analysis has not yet been extended to subject of degree.

Introduction

The structure of UK economic output is: <1% agriculture, 11% manufacturing, 11% other industry and 78% services (2010 figures)[8]. This is broadly similar to the economic structure of both the US and France but the UK has a higher proportion of its economy devoted to services than other leading nations such as Germany (71%) or emerging economic nations such as Brazil (67%), Russia (59%), India (55%) or China (43%).

The success of the UK service economy with London as a truly global financial city is a cause for celebration. However, events since 2008 and an ongoing and deepening recession are signals that in order to compete with the US and Germany and with emerging nations the UK has to remain in the business of high added-value, high-technology, sustainable engineering and manufacturing. In addition, to provide for its citizens it also needs to maintain capability in civil engineering, engineering construction, electricity production and distribution, gas, water and sanitation, transportation, process manufacture, nuclear engineering, electronics, food manufacture, fuels, high-value materials, consumer products, IT, software and healthcare services. All depend on engineering knowledge and skills.

The UK Commission for Employment and Skills (UKCES) does not predict much rebalancing of the UK economy towards production, at least in the medium term[9]. That is why an industrial strategy is required: to win the economic recovery and create both jobs and growth:

"I have travelled around in business and seen how other nations organise themselves and tilt policy in favour of their industrial base. At the highest level, an industrial strategy in my view is about giving the right signals to society that industrial activity is very important"

Sir John Parker, President of the Royal Academy of Engineering

The Daily Telegraph, 29th July 2012

Success of such a strategy will depend on the UK securing the engineering skills required to translate good ideas and the fruits of scientific research into innovative products and services and to operate the businesses that will provide jobs and growth.

As part of a strategic review of priorities in January 2011, the Standing Committee for Education and Training at the Royal Academy of Engineering (the Academy) identified a list of priorities including:

- Building an evidence base for the economic value obtained from the supply of engineering skills to the labour market.
- Compiling evidence on the demand for engineers and technicians in the UK workforce, today and into the future.
- Compiling evidence on sectors of the economy where engineering skills contribute to a world-leading advantage.
- Compiling evidence on where engineering skills can be applied to promote new sources of economic growth.

These were built into an 18-month research programme, the results of which were tested and augmented at a research seminar on the 27th June 2012 and are reported here.

8 World Bank (2012), World Development Indicators 2012, World Bank, 2012

9 UKCES (2011) Working futures 2010–20, UKCES, December 2011

During that time, the Academy:

- Drew the Science, Technology, Engineering and Mathematics (STEM) communities together to find consensus on what is meant by the terms 'STEM qualifications' and 'SET occupations'. These definitions enabled the subsequent econometric analyses reported here.
- Quantified for the first time the contribution to STEM education and skills made by the FE & Skills system in England through the Academy's FE STEM Data project[10,11].
- Extensively mined Labour Force Survey and other datasets including commissioning unique regression analysis undertaken at the Institute of Education to isolate the wage premia from SET occupations and STEM qualifications[12].
- Built the first comprehensive analysis of the supply of STEM qualifications by incorporating the findings of the FE STEM Data Project with data provided by HESA, HEFCE, BIS and the Department for Education.
- As part of its role hosting the Technician Council[13], commissioned an analysis from the Big Innovation Centre of the number of SET workers in the UK economy (segmented into 20 broad economic sectors) attributing economic data such as wages, gross value added, export data, employment rates.

In undertaking this work, the Academy has sought answer to some important questions:

- Are STEM skills more valuable (at a given level) than other skills (including basic skills)?
- If so more valuable to whom? To the individual? To the employer? To the economy?
- Where does STEM related value get captured? In some or all of the economy?
- Are STEM qualifications useful proxies for STEM skills (or do we need to look at wider competence)?
- Is the supply of STEM skills sufficient to meet current (business continuity) and future (business continuity plus potential growth) needs?
- Is public investment in STEM education, training, qualifications (or all three) justified and if so why?

and in particular

- **Is there a link between STEM education, training, qualifications (or all three) and valuable economic activity?**
- **Is there a link between STEM education, training, qualifications (or all three) and economic growth?**

These issues are explored in the pages that follow.

---

10 Andy Frost, Clive Greatorex, Matthew Harrison, David Mason (2010), FE and Skills STEM Data Summary report, October 2010, Blue Alumni / Royal Academy of Engineering **www.thedataservice.org.uk/statistics/other_statistics_and_research**

11 Matthew Harrison (project leader) 2011, FE STEM Data Project July 2011 report, Royal Academy of Engineering **www.thedataservice.org.uk/statistics/other_statistics_and_research**

12 Charley Greenwood, Matthew Harrison, Anna Vignoles (2011), Institute of Education / Royal Academy of Engineering **www.raeng.org.uk/news/releases/shownews.htm?NewsID=701**

13 **www.professional-technician.org.uk** (accessed July 2012)

The nature of engineering

There was consensus amongst those involved in this study that more needs to be done to ensure clarity on the terminology used when discussing the role of engineering in the labour market and in the economy. Confusion around terms such as 'professional', 'engineer' 'engineering', 'science' and 'technology' persists in the STEM, economics and public policy communities alike. These could be settled through coordination and increased dialogue between those communities.

In addition, the distinctions often made between 'productive' economic sectors and 'service' sectors should be more nuanced in future. For example the broad 'Business Services' grouping of Standard Industrial Classification (SIC) codes includes: architectural and engineering activities; technical testing and analysis; scientific research and development; other professional, scientific and technical activities.

There is a complex taxonomy used to describe the contribution to economic output made by engineering activities and through the application of engineering skills. The taxonomy applied to STEM education and skills development is equally complex. For example, terms drawn from:

- World Bank definitions of economic structure
- Standard Industrial Classifications
- Standard Occupational Codes
- The Joint Academic Coding System (JACS) codes
- External trade statistics

are commonly used in public policy discourse. In addition, distinctions are often drawn between a 'service economy' (or trade in services) and a 'productive economy' (or trade in goods) whereas both could be seen as components of a single economic system[14]. The terms 'engineering' and 'technology' also get intertwined[15] which adds to a sense of complexity and perhaps confusion.

For the purposes of this study alternative definitions are offered in Box 1 to provide richer insight into the nature of engineering and engineering skills, acknowledging the need to engage with the terms listed above as they are widely used in economic datasets and analysis.

14 Royal Academy of Engineering (2012), Industrial systems: capturing value through manufacturing, Royal Academy of Engineering, February 2012

15 Harrison (2010), Supporting the T and E in STEM: 2004–2010, Design and Technology Education: an international journal, Vol 16.1, pp17–25

Box 1: Defining 'engineering'

Inspiring visions of engineering are provided for the United States by the National Academy of Engineering[16]

"No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. Few professions turn so many ideas into so many realities. Few have such a direct and positive effect on people's everyday lives. We are counting on engineers and their imaginations to help us meet the needs of the 21st century.".

and by the Accreditation Board for Engineering and Technology[17]

"[Engineering] The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.".

Definitions developed in the context of professional engineering UK are[18]

"Engineering is concerned with developing, providing and maintaining infrastructure, products, processes and services for society. Engineering addresses the complete life-cycle of a product, process or service, from conception, through design and manufacture, to decommissioning and disposal, within the constraints imposed by economic, legal, social, cultural and environmental consideration.".

and[19]

"Chartered Engineers are characterised by their ability to develop appropriate solutions to engineering problems, using new or existing technologies, through innovation, creativity and change. They might develop and apply new technologies, promote advanced designs and design methods, introduce new and more efficient production techniques, marketing and construction concepts, or pioneer new engineering services and management methods. Chartered Engineers are variously engaged in technical and commercial leadership and possess effective interpersonal skills".

A useful insight into the T and E in STEM is provided by Malpas[20]

"Technology is an enabling package of knowledge, devices, systems, processes and other technologies, created for a specific purpose. The word technology is used colloquially to describe either a complete system, a capability, or a specific device. Engineering is the knowledge required, and the process applied, to conceive, design, make, build, operate, sustain, recycle or retire, something of significant technical content for a specified purpose; – a concept, a model, a product, a device, a process, a system, a technology".

16 National Academy of Engineering (2008), Changing the conversation: messages for improving public understanding of engineering. Washington D.C: The National Academies Press, 2008

17 This definition of engineering was used widely by ABET before the Criteria for Accrediting Engineering Programs were adopted in the year 2000 (and subsequently revised). Although still quoted frequently and attributed to ABET it is not used in current versions of the Criteria.

18 QAA (2012) QAA Subject Benchmark Statement for Engineering, QAA, 2010

19 Engineering Council, (2010), UK standard for professional engineering competence (UKSPEC). London: The Engineering Council, 2010

20 Malpas, Sir Robert, (2000), The Universe of Engineering: A UK definition. London: The Royal Academy of Engineering, 2000

Education, skills and growth

There is strong evidence that continuing years of education prove valuable to the individual. Earnings tend to rise in line with people's level of education with the earning premium for tertiary education (when compared with upper secondary) being more than 50% in over half of OECD countries[21]. By contrast, those will poor levels of education can earn substantially less than those with upper secondary education (23% less on average across all OECD countries).

Going beyond the returns to the individual, there is general agreement that investment in basic education yields wider economic benefits. For example:[22]

"Raising the average literacy and numeracy skill level of the workforce, and reducing the proportion of workers at the lowest level of skill, could yield significantly higher levels of -growth in GDP per capita"

Coulombe et al. 2004

There is also agreement that qualifications are a proxy for human capital[23]

"Educational attainment is a commonly used proxy for the stock of human capital – that is the skills available in the population and the labour force"

OECD 2011

However, when thinking beyond basic skills, doubts have been expressed about the links between skills and economic success, for example:[24]

"The larger and more complex the education sector, the less obvious any links to [economic] productivity become"

Alison Wolf

But a narrative of education and growth remains common, for example:[25]

"The key to the UK getting back on track is growth, founded on a rebalanced economy geared much more towards investment and export. Education and training have a central role [sic] to play in the process – my view is that skills are at the heart of our ability to sustain economic growth"

John Cridland

As well as good evidence for and general consensus on the impact of basic skills (for example, in the UK circa 10%, wage premium for adult literacy and numeracy skills is reported[26]), the case for the economic importance of tertiary / higher level skills is commonly made[27]. Rates of return on Apprenticeships are also commonly found to be high[28].

There is also strong evidence that many, but not necessarily all, qualifications provide wage premia[29]. Certain SET occupations provide premia too[30]. These occupations are found throughout the economy, although in differing concentrations[31]. However, the futures for some occupations, particularly those

21 OECD (2011) – Education at a Glance 2011, OECD, 2011 (page 138)

22 Coulombe, S., J.F. Tremblay and S. Marchand (2004), Literacy Scores, Human Capital and Growth across Fourteen OECD Countries, Statistics Canada, Ottawa, 2004 (page 8)

23 OECD (2011) ,Education at a glance, OECD, 2011 (page 30)

24 Alison Wolf (2002), Introduction to "Does Education matter?", Alison Wolf, Penguin books, 2002

25 CBI (2012), Page 4, Education and Skills Survey 2012, CBI / Pearson, 2012

26 De Coulon, A., O.Marcenaro-Gutierrez & A. Vignoles (2007), The value of basic skills in the British labour market, CEE Discussion Paper 77, 2007

27 For example : University Alliance (2010), 21st century universities: engines of an innovation driven economy, University Alliance, September 2010

28 A recent example – NAO (2012), National Audit office report on adult Apprenticeship, February 2012

29 For example – McIntosh (2004), Further analysis of the returns to academic and vocational qualifications, Steve McIntosh, Centre for the Economics of Education, January 2004

30 Charley Greenwood, Matthew Harrison, Anna Vignoles (2011), The labour market value of STEM qualifications and occupations, Institute of Education / Royal Academy of Engineering, 2011 in the so-called 'hollowed out middle'[32] of the range of standard occupational classes look vulnerable at least in the medium term[33,34].

Notwithstanding doubts over links between spending on education and its impact on economic prosperity[35], there is evidence that more spending can yield better attainment in national or international tests (such as the PISA tests)[36]. However, different nations deploying similar per capita spending achieve widely different test scores and inequalities exist – for example[37]:

- On average, across OECD countries, disadvantaged students spent 20% less time learning science at school than their more advantaged peers.
- Across OECD countries, on average, the odds of being a resilient learner for disadvantaged students who spend an extra hour a week learning science at school are 1.27 times greater than the odds of disadvantaged students who do not have that opportunity to learn science at school, after accounting for a host of student and school background factors, approaches to learning and school policies.

Even taking into account these complexities and inequalities, it is hard to see any systematic evidence of a significant and positive link between ranking in PISA tests and economic growth (Boxes 2, 3) as several of the worst performing nations in PISA tests have stronger economic growth than several of the best performing nations. There is some evidence that many of the countries that have performed significantly better than England in PISA tests also have stronger economic growth (Boxes 4, 5) but any relationship between these two factors is unlikely to be simple or even causal.

Box 2: Ten highest performing OECD / G20 countries in PISA tests 2009[38]

Reading	Mathematics	Science
Shanghai – China	Shanghai – China	Shanghai – China
Korea	Finland	Finland
Finland	Korea	Korea
Canada	Canada	Estonia
Estonia	Japan	Canada
Japan	Estonia	Japan
Australia	Netherlands	Australia
Netherlands	Switzerland	Poland
Norway	New Zealand	Netherlands
Poland	Australia	New Zealand
(UK 21st amongst OECD /G20)	*(UK 16th amongst OECD /G20)*	*(UK 21st amongst OECD /G20)*

31 For example – TBR (2011),The current and future science workforce, Fiona Dodd, Jon Guest, Andrew License TBR / Science Council, 2011

32 For a recent discussion of this trend where employment growth is seen in professional occupations and in semi-skilled and unskilled occupations but not in intermediate occupations see: University Alliance (2012), The way we'll work: Labour market trends and preparing for the hourglass, University Alliance, March 2012

33 For example – UKCES (2011), Working futures 2010-20, UKCES, December 2011

34 The work of the Technician Council in recognising a modern class of technician and promoting professional technician registration is an example of how intermediate occupations can be supported and their position in the labour market strengthened – Technician Council (2012), Professional Technician: the future, Technician Council, 2012 (available to download from **www.professional-technician.org.uk** – accessed July 2012)

35 Alison Wolf (2002), "Does Education matter?", Alison Wolf, Penguin books, 2002

36 OECD 2010 data quoted in Figure 7 of: DfE (2010), The case for Change, Department for Education, November 2010

37 OECD (2011), Against the Odds: Disadvantaged Students Who Succeed in School, OECD, 2011

38 OECD (2012), Education at a glance 2011 highlights,OECD, 2012 (page 87)

Box 3a: The ten best performing OECD / G20 countries in the three PISA tests (2009) with their recent economic growth

(average annual % GDP growth 2000-2010)[39]

China	10.8%
Finland	2.1%
Korea	4.1%
Estonia	4.6%
Canada	2.0%
Japan	0.9%
Australia	3.2%
Poland	4.3%
Netherlands	1.6%
New Zealand	2.6%

Box 3b: The ten worst performing OECD/G20 countries in the three PISA tests (2009) with their recent economic growth

Indonesia (39th in OECD/G20)	5.3%
Argentina (38th in OECD/G20)	5.6%
Brazil (37th in OECD/20)	3.7%
Mexico	2.1%
Chile	4.0%
Austria	1.8%
Russian Federation	5.4%
Turkey	4.7%
Israel	3.6%
Greece	2.6%

Looking for influences on economic growth beyond basic educational outcomes such as those measured by the PISA tests, economic models based around long term, stable growth[42] suggest that economic outputs remain in equilibrium with inputs (materials, labour, capital, management) so that a change in population is followed by a change in output to maintain equilibrium. In such models, growth in output per capita (i.e. *productivity*) depends only on the rate of technological progress: in the outputs themselves or in the means of their production.

The rates of output growth in the modern era are too great to be accounted for solely by increases in inputs and therefore the centrality of technological development to economic growth is commonly asserted[43].

Much of this technological development comes from innovation and the basic competence (human capital) shown in PISA tests plays a part – but so do research, development, IT, organisational capital and the application of higher skills (most frequently in SET occupations)[44].

The UK performance in a number of factors known to influence innovation can be summarised relative to international comparator nations as:

- The UK has had, for some time, a lower percentage of firms deemed 'innovation active' (36% in 1998–2000) than other European nations (for example Germany 61%). However the turnover return from this limited innovation is often best in Europe[45]

39 World Bank (2012) World Development Indicators 2012, World Bank, 2012 (page 214)

40 NFER (2010), PISA 2009: achievements of 15 year olds in England, NFER,2010 (page 16)

41 World Bank (2012), World Development Indicators 2012, World Bank, 2012 (page 214)

42 Solow (1956), Model of Cross-Country Growth Dynamics, Oxford Review of Economic Policy 1 23 (2007): pp. 45-62 – referenced in BIS Economics Paper No 15 – Innovation and Research Strategy for Growth, December 2011

43 Abramovitz, M. (1956) Resources and Output Trends in the United States since 1870, American Economic Review, vol. 46, no. 2, pp. 5–23 – referenced in BIS Economics Paper No 15 – Innovation and Research Strategy for Growth, December 2011

44 UKCES (2011) ,Skills and Economic Performance: the impact of intangible assets on UK performance, UKCES, October 2011

45 DTI (2005), International comparisons of the 3rd community innovation survey, DTI, 2005.

Box 4: Focus on England
PISA - Countries outperforming England in 2009 to a significant degree[40]

Reading	Mathematics	Science
Shanghai - China	Shanghai - China	Shanghai - China
Korea	Singapore	Finland
Finland	Hong Kong	Hong Kong
Hong Kong	Korea	Singapore
Singapore	Chinese Taipei	Japan
Canada	Finland	Korea
New Zealand	Lichtenstein	New Zealand
Japan	Switzerland	Canada
Australia	Japan	Estonia
Netherlands	Canada	Australia

Box 5: Recent economic growth (average annual % GDP growth 2000-2010)[41]

China	10.8%
Finland	2.1%
Hong Kong	4.6%
Singapore	6.0%
Korea	4.1%
Estonia	4.6%
Switzerland	1.9%
Canada	2.0%
Japan	0.9%
Australia	3.2%
Poland	4.3%
Netherlands	1.6%
New Zealand	2.6%
Norway	1.7%
UK	1.8%

- The UK gross investment in R&D is modest[46] (1.8% in 2010) compared with the US (3.2%) Japan (2.7%) and Germany (2.8%) but similar to China (1.7%). In addition, a much higher R&D percentage is invested in universities (27% in UK – 8% in China). The number of publication citations per unit investment in R&D is much higher in the UK than elsewhere (possibly reflecting the concentration of research in universities).
- The US produces four times the number of engineering graduates compared with the UK:[47]

  US graduations in engineering (2008-09)[48]:
  Bachelors – 137,500
  Masters – 38,000
  Doctoral – 8,000

  UK graduations in engineering (HESA 2010-11)
  Bachelors / MEng – 23,000
  Masters – 15,000
  Doctoral – 2,500

  India produces eight times the number of engineering graduates, China twenty times.
- The share of vocational education and training (VET) in the UK as a proportion of total upper secondary education is smaller (42%) than all the other industrial countries in Europe (Germany – 60%, France – 43%, Czech Republic – 79%) apart from Greece (34%), Italy (25%) and Ireland (3%)[49].
- 37% of the UK population has experience of tertiary (higher) education[50] compared with the OECD average of 30% and the EU21 average of 27%. (US – 41%, Germany – 32%, France – 30%).

UK innovation performance can be compared to international competitor nations in a number of ways including the number of patent registrations in key markets around the world[51]. In 2009, the UK was the 8th largest contributor to US patent registrations behind the US, Japan, Germany, South Korea, Chinese Taipei, Spain and Canada. In 1989 it was 5th behind the US, Japan, Germany and France.

46 Universities UK (2011), Driving economic growth, Universities UK, October 2011

47 G. Gereffi, V. Wadhwa, B. Rissing, R. Ong (2008), Getting the numbers right: international engineering education in the United States, China and India, Journal of Engineering Education, January 2008

48 NCES (2011),The condition of education 2011, NCES, 2011-. Also – Digest of Educational Statistic 2010, NCES 2011-015). Longitudinal data available in – Anderson, Fact book on Higher Education, American Council on Education

49 OECD (2010), Learning for jobs, OECD – page 13, 2010

50 OECD (2010), Learning for jobs, OECD, 2010

51 Royal Society (2011), Knowledge, networks and nations: scientific collaboration in the 21st Century, Royal Society, March 2011

Research programme

The Academy has undertaken an 18-month programme of econometric research in five areas:

- The number of working-age people self-declaring in the Labour Force Survey as working in SET occupations.
- An analysis of 20 broad economic sectors to identify the concentration of SET occupations in each.
- An analysis of the labour market returns to SET occupations and STEM qualifications
- An analysis of the signals of demand for SET occupations in the economy and forecasts of future demand.
- An analysis of the supply of STEM qualified people in England and the UK more widely.

The number of individuals in SET occupations

The work to quantify the labour market returns to SET occupations and STEM qualifications undertaken by Greenwod et al.[52] is based on the FE STEM Data Project classification of which Standard Occupational Codes (SOC) can be identified as SET. This has been used to produce estimates of SET workers (at both *Professional* and *Technician* levels) in broad sectors of the UK economy (Table 1).

However, the worker estimates in Table 1 are not corrected to account for the significant proportional of self-declared SET Professionals and Technicians who hold only low level qualifications. Figure 1 illustrates the typical distribution of qualification levels for the case of self-declared 'Professional Engineers'.

Analysing the four quarters of Labour force Survey data from 2009 using the classifications developed by the FE STEM Data Project and reported in Greenwood et al. there are 30 million workers in the UK economy[53]. Based on a very detailed inspection of the first quarter of 2011 LFS data (not seasonally adjusted) there are:

- **730,000 self-declaring 'engineers' of which 60% hold the tertiary level qualifications normally required for professional engineering registration**
- **700,000 self-declaring SET 'technicians / associate professionals' who hold the Level 3+ qualifications normally required for professional technician registration**
- **880,000 skilled engineering operatives.**

'Professional' engineers: LFS Jan-Mar 2011-NVQ level (circa 730,000 total)

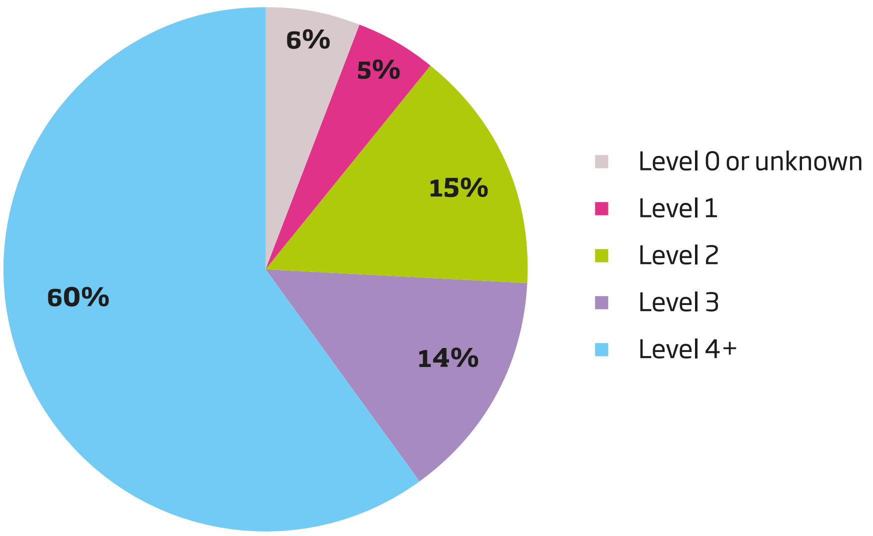


Figure 1: Distribution of qualifications amongst self-declaring 'Professional' engineers.

52 Charley Greenwood, Matthew Harrison, Anna Vignoles (2011), The labour market value of STEM qualifications and occupations, Institute of Education / Royal Academy of Engineering **www.raeng.org.uk/news/releases/shownews.htm?NewsID=701**

53 Author's calculations

	Number of technicians	Number of SET professionals	Total number of workers
Agriculture & Mining	10,000	40,000	440,000
Low-tech Manufacturing	90,000	140,000	930,000
Med-Low tech Manufacturing	110,000	320,000	780,000
Med-High tech Manufacturing	110,000	330,000	650,000
High-tech Manufacturing	30,000	120,000	160,000
Utilities	40,000	90,000	280,000
Construction	410,000	590,000	2,130,000
Retail & Wholesale	230,000	290,000	4,630,000
Transport & Storage	80,000	100,000	1,470,000
Accommodation & Food	–	–	1,890,000
Media & Publishing	80,000	50,000	370,000
Computing & Telecommunications	70,000	420,000	740,000
Finance & Insurance	30,000	100,000	1,110,000
Business Services	180,000	410,000	2,710,000
Support Services	30,000	70,000	2,270,000
Public Admin & Defence	170,000	150,000	1,510,000
Education	80,000	130,000	2,680,000
Health & Social Services	90,000	110,000	3,690,000
Arts & Entertainment	20,000	30,000	800,000
Other Services	60,000	90,000	800,000
UK Total	**1,930,000**	**3,600,000**	**30,040,000**

Table 1: Employment estimates from 2009 Labour Force Survey

(Source: Big Innovation Centre analysis for the Technician Council commissioned by the Royal Academy of Engineering – based on SOC code classifications from the FE STEM Data Project and reported in Greenwood et al. 2011)

This makes 2.3 million skilled people in the engineering-related skills base – 8% of the workforce. There are 7 million people working in the productive economy – 23% of the working population serving a similar proportion of the national economic output.

Analysing the four quarters of Labour Force Survey (LFS) data from 2009 again along with ONS Supply and Use tables, the Gross Value added (GVA) from *engineering-related* sectors was[54]:

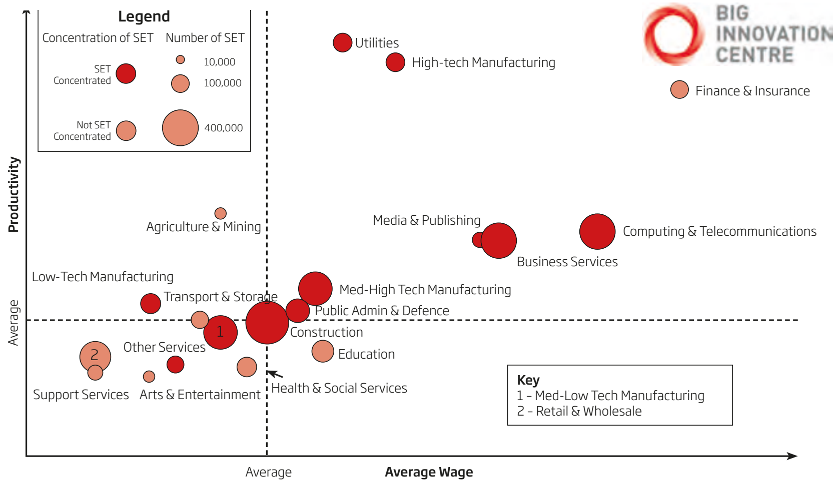
- **Manufacturing – £130 billion**
- **Utilities – £40 billion**
- **Construction – £90 billion**
- **Transport & storage – £60 billion**
- **Computing & Telecoms – £50 billion**

(Total £370 billion)

With the GVA of the total economy at £1.3 trillion in 2009, the easily identified 'engineering' output is observed to be 28% of the total economy.

54 Author's calculations

Deployment of SET occupations across the economy



Source: ONS Labour Force Survey, Annual Survey of Hours & Earnings, Supply & Use Tables, Business Registration & Employment Survey

Figure 2: UK economic indicators 2009 - average wages for SET professionals vs productivity. Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council

Results from analyses commissioned from the Big Innovation Centre by the Royal Academy of Engineering for the Technician Council are shown in Figures 2–6.

This research aims to represent graphically where those who self-declare that they work in SET occupations (as defined by SOC2000 codes using the conventions developed by the FE STEM Data Project and reported in Greenwood at al.) are deployed in the UK economy and some of the key characteristics of those sectors. It does this using scatter plots of economic indicators, with bubble size representing the number of SET workers in each sector. It is important to appreciate, however, that these plots do not imply a causal relationship between the variables presented. All data refers to 2009 unless otherwise stated (using the four 2009 calendar quarters of the LFS, with a weighted average giving the final figure – this removes any seasonal bias and increases the raw sample size to make the final estimates more robust robust) in order to remain consistent with UKCES 'Working Futures' forecasts 2010–2020.

The 20 economic sectors displayed in Figures 2–6 represent *all* of the UK economy. Each sector is constructed from a number of Standard Industry Classification (SIC) codes grouped together. The groupings were chosen carefully to give the closest practicable match to the various groupings used in the following ONS datasets:

- **Labour Force Survey**
- **'Blue Book'**
- **Annual Survey of Hours & Earnings**
- **Supply and Use Tables**
- **Business Registration & Employment Survey**

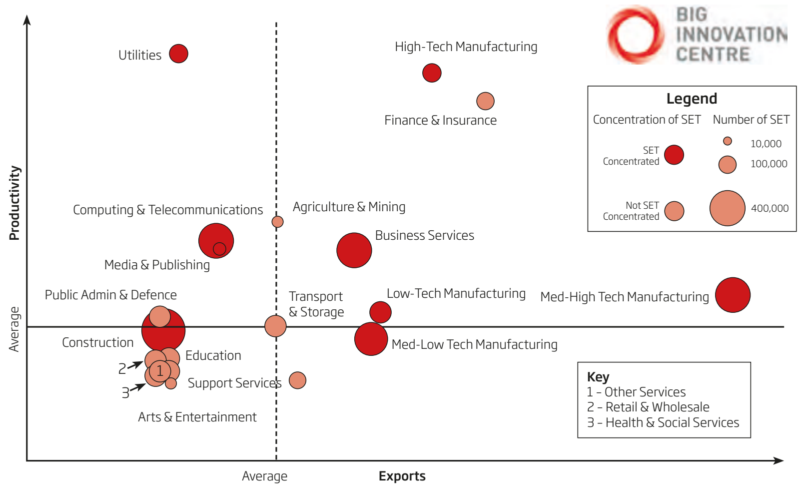
and in the UKCES 'Working Futures' forecasts 2010–2020.

Gross value added (GVA) is taken here to be a measure of sectoral output. GVA per employee is taken here as a proxy for productivity. One limitation of this measure of productivity is that it does not account for capital inputs of machines, computers and other aids to production. Some productive industries such as mining and parts of manufacturing are highly automated to the point where few workers are needed to produce a high output. For most sectors, however, it is a strong proxy for labour productivity.

Exports are shown in Figure 3. Some sectors do not lend themselves to international trade in their goods and services and this needs to be considered when assessing the relative trade performance of different sectors.

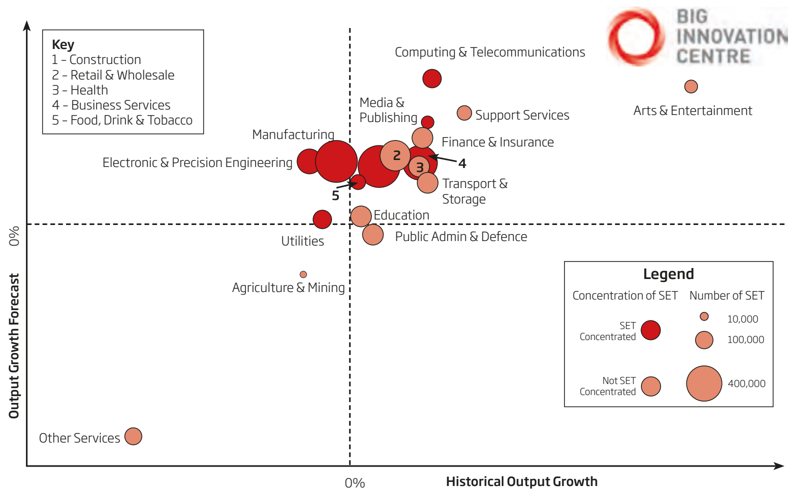
The employment forecasts in Figures 5 and 6 come from the forecasts published by UKCES in December 2011[55] and measure both the net change and the trend annual percentage change in sectoral employment between 2010 and 2020. This gives an impression of which sectors will be growing or declining

55 UKCES (2011), Working futures 2010-20, UKCES, December 2011



Source: ONS Labour Force Survey, Business Registration & Employment Survey, Supply & Use Tables,

Figure 3: UK economic indicators 2009 - productivity vs exports (with numbers and concentration of SET professionals). Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council



Source: ONS Labour Force Survey, Blue Book 2011, UKCES Working Futures 2010-20

Figure 4: UK economic indicators 2009 - output growth forecast vs historic growth (with numbers and concentration of SET professionals). Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council

in terms of future employment and also of how the structure of the UK economy will be different in 2020. It is important to note that this is a forecast. Any unexpected shocks to the UK economy occurring after the UKCES publication such as a prolonged period of recession would change the outlook.

The historical employment changes, presented in the same form as the forecasts and again taken from UKCES, illustrate the changing employment structure of the UK economy between 1990 and 2010.

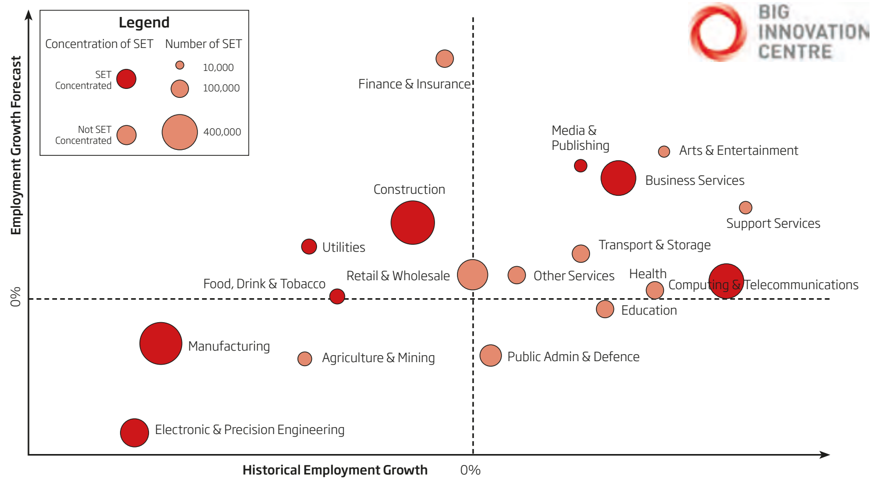
When viewing both the forecast and the historical employment data, the role of *replacement demand* should be borne in mind. The data presented in Figures: 5,6 only represents *net* changes in employment due to *expansion demand*. Much of the demand for workers is to replace those who have left, either to move to a different sector or because of retirement or incapacity. Some sectors that are shrinking in terms of employment, such as high-tech manufacturing, may still have significant job opportunities because of replacement demand that a simple view of net employment changes may obscure.

The bubble colour relates to the *concentration* of SET occupations in a given sector. Where the proportion of workers in SET occupations in a sector exceed the proportion in the economy as a whole, the bubble is coloured red.

A large number of sector-specific observations could be made following inspection of Figures: 2-6 (supplemented by inspection of the data behind these) but for brevity only the more general observations will be presented here:

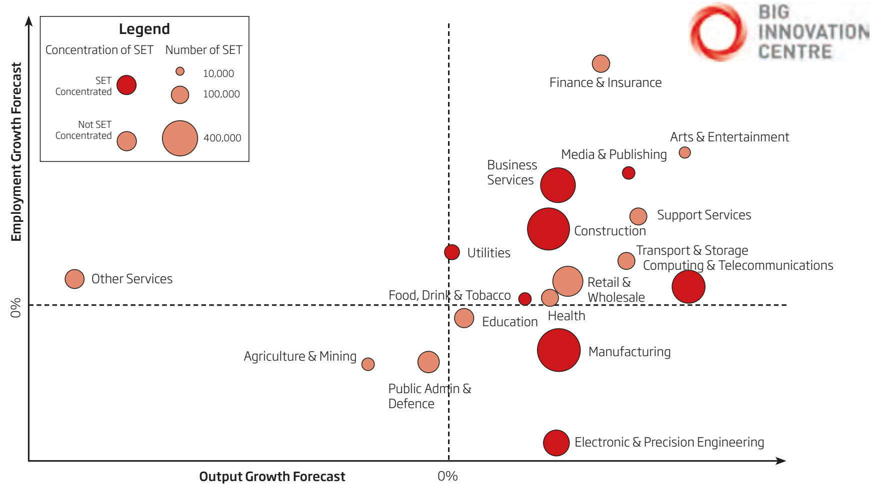
- There are 3.6 million self-declared SET workers in the UK

Figure 5: UK economic indicators 2009 - overall employment growth forecast vs historical employment growth (with numbers and concentration of SET professionals). Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council



Source: ONS Labour Force Survey, UKCES Working Futures 2010-20

Figure 6: UK economic indicators 2009 - employment growth forecast vs output growth forecast (with numbers and concentration of SET professionals). Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council



Source: ONS Labour Force Survey, UKCES Working Futures 2010-2020, Blue Book 2011

out of a working population of 30 million (12%). Of these SET workers, just over half (1.9 million) are technicians or skilled SET operatives. However, we know from analysis of the raw LFS data reported earlier that many of these do not hold the level of qualifications commonly required for professional registration.

- SET workers are found in every sector of the UK economy - least in Agriculture & Mining and most in Construction (Figure 2). Manufacturing, Computing & Telecommunications and Construction have the highest concentrations of SET workers.

- Sectors with both above average productivity and above average wages tend to have higher than average SET concentration - with Finance & Insurance being the exception (Figure 2).

- What is labelled as 'Business Services' is a sector worthy of particular attention. It has above average productivity and wages, a large number of SET workers and above average SET concentration (Figure 2). It has above average exports (Figure 3), good growth history and growth prospects (Figure 4). It has good employment prospects (Figures 5 and 6). The activities involved are:

Real Estate Activities
Legal & Accounting activities
Activities of head offices; management consultancy activities
Architectural and engineering activities; technical testing and analysis
Scientific research and development
Advertising and market research
Other professional, scientific and technical activities
Veterinary activities

Therefore the role of SET in the evolution of Business Services might be emphasised and discussed more in public policy discourse.

- The UK is clearly still in the valuable business of manufacturing. However, future jobs may mostly be there to replace retirements unless there is a rebalancing of the economy more towards an industrial base.
- Construction is an important employer of SET workers – after a period of shedding jobs it is forecast to be an expanding employer in the future.
- The importance to future growth of Computing & Telecommunications as a sector is clear. However it is also true that human and other forms of computing and telecommunication capital also enable the economic performance of many other sectors.

An inspection of HESA 'first destination' and 'longitudinal' data for graduating engineers[56] reveals:

- Engineering & technology graduate destinations (both at 6 months and 3.5 years survey points) appear consistent with what is known about the distribution of SET workers through the various sectors of the economy to meet the needs of the wider economy.
- Engineering & technology graduates are mostly (but not exclusively) found in the top three occupational groups (Senior Managerial, Professional, Associate Professional).
- Some differences in destinations for men and women are evident (data only available for first destinations) – higher proportions of women than men are found in sectors outside of the 'intuitively obvious' engineering sectors such as manufacturing and construction. Higher proportions of women than men are found in lower occupational groups.
- After 3.5 years most holders of engineering degrees are found in intuitively obvious engineering occupational groups and sectors.
- UKCES[57] two-digit SOC analysis suggests that after 3.5 years, 74% of engineering graduates are in SET occupations

56 **www.hesa.ac.uk** (accessed July 2012)

57 UKCES (2011), Working futures 2010-20, UKCES, December 2011

Labour market returns for SET occupations and STEM qualifications

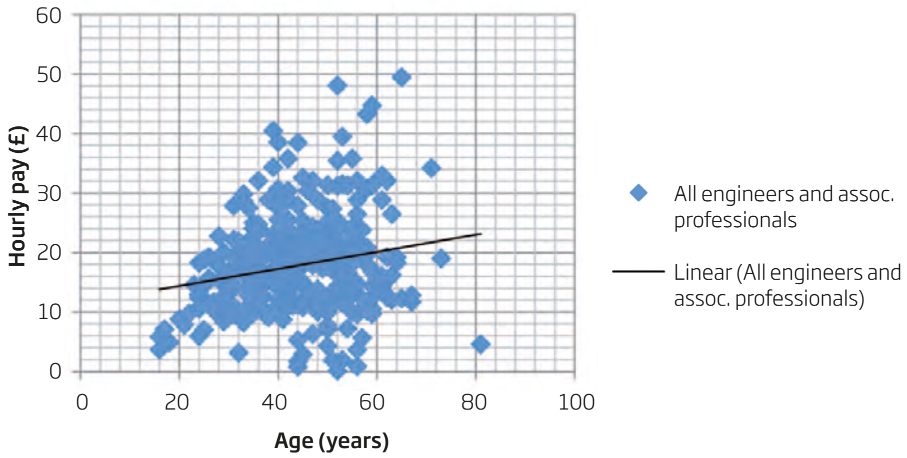


Figure 7: Raw LFS data, January-March 2011, for 'engineering professional' SOC codes. Wages are gross hourly wages.

Analysing the first quarter of Labour Force Survey data from 2011 using the classifications developed by the FE STEM Data Project and reported in Greenwood et al. reveals the following characteristics of the labour market for SET professionals, technicians and skilled operatives:

- The hourly pay of engineering professionals rises steeply with age (Figures 7,8). If age is taken as a proxy for experience then this suggest that engineering occupations pay a premium for experience.
- There is a lot of variability in wage data for engineering occupations (Figures 7, 8). For example, for older workers hourly wage can vary by a factor of three or more for individuals who are the same age in the same occupation (SOC code). This means that 'average' wage estimates are difficult to interpret when seeking to understand labour market behaviour amongst engineering occupations. This illustrates why Greenwood et al. used regression analysis to quantify the wage premia for STEM qualifications and SET occupations.
- The typical wage paid to the youngest people working in a 'professional' engineering occupation is only slightly more than the wages paid to young skilled engineering operatives (Figure 9). However, the premium paid for experience is much greater for professional engineering occupations compared to that paid for either engineering technicians or skilled engineering operatives – and they have access to the highest wages.

Although plotting raw LFS wage data is useful as it reveals the variability in wages obtained by individuals in similar occupations, statistically significant quantification of relative reward for SET occupations requires as much LFS data as possible and a sophisticated regression analysis to separate out the influence of competing factors: age, occupation, region, gender, qualifications and so forth.

Greenwood et al.[58] take Labour Force Survey data (27 quarters for the period March 2004 – December 2010 with 163,218 people surveyed aged 16–64 in England & Wales) and then identify those with STEM qualifications (using the FE STEM Data Project[59] coding conventions) and those working in SET occupations. Regression analysis is used to identify the relationship between:

- Qualification type
- Qualification level
- STEM subject
- Deployment of a STEM qualification in a SET occupation

58 Charley Greenwood, Matthew Harrison, Anna Vignoles (2011), The labour market value of STEM qualifications and occupations, Institute of Education / Royal Academy of Engineering **www.raeng.org.uk/news/releases/shownews.htm?NewsID=701**

59 Andy Frost, Clive Greatorex, Matthew Harrison, David Mason (2010), FE and Skills STEM Data Summary report, October 2010, Blue Alumni / Royal Academy of Engineering **www.thedataservice.org.uk/statistics/other_statistics_and_research**

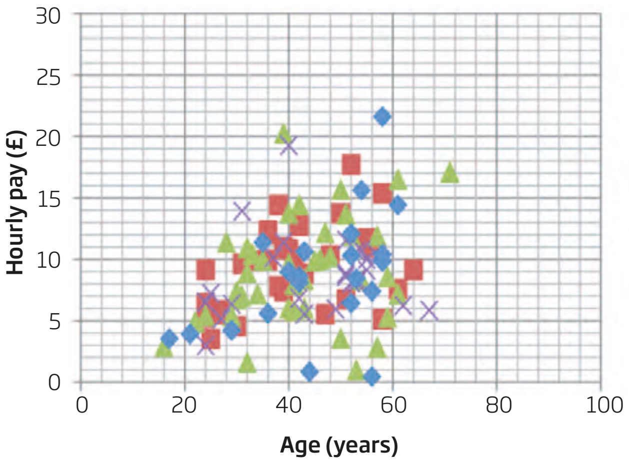


Figure 8: Raw LFS data, January-March 2011, for selected SOC codes shown in Table 1. Wages are gross hourly wages.

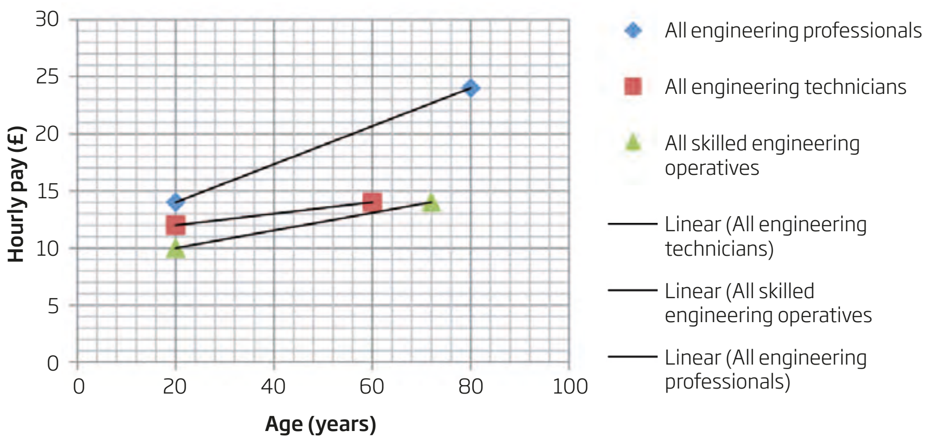


Figure 9: Comparison of linear regression lines taken from data shown Figure 2 with lines obtained from data relating to SOC codes for engineering technicians and skilled engineering operatives . Regressions of raw LFS data, January-March 2011. Wages are gross hourly wages.

on hourly wages. The method cannot account for the general ability of the individual so the findings are not necessarily causal.

Greenwood et al. find that the premium for working in STEM occupations is substantial

- 19% premium for STEM overall (average over all levels of occupation – best relative returns at occupations below Managerial)
- 10% premium for Science occupations
- 33% premium for Technology occupations
- 15% premium for Engineering occupations

Hybrid Science /Engineering occupations do not attract a premium.

Statistically significant evidence for substantial *additional* wage premium is found for many but not all STEM qualifications, particularly when used in SET occupations:

- First / Foundation degrees (up to 12% *additional* wage premium)
- HNC / HND (up to 11%)
- Level 3 NVQ (up to 10%)
- Level 3 City & Guilds (up to 14%)

Wage premia for engineering graduates have been calculated over many years as part of a general effort to understand the graduate premium and its nuances[60]:

60 Machin and Vignoles (2005), "Does Education Matter?", Steve McIntosh, (Machin & Vignoles –Eds), Princeton University Press, 2005 (page 182)

Trends in wage return: wage premium for engineering degree compared to 2 A levels

- 1993 – 19%
- 1996 – 20%
- 1999 – 23%
- 2002 – 26%
- 2009 – 32%[61] (average for all degree subjects in 2009 – 27%)

By way of comparison, the trends in wage premia for tertiary education graduates in general are[62]:

- Trends in wage premia for tertiary education graduates, 1999–2009

(100 is the reference wage for upper secondary education)

	1999	2009
UK	162	159
USA	166	179
France	150	146
Germany	135	157
OECD average	151	157

It is clear that engineering graduates not only command a significant wage premium, one that is bigger than the average for graduates, but that this premium has been increasing year after year when the average graduate wage premium has been falling in the UK[63] and in other (but not all) comparator countries.

A wage premium relative to A Levels for holding a degree in engineering is taken as good evidence that the demand for people with engineering degrees exceeds supply. The *rising* premium suggests the gap between demand and supply is widening over time. Furthermore, professional engineering registration is also associated with higher wages (Box 6).

Box 6: Professional registration for engineers and technicians and median hourly wages

Engineers and engineering technicians that meet certain competence standards set out by the engineering profession[64] can register as Chartered Engineers, Incorporated Engineers of Engineering Technicians. Analysis shows that these people enjoy higher median wages than is the norm for their occupations[65].

Median pay for engineering technicians (based on SOC conventions developed by the FE STEM Data Project and reported in Greenwood et al.) from an analysis of the Labour Force Survey data for the first quarter 2011 is £12 per hour[66]. Assuming 38 hour week and 230 working days in the year (46 weeks) this is equivalent to a gross annual salary of £21,300 per annum. Median wage for engineering professionals is found to be £29,700 per annum using a similar process. This represents a 40% uplift on median engineering technician wages.

The ERS survey of registered engineers and technicians[67] undertaken in June 2010 shows the median basic income (before bonuses etc.) of the Registered Technician to be £35,000 (circa £20 per hour). The median wage of the Incorporated Engineer was found to be £41,345 and the median wage of the Chartered Engineer to be £52,609. These are median values found for samples sizes of 1470 Chartered Engineers, 862 Incorporated Engineers and 423 Engineering Technicians in April and May 2010.

Comparing the ERS survey results for median wage of registered engineers and technicians with the medians for those occupations, it is clear that registered engineers and registered engineering technicians access significantly higher wages (at least 50% higher) than is the norm for those generic occupational classes. Given that the median wage for graduates of any discipline in the UK labour market is £31,000[68] the wage advantage enjoyed by those who are professionally registered in their engineering occupations – including at technician level – is clear.

61 BIS (2011), BIS Research Paper 45,Returns to Higher Education Qualifications, BIS, June 2011 (page 30)

62 OECD (2011), Education at a glance, OECD, 2011 (Table A8 2a)

63 For a longer view on the graduate wage premium in the UK, showing rising premium of 17 percentage points between 1980 and 2004 despite a four times increase in the number of graduates from the HE system – see Machin, S. & S. McNally (2007), Tertiary Education Systems and Labour Markets, report to the OECD for the Thematic Review of Tertiary Education, 2007

64 Set out in the UK Standard for Professional Engineering Competence, UKSPEC – available as a download from **www.engc.org.uk**

65 Author's calculations

66 Author's calculations

67 ERS (2010), Survey of registered engineers and engineering technicians, for the Engineering Council, ERS, 2010

68 BIS (2011), HE White Paper – putting students at the heart of Higher Education, BIS, 2011

Forecasts of demand for SET occupations

UKCES have published forecasts of employment growth in broad economic sectors for the period 2010–2020[69]. Analysis of the 2009 Labour Force Survey data has been carefully matched to the same economic sectors by the Big Innovation Centre under commission from the Academy. Knowing the populations and concentrations of SET professionals and SET technicians in each sector, a pro-rata forecast of *expansion demand* for SET workers is:

2012–2020 (rounding to the nearest 10,000)

- **SET professionals** ***110,000 in total***
- **SET technicians** ***70,000 in total***

Author's calculation

Estimates of retirement rates (rounding to the nearest 10,000) are made as:

- **SET professionals** ***90,000 per annum***
- **SET technicians** ***50,000 in annum***

Author's calculation

Making total forecast employment demand for the period 2012–2020 (performing the detailed calculation and rounding to the nearest 10,000 only on the final result)

- **SET professionals** ***830,000***
- **SET technicians** ***450,000 (also reported by the Technician Council[70])***

Author's calculation

Inspection of the sampled Labour Force Survey data reported in Greenwood et al.[71] shows that majority (around 80%) of these will be engineering and IT related occupations.

69 UKCES (2011), Working futures 2010–20, UKCES, December 2011

70 Technician Council (2012), Professional Technician: the future, Technician Council, 2012 (available to download from **www.professional-technician.org.uk** – accessed July 2012)

71 Charley Greenwood, Matthew Harrison, Anna Vignoles (2011), The labour market value of STEM qualifications and occupations, Institute of Education / Royal Academy of Engineering **www.raeng.org.uk/news/releases/shownews.htm?NewsID=701** – Table 7, Specification 3

Jobs and growth: SET analysis of the UKCES 2010–2020 forecasts

The data presented in Figures 2–6 can be ranked to identify key sectors for:

- **Growth**
- **Employment prospects in general**

and building on earlier calculations of the demand for SET occupations, the prospects for SET employment in particular.

Table 2 ranks the UKCES sectoral growth forecasts for the period 2010-2020. By way of comparison, in 2010 the output of the economy as measured by the chained volume measure of gross domestic product (GDP) was[72]

2010	+1.8%
2009	-4.4%
2008	-1.0%

The chained volume measure of GDP rose by 52.8% between 1990 and 2010 – an average of 2.64% per annum. Therefore, at face value, the UKCES forecast of an annual growth rate of 2.4% looks like a forecast of more or less 'business as usual' for the medium term out to 2020.

Table 2: UKCES sectoral growth forecasts for the period 2010-2020. Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council. (*) indicates a SET intensive sector.

Industry	SIC 2007 Definition	UKCES Working Futures 2010-20 & ONS Blue Book Output Growth Forecast 2010-2020 (% per annum)	
Computing & Telecommunications	61, 62	5.7%	*
Arts & Entertainment	90-93	5.6%	
Support Services	77-82	4.5%	
Media & Publishing	58-60, 63	4.2%	*
Finance & Insurance	64-66	3.6%	
Accommodation & Food	55-56	3.3%	*
Retail & Wholesale	45-47	2.8%	
Manufacturing	13-25, 29-33	2.6%	*
Business Services	68-75	2.6%	*
Electronic & Precision Engineering	26-28	2.5%	*
Health & Social Services	86-88	2.4%	
Construction	41-43	2.3%	*
Food, Drink, & Tobacco	10-12	1.8%	*
Transport & Storage	49-53	1.7%	
Education	85	0.3%	
Utilities	35-39	0.1%	*
Public Admin & Defence	84	-0.5%	
Agriculture & Mining	01-09	-2.1%	
Other Services	94-97	-8.9%	
		Average 2.4%	

72 ONS (2011) Blue book, ONS, 2011

The quarter on quarter change in chained volume GDP output around the time of the publication of the UKCES forecasts and since has been[73]

2011 Q1	+0.5%
2011 Q2	-0.1%
2011 Q3	+0.6%
2011 Q4	-0.4%
2012 Q1	-0.3%
2012 Q2	-0.7%

which would suggest that the overall UKCES growth forecasts should now be reviewed downward. However, given that the general structure of the UK economy will not change over the medium term, the ranking of sectors on growth shown in Table 2 should be largely unaffected.

Table 3 ranks the UKCES analysis of historical sectoral employment growth for the period 1990–2010. Table 4 ranks the sectoral employment growth forecast for the period 2010–2020. Table 5 ranks the result of the calculated total employment demand for SET professionals and Table 6 likewise for SET technicians.

The differences in ranking of sectors according to overall employment growth and total SET employment demand are striking. The ranking according to general employment forecasts reflect the structure of the economy: <1% agriculture, 11% manufacturing, 11% other industry and 78% services[74]. However, the total demand for SET professionals and technicians is a more complex mix of industry, service economy, manufacturing and other sectors reflecting the pervasive distribution of SET occupations throughout the economy.

Industry	SIC 2007 Definition	UKCES Working Futures 2010-20 Employment Growth 1990-2010 (% per annum)	
Support Services	77-82	3.0%	
Computing & Telecommunications	61,62	2.8%	*
Arts & Entertainment	90-93	2.1%	
Health & Social Services	86-88	2.0%	
Business Services	68-75	1.6%	*
Education	85	1.5%	
Media & Publishing	58-60, 63	1.2%	*
Accommodation & Food	55-56	0.5%	
Other Services	94-97	0.5%	
Transport & Storage	49-53	0.2%	
Public Admin & Defence	84	0.2%	
Retail & Wholesale	45-47	0.0%	
Finance & Insurance	64-66	-0.3%	
Construction	41-43	-0.7%	*
Food, Drink, & Tobacco	10-12	-1.5%	*
Utilities	35-39	-1.9%	*
Agriculture & Mining	01-09	-1.9%	
Manufacturing	13-25, 29-33	-3.5%	*
Electronic & Precision Engineering	26-28	-3.9%	*

Table 3: UKCES historical sectoral employment growth for the period 1990-2010. Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council). (*) indicates a SET intensive sector.

73 ONS (2012), ONS preliminary estimate of GDP time series data set Q2, ONS, 2012

74 World Bank (2012), World Development Indicators 2012, World Bank, 2012

Table 4: UKCES sectoral employment growth forecast for the period 2010-2020. Source: The Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council. (*) indicates a SET intensive sector.

Industry	SIC 2007 Definition	UKCES Working Futures 2010-20 Employment Forecast 2010-20 (% per annum)	
Finance & Insurance	64-66	3.4%	
Arts & Entertainment	90-93	2.1%	
Media & Publishing	58-60, 63	1.9%	*
Business Services	68-75	1.7%	*
Support Services	77-82	1.3%	
Construction	41-43	1.1%	*
Accommodation & Food	55-56	0.8%	
Utilities	35-39	0.8%	*
Transport & Storage	49-53	0.6%	
Other Services	94-97	0.4%	
Retail & Wholesale	45-47	0.3%	
Computing & Telecommunications	61,62	0.3%	*
Health & Social Services	86-88	0.1%	
Food, Drink, & Tobacco	10-12	0.1%	*
Education	85	-0.1%	
Manufacturing	13-25, 29-33	-0.6%	*
Public Admin & Defence	84	-0.8%	
Agriculture & Mining	01-09	-0.8%	
Electronic & Precision Engineering	26-28	-1.9%	*

Table 5: Calculated total (expansion plus replacement) sectoral employment demand for SET professionals for the period 2012-2020 (based on UKCES forecasts for the period and data from the Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council).

Industry	SIC 2007 Definition	Total demand SET professionals 2012-2020
Construction	41-43	170,000
Business Services	68-75	140,000
Manufacturing	13-25, 29-33	100,000
Computing & Telecommunications	61,62	100,000
Retail & Wholesale	45-47	70,000
Finance & Insurance	64-66	50,000
Transport & Storage	49-53	30,000
Utilities	35-39	20,000
Support Services	77-82	20,000
Public Admin & Defence	84	20,000
Education	85	20,000
Health & Social Services	86-88	20,000
Media & Publishing	58-60, 63	20,000
Other Services	94-97	20,000
Food, Drink, & Tobacco	10-12	10,000
Agriculture & Mining	01-09	10,000
Electronic & Precision Engineering	26-28	10,000
Accommodation & Food	55-56	---

Industry	SIC 2007 Definition	Total demand SET technicians 2012-2020
Construction	41-43	120,000
Business Services	68-75	60,000
Retail & Wholesale	45-47	50,000
Manufacturing	13-25, 29-33	40,000
Media & Publishing	58-60, 63	30,000
Transport & Storage	49-53	20,000
Computing & Telecommunications	61,62	20,000
Education	85	20,000
Public Admin & Defence	84	20,000
Health & Social Services	86-88	20,000
Utilities	35-39	10,000
Finance & Insurance	64-66	10,000
Support Services	77-82	10,000
Arts & Entertainment	90-93	10,000
Other Services	94-97	10,000
Agriculture & Mining	01-09	
Food, Drink, & Tobacco	10-12	
Electronic & Precision Engineering	26-28	
Accommodation & Food	55-56	

Table 6: Calculated total (expansion plus replacement) sectoral employment demand for SET professionals for the period 2012-2020 (based on UKCES forecasts for the period and data from the Big Innovation Centre commissioned by the Royal Academy of Engineering for the Technician Council).

Towards an industrial strategy

An industrial strategy is described here as greater explicit support and policy orientation towards areas of production in the UK economy including IT, infrastructure, construction, manufacturing and other elements of a widely-drawn 21st Century industrial base.

The UK Commission for Employment and Skills (UKCES) does not predict much rebalancing of the UK economy towards production, at least in the medium term[75]. Their predictions, published in December 2011, for annual growth in manufacturing of 2.6% (averaged over the period 2012–2020) and similar growth in construction of 2.3% look to be premature in manufacturing[76] and slow to materialise in construction due to ongoing recession[77].

With economic conditions remaining difficult in key areas of production, and these being vital to balance of trade, employment and growth, an *industrial strategy* looks increasingly important: to win the economic recovery and create both **jobs and growth.** Success of such a strategy will depend on the UK securing the engineering skills required to translate good ideas and the fruits of scientific research into innovative products and services and to operate the businesses that will provide trade, jobs and growth.

Nothwithstanding difficult economic conditions in 2012[78], with recent falls in exports[79], inspection of Tables 2–6 provides some clues for those considering the development of an 'industrial strategy'[80] for the UK out to 2020.

The top 5 sectors forecast for output growth shown in Table 2 all rely extensively on the pervasively deployed engineering disciplines of Computing, IT and Telecommunications. An industrial strategy should focus on getting skilled IT workers and other forms of IT capital into the economy as quickly as possible to support the short term route to **growth**. Longer term, there is a need to nurture a next generation of young people who have the requisite computing skills required to keep the UK competitive[81]

Tables 5 and 6 suggests that (in line with UKCES forecasts) the Construction sector has the capacity to generate high wage SET technician and SET professional jobs in the short to medium term. This sector also provides work for a significant proportion of the Business Services sector with the potential to produce further high wage professional SET jobs. An industrial strategy should focus on construction infrastructure and housing projects to support this route to **jobs**.

Tables 5 and 6 suggest significant future need for SET professionals and technicians in manufacturing. The majority of these are due to replacing existing workers leaving the sector through retirement and other means. Noting that the top 10 manufactured products *by value* in the UK are all connected with either motor vehicles, medicaments, aircraft or food and drink[82], the importance of maintaining skill levels in those areas is clear.

75 UKCES Working futures 2010–20, UKCES, December 2011

76 The Purchasing Manager's Index for manufacturing (PMI) has been at or below the 50 level (that separates expansion from contraction) for most of 2012. Source: Markit /CIPS News Release, 3rd September 2012

77 The PMI for construction has been fluctuating in the 50-55 mark for 24 months, dipping to 49.0 in August 2012 – the second lowest value since February 2010. Source: Markit /CIPS News Release, 4th September 2012

78 OECD has downgraded forecast for the UK to a contraction of 0.7% in 2012. Source: OECD Interim economic assessment, 6th September 2012 – **http://www.oecd.org/newsroom/economyeuropeanrecessionslowingglobaleconomysaysoecd.htm**

79 Total exports of goods fell by 8.4% in June 2012 compared with May 2012. Source: Monthly review of external trade statistics, June 2012 edition, ONS, 2012

80 The term 'industrial strategy' is in common usage when referring to a rebalancing of economic output more towards productive sectors. It reflects broad economic structural classification such as those used by the World Bank . The term 'industrial' however can mask the wider economic contribution made by cross-sectoral engineering-related activities such as those in computing and IT and the contribution made by engineering activities in the service sectors -see for example: Royal Academy of Engineering (2012), Industrial systems: capturing value through manufacturing, Royal Academy of Engineering, February 2012.

81 The Royal Academy of Engineering and others are addressing this issue by working with and within the UK school and college systems – for example see Royal Academy of Engineering (2012), Computing qualifications included in the 2014 Key Stage 4 performance tables: a guide for schools, Royal Academy of Engineering, June 2012

82 ONS (2012), Statistical Bulletin: UK manufacturers sales by product (PRODCOM) for 2011, 29th June 2012

Supply of STEM qualifications in England and the UK

SET professionals and SET technicians are deployed throughout the UK economy in varying concentrations. Employers will recruit to these occupations in a number of ways:

- **Experienced hires**
- **Training of existing employees**
- **Graduates**
- **Apprentices**
- **Individuals with STEM qualifications gained at school or college**

Earlier analysis of the UKCES forecasts suggested that the combined replacement and expansion demand for SET occupations for the period 2012–2020 will be

- **SET professionals** ***830,000***
- **SET technicians** ***450,000***

Which requires more than 100,000 STEM graduates per annum and circa 60,000 individuals with Level 3+ STEM qualifications[83]. The potential for recruiting these number of qualified individuals from schools (Box 7), colleges (Box 8) and universities (Box 9) is investigated here. The data presented in Boxes 7–9 suggest that:

- The requirement for more than 100,000 STEM graduates per annum for the period 2012-2020 will not be met by newly graduating STEM higher education students. With only circa 90,000 STEM graduates each year (including International students who presently cannot obtain visas to work in the UK after graduation) and knowing from the earlier analysis of HESA data that a proportion of STEM graduates choose non-SET occupations (26% of engineering graduates for example) there are clearly too few UK STEM graduates to meet the need. An uplift of at least 50% in the number of STEM graduates would be needed in general terms along with careful matching of precise occupational need and particular STEM discipline.
- The requirement for circa 60,000 individuals with Level 3+ STEM qualifications may be met by the FE & Skills sector at its current scale, although not solely from Apprenticeships unless significant uplift in engineering, ICT and particularly science Apprenticeships happens quickly. More likely a mix of Apprentices and individuals holding Level 3 and 4 vocationally-related STEM qualifications would be required.

83 As indicated earlier, analysis of the data reported in Greenwood et al. (2011), the majority of these (around 80%) will be engineering and IT related.

Box 7: STEM in Schools

This data has been taken from the Academy research[84] on the National Pupil Database examining subject combinations at Key Stage 4 in England.

GCSEs

The cohort taking GCSEs in 2009/10 in schools was 630,000. Of these:

- **14.8% (94,000) achieved A*-C in Mathematics and triple science**
- **49% (309,000) achieved A*-C in Mathematics and A*-C in 2 or more Science GCSEs (inclusive of triple science)**
- **39% (247,000) did not achieve A*-C in Mathematics**

A levels

The cohort taking A levels in schools in England in 2009/10 was 411,000. Of these individuals:

- **68,700 achieved Mathematics A level**
- **27,200 achieved Physics A level**
- **20,700 achieved both Mathematics and Physics A level**
- **31,200 achieved three or more STEM A levels**
- **131,230 achieved one or more STEM A levels**
- **280,000 achieved A levels not including any in STEM subjects**

Box 8: STEM subjects in Further Education (England only)

This data is from FE STEM data project[85]. FE Data is collected by qualifications achieved, not on learners. Learners are therefore estimated from FE STEM data analysis. In 2009/10:

- **943,000 STEM qualifications were completed by 16-18 year olds**
- **202,000 Engineering qualifications achieved**
- **121,200 qualifications at level 2 and below**
- **80,800 qualifications at level 3 and above**
- **235,000 Technology qualifications achieved**
- **164,500 qualifications at level 2 and below**
- **70,500 qualifications at level 3 and above**

- **The 934,000 STEM qualification achievements are estimated to have been achieved by:[86]**
- **150,000 Level 2 STEM learners**
- **75,000 Level 3 STEM learners**
- **33,000 Level 2 STEM apprenticeships completed**
- **29,000 Level 3 STEM apprenticeships completed**

Apprenticeships (UK wide)

Published figures from the Data Service[87] show:

- **There were 457,000 apprenticeship starts in 2010/10**
- **49,000 in Engineering and manufacturing technologies**
- **28,000 in Construction, Planning and the Built Environment**
- **19,500 in ICT**
- **10 in science and mathematics**
- **133,000 in business, administration and Law**
- **102,000 in retail and commercial enterprise**

84 Opportunity or Ability: Analysis of Key Stage 4 Science and Mathematics attainment in England 2010. Available to download from **www.educationforengineering.org.uk** (accessed – September 2012)

85 Matthew Harrison (project leader) 2011, FE STEM Data Project July 2011 report, Royal Academy of Engineering **www.thedataservice.org.uk/statistics/other_statistics_and_research**

86 Matthew Harrison, lecture at the Institute of Education, 17th November 2011

87 **www.thedataservice.org.uk** – accessed July 2012

Box 9: STEM subjects in Higher Education (UK wide)

Applications

Applications to Higher Education through UCAS[88] shows that as of the 30th June 2012:

- **Overall and when compared with 2011, there has been a 7.7% decrease in applications to all HE Institutions in the UK across all subjects (-8.9% for UK domiciled applicants). England suffered the worst decrease for UK domiciled applicants at 10.0%.**

By subject groups:

- **Engineering has seen the third smallest decrease at 2.6% of all the subject groups.**
- **Physical sciences subject group saw the smallest decrease at -1.0% with Mathematics and Computer Science at -2.5%.**
- **Subjects allied to medicine saw the only increase of any subject group at 0.10%.**
- **The Technologies group of subjects has seen a very large decline of -17.6% (albeit from a small baseline). This group includes: Minerals, Mining, Quarrying, Metallurgy, Maritime Technology, Polymer Technology, BioTechnology.**

First degrees achieved

Figures for 2009/10 graduates are as follows (all domiciles)[89]:

Engineering and technology:	21,955
Physical sciences	13,795
Computer science	14,255
Mathematical sciences	13,795
Biological sciences	32,185
Total STEM	88,660
Total Degrees	350,860
STEM proportion of all degrees:	25.3%

88 **www.ucas.ac.uk** – accessed September 2012

89 Engineering UK (2012), Engineering UK 2012: the state of engineering, Engineering UK, 2012 (page 183)

Conclusions

The findings of the Academy's research were tested by an invited panel of economists and other experts at a seminar on the 27th June 2012.

The seminar was described as an opportunity for experts in the complex issues around the impact of education and skills on the economy to compare findings and seek areas of consensus. Two principal questions were highlighted at the start of the seminar:

- **Is there a link between STEM education, training, qualifications (or all three) and valuable economic activity?**
- **Is there a link between STEM education, training, qualifications (or all three) and economic growth?**

The morning session was chaired by Dr David Grant FREng, outgoing Chair of the Royal Academy of Engineering Committee on Education and Training. It consisted of a series of short presentations from researchers in the field (the presentation slides are available from **matthew.harrison@raeng.org.uk**):

- The science workforce in the UK (Martin Houghton – TBR)
- SET occupations (Charles Levy – Big Innovation Centre)
- Demand for STEM skills in UK plc: the case of financial services (Sarah Hall – University of Nottingham)
- Engineering talent and economic recovery: graduate engineer career pathways, employability and mobility in the UK (Sarah Hall – University of Nottingham)
- The supply of STEM / SET skills (Liz Bell – UUK)
- The labour market value of STEM qualifications and occupations (Anna Vignoles – Institute of Education)
- Nuclear workforce planning (Stephen Rosevear – Cogent SSC)
- STEM workforce (Peter Glover UKCES)
- SET industries (Charles Levy – Big Innovation Centre)
- The particular case of engineering skills (Matthew Harrison – RAEng)

The afternoon session was chaired by Professor Helen Atkinson FREng, incoming Chair of the Royal Academy of Engineering Committee on Education and Training. Some prototype conclusions from the morning session were put up for discussion and refined to the following:

1. Key conclusion: **There is good econometric evidence that the demand for graduate engineers exceeds supply and the demand is pervasive across all sectors of the economy.** The implication of this is that the economy needs more graduate engineers for both engineering and non-engineering jobs. The evidence can be seen in a persistent, sizeable wage premium for people holding engineering degrees and this premium has grown over the last 20 years. There are also wage premia offered for other (but not all) STEM graduates but the size of the premium varies.
2. There is evidence that the demand for people in non-graduate SET occupations also exceeds supply because wage premia are offered for many of these occupations too.

3. There is good evidence that wage premia exist for many, but by no means all STEM qualifications. This is indicative of positive impact on productivity[90]

4. Independent models of future skills demand are predicting shortages of STEM qualified people for all occupational levels in SET (particularly professional and skilled trade levels). The models agree that much of this is replacement demand due to skilled people leaving the labour market but there are areas (nuclear new build, tunnelling, premium vehicle manufacture, banking and finance were some examples given by participants in the research) where demand is driven by expansion.

5. Surveys of the supply of STEM qualified people through the UK education and training systems when compared with models of demand suggest that that demand for STEM skills will exceed supply into the foreseeable future. Many employers also recruit experienced people from the international labour market of course but visa restrictions can make this complicated and in certain sectors (such as defence) this is not an option.

6. Independent mappings of the deployment of engineering (and STEM more generally) qualified people in the economy show STEM qualified people to be widely distributed through the economy with varying concentration in different sectors. Engineers and SET workers more generally are also widely distributed. This is a signal of the marketability of STEM qualifications and SET workers. Concerns may arise however if there is insufficient supply of STEM qualified people or SET workers to meet the needs in all sectors – noting that some sectors have inherently higher profitability and hence can offer higher wages than others.

7. The under-representation of women, those from certain ethnic minority groups and people with disabilities in SET occupations is well known[91]. There is also evidence of under-representation of people from lower socio-economic groups amongst those applying for STEM degrees[92] although more research is required to understand the impact of sequential subject decisions made prior to applying to university[93]. These under-representations provide justification for successive governments' focus on participation in and access to STEM qualifications. When considering government support for STEM, a narrative around the **strategic value** of STEM qualifications and SET occupations should also be explored with reference to innovation, international competitiveness and security of vital supplies and services (communication and IT, water, energy, food all rely on SET occupations). Case studies would be helpful. In addition, more work is required to understand the balance between the returns received from STEM qualifications and SET occupations by *the individual* and the *wider returns* received by the employer, the economy, society and so on.

90 Increasing productivity is one component of the simplest model for growth – the other being an increase in employment (the number of people working and the number of hours worked). Example source: BIS (2010), Economics Paper No 4: Supporting analysis for 'Skills for Growth' – the national skills strategy

91 UKRC (2010), Women and men in science engineering and technology: the UK statistics guide 2010, UK Resource Centre for Women in SET, 2010 (pages 81, 94, 103)

92 Engineering UK (2012), Engineering UK 2012: the state of engineering, Engineering UK, 2012 (page 166)

93 There are known links between household income and participation in higher education (Source: Jake Anders (2012), The link between household income, university applications and university attendance, FISCAL STUDIES, vol. 33, no. 2, pp. 185–210 ,2012) and the gap in participation between richer and poorer young people largely emerges before the point of application. The analysis has not yet been extended to subject of degree.

Starting from the clear need to stimulate economic growth and jobs in the UK, the key messages from this research are:

An industrial strategy, being greater explicit support and orientation towards areas of production in the UK economy including IT, infrastructure, construction, manufacturing and other elements of a widely-drawn 21st Century industrial base requires investment in particular types of human and other capital. A focus on UK skills in areas of existing and potential strength such as Computing & Telecommunications, Manufacturing and Construction could help deliver the objectives of and industrial strategy in the short to medium term.

SET occupations, and STEM qualifications can have significant value to the individual and the demand for them is pervasive across the economy signifying that they have wide value.

There is high demand for STEM graduates, and for certain disciplines the evidence is that demand exceeds supply.

This is discussed in Box 10 for the particular case of engineering graduates where the evidence for a shortage is strong.

> "I believe leadership requires three core skills: the ability to define a vision that fits your context, the ability to align diverse parties to work towards that vision, and an ability to execute that vision efficiently. Engineers, by the very nature of their training and their work, are equipped with these skills better than any other profession."
>
> **Lord Browne of Madingley**[97]

Box 10: Five signs that the economy needs more graduate level engineers

Sign 1

There is good econometric evidence that the demand for graduate engineers exceeds supply and the demand is pervasive across the economy. The evidence can be seen in a persistent, sizeable wage premium for people holding engineering degrees and this premium has grown over the last 20 years. There are also premia offered for other (but not all) STEM graduates but the size of the premium varies.

Sign 2

The UK Labour Force Survey shows that people in engineering occupations (and science, engineering, technology (SET) more widely) are found pervasively throughout the economy – although concentrations vary between sectors. Engineers are needed in all sectors of the economy – demand for them is coming from both service and productive sectors. The rising wage premium shows there is competition for a scare engineering resource. There is also evidence that engineering graduates are prized for their capabilities generally and there is competition to attract them into non-engineering roles too. This drives up the wage premium further.

Sign 3

Models of demand show the need for 830,000 SET professionals by 2020 with a high proportion being engineers (including IT). Demand is mostly replacement demand in the medium term. Further numbers will be demanded for deployment in non-SET roles. Surveys of the supply of STEM qualified people through the UK education and training systems show that this demand will not be met by fresh graduates from UK universities (only 89,000 STEM graduates per year). Many employers also recruit experienced people from the international labour market of course but visa restrictions can make this complicated and in certain sectors (such as defence) this is not an option.

Sign 4

Assessments of national strategic risk show that engineers are needed to keep vital industries and services going: energy, water, sanitation, communications, IT systems.

Rising wage premia, coupled with warnings of critical skills shortages from employers[94] and the research base[95] show that this vital resource is currently stretched very thin – and the median age of the Chartered engineer rises 10 years for every 14 years that elapse.

Sign 5

There are intangibles to consider: innovation[96], R&D capital, IT capital, organisational and leadership capital. Engineers have proven important to all of these.

94 These are rising towards a pre-recession high – see IET (2012), Engineering and Technology: skills demand in industry, Institute of Engineering and Technology, 2012

95 A vision for UK research, Council for Science and Technology, March 2010

96 For a ranking of investment in asset categories linked to innovation within UK firms of different sizes in different sectors – see NESTA (2010), Investing in innovation: findings from the UK investment in intangible asset survey, NESTA, July 2010

97 Royal Academy of Engineering (2011), For the engineering leaders of tomorrow, two lectures by Lord Browne of Madingley, Royal Academy of Engineering, 2011

ROYAL
ACADEMY OF
ENGINEERING

As the UK's national academy for engineering, we bring together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering. We provide analysis and policy support to promote the UK's role as a great place from which to do business. We take a lead on engineering education and we invest in the UK's world class research base to underpin innovation. We work to improve public awareness and understanding of engineering. We are a national academy with a global outlook and use our international partnerships to ensure that the UK benefits from international networks, expertise and investment.

The Academy's work programmes are driven by four strategic challenges, each of which provides a key contribution to a strong and vibrant engineering sector and to the health and wealth of society:

Drive faster and more balanced economic growth

Foster better education and skills

Lead the profession

Promote engineering at the heart of society

Royal Academy of Engineering
3 Carlton House Terrace, London SW1Y 5DG

Tel: +44 (0)20 7766 0600
www.raeng.org.uk

Registered charity number 293074