UK COMMISSION FOR EMPLOYMENT AND SKILLS

The Supply of and Demand for High-Level STEM Skills

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Intelligence Investment Impact

The Supply of and Demand for High-Level STEM Skills

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Foreword

The UK Commission for Employment and Skills is a social partnership, led by Commissioners from large and small employers, trade unions and the voluntary sector. Our ambition is to transform the UK's approach to investing in the skills of people as an intrinsic part of securing jobs and growth. Our strategic objectives are to:

- Maximise the **impact** of employment and skills policies and employer behaviour to support jobs and growth and secure an internationally competitive skills base;
- Work with businesses to develop the best market solutions which leverage greater investment in skills;
- Provide outstanding labour market intelligence which helps businesses and people make the best choices for them.

The third objective, relating to intelligence, reflects an increasing outward focus to the UK Commission's research activities, as it seeks to facilitate a better informed labour market, in which decisions about careers and skills are based on sound and accessible evidence. Relatedly, impartial research evidence is used to underpin compelling messages that promote a call to action to increase employers' investment in the skills of their people.

Intelligence is also integral to the two other strategic objectives. In seeking to lever greater investment in skills, the intelligence function serves to identify opportunities where our investments can bring the greatest leverage and economic return. The UK Commission's third strategic objective, to maximise the impact of policy and employer behaviour to achieve an internationally competitive skills base, is supported by the development of an evidence base on best practice: "what works?" in a policy context.

Our research programme provides a robust evidence base for our insights and actions, drawing on good practice and the most innovative thinking. The research programme is underpinned by a number of core principles including the importance of: ensuring 'relevance' to our most pressing strategic priorities; 'salience' and effectively translating and sharing the key insights we find; international benchmarking and drawing insights from good practice abroad; high quality analysis which is leading edge, robust and action orientated; being responsive to immediate needs as well as taking a longer term perspective. We also work closely with key partners to ensure a co-ordinated approach to research.

This Evidence Report examines the supply of and demand for science, technology, engineering and mathematics (STEM) skills in the UK. It has long been argued that STEM shortages, particularly at graduate and post-graduate levels, have detrimentally affected the performance of the UK economy. The present report is an attempt to look in more depth at the supply of and demand for STEM degree holders, as well as exploring the extent and nature of market imbalances.

Sharing the findings of our research and engaging with our audience is important to further develop the evidence on which we base our work. Evidence Reports are our chief means of reporting our detailed analytical work. All of our outputs can be accessed on the UK Commission's website at www.ukces.org.uk

But these outputs are only the beginning of the process and we are engaged in other mechanisms to share our findings, debate the issues they raise and extend their reach and impact.

We hope you find this report useful and informative. If you would like to provide any feedback or comments, or have any queries please e-mail info@ukces.org.uk, quoting the report title or series number.

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Deputy Director

UK Commission for Employment and Skills

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Executive Summary

Introduction

Science, technology, engineering and mathematics (STEM) skills are crucial to innovation and growth. **Studies have shown that innovation-active enterprises employ higher proportions of graduates in general and, in particular, a higher proportion of STEM graduates than their non-innovative counterparts (CIHE, 2007 p. 17).**

The report provides estimates of the supply of (employment plus an estimate of those seeking work in STEM occupations) and demand for (employment plus vacancies for STEM posts) STEM graduates. The results are primarily based on the Labour Force Survey, but many other sources of information are utilised.

The measures of supply and demand are brought together for the UK, at the national level for England, Scotland, Wales and Northern Ireland, and at the level of the nine planning regions for England. The study examines the estimated historical and projected market imbalances for STEM.

STEM Occupations and Sectors

Degrees are divided into:

- Medicine and related STEM (comprising Medicine and dentistry and Medical related subjects)
- Core STEM (comprising: Biological sciences; Agricultural sciences; Physical / environmental sciences; Mathematical sciences and computing; Engineering, Technology and Architecture)
- Non-STEM (all remaining subject areas)

The principal focus of the present study is on Core STEM, but comparisons are made with the other two degree groups and with non-graduates.

Medicine and related activities are separated from the rest of STEM because of: the extremely strong link between subject of degree and occupation and their tendency to dominate all other STEM jobs in the occupations and sectors where they are mainly located.

Occupations and sectors are classified as STEM by jointly examining their STEM densities (the share of the occupation's or the sector's total employment that comprises STEM graduates) and STEM proportions (the percentage of all STEM workers that are employed by that occupation or that sector).

Using LFS data to classify sectors and occupations into STEM, it was found that in 2011:

- Medicine and related STEM (Med STEM) occupations employ 65 per cent of Med STEM degree holders
- Core STEM occupations employ 40 per cent of Core STEM degree holders
- Med STEM sectors employ 60 per cent of Med STEM degree holders
- Core STEM sectors employ 45 per cent of Core STEM degree holders

Career Paths of STEM Graduates

New STEM Graduates

Evidence from HESA data does not point to major differences between STEM and non-STEM graduates in terms of their labour market status six months after graduation. Over the last ten years or so:

- newly qualified non-STEM were slightly more likely to be in employment than Core STEM, and slightly less hard hit by the recession
- Core STEM graduates are more likely be in education than both Med STEM and non-STEM graduates and the recession added a further incentive for this route

Data from the LFS suggests that a majority of new Med STEM graduates enter jobs in Medicine. In 2011,

- 58 per cent of employed new Med STEM graduates work in a Med STEM job in a Med STEM sector;
- 11 per cent work in non-STEM jobs in Med STEM sectors; and
- 23 per cent work in non-STEM jobs in non-STEM sectors.

Between 2001 and 2011, the proportion of graduates entering Medicine and related jobs in Medicine and related sectors increased.

LFS data on new graduates shows that in 2011:

- 16 per cent of employed new Core STEM graduates are working in Core STEM jobs in Core STEM sectors;
- 12 per cent are working in non-STEM jobs in Core STEM sectors;
- 6 per cent are working in STEM jobs in non-Core STEM sectors; and
- 66 per cent are working in a non-Core STEM job in a non-Core STEM sector (up from 52 per cent in 2001).

Thus, in 2011, only a third of new Core STEM graduates worked in either a Core STEM job or a Core STEM sector or both, which was down from 45 per cent in 2001. This drop is partly the result a change in occupational and sectoral classifications, but also reflects a general trend of dispersion of Core STEM workers from traditional Core STEM occupations and sectors, spreading out throughout the overall workforce. It may be the consequence of less demanding study programmes and the emergence of new subjects, such as sports science.

The recession is likely to have exacerbated this trend, forcing new graduates to take whatever jobs they could find. Several interviewees echoed the thoughts of an employer in the pharmaceutical sector, “With the economy in the current state, I’d imagine that graduates will take whatever they can get and hope that when the economy turns around, they can then start to get jobs that are better suited to their skills and qualifications”.

However, STEM degree holders working in a non-STEM occupation may still be using their STEM skills. A representative from a chemical firm stated that, “Most of our sales and marketing people have chemistry degrees, and a few chemical engineers, because we sell business to business ... so they have to be able to understand the chemistry, and talk the same language as these people”.

Many of the interviewees expressed concerns that difficulties in recruiting STEM graduates would become harder in the future when the economy picked up and that growth areas would require more STEM skills.

Some employers were optimistic that apprenticeships, which would eventually lead to a STEM degree, were the way to increase overall supply, to increase loyalty to the employer and create graduates with both STEM skills and a familiarity with the way business works. It was also pointed out that this route avoids the higher university tuition fees.

Careers of the Overall STEM Workforce

The share of employed Core STEM degree holders that work in Core STEM occupations declined between 2001 and 2010[1]. Although employment in Core STEM occupations grew faster than overall employment over this period, the increase in the supply of Core STEM degree holders was even larger, resulting in a declining share of the number of Core STEM degree holders working in Core STEM jobs. This may also be the result of new jobs and new sectors that require STEM skills that haven't been included in the definition of STEM, but are currently too small to be identified as STEM.

The likelihood that a Core STEM degree holder works in a Core STEM sector and/or occupation increases with age. In 2010:

- 63 per cent of employed Core STEM degree holders aged 55 to 59 worked in a Core STEM occupation compared with only 51 per cent of the overall STEM employment
- 48 per cent of those aged 50 to 54 who were employed and holding a Core STEM degree worked in a Core STEM sector, compared to 42 per cent of the overall Core STEM employment

While this may reflect career paths over time, it may also be because Core STEM sectors are more mature.

Scenarios based on Stock Flow Modelling

If the employment rate in 2020 rose to its 2007 value, there could be an additional 180,000 Core STEM degree holders in employment compared to a scenario based on the 2011 employment rates. While the difference between the employment rates (around 87 per cent for Core STEM in 2007 compared with 84 per cent in 2011) is small, it makes a large difference to Core STEM employment.

Increasing both the employment rates back to 2007 levels <u>and</u> the share of Core STEM graduates that work in Core STEM occupations to the 2001 levels of 60 per cent would lead to an additional 400,000 more Core STEM degree holders employed in Core STEM jobs in 2020 compared to a scenario based on the 2011 level of employment and level of STEM degree holders in STEM jobs.

[1] 2010 is used here as the occupational classification changes the occupational definitions in 2011.

There may well be a problem with individuals displaced from STEM occupations moving back into STEM if they have not kept pace with changes in science and technology. Several of the interviewees argued that shifts back into STEM jobs become difficult or impossible and this potential source of supply becomes lost. Seeing a similar problem in the USA, Hira (2009, p. 58) called for the Department of Labor to work with scientific and engineering professional associations to move towards the continuous education of STEM workers and the retraining of displaced mid-career STEM workers.

Retirement

Although the recession has slightly impacted on retirement trends, causing some older workers to retire when faced with redundancy, in general the inactivity rates have been decreasing for those aged 50 and over. In 2002, the inactivity rates for Core STEM degree holders aged 50-54, 55-60 and 60-64 were 11, 20 and 48 per cent, respectively. In 2011, the comparable inactivity rates were five, 18 and 47 per cent.

Stock flow scenarios comparing the supply of Core STEM degree holders based on current retirement rates with the supply based on a predicted future activity rates suggest that increases in retirement ages over current levels to an additional 60,000 Core STEM degree holders in the work force in 2020. However, it is the inflow of new STEM graduates that is more likely to help ensure workers have knowledge of the latest science and technology – retaining older individuals does not do this.

Commuting Patterns

Commuting is especially important to London, the South East, the East of England and the East Midlands. In 2011**,** as a result of commuting:

- London has a net gain of 87,000 Core STEM workers;
- South East has a net loss of 50,000 Core STEM workers;
- East of England has a net loss 20,000 Core STEM workers; and
- East Midlands has a net loss of 22,000 Core STEM workers.

Interviews with STEM employers consistently indicate that London acts as a magnet to STEM workers at the expense of other parts of the country. Employers have pointed to difficulties hiring engineers, scientists and software developers with the right skills because their location is outside of London. Exceptions include pharmaceuticals, whose location is gravitating to Cambridge / Oxford, and engineering companies, whose head offices tend to be outside of London.

Trends based on the historical commuting patterns observed from 2001 to 2011, indicate that the net gain of workers by London will increase and there will be higher net losses in the South East, East of England and East Midlands.

Supply, Demand and Market Imbalances

Most of the effects of the recession on Core STEM supply have been on the newly graduated. For this group, there was a sharp rise in the inactivity rate following the onset of the recession after 2007. Many of these inactive new graduates remained in full-time education (see Section 3.3). However, the effect on Core STEM as a whole has been much more modest, with a rise of 2.7 percentage points in the rate of inactivity in the UK.

The baseline projections assume that these individuals will become part of the supply as the economy recovers as Core STEM degree holders in post graduate education graduate and enter the workforce and new graduates will become more likely to enter the workforce upon graduation rather continuing with their education as jobs become more available.

Estimates of vacancy ratios (the number of vacancies divided by employment) do not suggest a higher vacancy rate for Core STEM vacancies (in all occupations) or for vacancies in STEM occupations only.

For instance, in 2007 the overall vacancy ratio for England was 2.6 but only 2.4 for Core STEM vacancies (in all occupations) and 2.7 for Core STEM occupations as a group. However, there are a few Core STEM occupations that do have higher than average vacancy rates (e.g. Engineering Professions had a vacancy rate of 4.5 in East of England and Architects had a vacancy rate of 6.4 in England).

Supply and demand calculations for 2020 under both the “2007” (pre-recession) and “2011” (recession) scenarios do not suggest an overall shortage of STEM graduates (in terms of numbers) in most regions or nations of the UK.

However the baseline “2007 scenario” predicts a few shortages such as: 7,000 Med STEM graduates in the UK, 2,000 Core STEM graduates in Scotland, and 1,500 Core STEM graduates in the South East. Under the less optimistic, 2011 scenario there is no overall predicted shortage.

This result needs to be interpreted with care. In particular, it does not mean there will be no shortages at all – as different disciplines will differ and employers can be looking for very specific areas of knowledge and expertise, for example:

- One interviewee noted that, “Companies like JLR are looking for electrical engineers but cannot find them as they have been ‘taken up’ by the power and energy industries: that’s a specific skill but it’s at quite a high level”.
- A representative of one of the major engineering companies noted, “For mechanical engineering, I would agree [there is no shortage]. However, for electrical / electronics, there are simply not enough graduates with the right degree and employers are trying to recruit from a small pool of those with the right degree content (i.e. higher-voltage direct current is a pre-requisite for the transmission and distribution industry: there the supply of graduates is inadequate)”.

It became clear from a number of the interviews that recruitment of certain types of Core STEM took place from a restricted number of universities – those that gave a rigorous foundation in the disciplines required. In order to cut costs, some universities have cut back on the equipment and laboratories, which has led to graduates with less hands-on experience.

Projected Core STEM unemployment per vacancy based upon the high (“2007”) scenario is close to unity (1.4) in 2020, a surplus of only one Core STEM degree holder per 100 STEM employees (broadly the same as the market for non-STEM). At this stage, specific shortages being experienced at the present will begin to evolve into more general shortages. The market for Med STEM is projected to be even tighter, while the market for non-graduates will still be fairly slack.

The results, however, are very sensitive to changes in demand, for example, based upon the “2007” scenario in 2020:

- A Core STEM vacancy rate of about four per cent produces an approximate balance between supply and demand for England as a whole.
- Increasing the vacancy ratios from those obtained by the proportional method to those obtained by regression analysis results in a shortage of 95,000 Core STEM degree holders in the UK.
- Rebalancing the economy towards manufacturing which results in a one per cent higher demand for STEM in 2020 would result in a small shortage of Core STEM under the 2007 scenario.

Under the prolonged recession (2011 scenario) there is still an excess of Core STEM supply. The same trends hold out for the four nations and the nine English planning regions, using the regression vacancy densities gives a shortage of Core STEM under the 2007 scenario but not under the 2011 scenario.

Core STEM vacancies are more likely to be hard-to-fill. Vacancies for Core STEM are more likely to be hard-to-fill than the vacancies overall and a return to 2007 vacancy rates suggest that there will be problems with Core STEM recruitment.

- Before the recession, 34 per cent of Core STEM vacancies in England were hard-to-fill, compared with 30 per cent of all vacancies and 27 per cent for non-graduates.
- After the recession, 26 per cent of Core STEM vacancies in England were hard-to-fill, compared with 22 per cent of overall vacancies and 18 per cent for non-graduates.

There are important differences with hard-to-fill vacancies across the regions and the cross-regional patterns seem sensitive to the overall level of economic activity.

These findings, along with the results of the interviews, are largely consistent with those of specific recruitment difficulties in some STEM-related sectors where employers report insufficient UK candidates of suitable quality.[2] The interviews also confirmed another earlier finding that, while in some instances these difficulties relate to the lack of applicants with suitable STEM skills, they may also result from "broader concerns about a lack of well-rounded candidates with technical skills, broader competencies, such as mathematical capability, and practical work experience".[3]

[2] In particular, the biosciences, engineering and IT of the quality they are seeking" (BIS, 2009 p. 4).
[3] BIS (2009, p. 4).

1 Introduction

1.1 Background to the interest in STEM skills

Science, Technology, Engineering and Mathematics (STEM) skills are widely recognised to be important for innovation and growth. The main economic battle will be fought over the production and use of new technologies that not only maintain and expand the demand for a country's products and services, but also offer highly skilled employment opportunities with high wages. As Romer and Griliches (1993, p. 345) succinctly put it,

> "Ultimately, all increases in standards of living can be traced to discoveries of more valuable arrangements for the things in the earth's crust and atmosphere… No amount of savings and investment, no policy of macroeconomic fine-tuning, no set of tax and spending incentives can generate sustained economic growth unless it is accompanied by the countless large and small discoveries that are required to create more value from a fixed set of natural resources."

It is not surprising, therefore, that there has been a long history of interest in the market for STEM skills, with a resurgence in recent years which reflects the need for the UK to shift up a gear given the emergence of the economic power houses of the Asia Pacific and South America. It is not possible for an advanced economy with relatively high labour costs, such as the UK, to sustain its competitive advantage by producing standard products, using standard processes (Dyson, 2010, p. 8); invention and innovation are required.

> "Advantage must come from the ability to create and then commercialize new products and processes, shifting the technology frontier as fast as their rivals can catch up". (Porter and Stern, 2002, p. 2)

At the same time, the record does not suggest that the aspiration to maintain the UK at the forefront of invention and innovation is being met. The Royal Society (2010, p. 70), for example, reports that the UK's investment in science and technology is falling behind its competitors and is putting the country at risk of losing talent abroad which, ultimately, will reduce economic prosperity. Without sufficient investment,

> "Britain potentially faces a situation similar to that which confronted the scientific community in the mid-1980s when year-on-year cuts had major impacts on facilities and infrastructure, destroyed morale, drove top scientists abroad and ultimately affected the nation's ability to remain at the leading edge of the technological and scientific frontier." (Levy and Hopkins, 2010, p. 33).

While not all acts of creativity can be traced to the door of those with STEM qualifications and not all of those with STEM qualifications are involved with invention and innovation, there is sufficient evidence to the link the two. For example, studies have shown that innovation-active enterprises employ higher proportions of graduates in general and, in particular, a higher proportion of STEM graduates than their non-innovative counterparts (CIHE, 2007, p. 17).

The Smith Review of STEM skills found that establishments with high levels of innovative activity have roughly twice the average share of employees educated at degree level (CIHE, 2007 p. 17). STEM graduates in particular are correlated with innovation and not just for traditional STEM enterprises. The Smith Review found that in innovative engineering based manufacturing businesses, eight per cent of their employees are STEM graduates and four per cent are graduates with other degrees (*ibid*. p. 17). In knowledge intensive service businesses (including financial services), innovative firms have 24 per cent of their employees with science and engineering degrees and 20 per cent with other degrees (*ibid*. p. 17).

Similarly, Levy and Hopkins (2010, p. 37) found that about 45 per cent of graduates working in innovation-active firms in manufacturing and knowledge-intensive business service industries had a degree in a STEM subject compared to only about 30 per cent of graduates in non-innovative firms. Levy and Hopkins (2010, p. 35) also report that the presence of STEM departments in universities is of central importance to the wider innovation system.

The DTI (2006b, p. 16) report that enterprises with a high level of innovative activity had approximately twice the average share of employees educated at degree level, but that STEM degrees in particular were associated with innovation activity in both STEM and non-STEM sectors.

According to a report from the Royal Society (2009), STEM skills are also of central importance to innovation in service sectors. The report notes that:

> "STEM capabilities are often internalised within highly innovative service organisations – one example is the search algorithm, which was the initial basis of Google's success".

STEM skills are central to the infrastructure of highly innovative services – computing, communications, IT and database technology have enabled many areas of service innovation; and,

> "… service sector organisations often rely heavily on external STEM capabilities for their innovations – dependent on bought-in expertise or technology, collaborations with suppliers, service users or consultants to solve challenges in innovative and competitive ways". (*ibid*. p. ix).

1.2 Previous Reports on Supply of STEM Skills

Some previous reports on the supply of STEM skills found a balance between supply and demand for STEM at a broad level but make a distinction between shortage of STEM qualified workers in general and in a shortage of STEM degree holders with the right skills. For instance, The Royal Society (2008, pp. 12-13) states:

> "We concluded in '*A degree of concern?'* that, at a broad level, there is a balance between supply and demand, and we continue to believe that this is the case. However, further consideration has suggested that, notwithstanding this broad balance, there are specific industries/sectors or particular subjects where the supply of adequately qualified STEM graduates/workers does not fully meet the demand, so that shortages exist." (Royal Society 2008 p. 14).

Semta also suggests that there is no problem with supply but that there may be with the quality of graduates.

> "Since the fraction of graduates from the relevant courses being recruited by Semta employers is comparatively low (less than a third for the broader analysis and less than 15% - and often considerably lower - for the narrow analysis) there is no shortage of numbers of graduates from relevant courses. This does not mean that there are no issues with the attractiveness of both applicants and recruiting employers in this marketplace: the issues are likely to be of perceived quality of applicants and the image of Semta's sectors to these graduates." (Semta, 2010 p. 71).

On the other hand, the Roberts Review (2002, p. 2) expresses concerns about the future supply of STEM graduates, citing a decline of enrolment in some STEM subjects. Although this decline in enrolment in STEM courses has been reversed in the decade after the review was published, later studies express concerns about students studying the "wrong" STEM subjects.

The Sainsbury review finds that although the number of STEM students has increased in recent years, both in absolute and percentage terms, there are still concerns "that there may be a significant mismatch between STEM subjects taken by students and the job opportunities that are likely to be available to them, and that this mismatch may be disappointing for them and may lead to shortages in the economy" (Sainsbury Review, 2007 p. 7). According to the House of Lords (2012 p. 35), "… a significant proportion of the growth of STEM graduates in recent years has occurred in newer courses, rather than the more traditional STEM subjects, which have reportedly been popularised by, for example, television programmes on forensic science or by changes in popular culture leading to an increase in sports science courses."

The House of Lords report also finds that even students enrolled in more traditional STEM courses may lack the necessary skills for employment:

> "The ABPI told us, for example, that "… although the numbers of STEM students and graduates have been increasing in recent years … many choose to study subjects which do not provide the appropriate skills for roles in academic or industrial research and development or for other jobs in industry .... Many will not have studied the topics which provide essential skills for bioscience research". We also learned, to our astonishment, that graduates from biochemistry can leave HEIs with limited experience of practical laboratory work." (2011, p. 46).

A recent report by the Royal Academy of Engineering (2012), predicts a shortage of STEM workers between 2012 and 2020. The report estimates the future demand for STEM professionals using the projected employment demands by sector from Working Futures IV and using LFS data on populations and concentrations of STEM professionals in each sector to obtain a pro-rata forecast of demand for STEM workers (Royal Academy, 2012 p. 23). Based on these calculations, the report concludes than an additional 830,000 STEM professionals will be required in the UK between 2012 and 2020 (*ibid.* p. 23). The report estimates that the annual supply of STEM workers[4] will increase around 90,000, the number of first degrees obtained in STEM in 2010/11 (*ibid.* p. 31), resulting in a shortfall of around 10,000 per year.

[4] The Royal Academy's definition of STE includes Engineering and Technology, Physical Sciences, Computer Sciences, Mathematics and Biological Sciences. It does not include Architecture, Agriculture Sciences or medical subjects.

The recent Heseltine Report (2012 p. 178) also expressed concerns about the future supply of STEM:

> "Universities and employers should develop a model where a commitment from firms of between a third and a half of a student's course fees will commit the student to working for that employer for a fixed number of years after graduation. … This approach is likely to be particularly valuable in the STEM … sectors where there remain concerns that there will be a shortfall of graduates in filling the anticipated vacancies. It is estimated that there will be a requirement for more than 100,000 STEM graduates per annum for the period 2012–2020 and that this will not be met by newly graduating STEM students who currently number only about 90,000 per year. The gap will, in fact, be wider than this because a significant proportion of STEM graduates will ultimately choose non-STEM occupations. It is estimated, for example, that 26% of engineering graduates do not enter the engineering profession."

1.3 Issues with the STEM market

If high level STEM skills are so essential to underpinning the UK's competitive advantage, then it clearly would be of considerable concern if evidence can be found of shortages in the supply of such skills. Equally, while STEM skills might be widely employable in different sectors, on balance, they are expensive to produce and individuals and society may not need to bear the additional cost if they are not in short supply.

While the potential importance of STEM shortages is without question, establishing the magnitude of current and possible future market imbalances is problematic. The House of Lords Report (2012, p. 6), for example, points to a "lack of reliable data on the supply and demand of STEM graduates and postgraduates" which makes it "very difficult to assess whether there is in fact a shortage of STEM graduates and postgraduates and in which sectors." Similarly, BIS (2009, p. 6) concluded that "any numerical estimate of future demand for STEM qualifications – and particularly specific STEM subjects – will be highly speculative."

There is an important issue as to what constitutes STEM degrees, STEM occupations and STEM sectors. While it is fairly easy to spot, say a STEM firm (e.g. Caterpillar, GKN and Rolls-Royce would be obvious examples), it is much more difficult to draw a line between what is STEM and what is not STEM. While the present study attempts a systematic investigation of STEM densities (the percentage of a sector's or occupation's workforce that hold STEM qualifications) and STEM proportions (the proportion of the nation's or region's STEM held by a particular sector or occupation), the issue of precisely where to draw the line between STEM and non-STEM never goes away.

It is important to consider both when classifying occupations and sectors. For instance, some sectors with a high STEM proportion such as retail trade and the finance sector would not be viewed as traditional STEM sectors. In retail the density is very low, which is a good reason to exclude it. However, the density in finance is fairly high. While it may be argued that finance is directly using STEM skills, particularly mathematics and statistics, it is not so clear that the recruitment of physical scientists and engineers to the sector because of their numeracy skills is necessarily the best use of their talents from society's perspective. Several interviewees argued that training physical scientists and engineers is relatively expensive (e.g. in developing laboratory skills), so these degrees may not be the most efficient way of producing the skills the financial services sector needs.

This analysis highlights other issues with understanding the market for STEM, particularly in defining STEM sectors (as opposed to STEM occupations). First, high STEM sector densities may be the result of small sector sizes, where it is the supply of individuals to the sector rather than the demand for STEM skills which is important (particularly as STEM graduates can often do non-STEM work, but non-STEM graduates can rarely carry out STEM activities). Second, small enterprises and emerging sectors (arising from new inventions and innovations) are likely to be both under-sampled by surveys such as the LFS, and to be hidden away within larger sectors until they become sufficiently important in size.

While the supply chain of STEM individuals begins with the choice of and success in relevant GCSE and A-level subjects (such as science and mathematics), these issues largely lie outside of the scope of the present study (although reference is made to them). The present focus is on the graduate level within the economy. It is already clear that many individuals who graduate in STEM subjects do not enter what would normally be considered STEM occupations or sectors. Individuals may become disaffected with their degree subject, or find higher wages or better working conditions in non-STEM occupations and sectors.

A further supply issue concerns the availability of individuals with STEM qualifications. There are a number of aspects to this: whether there are STEM individuals in unemployment, but seeking work (who are effectively available); the size of the STEM stock who are inactive (who might be brought out of inactivity if labour market conditions were "right"); the size of the STEM stock moving into retirement (who are unlikely to move back into the workforce); finally, there are STEM individuals who take up STEM jobs, but, during the course of their careers, move into non-STEM occupations and sectors (who might be brought back again).

The focus of interest on the demand side is on the need to fill jobs involving activities that can only be satisfactorily carried out by individuals with STEM skills. In other words, if there was a vacancy for the post today, the job would be advertised as requiring applicants to hold a STEM degree. In practice, no systematic information of this type is available even for current vacancies, as the ONS vacancy data set only has the number of vacancies by sector. However, some insights about the relative vacancy rates of different graduate and non-graduate groups can be obtained from the occupation-specific vacancy data in the national employer skills surveys (see the 2007 NESS for England, (UKCES, 2008); Future Skills Wales 2005 (Young and Morell, 2005), Skills in Scotland 2008 (Scottish Government, 2009), the Northern Ireland Skills Monitoring Survey 2008 (Shury and Davies, 2009) and the 2011 Employer Skills Surveys (ESS) (UKCES, 2012a, 2012b, 2012c, 2012d, 2012e)).

A further issue is that some individuals in employment and, therefore, still a part of the demand side, may be working in STEM activities, but will not hold a STEM degree. This seems likely to be particularly true of older individuals who may, for example, have picked up an HND during their careers, but developed their STEM skills on the job or in other ways that do not involve taking a degree.

Employers will also have a view of the subject area, the knowledge base within that subject area and other aspects relating to the quality of individuals that they want to employ. This will be reflected the extent of skill shortages, where potential applicants are put off applying by the high standards required or applicants are found wanting in certain ways. It will also be reflected in skill gaps amongst the existing workforce insofar as science and technology continue to progress and employees fail to keep their skills and knowledge base up to date.

1.4 Aims and contents of the report

The main aim of this report is to address the above issues in as systematic a way as the data available will allow.

Chapter 2 first defines the groups of interest to the study, working with four groups of individuals – three holding a first degree or higher (Core STEM, Medical and related STEM and non-STEM) and one group representing those with qualifications below degree level. This chapter also investigates the occupations and sectors which may be considered to be STEM intensive, based upon both a sliding scale of the proportion of STEM degree holders within the occupation or sector and the proportion of the economy-wide STEM degree holders employed in the occupation or sector. These occupations and sectors have been chosen because they are so important from a demand perspective (high densities of STEM within the occupations or sectors), from a supply perspective (high proportions of the economy's STEM employed in those occupations or sectors) or both.

Before moving to explicitly model supply and demand, Chapter 3 examines the career paths of STEM graduates. Career choices at various ages, but particularly on graduating, have important implications for the supply of STEM – higher retention rates of STEM degree holders in STEM occupations and sectors would be one way of solving shortages. The supply side issues are informed both by the first destinations of graduates (HESA) and early careers (Futuretrack) surveys, as well as by the changes in careers amongst older individuals mapped using LFS data. These factors are brought together in two ways: estimates of supply at a national and regional level and a national stock-flow model that enables the exploration of various policy levers that can be used to alter the pattern and magnitude of supply.

Chapter 4 deals with the issue of commuting patterns amongst STEM graduates. At the national (UK) and four nation state levels, commuting across national boundaries (not to be confused with migration) is a relatively insignificant phenomenon. However, at the regional level, there are important cross-border commuting flows for a number of the 9 planning regions of England. The rationale for dealing with commuting is partly that future supply is best modelled by focusing on STEM individuals by place of residence, adjusting for commuting. In addition, however, it allows the analysis to focus on London as a "magnet" for graduates and STEM graduates in particular, and the difficulties that this can create for supply to other regions.

Chapter 5 deals with the quantitative modelling of supply, demand and market imbalances. The research has developed a new database relating to the market for STEM skills, which combines LFS information with other data sources (e.g. the NESS / ESS). The model is designed to provide estimates of supply (employment plus an estimate of those seeking work in STEM occupations) and demand (employment plus an estimate of vacancies for STEM posts). So the degree of market imbalance is given by some measure of vacancies to “job seekers”. Estimates of supply, demand and the resultant market imbalance are characterised by conceptual and practical issues.

From a demand perspective, there are no official estimates of vacancies for STEM. The present study utilises the NESS / ESS data on vacancies by matching LFS information on STEM densities at a detailed occupational level to identify vacancy rates for STEM and non-STEM groups. While econometric estimates of the vacancy rates are generated for each of the four qualification groups, for various reasons they are not thought to be reliable and an alternative measure of vacancies by qualification has been adopted that apportions vacancies amongst the four groups. The projected employment plus vacancies using this second measure of vacancies gives the baseline total demand for each group.

A “Leitch type” measure of supply[5] is not relevant when considering the supply to STEM occupations and sectors - individuals with STEM qualifications are not constrained to STEM occupations or STEM sectors and, indeed, not all STEM occupations are entirely populated by those holding STEM degrees or even, to a lesser extent, STEM qualifications. Some constraints need to be placed to restrict the population to those likely to be willing and able to supply themselves to STEM occupations or sectors.

Chapter 5 brings the measures of supply and demand together at the national and regional levels to examine projected future market imbalances for STEM. The projections of supply, demand and, thereby, market disequilibrium are made to 2020 (and through to 2025) using a range of econometric techniques (e.g. linear and logit models). However, it does not make sense to model all of the variables in this way. Key variables, such as employment and unemployment rates are strongly affected by the recession, which began in 2008 and affects the whole of our data period after that point. Projections based on these trends would give an extremely pessimistic outcome.

[5] Leitch (2006) projected the number of l individuals in the population at a particular QCF level but did not look at the subject matter of the qualification. Thus the work did not distinguish between STEM and non-STEM skills or whether individuals use their degree discipline.

Rather than model these key variables, values for them are imposed in a variety of ways.[6] Market imbalances for STEM are explored under two baseline scenarios, the most important of which assumes that the economy recovers to its 2007 level by 2020. In addition, Chapter 5 also examines the market outcome if these key variables continued at their 2011 levels (a more pessimistic scenario), as well as a number of other more optimistic scenarios. While market imbalances are explored in terms of vacancy / unemployment rates, the analysis also considers hard-to-fill vacancy / unemployment rates.

While the present report is based upon a mainly statistical analysis the report also utilises the results of two rounds of interviews, the first informing the design of the quantitative work[7] and the second seeking feedback on a number of the key results of the statistical analysis.[8] The informants include representatives of both suppliers and users of high level STEM skills, as well as other interested parties. The list includes higher education bodies, professional institutions representing STEM interests, SSCs, professional bodies, key employers and employer representative bodies, relevant research councils, etc. The results of these interviews are woven into the main text, where they add qualitative insight to the more quantitative discussion.

[6] It was originally intended to make the projections of employment and qualification levels consistent with the results of *Working Futures 4*. However, WF4 uses the 2008 based ONS population projections, which were significantly modified in the 2010 based projections. In addition, the recession has been more prolonged than in the published version of WF4.
[7] Eight interviews were conducted to examine supply-side issues; interviews were also conducted with 11 users of STEM skills to gauge demand for STEM skills; a further five interviews were conducted with key stakeholders.
[8] These involved a further 14 interviewees, broadly structured in the same way as the first tranche of interviews.

2 STEM Occupations and Sectors

Chapter Summary

- Core STEM sectors and occupations were identified in order to look for areas of high levels of vacancies and demand.
- An occupations (at the 3 digit level) is considered STEM if at least 15 per cent of its workforce is a STEM degree holder and the occupation as a whole employs at least 0.5 per cent of the STEM workforce.
- In order to be classified as a STEM sector (classified at the four digit level), at least 15 per cent of the sector's workforce must be a STEM degree holder and the sector as a whole must employ at least 0.06 per cent of the Core STEM workforce (0.1 per cent for Med STEM sectors).
- In 2011, there are four Med STEM occupations, which employ 65 per cent of Med STEM degree holders.
- Nine Med STEM sectors are identified for 2011, and these sectors employ almost 60 per cent of all Med STEM degree holders.
- In 2011, there are 10 Core STEM occupations, which employ 40 per cent of Core STEM degree holders.
- 66 sectors for Core STEM are identified for 2011, and these sectors employ 45 per cent of the UK's Core STEM graduates.

2.1 Introduction

The present chapter presents an exploration of the LFS with regard to the employment of STEM qualified individuals by occupation and sector. Core STEM sectors and occupations are identified in order to look for areas of high levels of vacancies and demand.

Degree holders are categorised as “Medicine and related STEM”, “Core STEM” and “non-STEM”, the aim of which is to differentiate occupations and sectors into intensive and non-intensive users of individuals holding degrees in these various subject groupings. All other individuals, those holding qualifications below degree level, form a fourth group.

The three degree classes are as follows:

- **Med STEM** comprise: Medicine and dentistry (JACS[9] 01); Medical related subjects (02).
- **Core STEM** comprise: Biological sciences (03); Agricultural sciences[10] (04); Physical / environmental sciences (05); Mathematical sciences and computing (06); Engineering (07) and Technology (08); Architecture (09).
- **Non-STEM** - all the remaining degree subject areas;

The LFS is employed to analyse the distribution of STEM (and non-STEM) degree holders using the above groups, by four digit SIC and by both three and four digit SOC.[11]

Two measures of STEM concentration are used:

- densities – which are calculated as the number of STEM degree holders within a sector or occupation divided by the total number of employees in that sector or occupation;
- proportions – which are calculated as the number of STEM holders within a sector or occupation divided by the total number of the corresponding STEM group employed within the economy.

[9] Joint Academic Coding System.

[10] Some consideration was given to separating veterinary sciences from agricultural sciences and putting it in the medicine related STEM group, but it was decided to leave it within agricultural sciences.

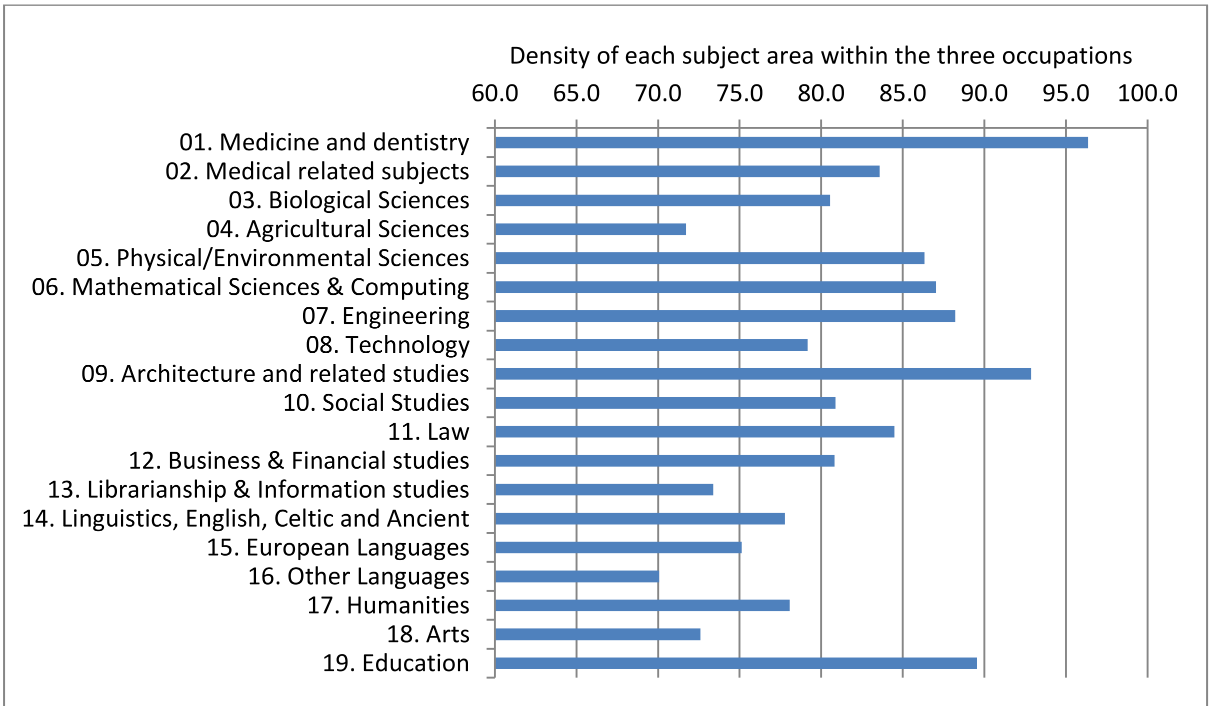
[11] The main results are contained in OUTPUT-5.xls, which provides a number of summary sheets, as well as detailed calculations.

The first – the density – is an indication of the makeup of the workforce in a given sector or occupation, in other words, what proportion of the sector's or occupation's workforce holds a Med STEM degree, a Core STEM degree or the proportion of the sector's workforce that holds a non-STEM degree. The second – the proportion in the economy – reflects the importance of the sector or occupation as an employer of STEM holders and answers questions such as what proportion of the nation's Medicine and related employed STEM are located in hospitals and what proportion are employed in social welfare activities.

2.2 Categorising Occupations

The nature of the STEM work that policy makers are concerned about is broadly consistent with limiting the STEM occupations to Management occupations, Professional occupations and Associate professional occupations. These three occupational groups are by far the most important sources of employment for STEM degree holders – over 80 per cent of all STEM degree holders are employed in these occupations (see Figure 1). However, there is some variation across STEM subject areas, ranging from 71.7 per cent in agricultural sciences to 96.4 per cent in medicine and dentistry, but seven of the nine STEM subjects are above 80 per cent and Technology is very close to 80 per cent. Of the ten non-STEM subjects, six of them lie below the 80 per cent mark.

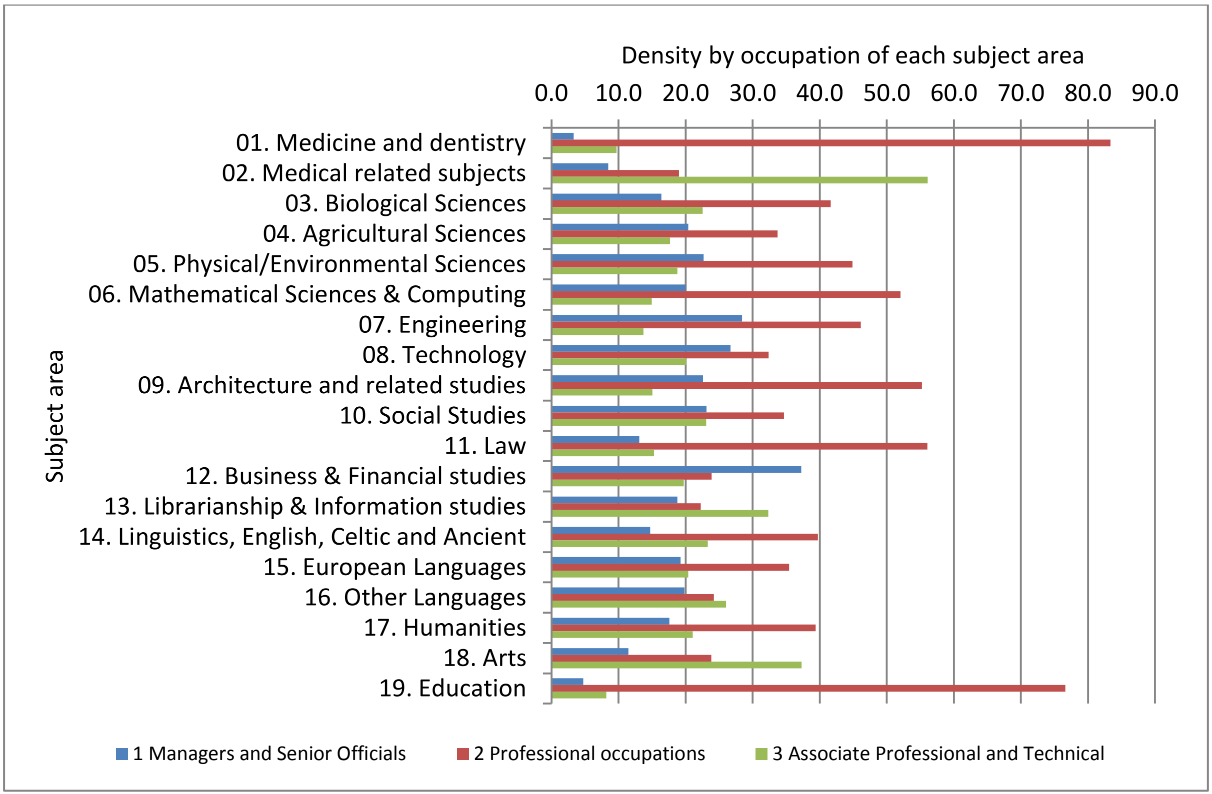
Figure 1 Proportion of degree holders working in management, professional and associate professional occupations, by subject area of degree (average of all years 2001-2011)



Source: LFS

Some consideration was given to whether the Associate professional group should be included within the STEM occupations. It is a reasonably important occupational group for most of the STEM qualifications (see Figure 2), except, perhaps Medicine and dentistry (10 per cent); the remaining STEM subjects lie between 14 (Engineering) and 23 per cent (Biological sciences), with the exception of the high proportion of Medical related degree holders (56 per cent).[12] Our initial exploration of the data suggests that, for some subjects and occupations, Associate professional occupations may be a way in which younger people work their way into Professional and Managerial occupations, for others it may be a career choice with no apparent link to STEM activities. A number of the interviewees considered the Associate Professional group to be important and, in the final analysis, the group was included in the lists of STEM occupations.

Figure 2 Proportion of degree holders working in management, professional and associate professional occupations, by subject area of degree (average of all years 2001-2011)



Source: LFS

[12] This was primarily because nursing was treated as a semi-professional occupation until SOC 2009, when it was reallocated to the Professional group.

Defining occupations based on the proportion of STEM graduates employed could lead to odd results because if enough STEM graduates flock to a job then it will tend to be considered a STEM job even if no "science" is involved. This might be the result of market forces, for example, because physical science degree holders tend to be highly numerate, they may be attracted to jobs with high salaries in certain parts of the finance sector. It might be that, if there were more quantitative financial economists on the market, the STEM holders would not be hired; equally, specialist STEM knowledge may be valued highly in certain areas of finance.[13]

In fact, this issue may not even be the result of market forces, but, particularly, amongst small sectors, simply the result of chance. For example, "Fur processing" only had an estimated 284 employees in total in 2001, of which 194 were Technology degree holders. It can be seen that the unweighted sample will be very small, say five individuals in total. While, say, the three Technology degree holders may make intensive use of their subject knowledge, equally, it could be that, by chance, the individuals with Technology degrees were picked up in the sample and then weighted upwards.

2.2.1 Categorising STEM Occupations

The study first proposes a separation into three groups of occupations and sectors:

- Medicine and related, because: of the extremely strong link between subject of degree and occupation and their tendency to dominate all other STEM jobs in terms of the numbers of All STEM individuals within the occupations and sectors where they are employed[14];
- Core STEM, where the density and / or proportion of Core STEM subject holders (see Section 2.1) are relatively high within that occupational group;
- non-STEM, where the density and / or proportion of Core STEM subject holders (see Section 2.1) are relatively low within that occupational group

"STEM" occupations are defined on a sliding scale of "density" against "proportion". This can be illustrated using the following combinations:

[13] A number of the interviewees hinted that employers found more than numeracy skills in their STEM employees, such as understanding complex information, analytical and problem solving skills.

[14] Veterinary science (which is included in JACS group "D - Veterinary Sciences, Agriculture and Related Subjects" and within the LFS was placed in 3-Biological Sciences until 2003 and then in 4-Agricultural Sciences) could potentially be moved into medical and related for similar reasons but it was decided not to do this as it fits in with other occupations within the agriculture group.

- high STEM density occupations – where both the proportion of STEM within the occupation is high and the occupational group sufficiently large to reduce the likely incidence of statistical issues;
- moderately high STEM density occupations where the occupational group is also (at least) a moderately large employer of STEM;
- moderately low STEM densities where the occupational group is a large employer of STEM within the economy.
- "non-STEM" occupations – where both the within occupation STEM density (STEM per employee within the occupation) and STEM proportion (e.g. the share of the total workforce working in the occupation) are low.

There is no simple way of drawing a line between STEM and non-STEM jobs. Some occupations are clearly non-STEM, in 2001, for example at the four-digit SOC (more detailed) level:

- 165 of the 357 had no Med STEM workers;
- 76 of the 357 occupations had no Core STEM workers;
- only 57 occupations had neither Med nor Core STEM.[15]

Occupations with no STEM employees therefore have both zero density and zero proportion for the relevant STEM group.

Occupations were classified into the STEM groups at both the three- and four-digit level. The discussion here focuses on the three-digit level because that was the level adopted in the supply and demand analysis in Chapter 5. More detail on classifications at the four-digit level can be found in Section 1.1 of the Annex. While a considerable amount of exploratory work of "STEM occupations" was at the four-digit level, the analysis of market imbalances (Chapter 5) was carried out at the three-digit level where the vacancy data were more reliable.

As explained above, there appear to be two dimensions, which can be thought of as: (i) the importance of STEM to an occupation (i.e. the STEM density); and (ii) the importance of the occupation to STEM (i.e. the STEM proportion). As the STEM proportion falls, the smaller the number of STEM it employees, the smaller its importance to suppliers of STEM skills and the less likely it is to have meaningful observations of supply and demand from survey information such as the LFS.

[15] 68 occupations had no non-STEM graduates and only 40 occupations had no graduates at all.

In the light of this, it was decided to combine both dimensions in selecting occupations that might be termed to be STEM jobs, reflecting an attempt to produce a balance between supply and demand factors. Thus, occupations are allocated to STEM if they meet the criteria in Table 1.

Table 1 Selection Criteria for Occupations, 2001 and 2011 (%)

Balance of supply and Demand	Density	Proportion
High demand/low supply	≥ 50.0	0.49-1.99
Medium demand and supply	25.0-49.9	2.0-4.99
Low demand/high supply	15.0-24.9	≥ 5.0
Non-STEM occupation	<15.0	< 0.50
Note: three digit SOC		

The first STEM group is where there are only between *about* half a per cent to two per cent of total STEM workers in the economy working in the occupation, but the average STEM density in the occupation is at least one in two (i.e. highly important to employers, but not, on average, to suppliers - labelled "high demand / low supply"). In the second group STEM holders form between a quarter and half of their employees and between two and five per cent economy's STEM employees. The final STEM group has a density of between fifteen and twenty-five per cent who are STEM, but five per cent or more of the economy's employed STEM workers (i.e. highly important to potential suppliers of STEM skills, but not, on average to buyers - labelled "low demand / high supply").

2.2.2 Medicine and Related STEM Occupations

In 2001 and 2011, four occupations met the criteria discussed in Table 1 for Med STEM graduates. Combined, the occupations listed employed 64 per cent of all graduates with Med STEM degrees in 2001 and 65 per cent in 2011.[16] See Table 2 for a list of the occupations that are classified as Med STEM. In both years, Med STEM occupations included Health professionals, Health associate professionals and Therapists. Nursing and midwifery professionals was included in 2011 but not 2001 (note that the occupational classifications changed between 2001 and 2011, moving nursing out of the associate professional group into the professional group) and Health and social services managers was in the list in 2001 but not 2011.

[16] Note there is a change in occupational classification between the two years.

2.2.3 Core STEM Occupations

The Core STEM occupations also have been selected at the three-digit level on the basis of the “rules” set out in Table 1 above. Applying the criteria in Table 1 gives 11 Core STEM occupations for 2001; combined, these occupations employed 60 per cent of Core STEM graduates. In 2011, there are 11 Core STEM occupations, which, combined, employed 42 per cent of Core STEM graduates (see Table 2).

In 2001, two three digit occupations had workforces containing mostly Core STEM workers (Science professionals and Architects (75 per cent of workers have a Core STEM degree), Town planners, surveyors (71 per cent)). Engineering professionals (with a proportion of 10 per cent) ranked at the top in terms of importance as an employer. In 2011, the top two occupations in terms of relative numbers of STEM workers were Natural and social science professionals (70 per cent of workers in this occupation held a Core STEM degree) and Conservation and environment professionals (69 per cent).

The fall in the overall proportion of Core STEM employees in Core STEM occupations is not just a function of the change in occupational classification, as there is a downward trend year on year throughout the period. It appears that Core STEM individuals are becoming more widely spread across occupational groups.

Comparisons of 2001 with 2010 data (2010 is the last year of LFS data prior to the change in classification) confirm this. Employment in the Core STEM occupations as a group increased faster (by 17 per cent) than total employment (only four per cent increase) between 2001 and 2010. The Core STEM density, however, remained relatively constant.[17] However, the number of employed Core STEM degree holders increased by an even greater rate, and as an end result, the share of Core STEM degree holders working in Core STEM occupations declined from around 60 per cent in 2001 to around 50 per cent in 2010. Regression analysis did not reveal any “emerging” Core STEM occupations (e.g. occupations that did not meet the criteria for STEM in 2001 or 2011 but would meet the criteria by 2020).

[17] SOC 213 Info & Communication technology is a notable exception to this, exhibiting a 12 percentage point increase in Core STEM density between 2001 and 2010.

Table 2 Med STEM Occupations, 2001 and 2011

	Med STEM Occupations, 2001				Med STEM Occupations, 2011		
SOC	**Title**	**Density**	**Proportion**	**SOC**	**Title**	**Density**	**Proportion**
221	Health professionals	80.0	16.1	223	Nursing and midwifery professionals	81.7	33.9
321	Health associate professionals	78.0	37.3	221	Health professionals	72.6	22.7
322	Therapists	62.2	5.6	222	Therapy professionals	65.6	5.9
118	Health and social services managers	38.9	5.0	321	Health associate professionals	28.9	2.6
	Share of Med STEM Employment:		64 %		Share of Med STEM Employment:		65 %

Table 3 Core STEM Occupations, 2001 and 2011

	Core STEM Occupations, 2001				Core STEM Occupations, 2011		
SOC	**Title**	**Density**	**Proportion**	**SOC**	**Title**	**Density**	**Proportion**
211	Science professionals	75.3	3.5	211	Natural and social science professionals	70.3	3.5
243	Architects, town planners, surveyors	70.8	4.6	214	Conservation and environment professionals	68.7	1.0
212	Engineering professionals	57.7	9.9	243	Architects, town planners and surveyors	64.5	4.2
312	Draughtspersons and building inspectors	54.9	1.7	212	Engineering professionals	62.2	7.2
355	Conservation associate professionals	54.4	0.5	215	Research and development managers	57.7	0.6
213	Information and communication technology	47.7	8.5	213	Information technology and telecommunications professionals	53.9	11.7
232	Research professionals	41.5	1.0	311	Science, engineering and production technicians	33.0	2.6
311	Science and engineering technicians	33.3	3.9	112	Production managers and directors	31.7	3.7
112	Production managers	28.7	6.7	242	Business, research and administrative professionals	24.3	4.5
113	Functional managers	20.5	9.4	231	Teaching and educational professionals	17.4	7.1
231	Teaching professionals	18.7	9.0				
	Share of Core STEM Employment:		60 %		Share of Core STEM Employment:		42 %

Source: 26 SOC2001&2011MedCoreNonNQF4&5FTPTSE.xls

2.3 STEM sectors

While STEM density seems to make a lot of sense in terms of occupations, with high proportions of STEM in Management, Professional and Associate professional occupations, the same cannot be said for sectoral densities. The fact that the activity of the sector is generally some form of production that requires a mix of qualification levels and occupations implies that situations will occur where there are groups of STEM degree holders working in key STEM activities (e.g. R&D) but associated with low STEM densities within employment in the sector as a whole.[18]

Despite the issues of identifying STEM sectors, the sectoral dimension is an important one, as it is the firms and organisations within the sectors that are the source of demand for STEM skills. Thus, as with occupations above, sectors have been classified into STEM groups (Medical and related, Core STEM and non-STEM) based on their proportions and densities.

Although it can be hard to draw the line between STEM and non-STEM in some cases, there are some sectors that are clearly not STEM. For example, in 2011[19]:

- 428 of the 615 four digit SICs had no Med STEM;
- 171 of the 615 sectors had no Core STEM workers;
- only 159 sectors had neither Medicine and related nor Core STEM;
- 162 sectors had no non-STEM graduates;
- 110 sectors had no graduates at all.

Sectors with no STEM employees therefore have both zero density and zero proportion for the relevant STEM group. Sectors (at the four-digit level) are allocated to STEM if the balance between supply and demand meets the criteria in Table 4.

[18] On the other hand, as discussed above, defining sectors based on the density of STEM graduates employed could lead to odd results, because, if enough STEM graduates flock to a sector, then it will tend to be considered a STEM sector even if no "science" is involved. This is more particularly the case for small sectors.
[19] Note that the 2001 and 2011 four digit classifications differ and are not directly comparable with one another.

Table 4 Selection Criteria for Sectors, 2001 and 2011 (four-digit level)

Balance of supply and demand	Density (%)	Proportion (%)
High demand/low supply	≥ 25.0	0.10-0.49 (Medicine and related) 0.06-0.49 (Core STEM)
Medium demand and supply	20.0-24.9	0.50-0.99
Low demand/high supply	15.0-19.9	≥ 1.00
Non-STEM sectors	<15.0	< 0.10

Note: for further discussion, see Section 2.2.

The first rule implies that even if a sector only employs between 0.1 per cent and 0.5 per cent of the total STEM in the economy, this sector will still be included as STEM if the average STEM density across enterprises in the sector is one in four. Such a sector is of relatively low importance to suppliers of STEM skills (other things equal), because it is quite small, but STEM skills are extremely important to employers in the sector (labelled "high demand / low supply"). The second STEM group has STEM holders forming between one in four and one in five of their employees and between 0.5 per cent and one per cent of the economy's STEM employees. The final STEM group, "low demand/high supply," has a lower density (between one in five and one in seven employees are STEM), but employs at least one per cent of the economy's STEM workers. Thus, these sectors employ a large number of STEM degree holders but STEM graduates make up a relatively small share of the sectors' workforce.

2.3.1 Medicine and Related STEM Sectors

Based upon these rules, five sectors cover almost 60 per cent of those with Med STEM degrees employed in 2001 (see Appendix A for the full listing). All other sectors are effectively ruled out by the 15 per cent lower limit, so, while the Retail trade, Regulation government agencies (not Social Security), two areas of social work, Primary education, Tertiary education and Labour / personnel recruitment each have more than one per cent of the nation's Med STEM, they all have less than 15 per cent density ratios (and mainly less than 10 per cent).

Nine sectors meet the above criteria in 2011 and, combined, they employed nearly 70 per cent of those with Med STEM degrees. See the Appendix for a complete list of sectors classified as Med STEM (in particular, Tables A.1 and A.2). There are, of course, other large employers of Med STEM skills that have not been classified as STEM sectors, such as the Retail trade, where the Med STEM density is only 3.2 per cent, although the sector employs 6.8 per cent of all Med STEM employees in the economy.

2.3.2 Core STEM Sectors

The sectors have been selected on the basis of the "rules" set out in Table 4 above, although the "proportion" rule has been relaxed slightly from that of the Medicine and related group because of the larger numbers of Core STEM workers. The adjustment has been made such that the smallest sector that can be selected has about 1,300-1,400 Core STEM workers (roughly the same number adopted for the smallest Med STEM sector).

Forty-one of the sectors meet the criteria discussed above in 2001, employing, in total, 41 per cent of Core STEM graduates. The lower overall coverage than the Medicine and related group reflects the lower sectoral than occupational concentration of Core STEM employees. See the Appendix (Table A.3) for a complete list of sectors classified as Core STEM. Sixty-six sectors meet the criteria in 2011, employing 45 per cent of Core STEM employment in the UK (see Appendix A, Table A.4).

Examples of sectors with a high STEM density (based on 2011 data) include: Research and experimental development on biotechnology (66 per cent); Architectural activities (63 per cent); Other R&D on natural sciences and engineering (58 per cent); Other software publishing (56 per cent); Manufacture of other inorganic basic chemicals (53 per cent); and Engineering activities and related technology consultancy (52 per cent).

2.4 Diversity of STEM occupations and sectors

It is difficult to say anything about possible imbalances from the categorisation of STEM occupations and sectors carried out in the present chapter. The work in this chapter was undertaken to identify occupations and sectors likely to be important in the context of STEM graduates and of sufficient size to be able to say something statistically meaningful about them. In doing so, the analysis has been able to make a distinction between: (i) occupations and sectors that are highly STEM dependent in the sense that the density of STEM within the occupation or sectoral workforce is high; (ii) occupations and sectors that are important employers of STEM graduates in the sense that they employ a significant proportion of the STEM available in the economy as a whole.

What is clear is that individuals with Medicine and related degrees have a much higher probability of working in the same occupations and sectors than do individuals with Core STEM degrees. In both 2001 and 2011, four occupations employed nearly two-thirds of Med STEM graduates. In contrast, there were 11 Core STEM occupations in 2001 which employed 60 per cent of the Core STEM graduates. In 2011 (after a change in occupational classifications), there were 10 Core STEM occupations, employing only 42 per cent of Core STEM graduates. No new Core STEM occupations were projected to emerge by 2020.

The nine Med STEM sectors in 2001 employ nearly 70 per cent of those with Med STEM degrees and five sectors identified for 2011 employ almost 60 per cent of those with Med STEM degrees. Forty one Core STEM sectors are identified for 2001, employing, in total, 41 per cent of Core STEM graduates, which compares with sixty six sectors in 2011, employing 45 per cent of Core STEM in the UK. The higher numbers of occupations and sectors identified for Core STEM is not surprising given the greater range of degree disciplines covered by this group, as well as a greater range of uses to which they can be put.

Thus, a considerable proportion of Core STEM is employed in occupations and sectors where the density of Core STEM is low. In addition, there are some sectors employing very large numbers of STEM, where STEM densities are very low, which seem to have little link to the crucial policy issues surrounding STEM (e.g. Retail sale non-specialist stores food/beverage/tobacco, 47.11, which employs more than one per cent of all Core STEM, with a density of four per cent in 2011). Examples can even be found for the Med STEM, where, in 2001, the Retail trade employs seven per cent of all Med STEM degree holders in the UK, with a density of only three per cent (these will include pharmacists and opticians).

A similar issue exists with the employment of STEM within various parts of Financial services. No part of the Financial services sector is captured as a supposedly STEM sector in 2001 and only one four digit sector in 2011 (Securities and commodity contracts brokerage, with density 20.8 and proportion 0.6), but several sectors are close to meeting the criteria and work reported in the Technical Report (see Section 1.2 of the Technical Report) suggests a number of such sectors will emerge as “STEM sectors” by 2020.

3 Career Paths of STEM Graduates

Chapter Summary

- The literature review suggests that roughly half of STEM degree holders work in non-STEM jobs.
- Finance and teaching are significant recruiters of STEM, particularly those with more quantitative skills. The Finance sector has been particularly attractive to STEM degree holders because of the high salaries that have been on offer.
- New graduates with Medicine and related STEM degrees are more likely to be in employment than those with Core STEM or non-STEM degrees.
- In 2011, 56 per cent of new Medicine and related STEM graduates worked in a Medicine and related STEM occupation and 28 per cent of new Core STEM graduates worked in a Core STEM occupation.
- Nearly 70 per cent of new Medicine and related STEM graduates worked in a Medicine and related STEM sector and a third of new Core STEM graduates worked in a Core STEM sector in 2011.
- The share of Core STEM degree holders that work in Core STEM sectors and occupations increases with age – individuals in their 50s are much more likely to be working in STEM than those in their 20s. This is consistent with the lower vacancy rates and thereby recruitment in Core STEM sectors (see Chapters 5 and 6).
- Stock flow simulations on Core STEM supply show that increasing economic activity rates to pre-recession levels or increasing the share of STEM degree holders that work in STEM jobs or increasing the retirement age can lead to large increases in the supply to STEM jobs.
- The share of older STEM individuals remaining in the workforce increased until the recession hit and now has returned to pre-recession levels.

3.1 Introduction

This section focuses on various dimensions of the supply of individuals with STEM skills to STEM jobs. The analysis includes the first destination of STEM graduates, their subsequent career paths and the retirement of STEM graduates. An employer from a major engineering firm suggested that the initial career choices are often crucial; if an individual chooses a non-STEM occupation, this suggests that they do not want to develop a STEM career path. The exception to this appear to be where the individual is unable to find an immediate job offer in a STEM occupation and might take a stop-gap job whilst waiting for STEM work to become available. Even if the individual immediately moves into STEM on or soon after graduation, subsequent career moves may still take them outside of STEM occupations and sectors.

A proportion of STEM holders move into non-STEM occupations and sectors immediately on qualifying. In some cases this may be seen as a stepping stone for moving into STEM activities later in their career. In other cases, it will be part of a long term strategy that will never converge on STEM. One manager of a large UK division of a major engineering equipment manufacturer (interviewed during the course of the project) points to the fact there are always individuals who become disenchanted with their STEM subjects during the course of their degree, who are lost from STEM occupations and sectors forever. Similarly, those in STEM occupations and sectors may want to move out of them at some stage in their career, an obvious example is that of moving into non-STEM (as opposed to STEM) managerial roles as they gain experience.

From a labour market perspective, the nature and degree of occupational and sectoral mobility of STEM degree holders is crucial in understanding the supply of STEM skills in the UK. It seems likely, for example, that the quantitative nature of a number of STEM disciplines (e.g. Physical sciences, Engineering and Mathematics) will find a natural haven in certain occupations and sectors (e.g. banking, finance and actuarial work). On the other hand, the non-quantitative nature of many non-STEM disciplines makes entry into STEM jobs impossible.

While it might be seen that STEM holders in non-STEM jobs are filling an important gap that would be difficult to fill otherwise, this may not be an economically or socially efficient way of meeting these needs, if the STEM degree holders are not using the majority of the knowledge gained at university and the costs of producing STEM skills are high. In addition, although STEM degree holders may be highly productive in non-STEM activities, such individuals are unlikely to be working on developing and applying the new science and technology that are so important to international competitiveness.

The second round interviewees were asked to address the issue, but generally seemed to take the view that, the more STEM the better, irrespective of where they worked. One respondent argued that the “government recognises the high expense of STEM degrees and therefore wants to force them to do STEM work”. He added that STEM degree holders working in non-STEM areas, “should not be seen as leakage but diffusion of essential talent. We want a range of hugely talented people in the whole range of the UK economy.”

Despite such views, a key lever for technological success may lie in ensuring a higher proportion of STEM graduates move into and stay in STEM occupations and sectors. However, this will only happen if there are sufficiently attractive STEM jobs available. One interviewee from a Research Council referred to this as a “chicken and egg” problem – while there was generally not enough STEM graduates, problems stemmed from lack of demand as well. In their view the “right economy” currently does not exist and, until it does, “a lot of the demand is in people’s heads”. If we have the economy we want “which is based on technology and the application of knowledge in clever and innovative ways, you need more of these people”. However, “we will not get that kind of economy without these [STEM] people, as companies are not sophisticated enough to do the kinds of things required in such an economy”.

To understand the leakages out of STEM activities, it is important to explore the career paths of STEM graduates and, briefly, the reasons why these career paths emerge. While a great deal is known about the numbers graduating in STEM subjects and the numbers holding STEM qualifications (e.g. Kumar, *et al*. 2012), much less known about the career paths of such individuals and the extent to which STEM qualification holders work outside of STEM occupations and sectors during their careers. The present paper draws upon a number of sources of data to illustrate the career paths of STEM graduates and how these career paths are changing with the passage of time.

3.2 STEM Graduates' Careers: Literature Review and Interview Responses

3.2.1 First Destinations and Early Career Choices of Core STEM Graduates

New STEM graduates are likely to enter a "knowledge" job which comprises an occupation in the top three occupational categories (Managers and senior officials, Professionals, Associate professionals and skilled technicians) (Levy and Hopkins, 2010 p. 22). Levy reports that more than 90 per cent of new health graduates (graduates with degrees in Medicine and dentistry, Veterinary sciences and Subjects allied to medicine) work in a knowledge profession as do more than three-quarters of new graduates in Architecture, building and planning and Engineering and technology (*ibid*. p. 22). New graduates in Mathematics and Sciences are less likely to enter knowledge jobs, but still more than half do so (72 per cent for Mathematics, 61 per cent for Physical sciences and 52 per cent for Biological sciences) (*ibid*. p. 22). By way of comparison, less than half of new History and philosophy majors (45.6 per cent) enter a knowledge job (*ibid*. p. 22).

The Royal Society (2006) examined the sectors of employment for new graduates. It found that only a small proportion of new graduates enter employment in businesses within the R&D sector; in 2003/04, six per cent of graduates in Chemistry, three per cent in Biology and Physics, and one per cent in Engineering and technology (Royal Society, 2006 p. 43). Manufacturing is a traditional destination for new STEM graduates, but the proportion of new STEM graduates going into the Manufacturing sector has been declining. The Royal Society reports that the proportions of graduates entering Manufacturing upon graduation fell from 37 per cent in 1994/95 to 27 per cent in 2003/04 for Chemistry graduates, from 38 per cent to 22 per cent for graduates of Engineering and technology and from 18 per cent to seven per cent for Physics graduates (*ibid*. pp. 43-44).

Many new STEM graduates do not enter a STEM job. Engineering UK reports that, in 2010/11, the percentage of first degree Engineering and technology graduates going into an Engineering and technology occupation was 66 per cent; a further two per cent of graduates went into another STEM occupation; and the rest went into non-STEM occupations (Kumar, *et al*. 2012, p. 150).

These findings are also broadly consistent with the Roberts Review (2002), which reports on the first destination of first degree graduates entering employment in 1999/2000. The proportion working in Finance ranged from less than five per cent for graduates in Engineering and technology to around 10 per cent for the Physical sciences and to about a quarter in Mathematics (*ibid*. p. 26). The Royal Society (2006, p. 44) reports that in 2003/04, "… 43% of maths graduates, 18% of biology, 20% of chemistry, 30% of physics, 20% of computer science and 23% of engineering and technology graduates entered employment in … financial and other business activities (including areas such as accountancy, management consultancy, law and advertising". The proportion working in "other sectors" (not including education or the public sector) ranged from 45 per cent in the case of Biological sciences graduates to just over one fifth of Mathematics graduates (Roberts Review, 2002 p. 26).

Thus, the top two careers of STEM graduates who enter non-Core STEM jobs appear to be teaching and finance. For instance, CIHE (2009, p. 8) find a third of mathematics graduates enter finance, as do 17 and 11 per cent of physics and technology graduates, respectively. Graduates of Biological sciences (21 per cent), Biology (17 per cent), Chemistry (14 per cent), Mathematical sciences (18 per cent) and Physics (18 per cent) are particularly likely to choose teaching (CIHE, 2009, p. 8). DIUS (2009, p. 57) also reports that, while 95 per cent of those in medicine and dentistry worked in a "scientific occupation" and around half of science graduates worked in science occupations three and half years after qualifying (DIUS, 2009, p. 51), this fell to about 25 per cent of those in mathematics (*ibid*. p. 57). DTI (2006a, p. 23) concur that a large number of mathematics degree holders went into finance.

The interviews confirm that a large number of Core STEM graduates take non-STEM jobs. The Finance industry was mentioned again and again as a "poacher" of STEM graduates. Not only does the finance industry take STEM graduates, according to the interviewees, it often takes the best and the brightest. A representative from an SSC stated that, "Engineering graduates who have got 'firsts' are snapped up…the financial companies go out to universities and they poach them because they absolutely love engineers." As a result, those with a "first" go into the financial sector "far more than they should", and Engineering companies are getting the remaining graduates with a 2:1 or a 2:2 – although these are still good, "they haven't got that extra something".

However, a senior HR person in the banking sector said that recruiters and companies tend to be moving away from a first or a 2:1 as criteria for success. "A 2:2 in a science degree holds massive credibility over a 2:1 in other subjects". She noted that, if she was trying to recruit someone into a finance role, a science or technology background would be much more important to show their numeracy skills than someone with a different degree, even at a higher level.

Other interviewees shared this view; one employer stated that, "Finance is a big poacher from STEM, a really big poacher." Another employer said that Financial services is quite appealing to people with STEM degrees because it pays attractive wages and that The Big Four (finance/professional services) and similar high-profile graduate recruiters are quite "aggressive" in their recruitment of graduates and are "really visible" on campus ("a really dominant physical presence and they are competing with each other"). However, others, both employers and SSCs, argued that Finance was not as big a competitor as it once was due to the recession.

The numeracy skills of STEM seem to be the principal attraction for the Finance sector. The senior HR interviewee in Finance noted that, "science grads are so highly numerate, they have those analytical skills that you don't really get with other subjects and we really need that in our finance department, we're so heavily scrutinised by the FDA and regulatory bodies, meaning that if we can have someone working in our treasury department who is just absolutely flawless in their numeracy skills, then yes, we will want them". However, the discussion hinted that there might be something slightly more than just numeracy skills. Overall, she felt that such graduates brought an "…independence and that ability to stand back and look at the facts and evidence-based methods" to the company. It is the way that science graduates approach things, such that their analysis skills "really separates them".

DIUS notes that,

> "Even after factoring in STEM graduates who work in finance (around 4-8%) and in teaching (around 9%), this still left a significant proportion of STEM graduates working in non-STEM related occupations of around 34%-38%" (DIUS 2009, p. 51).

Table 5 shows the proportion of a cohort of first degree graduates working in a scientific occupation three and a half years after qualifying (in the 2006/7 academic year). It shows that 49% of the STEM graduates ended up in STEM occupations, while only five per cent of non-STEM graduates work in STEM occupations (DIUS, 2009, p. 57). Overall, 24% of all graduates (STEM and non-STEM) worked in STEM occupations (*ibid*. p. 57).

Table 5 Proportion of First Degree Graduates Working in Different Occupations, Three and a Half Years after Qualifying (graduates qualified in 2006/07)

	Scientific Occupations	Finance (i)	Finance (ii)	Teaching	Other
Medicine and dentistry	95	1	0	0	4
Subjects allied to medicine	80	1	1	3	15
Biological sciences	22	2	3	21	52
Biology	*31*	*0*	*3*	*17*	*49*
Sports science	*1*	*4*	*2*	*31*	*62*
Psychology	*23*	*2*	*5*	*20*	*50*
Veterinary and agriculture	28	2	3	8	59
Physical sciences	30	4	4	14	48
Chemistry	*36*	*5*	*1*	*14*	*44*
Physics	*44**	*10*	*7*	*18*	*21*
Forensic and archaeological science	*60**	*0*	*0*	*0*	*40*
Mathematical sciences	25	20	13	18	24
Computer science	47	4	9	6	34
Engineering and technology	59	3	3	3	32
Engineering	*61*	*2*	*3*	*3*	*31*
Technology	*38**	*6*	*5*	*0*	*52*
Architecture, building and planning	53	0	1	0	46
All STEM	49	4	4	9	34
Non-STEM	5	7	7	18	63
TOTAL	24	5	6	14	51

Notes. Finance (i) is defined as: Financial institution managers (1151), Chartered and certified accountants (2421), Management accountants (2422), Management consultants, actuaries, economists and statisticians (2423), Finance and investment analysts (3534), Taxation experts (3535), Financial and accounting technicians (3537). Finance (ii) is defined as all SIC 65, 66, 67, but excluding those occupations included under Finance (i). Finance (i) + Finance (ii) would cover all finance occupations. Finance (i) includes occupations more traditionally associated with high-earning financial careers. * Statistics based on fewer than 50 observations.

Table 5 is roughly consistent with the finding that four per cent of Physical sciences graduates, two per cent of Engineering graduates and 20 per cent of Mathematical sciences graduates go into the financial sector (Kumar, *et al*. 2012, p. 150). Salaries offered by the financial services sector, where many STEM graduates thrive, out-competed the other commercial and the academic sectors substantially for a considerable period (CIHE, 2007 p. 15). Therefore, many STEM graduates enter financial services where their numeracy and analytical abilities are financially better rewarded.

It seems quite likely, that the “poaching” of high quality Core STEM graduates is likely to create recruitment problems for Core STEM employers, insofar as the applicants they are left with have poorer degree results. In addition, if financial services continue to dominate the economy, then as the economy moves out of recession, shortages in terms of hard-to-fill vacancies will emerge outside of financial services.

3.2.2 Factors Influencing Career Choices

While there is an extensive literature on the influences on career choices, turnover and the like, much of this is generic, with no explicit reference to STEM degree holders. Such influences include wages, within organisation career opportunities, organizational socialization[20] and internal career anchors[21] (Bigliardi, *et al*. 2005). However, more is known about the influences on individuals at the time they graduate and move into the labour market.

In a survey of university students, BIS (2011, p. 27) find that only a small proportion of STEM students report that they do not wish to pursue a STEM degree-related career by the time they are nearing graduation. The authors report that only one in eight STEM final year students, one in ten STEM PhD students and one in twenty taught STEM postgraduates definitely *did not want to,* or *did not think they wanted to*, pursue a career directly related to their degree when they graduated.

This proportion varies by subject, but not hugely, so that in all subjects only a minority (none above one in five or so of final year undergraduates) did not want to pursue a career directly related to their degree, and this did not seem to vary by gender (*ibid*. p. 27). The authors report that STEM undergraduates who definitely intended to pursue a STEM career were motivated by expected excitement, interest and challenge in the work, wanting to continue in a field they enjoyed, or wanting to put their learning into practice (*ibid*. p. 29).

The reasons for not staying in STEM are mainly to do with students finding other fields of interest (BIS 2011, p. 30). The authors find little evidence of students being prevented from pursuing a STEM career by an external reason [e.g. students being rejected by STEM employers, too few jobs, or too few jobs in preferred location] (BIS 2011, p. 30). Potential earnings do not seem to have a strong role (mentioned by less than a third of students who might not or definitely do not want a STEM career) (BIS 2011, p. 31).

[20] Where the organization encourages workers to be both organizationally and professionally committed, and has a process for the engineers’ professional development, whilst removing barriers to their integration within the organization (*ibid*. pp. 426-427).

[21] An individual’s career anchor is their self-concept of self-perceived talents and abilities, basic values, and their sense of motives and needs as they relate to their career (*ibid*. p. 427).

However, the Roberts Review (2002, p. 14) notes that the Financial services sector tends to offer more generous pay and more attractive career prospects to Science and Engineering graduates and that salaries offered to such graduates can often be 20 per cent or more higher than those offered by many R&D firms.

DIUS (2009, p. 51) reports that, while there are high returns to science graduates who work in science occupations, and employers frequently claiming that they face problems in recruiting science graduates, there appears to be a large proportion of science graduates who work in non-science occupations (and do not get a premium for doing so). DIUS (2009, p. 51) concludes that:

> "Preliminary evidence on over-education, job satisfaction, unemployment since graduation, and satisfaction with degree subjects studied, suggests that the most likely explanation is some kind of mismatch between the type of skills STEM graduates have, and the type of skills sought in science occupations."

The contrast between the expressed positivity about STEM careers in the BIS report and the attrition from Core STEM activities early after graduation suggests that there must be more to this result than finding other fields of interest.

3.2.3 Career Moves of more Mature STEM Degree Holders

STEM degree holders may face different prospects for career development and career opportunities in STEM occupations and jobs. The importance of having a variety of career opportunities within an organization is confirmed in the case of Design engineers in the work of Bigliardi, *et al*. (2005, p. 437). The authors argue that there are certain areas where STEM degree holders work, such as in R&D organizations, where it is a struggle to find effective internal structures for their organization that allow career development. They argue that, while specific career paths may not be as critical as a variety of creative opportunities for engineers, "… unless organizations hold some promise of advance, they will not retain or attract top-quality technical professionals" (*ibid*. p. 437). This confirms one result found by Tremblay, *et al*. (2002, p. 17 – see below), that, when distinguishing between technical versus managerial paths one variable in particular has discriminant power, namely the desire for promotion.

A number of the career moves of more mature STEM degree holders will be between different STEM occupational groups. For example, an early study conducted by the US Engineering Manpower Commission reports that: 63 per cent of Engineers in the United States were employed as Managers by the age of 65; 37 per cent of Engineers have more than nominal managerial duties during their first five years of employment; and that 73 per cent of Engineers have significant managerial responsibilities by the age 45-50 (Sedge, 1985, p. 56). While this may be a within STEM move (e.g. from engineer to engineer-manager), it may also be the individual makes increasingly less use of their engineering skills, but more use of their evolving management skills.

Joseph, *et al*. (2012) report on the career histories of 500 individuals drawn from the US National Longitudinal Survey of Youth (NLSY79), who had worked in the information technology workforce. The authors note that, traditionally, researchers have portrayed individuals' IT careers as either technical or managerial (e.g. Kaiser 1983; Zabusky and Barley 1996). However, analysis of the NLSY cohort reveals that the careers of the IT workforce are more diverse than the dual IT career path (technical *versus* managerial). The authors suggest an alternative three-fold categorisation of: (i) IT careers; (ii) equally high paid professional labour market careers; and (iii) lower paid secondary labour market careers. Of the 500 individuals in the IT workforce: 173 individuals continued in IT careers, while 327 individuals left IT either for other high-status non-IT professional jobs in the professional labour market or for lower-status, non-IT jobs in the secondary labour market. The authors report that "…by tracing the diverse trajectories of career mobility, we enrich our understanding of how individuals construct boundary-less careers that span not only organizational but also occupational boundaries".

In a study of Canadian engineers, Tremblay, *et al*. (2002) also suggest that the dual route (technical versus managerial) is too simplistic. The study explores five career paths for Engineers: management, technical, project-based, entrepreneurial and hybrid. The authors explore engineers' preferences for these routes using questionnaire surveys, collecting, at the same time, some of the individual characteristics that may influence their preferences. Using the influences to predict their preferences, the most accurate prediction was for engineers with a clear career orientation in mind. The authors report that approximately half of all engineers would like to change their career path – most of this group did not have clear preferences (*ibid*. p. 17). Not surprisingly most of those satisfied with their existing situation report a preference for continuing along that career path.

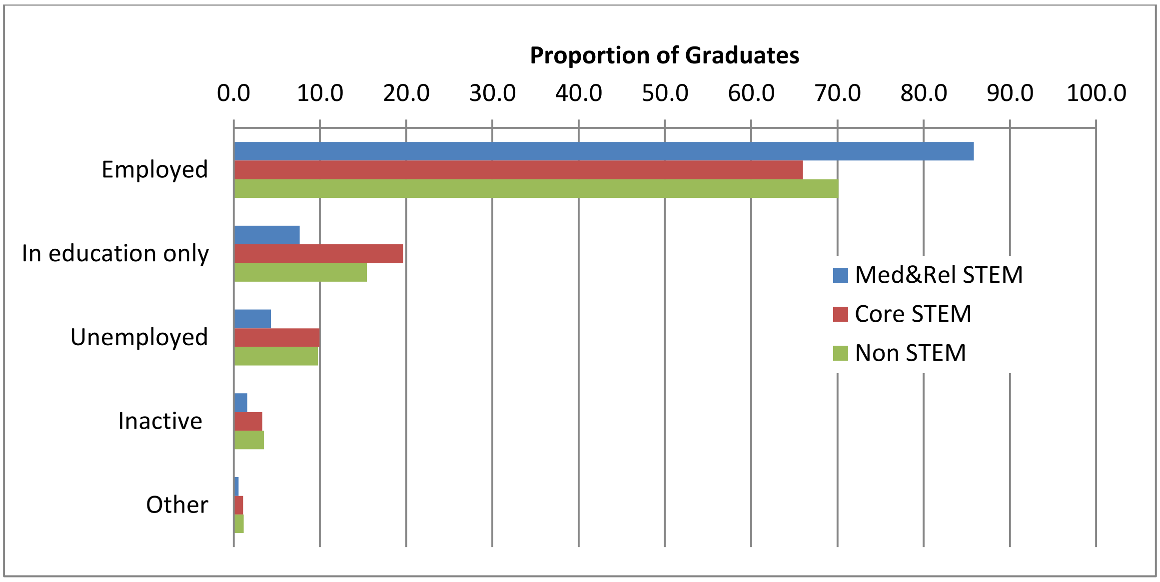
Nothing has been found on the movement of: (i) non-STEM degree holders into STEM occupations; or of STEM degree holders from non-STEM occupations to STEM occupations. There may well be a problem with individuals displaced from STEM occupations moving back into STEM if they have not kept pace with changes in science and technology. Focusing on this, Hira (2009, p. 58) calls for the US Department of Labour to work with scientific and engineering professional associations to move towards the continuous education of STEM workers and the retraining of displaced mid-career STEM workers.

3.3 First Destinations of STEM Graduates: Empirical Findings

3.3.1 Economic Activity Rates, Young STEM Graduates

Both HESA first destination data and the LFS provide information on the employment status of STEM graduates. According to HESA, Med STEM graduates are the most likely to be employed, followed by non-STEM graduates, then Core STEM. As Figure 3 shows, in 2010-11, 86 per cent of Medicine and related STEM graduates were employed, compared with 70 per cent of non-STEM graduates and 66 per cent of Core STEM graduates. The unemployment rate was four per cent for Med STEM graduates and 10 per cent for both Core STEM and non-STEM. Med STEM graduates were much less likely to be in education than other graduates.

Figure 3 Employment Status Six months after graduation in 2010-11



Source: HESA First Destination

The lower employment rates for Core STEM in 2010-11 in Figure 3 are due to the large numbers of Core STEM graduates remaining in education. In 2010-11, 20 per cent of new Core STEM graduates are in full time education compared with 15 per cent of non-STEM and eight per cent of Med STEM. See Section 2.1 and Figure A.1 in the Annex for a discussion on how employment status of new STEM graduates has changed over time.

The LFS can also be used to look at the economic status of individuals soon after gaining a degree using the question of what the individual was doing 12 months ago and selects on those who were in full time education 12 months ago, but not in full time education today. It then analyses those who report a degree subject. Table 6 gives the results for the percentages employed, unemployed and inactive for 2001 and 2011. The LFS data give lower 2011 employment rates for Med STEM and Core STEM than HESA. However, the pattern is seen: Med STEM new graduates have the highest employment rate and Core STEM have the lowest.

Table 6 Economic Activity of Recent Graduates, QCF 4+, LFS

	2001				2011				Percentage point change			
	%EMP	%Unemp	%Inactive	total	%EMP	%Unemp	%Inactive	total	%EMP	%Unemp	%Inactive	total
Med STEM	**80.2**	**2.1**	**17.6**	**100.0**	**79.5**	**4.0**	**16.5**	**100.0**	**-0.7**	**1.9**	**-1.1**	**0.0**
Core STEM	**80.9**	**4.9**	**14.2**	**100.0**	**61.5**	**9.2**	**29.3**	**100.0**	**-19.4**	**4.3**	**15.1**	**0.0**
Non-STEM	**78.3**	**8.3**	**13.3**	**100.0**	**71.5**	**10.6**	**17.9**	**100.0**	**-6.8**	**2.2**	**4.6**	**0.0**

Source: LFS

Between 2001 and 2011, the employment rate dropped for non-STEM and most particularly for Core STEM, but did not change much for Med STEM. Although Core STEM out-performed non-STEM in 2001 in terms of its higher employment rate and lower unemployment rate, by 2011 the situation had reversed. In 2011, Core STEM had the lowest employment rate of the three groups and a much higher inactivity rate. The unemployment rates in 2011 were similar between Core STEM and non-STEM but Med STEM had a lower unemployment rate. See Figure A.2 in the Annex for graphs and more discussion on how employment status of new STEM graduates has changed over time. The higher inactive rate for Core STEM is due to the higher numbers in education (see Section 3.3.1).

Similar time trends were seen in the HESA data. The employment rate of all groups dropped after the recession hit in 2007 and then started to creep back up again but as of 2011, employment rates had not returned to 2007 levels (see Figure A.1 in the Annex for details).

Another source of information on labour market status of new graduates is Futuretrack. Table 7, from Futuretrack (Purcell, *et al*. 2012, p. 62), shows the employment status of graduates in the winter of 2011/12, who completed their course in 2009 and 2010 (all students started their courses in October 2006 but completion dates vary as the length of courses vary). As Table 7 shows, Med STEM graduates (listed as Medicine and dentistry and Subjects allied to medicine in the table) have some of the highest employment rates. However several non-STEM subjects such as Education and Business and administrative studies also have high employment rates and some Core STEM subjects such as Biology and Architecture show low employment rates. Graduates with degrees in Core STEM subjects such as Physical sciences and Biology, veterinary science and agriculture have the highest rates of still being in study, consistent with the evidence presented above.

Table 7 Distribution of Main Current Activity by Undergraduate Degree Subject (%)

Broad subject group of undergraduate degree	Employed*	Studying	Unemployed	Other
Medicine and dentistry	92	6	2	0
Education	86	6	8	1
Business and administrative studies	84	5	10	1
Subjects allied to medicine	82	11	5	2
Mass communication and documentation	78	5	14	2
Creative arts and design	77	7	14	2
Mathematical and computer sciences	76	11	11	2
Social studies	75	10	13	2
Engineering, technologies	74	14	10	1
Interdisciplinary subjects	71	13	13	2
Law	69	14	14	3
Linguistics and classics	67	16	14	3
Languages	65	18	13	3
Historical and philosophical studies	65	15	16	4
Biology, veterinary science, agriculture and related	65	20	12	3
Architecture, building and planning	64	17	15	4
Physical sciences	60	28	10	2
Total average	73	13	11	2

Source: Futuretrack 2006, Stage 4 UK graduates only (weighted) *'Employed' includes those in paid employment or self-employed.

3.3.2 Early Occupation "Choices," Future Track

Table 8, also from Futuretrack (Purcell, *et al*. 2012, p. 63), breaks down the employment into various categories to determine whether graduates are using knowledge from their degrees in their current job, and in what ways. Graduates with degrees in more vocational courses such as Medicine and dentistry, Subjects allied to medicine, Education and Engineering technologies are more likely to be using their degree knowledge as "experts" (note that this does not mean an engineering degree holder is necessarily utilising their engineering knowledge).

A high share of graduates with STEM degrees in Biological sciences (37 per cent) are in a non-graduate job (even though this group includes veterinarians), while Engineering and technology graduates had the lowest proportion of individuals in non-graduate jobs (16 per cent). On balance, the highest proportions of non-graduate activities are to be found amongst the non-STEM disciplines.

Some of this is due to the recession. The impact of the recession can be seen in the "increased proportions of graduates from subject groups which previously appeared to experience more rapid integration into appropriate occupations for graduates in non-graduate jobs or unemployed: Architecture, Building and Planning, Law, Mathematics and Computer Sciences, and Education" (Purcell, *et al*. 2012, p. 64). It is also reflected in the high unemployment and inactivity rates and, while the average proportion for the two rates combined are slightly lower for non-STEM than Core STEM, the latter are much more likely to be inactive than unemployed than the former (often meaning that they are in education).

Table 8 Current Occupational Category or Alternative Activity of UK Graduates in Winter 2011 by Broad Subject Studied

	Type of current occupation or other activity (%)						
	Expert	Strategist	Communicator	Non-graduate job	Employed, occupation not know	Unemployed	Other activity
Medicine and dentistry	92					2	6
Subjects allied to medicine	67	0	1	13	1	5	13
Biology, veterinary science, agriculture and related	20	2	5	37	1	12	23
Physical sciences	29	4	3	24	1	10	30
Mathematical and computer science	41	4	8	23	1	11	13
Engineering technologies	51	2	4	16	1	10	15
Architecture, building and planning	21	6	5	28	4	15	22
Social studies	30	6	8	29	3	13	12
Law	20	4	6	36	2	14	17
Business and administrative studies	17	8	16	41	2	10	6
Mass communication and documentation	10	3	31	34	1	14	7
Linguistics and classics	13	3	15	34	1	14	19
Languages	19	5	13	26	2	13	22
History and philosophical studies	18	6	11	29	2	16	19
Creative arts and design	20	2	15	37	3	14	10
Education	14	2	44	24	1	8	6
Interdisciplinary subjects	20	5	12	33	2	13	16

Source: Futuretrack 2006, Stage 4 UK-domiciled graduates (weighted). (Purcell, et al. 2012, p. 63)

3.3.3 Occupations of Young Graduates, LFS

This section looks at the supply of new entrants with STEM and non-STEM degrees and how this has changed over time using LFS data. The discussion also examines the number of new entrants working in STEM and non-STEM occupations and how this has changed over time. Finally this section looks at the interplay of the two and how the number of STEM graduates working in STEM and non-STEM jobs has changed over time and compares it with the number of non-STEM graduates working in STEM and non-STEM jobs.

Since 2001, the number of employed new graduates has declined for Med STEM graduates but has increased for Core STEM and non-STEM. Between 2001 and 2011, the number of employed Medicine and related new graduates declined from 73,200 to 65,700. However, this does not indicate a further drop into the future since between 2001 and 2005, the number of Med STEM graduates declined and then started increasing (but has not yet returned to its 2001 value).

The numbers of Core STEM employed new graduates was higher in 2011 (204,600) than in 2001 (183,000). However the 2011 value was below the high water mark of 243,300 observed in 2008. Between 2001 and 2011, the number of new employed non-STEM graduates increased from 337,900 to 456,700.

The number of new graduates employed in Med STEM and Core STEM occupations has declined between 2001 and 2011. In 2001, there were 42,200 new graduates working in Med STEM occupations and 77,600 new graduates working in Core STEM occupations. In 2011, the numbers declined to 39,700 and 59,000, respectively. Over this time period, the number of new graduates working in non-STEM occupations increased from 474,100 to 628,300.

3.3.4 First Destinations of New STEM Graduates

Occupations of New STEM Graduates, 2001-2011

Med STEM graduates enter Medicine and related occupations and non-STEM occupations in a roughly a 60:40 ratio. The proportion of Med STEM graduates entering Core STEM occupations is small, one to four per cent most years. Between 2001 and 2006, the proportion of Med STEM graduates entering Med STEM jobs increased from 49 per cent to 63 per cent. Then the proportion of Med STEM graduates working in Med STEM jobs decreased and, by 2011, only 56 per cent of Med STEM graduates entered a Med STEM job. This is reflected in the trends in the proportion working in non-STEM jobs, which was 49 per cent in 2001, 36 per cent at its minimum in 2006 and 41 per cent in 2011.

New Core STEM graduates were much more likely to work in a non-Core STEM occupation than a STEM occupation. In 2001, 69 per cent of Core STEM graduates worked in a non-STEM occupation, three per cent in a Med STEM occupation and 28 per cent in a Core STEM job. Between 2001 and 2011, the proportion of Core STEM graduates working in a Core STEM job decreased, while the proportion working in a non-STEM job increased. By 2011, 81 per cent of core STEM graduates were working in a non-STEM job compared to only one per cent and 19 per cent working in Med STEM and Core STEM jobs, respectively. This should not be treated as attrition – Core STEM degree holders may still be using their degree discipline in non-Core STEM occupations.

Non-STEM graduates overwhelmingly work in non-STEM occupations. In 2001, 92 per cent of non-STEM graduates worked in a non-STEM job and seven per cent worked in a Core STEM occupation. Between 2001 and 2011, the proportion of non-STEM graduates working in non-STEM jobs increased, while the proportion working in Core STEM jobs declined. By 2011, 96 per cent of non-STEM graduates were working in a non-STEM job and only four per cent were working in a Core STEM job, with no more than one per cent working in Med STEM jobs.

Sectors of New STEM Graduates, 2001-2011

Med STEM graduates were most likely to enter Medicine and related sectors, then non-STEM sectors. Only a small proportion of Med STEM graduates worked in Core STEM sectors. In 2001, 50 per cent of Med STEM graduates worked in a Med STEM sector, 44 per cent worked in a non-STEM sector and six per cent in a Core STEM sector. The proportion of Medicine and related graduates working in Med STEM sectors has increased over time. By 2011, 69 per cent worked in Med STEM sectors, 24 per cent in non-STEM sectors and seven per cent in Core STEM sectors.

New Core STEM graduates were much more likely to work in a non-STEM sector than a STEM sector. In 2001, 65 per cent of Core STEM graduates worked in a non-STEM sector, three per cent in a medicine or related STEM sector and 32 per cent in a Core STEM sector. Between 2001 and 2011, the proportion of Core STEM graduates working in a Core STEM sector did not change much. In 2011, 66 per cent of Core STEM graduates were working in a non-STEM sector compared to only six per cent and 28 per cent working in Med STEM and Core STEM sectors, respectively.

Non-STEM graduates overwhelmingly work in non-STEM sectors. In 2001, 83 per cent of non-STEM graduates worked in a non-STEM sector, 15 per cent worked in a Core STEM sector and two per cent worked in a Med STEM sector. Between 2001 and 2011, the proportion of non-STEM graduates working in non-STEM sectors increased slightly while the proportion working in STEM sectors declined. By 2011, 86 per cent of non-STEM graduates were working in a non-STEM sector, 10 per cent were working in a Core STEM sector and three per cent in a Med STEM sector.

3.4 STEM Careers of the Overall Workforce

Outside of first destinations of graduates, little seems to have been written about the careers of STEM degree holders. Again, the rationale from the point of view of investigating supply and demand, is that it is important to map not only the proportion of STEM degree holders moving into STEM occupations and sectors, but also the proportions moving out, including those retiring who may need replacing.

According to the LFS, between 2001 and 2010 the share of Core STEM graduates working in Core STEM sectors and occupations declined. In 2001, 46 per cent of Core STEM graduates worked in a Core STEM sector compared with 42 per cent in 2010. The drop was even larger for occupations: in 2001, 62 per cent of Core STEM graduates worked in a Core STEM occupation compared to only 51 per cent in 2010.

Table 9 Share of Employed Core STEM Graduates Working in Core Sectors and Occupations in the UK, 2001 and 2010

	% in STEM Sector		% in STEM Occupation	
Age	**2001**	**2010**	**2001**	**2010**
20 to 24	31	28	38	25
25 to 29	44	40	56	44
30 to 34	46	40	62	51
35 to 39	43	46	62	56
40 to 44	42	45	62	56
45 to 49	43	45	68	57
50 to 54	42	48	69	55
55 to 59	41	47	64	63
60 to 64	41	47	65	52
Overall	46	42	62	51

Source: LFS; STEM Time Series Model (national and regional).xls

As shown in Table 9, the likelihood of a Core STEM graduate to be employed in a Core STEM occupation increases with age. Workers aged 55 to 59 are more than twice as likely to be working in a Core STEM occupation than workers aged 20 to 24. The likelihood of working in a Core STEM sector increases with age as well, in 2010 workers aged 50 to 54 were the most likely to be working in a Core STEM sector.

The issue of STEM graduates going into non-STEM jobs frequently came up in the interviews. One person from a large IT company came across people with a degree in computing science choosing to go into marketing “quite regularly.” A representative from a Chemical firm stated that, “Most of our sales and marketing people have chemistry degrees, and a few chemical engineers, because we sell business to business ... so they have to be able to understand the chemistry, and talk the same language as these people”. The interviewee noted that they have previously recruited people into marketing from a non-Chemistry background, for example, someone with a marketing-related degree; while they generally do well, they have to be moved off the communications side when there is a technical issue to deal with.

An interview with a science-oriented, charitable foundation stated that in some STEM sectors, particularly in Pharmaceuticals, people have done a STEM degree but then taken a job traditionally filled by a non-graduate. “This hasn’t been particularly successful because those graduates don’t actually have the skills to do those jobs which tend to be more practically-focused and sometimes somewhat mundane, and it’s certainly not the job that someone will have done a degree for.” The interviewee suggested that the recession probably plays a part in this “With the economy in the current state, I’d imagine that graduates will take whatever they can get and hope that when the economy turns around, they can then start to get jobs that are better suited to their skills and qualifications”.

An employer in the pharmaceutical sector found that graduates would enter into non-STEM jobs in order to get their foot in the door and to progress into a STEM career. Some graduates (usually those with poorer qualifications) will not apply for STEM jobs and will instead try and get into the company on a lower level (e.g., an administrative role). “They probably think ‘I’m not going to get in that way, so I’m just going to try and get in the door and then move across’”. As a result, they have people in roles that are not best suited to them and people who are not interested in doing their current job.

Many interviewees stated that a considerable proportion of experienced STEM graduates end up in management. One interviewee from an SSC stated that those “considered high-fliers” move into management and “use less of their STEM.” However, others viewed a STEM degree as a requirement for progression into management and the associated job as being a technical one. One large IT employer said that in a technical area, this would be much more difficult for a non-STEM person to progress into management. People reporting into this person would need to respect the manager as having an understanding of the technical role. An Engineering employer shared this view, stating that managers needed to have the technical skills in order to be effective leaders.

For a more detailed discussion on STEM careers based on cross sectional information from the LFS see Section 2.2 of the Annex.

3.5 Future Trends in STEM Supply: Scenarios from a Stock Flow Model

A stock flow model has been developed that allows the user of the model to test what happens to supply under various scenarios, for example, increases in the supply of new STEM graduates, increases in the retention of STEM individuals within STEM jobs and the impact of retirement. For simplicity, the present discussion focuses on Core STEM degree holders.

3.5.1 STEM supply scenarios

Modelling future STEM supply scenarios is a particularly daunting task. The model developed is based on the general principles of stock flow analysis. However, the demographic factors that give stock flow models their strength are a relatively small component of the model and the model has been extended in a number of ways to cope with this. The model is explained fully in Chapter 2 of the Technical Report.

The model provides an estimate of the supply of STEM graduates in 2020 based on a pre-recession (assumes that activity rates return to 2007 level) and a recession scenario (assumes that activity rates remain at a 2011 level). Both scenarios assume that a third of new graduates will have a STEM degree (that number has not changed much between 2001 and the end of the forecast period). The 2007 pre-recession scenario had an average inactivity rate of 10 per cent in 2020[22] and the 2011 scenario had an average of 15 per cent. Historical LFS data was used to fill in the earlier years. See Section 2.3 of the Annex for more details.

There is a huge difference between the two scenarios – if the activity rates in 2020 return to 2007 levels, an additional 118,000 people with STEM degrees will be available for employment. However, this is very much an upper estimate as some people moving from inactivity into employment will be less likely to have the skills, experience and motivation to work in cutting-edge STEM jobs than the overall workforce. Furthermore, older inactive individuals taking retirement in the recession are unlikely to move back into employment when the economy recovers. However, many inactive STEM degree holders in 2011 are young people in post-graduate education and these people are very likely to return to the workforce after finishing their degree. The additional years of education these post-graduates have completed might provide the up-to-date skills needed by employers. See Section 1.3 of the Annex more details.

3.5.2 STEM retention rate

The impact of the STEM retention rate on the supply of Core STEM graduates to Core STEM sectors and occupations in 2020 was also examined.

In the sector scenario, it was assumed that the share of employed STEM graduates working in STEM sectors increases by 10 percentage points over the historical levels (in 2011, 43 per cent of employed Core STEM graduates worked in Core STEM sectors and that value has remained roughly constant since 2001). The scenario also examines the impact of the employment rate. This increase in retention and a return to 2007 employment rates, leads to an additional 400,000 Core STEM degree holders working in Core STEM sectors in 2020. Applying a similar analysis to the Core STEM occupations (assuming that the share of Core STEM workers working in Core STEM increases from the 2010 levels of 51 per cent back to the 2001 levels of 60 per cent) would also lead to a 400,000 increase in supply if the economy returns to 2007 levels. See Annex Table A.6 for full results.

[22] An individual employment rate for each age band was put into the stock flow value, the average employment rate is just to provide an indication of the difference between the two scenarios.

3.5.3 Increasing share of STEM graduates

Another scenario examines the impact of increasing the share of new graduates obtaining a STEM degree on the size of the STEM workforce. As the share of new graduates holding a STEM degree has remained approximately constant at a third over time, this might be the hardest factor to change. The stock flow model suggests this change would result in an increase in around Core 400,000 STEM degree holders in the UK by 2020. The impact of increasing the number of new STEM graduates on the STEM workforce depends on the employment rate and the share of STEM graduates entering STEM sectors and occupations. Thus, under the pre-recession 2007 scenario increasing the number of STEM graduates will lead to a bigger increase in the STEM workforce than increasing it under the more pessimistic 2011 scenario. See Annex Table A.7 for full results.

3.6 Impact of Retirement on Supply

The UK pension age for women has been increasing incrementally from 60 and will reach 65 by 2018. Between 2018 and 2020, the pension age will increase to 66 for both genders. The pension age is expected to increase again to 67 after 2025. This will accelerate the trend of older individuals working longer and retiring later. Although the recession has slightly impacted on this trend by causing older workers to retire when faced with job losses, in general the inactivity rates have decreased for those aged 50+. In 2002, the inactivity rates for Core STEM degree holders aged 50-54, 55-60 and 60-64 were 11 per cent, 20 per cent and 48 per cent, respectively. In 2011, the comparable inactivity rates were five per cent, 18 per cent and 47 per cent. There are only a few years of data on people aged 65-69 but the inactivity rate is around 70 per cent.

Table 10 below shows the current supply of active Core STEM degree holders (based on a three year average of 2009-2011 data). Table 10 also shows the future supply of older workers in 2020 assuming that the current activity rates (average of the three years, 2009 to 2011) hold and assuming that the activity rates increase in line with past trends. A forecast of historical data, indicates that the inactivity rates in 2020 will be four per cent, 12 per cent, 40 per cent and 63 per cent for Core STEM degree holders aged 50 to 54, 55 to 59, 60 to 64 and 65 to 69, respectively.

Table 10 Impact of Increases in Retirement Age on the Supply of STEM Graduates, 2020

Ages	Current Supply[23]	2020 (current activity)	2020 (forecast activity)	2020 Diff
50 to 54	313,777	442,339	457,123	14,784
55 to 59	248,205	355,976	374,282	18,306
60 to 64	151,202	187,529	201,263	13,734
65 to 69	53,466	99,320	110,243	10,923
Total 50+	766,650	1,085,164	1,142,911	57,747

Source: LFS; StockFlow 20-64.xls

Increases in the retirement age will lead to a larger supply of Core STEM graduates in the workforce in the order of 60,000 by 2020. However there is a trade-off – new graduates are more likely to knowledgeable about new areas of science and technology and older workers may be more likely to have out of date skills. Thus, increasing the retirement age and retaining older individuals may increase the supply of STEM degree holders in employment but not necessarily increase the number of STEM workers with up to date knowledge of science and technology.

3.7 Impact of Gender on Supply

One topic frequently raised during the second round of interviews was the difference in the discipline choices of males and females. The paucity of female numbers in certain subject areas, and their subsequent lack of representation amongst certain professions, was noted by many of the interviewees. One interviewee noted that of 13,000 apprenticeship starts in engineering, only 400 were by females.[24]

A representative at the Institute of Mathematics and its Applications (IMA) reported that, “The paucity of [female] students taking Physics A level across the country had led to very few female Physicists”. A senior manager at a major engineering employer noted that, even by age 10 there is a level of conditioning which starts to put girls off – his company has around 16 per cent of female engineers, as opposed to 10 per cent nationally. An interviewee in IT reported that, in web development and digital marketing (more “applied stuff”), the ratio of males to females is more even (60: 40). but in “hardcore IT engineering stuff” it is around 80:20.

[23] Based on an average of 2009-2011 data
[24] According to WISE, while the overall number of apprenticeship starts was 244,400 men (47%) and 276,200 women (53%) in 2011/12, the percentage of female starts in all STEM areas was 10 per cent or less of the total and, in four of the six areas reported, was 2 per cent or less.
http://www.wisecampaign.org.uk/files/useruploads/files/resources/statistics/apprenticeship_statistics_update.pdf

One of the major banks reported that they are actively addressing gender issues and have just hired a Global Head of Diversity to “push this through”. The interviewee reported there to be a tiny number of female leaders in tax and that they would be trying to increase this in the next 10 years. She added, “There is also no immediate pipeline of women here, either. They are encouraging women to take on internships, etc. ‘There is a massive, massive imbalance.’”.

A representative from the Royal Society of Chemistry argued that, “…the gender balance in the Chemistry population at various points is not bad” (e.g. at A level, degree level and post-graduate level the ratio is around 60:40 (”not horrendous”) but after that, there is a big drop-off. For example, “…the difference between the number of women compared with men at senior lecturer level in academia is very low.” A representative of the Society of Biology also noted that, even in disciplines that start more equally, there can be a problem later on (e.g. only 18 per cent of university professors in biosciences are women). However, according to one employer, gender imbalance is not an issue in pharmaceuticals – his own company has a limited gender imbalance. He noted that the pharmaceutical industry typically offers good benefits (maternity leave, etc.) and that most people return after maternity (good retention).

In general, however, there appears to be further problem for women at the early family-formation stage. Several of the interviews revealed that women are lost to STEM when they take career breaks in order to start a family. One representative from a science-oriented, charitable foundation stated that they felt “STEM careers are not very favourable for women who are considering having families” and they had heard enough anecdotal evidence to make them worry. In the research field this is perhaps more understandable, in that taking a career break might be difficult (keeping up to date with the latest research, etc.), although the interviewee did not know why this should also be the case in industry.

However, it was reported that, while there are good schemes in various companies to keep women engaged while on maternity leave, there is no mechanism if a woman wants to take 3-4 years off for a career break. Another respondent argued that, “Many who have left STEM, even for a short while, especially in the Physical sciences and Engineering areas, find that they cannot come back in, especially women (the proportion of women with STEM degrees in these subjects who do not work in Engineering or Physical sciences is 70 per cent)”. These findings may have implications for other STEM graduates as well, who take non-STEM jobs or experience long periods of unemployment or inactivity.

While there are some small initiatives (such as the Daphne Jackson Trust), the representative of the RSC suggested the need for a “cohort-changing scheme” to get people back into the system. He argued that the barriers are not all about keeping up with skills, but about opportunity (women are often locked into a particular geographical location) and engagement (maintaining a link between employers and those on career breaks). Another respondent argued that, “nobody is ‘tapping into’ the situation for girls and there is lots of evidence of girls being put off by teaching, careers advice, etc. Women do not just drop out of STEM to have children, they are put off at various stages”.

4 Commuting and Labour Supply

Chapter Summary

- Net commutes for each nation and region are calculated by taking the difference between the total employed population residing in the region and the total population working in the region.
- Commuting of Core STEM graduates is especially important to the supply of London (net gain of 87,000 Core STEM workers in 2011); the South East (loss of 50,000 Core STEM workers); the East of England (loss of 20,000 Core STEM workers); and the East Midlands (loss of 22,000 STEM graduates in 2011).
- Trends based on the patterns observed from 2001 to 2011, indicate that the net gain of Core STEM workers by London will increase and the net loss of Core STEM in the South East, East of England and East Midlands will increase.
- The supply of Core STEM (and other groups) at the national and regional level is estimated by taking the resident employed and unemployed population and adding in the net commute.

4.1 Introduction

It is important to have an understanding as to what supply and demand mean at the national and regional levels because individuals, particularly more qualified individuals, are mobile and can commute across national and regional boundaries. Thus, while for many employers the location of their jobs is relatively regionally fixed, this is more rarely the case in terms of labour supply. The implication of this is that each employer will have a larger labour supply than those available within the region, but, at the same time, each employer will be competing for that larger labour supply with employers from other regions. Estimation of associated conceptual model[25] is outside the scope of the present study, and the present model takes the regional supply to be the number of employed plus unemployed STEM resident in the region plus the (projected) net inflows of STEM into the region; demand is regionally fixed.

[25] Such a model requires each individual supplier to have a probability of supply to different regions and each organisation to have a probability of hiring from each region (where for each individual and each organisation the probabilities sum to unity). Under these conditions, the sum of net commutes for the employed will be zero at the national level and the sum of potential net commutes (of the unemployed) will also be zero. Otherwise summing across regions would over-estimate total supply and total demand at the national level.

Many employers appear to see the world in this way. For example, a considerable number of the employers interviewed noted how companies outside London expressed concerns about recruitment in their region, because they struggle to compete with London for STEM graduates. One interviewee thought that this was a problem created by all major cities, implying that London will have the largest effect.

4.2 Historical Commuting Patterns in the UK's Nations and Regions

In order to determine the net flows of workers across the regions of England, the supply of workers residing in the region and the total employment in the region was examined for each STEM group from 2001 to 2011. Table 11 illustrates the commuting activities of Core STEM degree holders in 2011. The row for each geographical area illustrates the proportion of the area's resident Core STEM workers that work in the region. For instance, Table 11 shows that 89 per cent of Core STEM graduates living in London also work in London and that 80 per cent of Core STEM graduates living in the South East work in the South East.

The columns for each region (or nation) represent the share of each other region's graduates that work in the region. For instance, the column for London in Table 11 indicates that 16 per cent of the South East's resident employed Core STEM population worked in London in 2011.

The matrix also shows that in some areas, commuting is not important. For instance, in Northern Ireland, 99.6 per cent of the Core STEM residents worked in the country. Matrices constructed for Med STEM, non-STEM, all QCF4+ graduates and all non-graduates show a similar trend to the Core STEM. For more discussion on commuting, see Section 3.2 of the Technical Report.

Table 11 Geographical Distribution of the Employers for Each Region's Residents, 2011 (Core STEM)

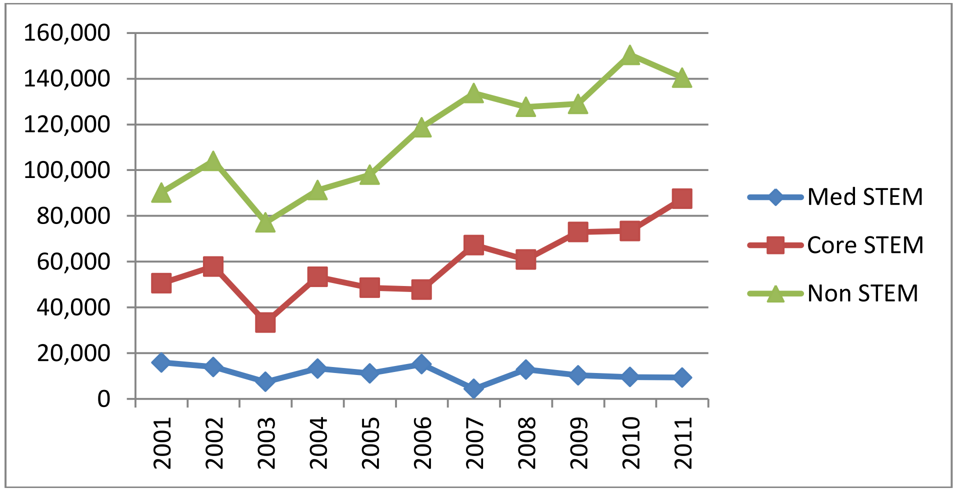
Place of Residence	Place of Work: London	South East	East of England	South West	West Midlands	East Midlands	Yorkshire and Humber	North West	North East	Wales	Scotland	Northern Ireland	England	Total
London	89.22	6.42	2.86	0.29	0.00	0.00	0.00	0.00	0.00	0.29	0.92	0.00	98.78	100
South East	15.84	80.54	1.46	0.95	0.41	0.42	0.10	0.12	0.00	0.16	0.00	0.00	99.84	100
East of England	14.77	2.33	81.86	0.34	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100
South West	0.73	4.01	0.14	93.69	0.37	0.40	0.00	0.00	0.00	0.46	0.19	0.00	99.34	100
West Midlands	0.78	0.74	0.34	2.03	89.96	2.62	0.00	2.00	0.00	1.15	0.37	0.00	98.48	100
East Midlands	1.94	1.89	1.97	1.08	3.74	82.63	3.96	2.62	0.00	0.17	0.00	0.00	99.83	100
Yorkshire and Humber	1.28	0.45	0.00	0.00	0.70	2.00	93.09	2.09	0.39	0.00	0.00	0.00	100.00	100
North West	0.56	0.21	0.15	0.26	1.30	0.61	1.16	93.73	0.00	1.80	0.23	0.00	97.97	100
North East	0.00	0.00	0.00	0.00	0.71	0.00	4.60	0.49	93.17	0.00	1.03	0.00	98.97	100
Wales	0.22	0.56	0.00	4.28	1.98	0.00	0.00	1.81	0.00	91.15	0.00	0.00	8.85	100
Scotland	0.00	0.36	0.12	0.32	0.00	0.00	0.32	0.29	0.00	0.16	98.42	0.00	1.42	100
Northern Ireland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	99.61	0.00	100
England	22.51	19.00	9.70	10.13	8.04	7.06	8.12	10.98	3.73	0.44	0.29	0.00	99.26	100

Source: LFS; 20CurrentResidencebyCurrentWork.xls.

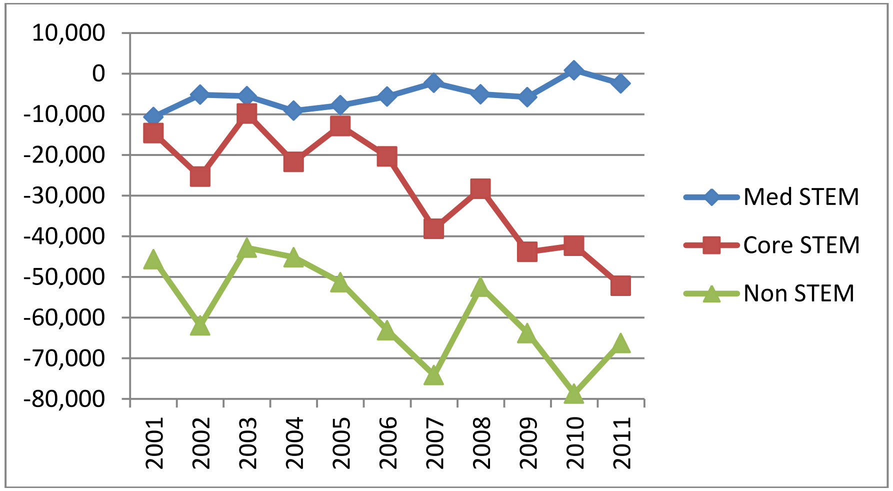
The patterns shown in 2011 are consistent with historical trends. Figure 4 summarises the commuting patterns over time for the four regions with the largest net flows. London is the only region that has consistently had a high influx of graduates and that although the net migration of Med STEM graduates has been relatively constant, the migration of Core STEM and non-STEM graduates has been increasing over the past few years. The South East, East of England and East Midlands have had a constant negative net flow of workers. In the South East and East of England, the net migration of Med STEM graduates has remained constant over time but the net loss of Core STEM and non-STEM graduates has been increasing. In the East Midlands, the net loss of Med STEM graduates from that region has declined over time while the net loss of Core and non-STEM graduates has tended to increase. For more discussion of commuting matrices, see Section 3.2 of the Technical Report.

Figure 4 Net Commuting of the Medicine and Related STEM, Core STEM and non-STEM Graduate Workforce for Selected Regions, 2001-2011

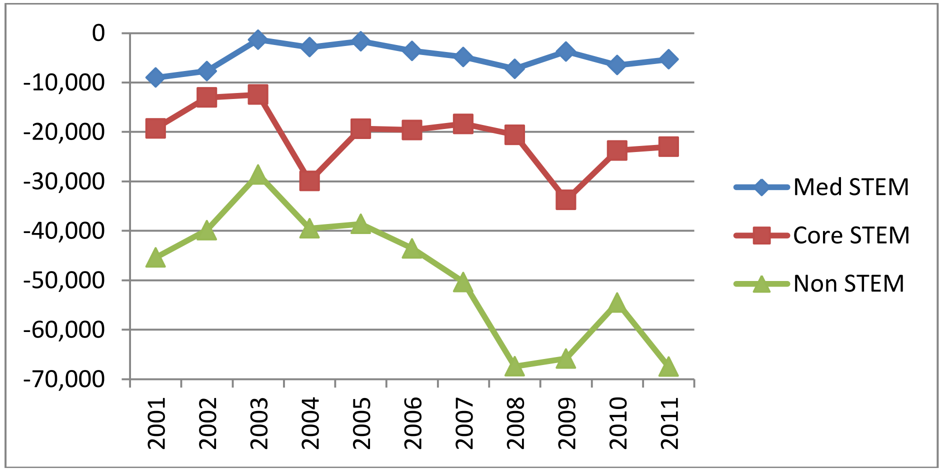
(a) London



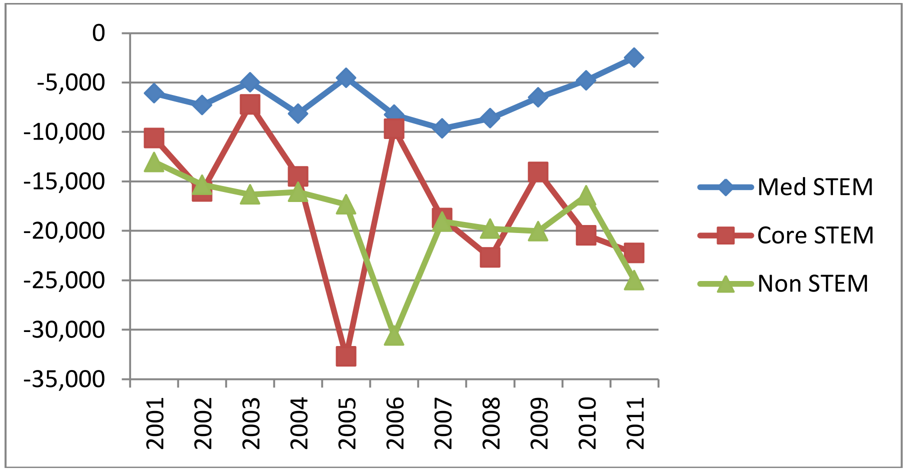
(b) South East



(c) East of England



(d) East Midlands



4.3 Future Commuting Patterns in the UK's Nations and Regions

Table 11 (along with the corresponding matrices for Med STEM, non-STEM, all QCF4+ graduates, and non-graduates) is used to project net flows among the nations and regions for 2020. Table 12 shows the net flows by region in 2002, 2007, 2011, 2020 and 2025. In order to translate the flows into numbers, the baseline, 2007 activity rates have been assumed. The net commute was calculated by taking the difference between the total number of Core STEM graduates working in the region and the total number of employed Core STEM graduates residing in the region. The data for 2002, 2007 and 2011 is based on historical LFS data. The data for 2020 and 2025 was projected using the population of QCF4+ graduates predicted by the UKCES Qualifications Model, assuming that a third of QCF4+ degree holders have a STEM degree (in line with the data from 2001-2011) and that the employment rate returns to 2007 pre-recession levels.

Table 12 Net Commuting of Core STEM graduates 2002 to 2025

	Historical			Forecast	
	2002	**2007**	**2011**	**2020**	**2025**
London	57,967	67,330	87,503	137,313	166,043
South East	-25,346	-38,139	-52,140	-105,641	-142,558
East of England	-13,014	-18,355	-23,005	-36,227	-38,729
South West	-3,285	2,983	3,033	6,464	9,059
West Midlands	7,422	5,635	-1,433	-15,553	-22,986
East Midlands	-16,004	-18,708	-22,250	-22,572	-21,406
Yorkshire and the Humber	-3,262	2	2,501	13,434	18,356
North West	172	-4,612	-743	2,923	2,207
North East	-3,012	-2,965	-8,792	-5,607	-7,172
Wales	-7,904	-584	1,306	21,351	32,633
Scotland	4,123	6,913	-2,424	4,446	4,967
Northern Ireland	-276	0	-1,043	-332	-415
England	1,639	-6,828	-15,325	-25,466	-37,185

Sources:LFS; 20CurrentResidencebyCurrentWork.xls and STEM Time Series Model (national and regional).xls

Using the net flows at least allows the present study to examine the effects of commuting on the market outcome in different regions and explore, in particular, the effects of London on other regions.

5 Market Supply, Demand and Imbalances

Chapter Summary

- There is some evidence of a link between vacancy rates and Core STEM densities, however this depends upon the method of analysis used.
- Estimates of vacancy ratios rates generally do not suggest a higher vacancy rate for Core STEM vacancies (in all occupations) or for vacancies in STEM occupations only.
- Supply and demand calculations for 2020 under both the “2007” and “2011” scenarios do not suggest an overall shortage of STEM graduates (in terms of numbers) in most regions or nations of the UK.
- Vacancies for Core STEM degree holders are more likely to be hard-to-fill than other vacancies.
- Mismatches between supply and demand for Core STEM appear to be more about lack of suitably qualified candidates rather than a numerical shortage of STEM degree holders.

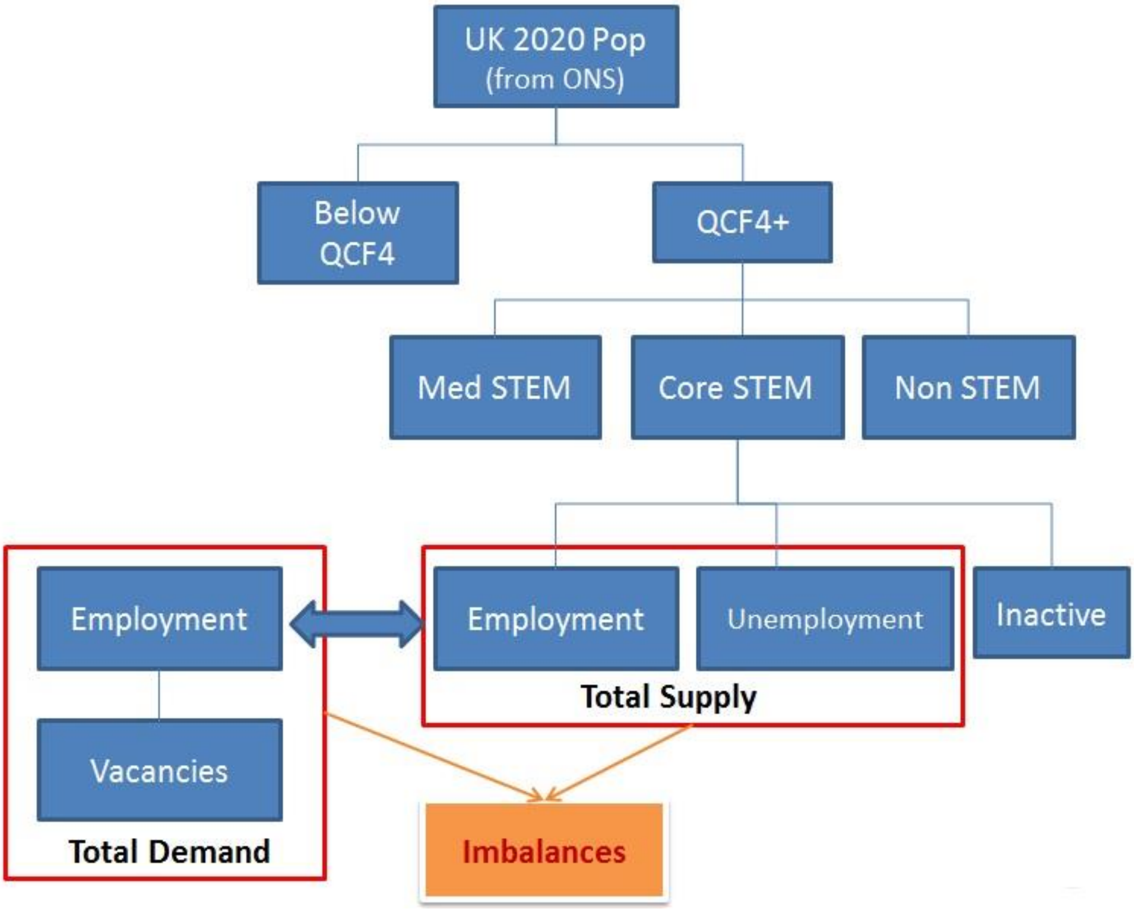
5.1 Introduction

The main underpinnings for the present projections are the qualification projections of the main Qualifications Model developed for the UKCES, which have been up-dated annually over a number of years (see, for example, *Ambition, 2020 – 2009 Report* and *Ambition 2020 – 2010 Report*, UKCES 2010 and UKCES 2011).

The latest version of the model, produced in June 2013, provides qualification proportions and numbers by the levels of the Qualifications and Credit Framework for 2020 (and 2025) (see Bosworth 2013a, Bosworth 2013b and Bosworth 2013c). For the present study, these numbers are broken into three degree and above (QCF4 and higher) groups using the trends in Med STEM, Core STEM and non-STEM groups, as well as a non-degree group (see Figure 5). Section 5.2 discusses the historical evidence of shortages amongst these four groups, based upon an analysis of the NESS / ESS surveys carried out by UKCES.

Before briefly outlining the modelling of supply and demand (Sections 5.3 and 5.4), it is worth saying something about the role played by the economy. The prolonged recession that has occurred at the end of the data period means that any projections made on trend data will almost certainly produce a bleak view of the future. For this reason, the baseline projection in the present study simply assumes that a recovery is made from the economic activity and vacancy rates of 2011 to those of 2007. While this seems a modest improvement, at the time of writing there is still some uncertainty that this will be achieved. In addition, however, the model explores a number of more and less ambitious scenarios.

Figure 5 Flow Chart of Supply and Demand



The demand side of the equation is formed by employment and vacancies. Baseline overall employment at the UK level is fixed by applying the 2007 employment rate to the ONS (2010 based) population estimates (see Figure 5). Vacancy ratios, which are an important element in determining demand are significantly higher for 2007 than 2011. The growth in population and the restoration of the 2007 employment and vacancy rates combine to produce a significant rise in demand. While there are no published vacancy rates for different degree holders or different levels of qualification, these are estimated using econometric techniques and by a proportional allocation method. While the results of both methods are interesting, they should be treated with caution for the reasons discussed below.

The supply side of the equation is formed by employment plus the unemployed (again, see Figure 5). While the recession appears to have shifted a proportion of newly qualified graduates into inactivity (see Section 3.3.1), overall inactivity rates for all individuals aged 16 to 64 increased more modestly between 2007 and 2011. The overall population projections are the ONS (2010 based) population estimates for the UK, nation states and regions. These have already been translated into supplies of individuals at different qualification levels in a series of modelling activities undertaken for the UKCES, which gives a projected breakdown of the proportions and numbers of individuals holding QCF level four and higher.

Using this baseline scenario, a variety of trends are fitted to the data on both the demand and supply sides at the UK, national and regional levels, that allow a picture of the market for Core STEM to emerge. As supply is measured using place of residence and demand is measured using place of work, commuting patterns play an important role in resolving potential mismatches in supply and demand. Commuting is insignificant at the UK level, but of considerable importance at the regional level. By dealing with commuting patterns directly, it is possible to see how some regions appear to be advantaged and others disadvantaged by net migration.

Section 5.2 examines the vacancy rates for STEM and non-STEM groups, using econometric techniques and a proportional method. Section 5.3 outlines the modelling of future supply and Section 5.4 discusses demand. Section 5.5 brings the supply and demand estimates together and discusses the magnitude and nature of the market imbalances suggested by the model. Section 5.6 looks at supply and demand for Core STEM occupations in England.

5.2 Vacancy rates for STEM and non-STEM groups

This section discusses estimates for vacancy rates for STEM and non-STEM groups: first, using a proportional allocation method and, second, using regression analysis. The allocation method yields vacancy rates that keep the qualification mix constant (assuming wastage rates are the same across qualification groups), so it under-estimates demand in occupations in which employers wants to increase the proportion of the work force that are Core STEM. The regression analysis, on the other hand, gives a high estimate of Core STEM vacancy rates, which seems difficult to justify for reasons set out in Section 5.2.2.

5.2.1 Estimates of Vacancy Rates

There are a range of historical measures of skill needs and skill shortages, mainly collected as a part of the NESS / ESS exercises. Vacancy rates, for example, are constructed as the ratio of vacancies to employment and are an indicator of demand-side imbalance – the extent to which firms wish to maintain or expand their workforce. The extent to which vacancy rates translate into problems for employers depends, in part, on the speed with which such vacancies can be filled with sufficiently skilled individuals.[26] But overall demand is employment plus vacancies.

Official estimates of vacancy rates, from the ONS Vacancy Survey, are only available by sector. However, the NESS / ESS surveys carried out by the UKCES contain both occupation and sector information, although no direct information about vacancies for STEM and non-STEM degree holders. While many factors may affect vacancy rates, such as economic performance and growth, these lie outside of the scope of the present study. In the present context, the question arises whether there is some form of relationship between STEM densities and vacancy rates.

Vacancies are estimated for the STEM groups using a proportional method. In this method, the number of vacancies for an occupation at the three-digit level (from England's 2007 NESS and from the 2011 ESS for the UK and the nations) is multiplied by the STEM density. Thus if an occupation has a STEM density of 50 per cent, it is assumed that 50 per cent of those vacancies are for STEM degree holders.

[26] Thus, a more telling measure is that of hard-to-fill vacancies, with higher hard-to-fill vacancy ratios a clearer indicator of demand-side imbalance than higher total vacancy ratios.

This essentially gives a vacancy rate that would keep the qualifications mix of the occupation roughly constant (this would depend on the wastage rates for the different qualification groups being the same). Of course, vacancies for STEM degree holders might be higher than this if the employer wants to increase the STEM density of its workforce and the ratios in Table 13 could be an under-estimate. The vacancy densities for each STEM group are calculated by summing up all the vacancies allocated to the STEM group and dividing by the total employed population of the STEM group (from LFS data).

Estimating vacancy densities for Wales, Scotland, Northern Ireland and the UK in 2007 is more difficult, as data for 2007 are only available for England. For Scotland and Northern Ireland, national estimates of vacancies (at the one-digit occupational level) from 2008 are used. For Wales, data from the 2005 national survey is used but the allocations of vacancies to occupations is based on the allocation of hard-to-fill vacancies rather than overall vacancies (the latter is not published). The UK densities for 2007 are calculated using a weighted average of the four Nations.

Table 13 shows the estimated vacancy densities in 2007 and 2011 for the UK, four Nations and the nine English planning regions. Vacancy densities tend to be the highest for non-graduates, followed by Core STEM. Virtually all of the ratios in 2007 are higher than the 2011 values. The estimated vacancy ratios for Core STEM in Table 13 are lower than those calculated by the regression method in Section 5.2.2 below.

Table 13 Estimated Vacancy Ratios by STEM Group, 2007 and 2011

		LO	SE	EE	SW	WM	EM	YH	NW	NE	EN	WA	SC	NI	UK
2007	Non Grad	3.4	3.2	2.8	2.7	2.6	2.1	2.4	2.6	2.0	2.8	3.4	2.8	2.3	2.8
	Med STEM	2.3	2.8	1.2	1.8	1.4	2.2	1.7	1.5	1.7	1.9	2.9	3.3	2.4	2.0
	Core STEM	3.0	2.8	2.4	1.9	3.4	1.8	2.3	1.9	2.7	2.4	2.3	2.6	2.3	2.4
	Non-STEM	3.1	2.8	2.1	2.2	2.2	1.8	2.0	2.2	2.0	2.4	2.2	2.7	2.6	2.4
	Overall	3.2	3.1	2.6	2.5	2.6	2.0	2.3	2.4	2.1	2.6	3.1	2.8	2.0	2.7
2011	Non Grad	3.0	3.2	3.0	2.4	2.1	2.5	2.0	2.1	2.0	2.6	2.4	2.1	2.7	2.5
	Med STEM	2.2	2.3	2.6	1.8	2.1	1.5	1.4	1.6	1.4	1.9	1.6	1.3	1.9	1.9
	Core STEM	2.5	2.3	2.7	1.6	1.6	1.6	1.8	1.7	2.0	2.1	1.6	2.1	1.9	2.1
	Non-STEM	2.4	2.3	2.1	1.7	1.6	1.8	1.7	2.0	1.9	2.0	2.0	1.7	1.9	2.0
	Overall	2.8	3.0	2.9	2.1	2.0	2.3	1.9	2.0	2.0	2.4	2.2	2.0	2.6	2.4
Difference 2011 - 2007	Non Grad	-0.4	0.0	0.3	-0.3	-0.5	0.4	-0.4	-0.5	0.0	-0.2	-1.0	-0.8	0.4	-0.3
	Med STEM	-0.1	-0.5	1.4	0.1	0.7	-0.7	-0.3	0.0	-0.3	0.1	-1.3	-2.0	-0.5	-0.2
	Core STEM	-0.4	-0.5	0.3	-0.3	-1.8	-0.2	-0.5	-0.2	-0.7	-0.3	-0.6	-0.5	-0.5	-0.4
	Non-STEM	-0.6	-0.5	-0.1	-0.5	-0.6	-0.1	-0.3	-0.2	-0.2	-0.4	-0.2	-1.0	-0.7	-0.4
	Overall	-0.5	-0.2	0.3	-0.3	-0.6	0.2	-0.5	-0.4	-0.1	-0.2	-0.9	-0.9	0.7	-0.3

Source: Vacancy Calculations 2007 and 2011.x

5.2.2 Alternative methods of estimating Vacancy Rates

There are some drawbacks to using the proportional method discussed above in order to estimate STEM vacancy rates. This method allocates vacancies rates according to the current STEM density in the occupation. However, employers want to increase the relative numbers of STEM workers in a particular occupation, then this method provides an under-estimate of the STEM vacancy rates. An alternative method of estimating STEM vacancy rates based on a regression analysis is explored and discussed fully in Section 4.2 of the Technical Report.

The results from the regression suggest significantly higher Core STEM vacancy ratios, compared to non-graduates and the other graduate groups, particularly in 2007, with the recession washing away some of the difference in 2011. While the regression results tend to give significantly higher vacancy ratios for Core STEM than non-Core STEM groups and the overall fit of the estimated equation is significant, the explanatory power is very low. The research chose not to use these results in the main scenarios for a number of reasons.

Resources did not allow the inclusion of control variables, such as the state of the economy. While the positive and significant coefficient on Core STEM suggests that it would be interesting to pursue this result, it may well be that the inclusion of other explanatory variables will reduce the size and significance of the effect of Core STEM on vacancy rates.

The preferred estimates on statistical ground restrict the sample to occupations that employ at least one Core STEM worker (on the grounds that many occupations will never employ a Core STEM worker, but will still have vacancies). This still produces a bias against Medicine and related degree holders as these are concentrated in many fewer occupations than Core STEM employees (all non-STEM degree holders and non-graduate employees are widely diffused across occupations and are not a problem).

Most problematically, however, while the regression results suggest a significantly higher level of Core STEM demand, they do not seem to reflect what a more qualitative analysis of the data indicate. In particular, calculating the vacancies for the Core STEM occupations, where STEM densities are amongst the highest, produces lower vacancy rates than for other qualification groups and much lower than those suggested by the regressions.

5.3 Modelling future STEM supply

5.3.1 Qualifications Modelling

The projections draw upon the qualification modelling produced for the UKCES and, in particular, the unpublished projections produced in 2013.[27] These give estimates of the supply of qualification levels QCF1 to QCF8, plus the no qualification group to 2020 (and 2025). These estimates are pinned to the ONS population projections, 2010 (which are still the most recent available at the time of writing). They separately model immigration and emigration, although the qualification statistics for these groups are weak. The projections provide estimates of the numbers and proportions of individuals holding QCF4 and higher (e.g. degree and above) and those with lower than QCF4 (non-degree level). This modelling is broken down by the national and regional level.

On the supply side, the numbers of individuals in the population holding the various types of degree in 2020 are derived by projecting forwards the proportions of individuals in the three categories (Med STEM, Core STEM and non-STEM graduates); those without a degree level qualification are already modelled by the earlier work.[28] Historical data used to construct these proportions are from the LFS, 2002 to 2011. These proportions are applied to the numbers of individuals with QCF4 and above projected by the UKCES qualifications model. See Section 4 of the Technical Report for more details on the allocation of QCF4+ into STEM.

5.3.2 Economic Activity Rates

The supply side of the labour market normally involves information about employment and unemployment. This provides information about the number of individuals willing and able to supply their services at (or very soon after) that point in time. However, in the context of projecting labour supply over the medium to long term, it is also possible for individuals who are currently inactive to move back into the labour market as economic conditions improve.

[27] Published projections can be found in UKCES (2010b) and UKCES (2011c). Full details of the main UK model are contained in Bosworth (2013a).
[28] See Technical Report for details on how the QCF4+ population is allocated into the STEM groups

Employment rates generally declined between 2007 and 2011 as a result of the recession. For instance, Table 14 shows the variations across the UK and the four nation states for Core STEM graduates. The highest percentage point fall in employment rates was in Scotland (five percentage points), followed by England and Wales, whereas the employment rate appears to have increased in Northern Ireland (four percentage points). The effect on supply is less than this, however, as the rate of unemployment moves in the opposite direction. The data in Table 14 also suggest that a certain amount of the movement out of employment during the recession resulted in an increase in inactivity, which may well be reversed when the economy begins to pick up. See Chapter 3 of the Technical Report for a detailed discussion of changes in the economic activity rates by nation state and region of the UK for all four qualification groups over time.

Thus, in the baseline projection, it is assumed that overall economic activity rates move from their 2011 position, back to their 2007 values by 2020.[29] This gives a starting point for total employment, unemployment and inactivity broken down by the three degree qualification groups and the lower than degree group. Thus, LFS data are used to derive the total supply of individuals in each group by adding employment and unemployment.

Table 14 Economic Activity Rates of Core STEM Graduates, UK and the Four Nation States, 16-64 year olds

		England	Scotland	Wales	Northern Ireland	UK (STEM)	UK (all)
2007	% employed	87.3	86.0	82.6	85.0	86.9	72.4
	% unemployed	2.6	1.6	3.1	3.6	2.6	4.0
	% inactive	10.1	12.4	14.3	11.4	10.5	23.6
2011	% employed	82.8	81.0	81.7	88.8	82.8	70.1
	% unemployed	3.9	4.7	6.7	2.7	4.1	6.2
	% inactive	13.2	14.3	11.6	8.5	13.2	23.7
Difference 2011-2007	% employment	-4.5	-5.0	-0.9	3.8	-4.2	-2.3
	% unemployment	1.3	3.1	3.6	-0.9	1.5	2.2
	%inactive	3.2	1.9	-2.7	-2.9	2.7	0.1

Source: LFS; STEM Time Series Model (National and Regional).xls

[29] Fieldwork for NESS 2007 took place between April and July 2007 (UKCES, 2008, p. 23). This appears to largely precede the recession, which official statistics suggest began in 2008. The data from the ESS, 2011 were collected at a point well into the recession and will reflect the position at the end of our historical data period. The baseline scenario for the projection period is that, as the economy recovers to rates of growth similar to that of the pre-recession period, economic activity and vacancy rates will look more like their 2007 than their 2011 values.

Table 15 Economic Activity Rates, Nine Planning Regions of England, Core STEM Graduates (ages 16-64)

		London	South East	East of England	South West	West Midlands	East Midlands	Yorks & Humber	North West	North East
2007	% employed	85.4	90.6	89.3	88.8	86.1	84.1	84.7	88.0	84.9
	% unemployed	3.0	1.8	2.8	2.4	3.7	3.2	3.4	1.6	3.1
	% inactive	11.6	7.7	7.9	8.8	10.2	12.7	11.9	10.4	12.0
2011	% employed	79.4	84.7	86.2	86.0	81.7	84.3	82.8	80.1	81.6
	% unemployed	6.1	2.5	2.5	2.6	4.9	3.2	4.2	4.3	4.7
	% inactive	14.5	12.8	11.3	11.4	13.4	12.5	13.0	15.6	13.7
Difference 2011-2007	Employment	-5.9	-5.9	-3.1	-2.8	-4.4	0.3	-1.8	-7.9	-3.3
	Unemployment	3.1	0.8	-0.3	0.2	1.2	-0.1	0.7	2.8	1.6
	Inactive	2.9	5.1	3.4	2.6	3.2	-0.2	1.1	5.1	1.7

Source: LFS; STEM Time Series Model (National and Regional).xls

Similar trends are seen for the nine English planning regions, as show in Table 15. The Core STEM employment rates in 2011 ranged from 77 per cent in the North West to 84 per cent in the East of England and the South West. Employment rates were substantially higher in 2007 ranging from 85 per cent in London and the East Midlands up to 91 per cent in the South East. Unemployment and inactivity rates are generally the mirror image of the employment rates. Restoration of all of the rates to their 2007 levels would make a substantial difference to the supply of Core STEM graduates in all of the regions due to the drop in the inactivity rate.

5.3.3 Impact of Commuting on the Supply at the National and Regional Levels

At the UK level, the total supply can be calculated from the employment and unemployment groups. However, at the national, and especially at the regional level, the total supply of individuals in each group can no longer be obtained simply by adding employment and unemployment, because of differences in the region of residence and region of work. As shown in Chapter 4 above, while commuting is of little importance for some regions, this is not the case for London and a number of other regions. Thus, the projected net commute (calculated on the basis of the discussion in Chapter 4) is added to the supply for each region.

5.4 Demand

The starting point for demand is to assume that total UK employment on the demand side is the same for each STEM group as on the supply side calculated above.[30] However, the division of the employed group into qualification categories is based upon trends in the proportions of each of the four groups amongst the employed (rather than the whole population, as in the case of supply).

The demand side is completed by applying the estimated vacancy ratios for the three graduate groups and the non-graduate group to the levels of employment to estimate the numbers of vacancies. Total demand for each group is formed by adding projected employment and the number of vacancies.

[30] Calculations were carried out comparing the share of Core STEM based on total QCF4+ employment rather based on total QCF4+ population but the shares were identical for the UK and did not impact the result.

Thus, at this stage of the modelling the potential imbalances derive from:

- differences in the trend proportions of the four qualification groups between the employed population and the whole population (thus, if, for example, the non-graduate group became increasingly likely to be unemployed or inactive, the projected demand for them would be relatively lower);
- differences between the vacancy ratios and unemployment rate for each qualification type and level (with higher vacancies to unemployment leading to lower surpluses or higher shortages).

At the national and regional level, the employment for the demand side was obtained from the 2020 place of work and place of residence matrices, discussed in Sections 4.2 and 4.3. Thus, at the national (and especially regional level), the supply and demand employment populations differ.

5.5 Market imbalances

This Section examines the results of comparing the supply projections with the demand projections. It begins by exploring whether evidence can be found that hard-to-fill vacancy rates are higher for Core STEM than other qualification groups and what the implications of this would be for a return to the 2007 levels of activity or higher. Many of the people interviewed expressed concerns that difficulties in recruiting STEM graduates would become harder in the future when the economy picked up, particularly as key growth areas would require more STEM skills.

Some employers were optimistic that apprenticeships, which would eventually lead to a STEM degree, were the way to increase overall supply, to increase loyalty and create graduates with both STEM skills and a familiarity with the way business works.

A Sector Skills Council employee revealed that a lot of SMEs are using “home-grown” staff, using non-STEM people such as existing employees and then putting them through a degree (also apprenticeships): “someone who’s loyal”. Their focus is more on experience, rather than academic expertise. “I’ve seen lots of shop-floor workers become tradespeople and then eventually an engineer with a degree”. In discussing the STEM apprenticeships, the interviewee said that this was another route for SMEs although the apprentices still need academic ability to do the role (these go up to Level 6).

The Richard Review (2012, p. 3) came to a similar conclusion; "It is in the employers' interest because apprenticed employees provide benefits: they are more loyal and more effective. They understand their employers' business on a deeper level as they have grown up within it. They are more loyal to their employer because their own self-worth is tied to the quality of the employer whose training kite marks their accomplishment."

5.5.1 Estimates of Hard to Fill Vacancies, Proportional Method

One historical measure of imbalance is the hard-to-fill vacancy ratio (hard-to-fill vacancies per employee) from NESS/ESS. Again, similar to the overall vacancy ratio, this measure is not broken down by qualification group, but is available by occupation and sector. Hence, in a similar way to vacancies, the hard-to-fill vacancy ratio for each STEM group is estimated using the proportional method discussed in Section 5.2.1.

Table 16 shows the proportion of vacancies that are hard-to-fill by STEM group for the English regions in 2007 and 2011. The "All" row refers to the proportion of all vacancies in the region that are hard-to-fill (around 30 per cent in 2007 and 22 per cent in 2011 for England). The estimates for each STEM group are calculated by allocating a proportion of the reported hard-to-fill vacancies for each occupation to the STEM groups using the STEM densities and then dividing the total by the total number of vacancies allocated to the STEM group.

As Table 16 shows, vacancies for Core STEM are more likely to be hard-to-fill than the vacancies overall. For instance, in England 34 per cent of Core STEM vacancies are estimated to be hard-to-fill for 2007 compared with 30 per cent overall (the gap is larger for the regions in London, South East and East of England). Between 2007 and 2011, the share of vacancies that are hard-to-fill dropped for all regions and STEM groups. In 2011, 26 per cent of Core STEM vacancies in England are hard-to-fill compared with 22 per cent overall. Large variations are seen by regions. In 2007, Core STEM occupations are most likely to be hard-to-fill in the East of England and the North East (40 per cent and 39 per cent, respectively). In 2011, the incidence of hard-to-fill vacancies for Core STEM is highest in Yorkshire and the Humber (30 per cent) and the South East (29 per cent).

In 2007, vacancies for Med STEM are not more likely to be hard-to-fill than overall vacancies with the exception of the North East. However, in 2011, Med STEM vacancies are harder to fill than average vacancies in the East Midlands, East of England, South West and North West. This is because the recession tended not to lower the incidence of hard-to-fill vacancies for Med STEM as much as it did for the other groups.

Table 16 Proportion of Vacancies that are Hard-to-fill by STEM Group, English Planning Regions 2007 and 2011

2007	London	South East	East of England	South West	West Midlands	East Midlands	Yorks & Humber	North West	North East	England
Non Grad	31	31	30	36	26	31	29	25	30	30
Med STEM	23	25	23	35	31	27	16	20	42	25
Core STEM	38	39	40	36	13	32	33	31	39	34
Non-STEM	31	29	24	28	23	30	23	22	23	27
All	31	31	30	35	24	30	28	25	29	30
2011	**London**	**South East**	**East of England**	**South West**	**West Midlands**	**East Midlands**	**Yorks & Humber**	**North West**	**North East**	**England**
Non Grads	19	21	19	24	28	19	34	22	22	22
Med STEM	13	20	25	38	22	20	21	21	23	22
Core STEM	22	29	28	28	26	19	30	27	24	26
Non-STEM	17	21	17	20	22	16	35	26	17	18
All	18	21	19	24	27	18	33	23	21	22
Difference	**London**	**South East**	**East of England**	**South West**	**West Midlands**	**East Midlands**	**Yorks & Humber**	**North West**	**North East**	**England**
Non Grads	-12	-9	-12	-12	2	-11	5	-3	-8	-8
Med STEM	-10	-5	2	3	-8	-6	5	1	-19	-3
Core STEM	-17	-11	-12	-8	13	-13	-3	-4	-15	-9
Non-STEM	-13	-9	-7	-8	-1	-14	11	4	-6	-9
All	-13	-10	-11	-10	3	-12	6	-2	-9	-8

Source: ESS 2007 and NESS 2011; Vacancy Calculations 2007 and 2011.xls

Table 17 shows the proportion of vacancies that are hard-to-fill by STEM group for the UK and the four Nations in 2011 (data are not available for 2007). Like with the English planning regions, Core STEM vacancies are more likely to be hard-to-fill than vacancies overall (with the exception of Northern Ireland). Wales and Northern Ireland have a high incidence of hard-to-fill Med STEM vacancies (43 per cent and 50 per cent, respectively).

Table 17 Proportion of Vacancies that are Hard-to-fill by STEM Group, UK and the Four Nations, 2011

	England	Wales	Scotland	Northern Ireland	UK
Non Grads	22	34	21	22	23
Med STEM	22	43	20	50	24
Core STEM	26	28	23	25	26
Non-STEM	18	32	14	24	21
All	22	33	20	28	23

Source: ESS 2007 and NESS 2011; Vacancy Calculations 2011.xls

5.5.2 Future Supply and Demand for STEM, Baseline Scenarios

The baseline "high" scenario is based on 2007 values for economic activity rates and vacancy rates. The baseline "low" scenario is based on a number of the key 2011 values persisting into the future, rather than reinstating the 2007 values. The low scenario imposes lower employment and vacancy rates, as well as higher inactivity and unemployment rates than in the "high" baseline scenario. Supply is unaffected insofar as the reduced employment rate is off-set by the increased rate of unemployment, but demand is lessened vis-a-vis the baseline, because of the reduced vacancy ratio. This low scenario reflects what some of the interviewees say has happened in recent years as the depressed state of the economy has relaxed the shortages of STEM.

As both of these scenarios lead to excess supply of Core STEM, a number of other "higher" scenarios are also explored that would begin to take the labour market for Core STEM into excess demand. These "higher" scenarios introduce vacancy rates more in line with those suggested by the regression results, exploring vacancy ratios of four per cent and higher. In addition, it explores a higher employment level of Core STEM employees consistent with a rebalanced economy in which there is more production based around science, engineering and technology.

The supply of and demand for Core STEM graduates in the UK, four nations and the nine English planning regions is calculated for 2020 under the baseline "high" and "low" scenarios. As discussed above, the high scenario assumes 2007 activity and vacancy rates and the low scenario, 2011 values. The vacancy rates obtained by the proportional method are used.

Table 18 shows the projected UK supply of and demand for workers, for the four qualification groups, in 2020 under the two main scenarios. The supply does not vary much between the two scenarios as the only loss of supply would be due to an increase in the higher inactivity rate (2.7 percentage points for the UK) in the low scenario. A further difference in demand between the two scenarios is driven by the difference in the number of vacancies. Neither scenario predicts a "numbers shortage" (e.g. where the number demanded exceeds the number supplied) of Core STEM, Non-STEM or non-graduates in the UK. The high scenario predicts a shortage of around 7,000 Med STEM degree holders.

Table 18 Estimated Supply and Demand by STEM Group for the UK in 2020

UK 2020	**Supply**		**Demand**		**Supply less Demand**	
	High	**Low**	**High**	**Low**	**High**	**Low**
Core STEM	4,987,00	4,905,000	4,944,000	4,755,000	43,000	151,000
Med STEM	1,621,000	1,529,000	1,627,000	1,520,000	-7,000	9,000
Non-STEM	8,484,000	8,378,000	8,417,000	8,102,000	67,000	276,000
Below QCF4	16,653,000	16,903,000	15,865,000	15,412,000	788,000	1,491,000
All	31,745,000	31,715,000	30,854,000	29,789,000	891,000	1,926,000

Source: Supply and Demand.xls

Table 19 shows the projected supply of and demand for Core STEM degree holders in the four Nations in 2020 under the high and low scenarios. The supply at the national level is the projected active population adjusted for net commute. Neither scenario predicts a "numbers shortage" of Core STEM graduates in the UK, England, Wales or Northern Ireland. The high scenario shows a small shortage 2,000 of Core STEM workers in Scotland.

Table 19 Estimated Supply and Demand for Core STEM Graduates, Four Nations, 2020

	Supply with commuting		Demand		Supply less Demand	
	High	**Low**	**High**	**Low**	**High**	**Low**
England	4,192,000	4,103,000	4,151,000	3,984,000	40,000	119,000
Wales	189,000	196,000	186,000	184,000	2,000	11,000
Scotland	486,000	482,000	488,000	464,000	-2,000	19,000
Northern Ireland	120,000	124,000	118,000	123,000	2,000	2,000
UK	4,987,000	4,905,000	4,944,000	4,755,000	43,000	151,000

Source: Supply and Demand.xls

Table 20 shows the projected supply and demand for Core STEM degree holders in the nine English planning regions in 2020 under the high and low scenarios. Again, at the regional level, the supply is the projected active population adjusted for net commute. The high scenario suggests a small numbers shortage of Core STEM degree holders (1,500) in the South East. Otherwise, the estimates suggest there will not be a shortage of Core STEM degree holders in England.

Table 20 Estimated Supply and Demand for Core STEM Graduates, Nine English Planning Regions 2020

	Supply		Demand		Supply less Demand	
	High	**Low**	**High**	**Low**	**High**	**Low**
London	1,054,000	1,045,000	1,044,000	998,000	10,000	47,000
South East	724,000	696,000	725,000	687,000	-2,000	8,000
East of England	374,000	361,000	368,000	359,000	6,000	2,000
South West	451,000	441,000	447,000	434,000	4,000	7,000
West Midlands	297,000	289,000	293,000	276,000	4,000	13,000
East Midlands	272,000	272,000	265,000	265,000	7,000	7,000
Yorkshire and Humber	408,000	406,000	400,000	393,000	8,000	13,000
North West	462,000	444,000	461,000	428,000	800	16,000
North East	151,000	150,000	148,000	144,000	2,000	6,000
England	4,192,000	4,103,000	4,151,000	3,984,000	40,000	119,000

Source: Supply and Demand.xls

Supply and Demand in Context, UK

Table 21 shows the number of unemployed people per vacancy for the UK in 2020 by STEM group. The three graduates groups (Core STEM, Med STEM and Non-STEM) have a lower number of unemployed per vacancy than the non-graduate group. These ratios are in line with Working Futures IV overall estimates of five for 2011 and 2.5 pre-recession.

Table 21 Number of Unemployed People per Vacancy by STEM group, UK 2020

	No. Unemployed per Vacancy	
	High	**Low**
Core STEM	1.4	2.6
Med STEM	0.8	1.3
Non-STEM	1.3	2.7
Below QCF4	2.8	4.9
Overall	2.1	3.9

The surplus of Core STEM degree holders per 100 employees in the UK in 2020 is projected to be between one (high scenario) and three (low scenario), very similar to the values for non-STEM. For non-graduates, however, there is projected to be between five and 10 surplus workers per 100 employees. In med STEM, there is projected to be a shortage of 0.4 people per 100 workers in the high scenario and a surplus of 0.6 in the low scenario.

5.5.3 Future Supply and Demand, Alternative Scenarios

Several adjustments are made to the baseline 2007 scenario as well. Alternative versions of the 2007 scenario employ the vacancy ratios from the regression analysis (which are higher for Core STEM) in place of the ratios obtained from the proportional calculations (See Section 5.2.1). Another adjustment is made assuming that the employed Core STEM population (on the demand side) grows by an additional one per cent (see Section 5.2.2).

Impact of the Vacancy Rates

The supply and demand outcomes in this discussion are very dependent on the vacancy ratios. Increasing the vacancy ratios from those obtained by the proportion method with the higher Core STEM vacancy ratios obtained by the regression analysis changes the results. Using the higher vacancy densities predicts a shortage of 95,000 Core STEM degree holders in the UK in 2020 under the 2007 scenario. Under the prolonged recession (2011 scenario) there is still an excess of Core STEM supply. The same trends hold out for the four Nations and the nine English planning regions, using the regression vacancy densities gives a shortage of Core STEM under the 2007 scenario but not under the 2011 scenario.

In order to have a balance between Core STEM supply and demand in 2020 based on the 2007 scenario, the vacancy density would need to be around 4.05 (falling somewhere between the lower proportional result and the higher regression result).

Core STEM Growth Scenario

In 2011, Core STEM employment is around 3.9 million. That will increase to around 4.6 million in 2020 even assuming that the employment rates remain at 2011 levels due to demographic factors (e.g. the increase in the size of the working age population and in the increase of the proportion of the UK population that is qualified at the QCF4+ level). Under the 2007 scenario, the Core STEM employment will be even higher, at around 4.8 million.

However these basic scenarios assume that the relative size of the STEM employment in 2020 will remain roughly in line with its historical size. However, if the number of Core STEM degree holders in employment on the demand side increased by one per cent over this predicted value (from the 2007 scenario), say from a growth in emerging sectors or a change in the direction the UK economy due to technological change, then the excess supply seen in

Table 19 and Table 20 would become a shortage of 6,500 for the UK. Assuming a five per cent increase in the size of the Core STEM employment (demand side) would leave to a major shortage of 200,000 for the UK.

5.6 Core STEM Occupations

There is one further step to the modelling – a division between Core STEM occupations and non-Core STEM occupations in 2020. Core STEM occupations are identified at the 3-digit level based on the criteria set out in Chapter 2. The modelling of Core STEM supply and demand in Core STEM occupations is carried out for England and the nine English planning regions, as the vacancy data for the other three nations is incomplete in 2007.

5.6.1 Supply, Core STEM Occupations

The supply of Core STEM degree holders for Core STEM occupations is based upon the trends in the relative employment within Core STEM and non-Core STEM occupations of individuals holding Core STEM qualifications. The baseline supply projections assume that the proportions of Core and non-Core STEM occupations are the same for the unemployed as the employed.

The supply for Core STEM Occupations in 2020 is calculated from the total supply of Core STEM graduates obtained in Section 5.3 above. This supply is then multiplied by the share of Core STEM graduates that are forecast to work in STEM occupations in 2020. In 2010[31], 56 per cent of Core STEM graduates in England worked in Core STEM occupations but this is predicted to drop to 49 per cent by 2020. Similar trends are seen throughout the UK, with between 48 per cent (in the North East) and 60 per cent (in the East Midlands) of Core STEM degree holders working in a Core STEM occupation in 2010.

In order to adjust for commuting, the net movement of Core STEM degree holders in 2020, calculated in Section 5.3, is multiplied by the share of Core STEM degree holders working in STEM in England to obtain an approximate estimate of the movement of workers in Core STEM occupations.

5.6.2 Demand, Core STEM Occupations

The total employment for Core STEM occupations in England is equal to the employed population used on the supply side. In order to obtain demand at the regional level, the England employed population is multiplied the region's share of Core STEM workers in Core STEM occupations (determined from historical trends in LFS data from 2001 to 2010). For instance, London is projected to have 25 per cent of England's workforce in 2020, so 25 per cent of England total is allocated to London's demand.

[31] 2010 is used as the reference year rather than 2011 because the occupational classifications changed in 2011, making it difficult to compare 2011 results with prior years.

The vacancy ratios for Core STEM occupations are based on the 2007 and 2011 vacancy ratios for Core STEM occupations only, based on the ESS and NESS raw data. These ratios are discussed further in Section 5.6.3 below.

5.6.3 Vacancy Ratios for Core STEM Occupations

Table 22 shows vacancy ratios for Core STEM occupations. These vacancy ratios are calculated by taking the total number of vacancies for all the Core STEM occupations (from the ESS and NESS) and dividing by the total employment for all the Core STEM occupations (from LFS data). Data for Wales, Scotland and Northern Ireland is only available for 2011. All but one of the vacancy ratios are higher in 2007 than in 2011.

Table 22 Estimated Vacancy Ratios for Core STEM Occupations, 2007 and 2011

	2007	2011	Difference
London	3.0	2.3	-0.7
South East	2.8	2.0	-0.8
East of England	2.4	2.9	0.4
South West	2.0	1.2	-0.8
West Midlands	4.7	1.3	-3.4
East Midlands	2.1	1.7	-0.4
Yorkshire and Humber	2.4	1.9	-0.5
North West	1.8	1.2	-0.5
North East	3.2	1.9	-1.3
England	2.7	1.9	-0.8
Wales		1.4	
Scotland		2.3	
Northern Ireland		0.9	
UK		1.9	

Source: Vacancy Calculations 2007 and 2011.xls

The vacancy densities for Core STEM occupations are not higher than the overall vacancy densities for all occupations shown in Table 13. In 2011, only Scotland has a higher vacancy density for Core STEM occupations (2.3) than for all occupations overall (2.0). In 2007, roughly half of the regions had lower vacancy ratios for Core STEM occupations than for all occupations overall. Viewed individually, however some Core STEM occupations had vacancy ratios higher than the overall rates such as Engineers and Architects.

5.6.4 Hard to Fill Vacancies, Core STEM Occupations

Table 23 looks at the proportion of vacancies that are hard-to-fill for the Core STEM occupations (the earlier tables focused on all occupations). Table 23 shows that the share of vacancies that are hard-to-fill dropped between 2007 and 2011 for all the regions other than the West Midlands. Comparing the shares in Table 23 with the overall data in Tables 21 and 22 shows that Core STEM occupations tend to have a higher ratio of hard-to-fill vacancies than all occupations overall. For instance in 2007, 30 per cent of vacancies in England were hard-to-fill but 40 per cent of those in Core STEM occupations were hard-to-fill. The relative position holds up during the recession in which 22 per cent of all vacancies in England were hard-to-fill compared with 28 per cent of vacancies in Core STEM occupations.

Table 23 Proportion of Vacancies that are Hard-to-fill in Core STEM Occupations

	2007	2011	Difference
London	42	24	-18
South East	47	35	-12
East of England	54	28	-26
South West	43	33	-11
West Midlands	15	26	10
East Midlands	38	19	-19
Yorkshire and Humber	40	33	-7
North West	42	27	-16
North East	47	21	-26
England	40	28	-12
Wales		22	
Scotland		25	
Northern Ireland		26	
UK		27	

Source: Vacancy Calculations 2007 and 2011.xls

Note that the Occupational Classification changed between 2007 and 2011

The hard-to-fill vacancy data is consistent with the findings with the interviews. There may not be an overall shortage of Core STEM degree holders but there appears to a shortage of the right candidates to fill specific roles.

5.6.5 Supply and Demand in Core STEM Occupations

Supply and demand calculated for Core STEM degree holders in Core STEM occupations in 2020 are shown in Table 24.[32] Table 24 does not predict a shortage of supply for Core STEM occupations in England overall but there are potential regional shortages (again comparable data are not available for the other three nations).

After adjusting for commuting, under the high scenario, shortages are predicted for East of England (2,844), East Midlands (6,800), Yorkshire and the Humber (9,600), North West (1,000) and North East (21,800), these are offset by surpluses in London, the South East and the South West.

[32] Forecasts are not provided for Scotland, Wales and Northern Ireland because the 2020 high scenario is based on the 2007 vacancy ratios which are available for England only.

Table 24 Estimated Supply and Demand for Core STEM Occupations, Nine English Planning Regions, 2020

	Supply		Demand		Supply-Demand		Net Commuting		Commuting Adjusted Supply-Demand	
	High	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**
London	459,000	457,000	481,000	451,000	-23,000	5,000	67,000	64,220	44,000	69,000
South East	356,000	341,000	282,000	265,000	74,000	76,000	-52,000	-48,515	22,000	27,000
East of England	199,000	193,000	184,000	175,000	15,000	18,000	-18,000	-17,363	-3,000	200
South West	198,000	193,000	182,000	172,000	16,000	21,000	3,000	3,000	19,000	24,000
West Midlands	164,000	159,000	156,000	142,000	9,000	18,000	-8,000	-7,000	1,000	11,000
East Midlands	144,000	145,000	140,000	133,000	4,000	12,000	-11,000	-12,000	-7,000	700
Yorkshire and Humber	178,000	178,000	194,000	184,000	-16,000	-6,000	7,000	6,000	-10,000	200
North West	191,000	183,000	194,000	184,000	-3,000	-800	1,000	2,000	-1,000	2,000
North East	63,000	62,000	82,000	76,000	-19,000	-14,000	-3,000	-3,000	-22,000	-17,000
England	1,952,000	1,911,000	1,896,000	1,782,000	56,000	129,000	-12,000	-12,000	44,000	117,000

Source: Supply and Demand.xls

6 Conclusions

6.1 STEM Occupations and Sectors

The share of Core STEM degree holders working in Core STEM occupations is declining. In 2001, 60 per cent of Core STEM degree holders worked in Core STEM occupations, and this declined to 40 per cent by 2011.[33] The share of new Core STEM graduates working in Core STEM occupations is even lower, only 22 per cent in 2011. Between 2001 and 2011, the share of new Core STEM graduates working in either a Core STEM sector and/or occupation declined from nearly half in 2001 to only a third in 2011. This suggests that Core STEM workers are becoming more dispersed throughout the economy and employment is moving away from traditional employment in the manufacturing sector. This could also suggest that the definition of a STEM job or STEM sector is changing so fast that new STEM roles in emerging sectors and technologies are being missed by the classification systems.

Initially, Core STEM sectors and occupations were identified in order to look for areas of high levels of vacancies and demand. However, analysis of vacancy ratios by occupation did not lead to evidence of high levels of vacancies in STEM. The vacancy ratios for Core STEM degree holders (in all occupations) and the vacancy ratios across all Core STEM occupations as a group are not higher than the overall ratios. However, the vacancy ratios for specific Core STEM occupations (e.g. engineers) are higher than average.

However, ratios for hard-to-fill vacancies are higher for both Core STEM degree holders (in all occupations) and for Core STEM occupations only as a group. This suggests that there is a mismatch between supply and demand for quality Core STEM workers. In the future, in order to hone in on areas of mismatch, hard-to-fill vacancies and very narrow specific, sectors and occupations of key emerging technologies (KETs) (e.g. nanotechnology) would be the place to look. However, these new technologies and sectors are so new and small that they are often “hidden away” in the broad group of STEM sectors and occupations, such that trends in supply and demand unique to these areas are easily masked.

[33] The SOC changed between 2010 and 2011 but the share of Core STEM degree holders working in Core STEM occupation had declined to 50 per cent in 2010 before the classification change.

6.2 Imbalances between Supply and Demand

Distinctions must be made between overall imbalances, where individuals are effectively treated as being homogenous and, thereby, direct substitutes for one another, as well as specific imbalances, where individuals differ in the detail of their qualifications, skills, experience and quality. Thus, a distinction is made between a “numbers problem”, where there is simply not enough STEM to “go around” and, for want of a better term, a “quality problem” – while there are enough STEM to meet the demand, some proportion of those available are not suitable for the types of job available.

6.2.1 Overall Shortages

Supply and demand calculations for 2020 under both the “2007” and “2011” scenarios do not suggest an overall shortage of STEM graduates (in terms of numbers) in most regions or nations of the UK. However the baseline “2007 scenario” predicts a few shortages such as: 7,000 Med STEM graduates in the UK, 2,000 Core STEM graduates in Scotland, and 1,500 Core STEM graduates in the South East. Under the less optimistic 2011 scenario there are no overall predicted shortages. This result is mirrored in the experience of several employers interviewed, who felt that the current supply of engineers had improved due to the recession, as other employers had drawn back on recruitment.

The existence of overall imbalances is particularly sensitive to the vacancy rates in the model and there are no direct measures of STEM vacancies. The “proportional method” is the preferred way of generating vacancies for the baseline projections. Even these may be optimistic as they reflect what would happen if qualification structure remained constant within each occupation, when in fact, the empirical results suggest that Core STEM densities within the Core STEM occupations have been falling.

The vacancy measures based on the regression results produce a scenario with a considerably higher level of Core STEM demand. However, they do not seem to reflect what the data tell us in other ways. For example, calculating the vacancies for the Core STEM occupations, where STEM densities are amongst the highest, give lower vacancy rates than for other qualification groups and much lower than those suggested by the regressions.

A rebalancing of the economy towards manufacturing that is designed to produce one per cent higher employment of Core STEM in 2020 would result in a small shortage of Core STEM under the 2007 scenario (which would be further exacerbated by a higher number of vacancies).

The baseline forecast does not predict a shortage of Core STEM graduates for Core STEM occupations at the national (England) level, but there are a number of predicted shortages at the regional level that will not be resolved by commuting.

6.2.2 Specific, "Quality" Shortages

The hard-to-fill vacancy rates suggest that, even if there are no numerical shortages of STEM degree holders to go into STEM degree jobs, there is still a mismatch between supply and demand in some cases. The share of vacancies that are hard-to-fill is higher for Core STEM vacancies (in all occupations) than for vacancies overall in both the 2007 and 2011.

For example in 2007 in the East of England, 30 per cent of vacancies are hard-to-fill compared with 40 per cent of vacancies for Core STEM. When only looking at Core STEM occupations, 57 per cent are hard-to-fill in the East of England in 2007. This is consistent with some of the interviews that referred to problems of "quality not quantity" or with problems getting candidates with the right specific skills.

Despite concerns about the quality of graduates, most of the people interviewed felt that the overall quality of the UK graduates was as good as the rest of Europe. Thus, the findings of the interviews, along with those of the quantitative work, are largely consistent with the existence of specific recruitment difficulties in some STEM-related sectors where employers report insufficient UK candidates of suitable quality.

Examples can be found both in earlier reports (e.g. BIS, 2009, p. 4) and in the interviews conducted for the present report, in biosciences, engineering and IT of a number of companies reporting difficulties in finding the quality of recruits they are seeking. Interviews with employers and SSCs in certain sectors such as Engineering, certain other parts of Manufacturing and Oil and gas, revealed difficulties with recruiting engineers due to lack of supply.

However, in a number of these cases, the employers were looking for highly specialist skills, which the interviewees reported were being trained in fewer and fewer UK universities because of the need to manage costs. Fluid dynamics was reported by one employer and laboratory skills by another. In some cases only a handful of UK universities were supplying the required quality of graduates to these specialist markets.

Interviewees in life sciences expressed concerns about the quality of graduates rather than overall quantity. Others pointed to the lack of graduates with practical skills, and both life science and mathematics skills (especially in areas of bio-informatics, health economics and statistical skills). An employer in the pharmaceutical industry revealed that, although there is no overall shortage of people with relevant STEM degrees, there is a shortage of those with specific skills in the job market, and those with higher degrees (e.g. statistical skills, clinical skills). "In general terms it's OK, but when we get down to the specifics, we find that we're actually struggling".[34]

A number of the interviewees reported that shortages were particularly acute for experienced STEM staff. For instance, an interviewee from an aerospace company reported difficulties in recruiting staff with three to eight years of experience in manufacturing and engineering; a representative from a chemical company reported losing staff after five years and problems in recruiting chemical engineers with three to six years of experience; while an interview with a pharmaceutical company revealed problems recruiting staff with specific skills such as biometric and clinical monitoring with at least two years' experience. Interviews revealed frustration at having to train up new graduates and then having to worry about them being poached by competitors.

However, while the interviews confirm difficulties relating to the lack of applicants with the "right" STEM skills and experience in certain fields, they also result from "broader concerns about a lack of well-rounded candidates with technical skills, broader competencies, such as mathematical capability, and practical work experience" (BIS, 2009, p. 4).

The vacancy ratios for Core STEM degree holders (in all occupations) and the vacancy ratios across all Core STEM occupations as a group are not higher than the overall ratios. However, the vacancy ratios for specific Core STEM occupations (e.g. engineers) are higher than average.

6.3 Regional Supply and Demand

Commuting is especially important to London, the South East, the East of England and the East Midlands. In 2011**,** as a result of commuting:

- London has a net gain of 87,000 Core STEM workers;
- South East has a net loss of 50,000 Core STEM workers;
- East of England has a net loss 20,000 Core STEM workers; and
- East Midlands has a net loss of 22,000 STEM workers

[34] Specific roles which are hard to recruit include Epidemiologists and Outcomes researchers (i.e. those who conduct research into the health economics of diseases, and drugs used in those conditions, and into measures of "patient-reported outcomes" such as health-related quality of life and satisfaction with treatment).

The projections of regional imbalances did not foresee a “numbers shortage” for London.

The responses of STEM employers are consistent with London being a magnet of STEM workers at the expense of other parts of the country (although one interviewee saw it as a more general “big city” problem). Employers have pointed to difficulties hiring engineers, scientists and software developers with the right skills, because their location is outside of London. An employer in oil and gas stated that they have struggled to bring engineers into the business for various reasons, including our location (North East), because there are not many engineers in the local community generally and “…compared to London, for example, it’s not that attractive to come up to the North East.”

A chemical manufacturer struggling to recruit chemists and chemical engineers said that the organisation was somewhat challenged geographically, with sites not in the most attractive areas: “we don’t have any presence in London.” Another interviewee referred to a small start-up company in need of “very specific” IT skills that struggled with being able to afford the salary of such individuals and struggling to find someone locally because the right skills are in London and not Coventry. Another firm in the Midlands, a small engineering company, pointed to its location as a drawback in terms of recruiting because of its close proximity to larger firms that are taking all the local candidates.

London’s “pull” with regard to STEM graduates is not limited to STEM jobs. London is also a big draw of STEM graduates into non-STEM jobs in the finance sector. The loss of often the highest quality STEM graduates into finance is a major concern. One interviewee noted that, once you work in London, “it’s really hard to get out” etc.). as the Core STEM work her partner does, “doesn’t really exist outside of London”. Several interviewees reported on job security, one saying that if you move out of London for a job: “…how many opportunities are out there if you lose your job in a year’s time?”.

The interviews indicated that SMEs and intermediaries in the “supply chain” felt that they had a harder time than the large companies (often at the end of the supply chain) because of the smaller salaries and lack of name recognition. These concerns mirror findings in a BIS report (BIS, 2012 pp. 26-27), “Dialogue with industry and departmental sector teams has highlighted common issues [including] the availability of particular skills such as STEM or access to necessary skill sets to enable SMEs to grow; and access to finance either for growth capital or for R&D and broader innovative activity.”

6.4 Comparison with Earlier Reports

A recent report by Royal Academy of Engineering (2012) predicts a “numbers shortage” of Core STEM workers between 2012 and 2020. The estimates of supply and demand for 2020 presented in this report differ from those of the Royal Academy, which predicts an annual shortfall of 10,000 of STEM workers between 2012 and 2020. A major difference is in the estimates of supply. The Royal Academy’s report estimates that the annual increase in supply will be around 90,000, which correspond with the number of new graduates with first degrees in STEM 2010/11 (2012, p. 31). However, analysis in Chapter 5 predicts a larger increase in supply. The estimates of supply in Chapter 5 of this report account for inflows of new graduates, immigration, older individuals working longer, and movements from inactivity into employment as the economy picks up.

Historical estimates from LFS data on the supply of Core STEM workers aged 16-64 suggest an annual increase of more than the 90,000 predicted by the Royal Academy. For instance, in the eight years between 2002 and 2010, the number of people with a STEM degree increased by 1,200,000, an average of 150,000 STEM degree holders per year. The supply (employed plus unemployed population) increased by 1,000,000 between 2002 and 2010 (or by an average of 130,000 per year) as the number of inactive Core STEM degree holders shot up with the onset of the recession.

The current model assumes that a similar trend will continue between 2012 and 2020. The model assumes that immigration will continue in line with the ONS forecasts, which will contribute to the future supply of STEM. Improvements to the economy will likely to reduce inactivity rates, and as the new graduates that enrolled in post-graduate education when the recession hit finish their degree, they will enter the active supply. The active population of older Core STEM degree holders is likely to increase as the retirement age goes up and people continue to working longer.

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Appendix

Table A1 Selected Sectors – Medicine and Related (2001)

Code	Sector name	Demand side ordering		Code	Sector name	Supply side ordering	
		Density	Proportion			Density	Proportion
85.12	Medical practice activities	45.9	6.992	85.11	Hospital activities	43.1	42.702
85.13	Dental practice activities	45.0	2.911	85.14	Other human health activities	42.9	7.110
85.11	Hospital activities	43.1	42.702	85.12	Medical practice activities	45.9	6.992
85.14	Other human health activities	42.9	7.110	85.13	Dental practice activities	45.0	2.911
24.15	Fertiliser, etc. manufacture	34.9	0.123	24.15	Fertiliser, etc. manufacture	34.9	0.123
	Total		59.838		Total		59.838

Table A2 Selected Sectors – Medicine and Related (2011)

Code	Sector Name	Demand side ordering		Code	Sector Name	Supply side ordering	
		Density	Proportion			Density	Proportion
86.23	Dental practice activities	48.6	3.0121	86.1	Hospital activities	48.4	37.9319
86.1	Hospital activities	48.4	37.9319	86.9	Other human health activities	41.4	10.5184
86.21	General medical practice activities	46.6	5.4621	86.21	General medical practice activities	46.6	5.4621
86.9	Other human health activities	41.4	10.5184	86.23	Dental practice activities	48.6	3.0121
86.22	Specialist medical practice activities	38.6	0.9590	84.12	Reg of activities providing social services	19.3	3.0096
47.73	Dispensing chemist in specialised stores	29.4	2.5529	87.1	Residential nursing care activities	16.9	2.8638
84.12	Reg of activities providing social services	19.3	3.0096	47.73	Dispensing chemist in specialised stores	29.4	2.5529
87.1	Residential nursing care activities	16.9	2.8638	47.78	Other retail sale new goods in specialised stores	16.1	1.1416
47.78	Other retail sale new goods in specialised stores	16.1	1.1416	86.22	Specialist medical practice activities	38.6	0.9590
	Total		67.45		Total		67.46

Table A3 Selected Sectors – Core STEM (2001)

Code	Sector name	Demand side		Code	Sector name	Supply side	
		Density	Proportion			Density	Proportion
24.11	Industrial gas manufacture	54.1	0.097	74.2	Archit.,engineering,etc consultancy	52.2	7.076
74.20	Archit.,engineering,etc consultancy	52.2	7.076	72.2	Computer software consultancy	40.9	6.010
24.12	Dye,pigment manufacture	51.2	0.133	80.302+3	First & post degree level education	27.4	4.511
73.10	Research, natural sciences, engineering	46.0	1.817	80.21	General secondary education, state	17.2	3.672
24.14	Organic chemical manufacture	44.4	0.099	73.1	Research, natural sciences,engin.	46.0	1.817
72.10	Computer hardware consultancy	42.3	0.120	64.2	Telecommunications	15.1	1.736
72.20	Computer software consultancy	40.9	6.010	72.6	Other computer activities	30.8	1.606
26.24	Other technical ceramic man.	38.9	0.080	75.22	Defence	15.2	1.538
24.20	Pesticides,etc manufacture	38.7	0.096	35.3	Aircraft, spacecraft manufacture	22.9	1.441
11.10	Crude oil,gas extraction	38.6	0.400	74.14	Business, management consultancy	22.5	1.340
29.31	Agricultural tractors manufacture	37.5	0.095	30.02	Computers, IT equipment	29.0	1.262
74.30	Technical testing, analysis	37.3	0.387	24.42	Pharmaceutical preparations manu.	28.2	1.195
11.20	Oil,gas services (not surveying)	35.0	0.474	40.1	Electricity generation, supply	24.3	1.085
21.24	Wallpaper manufacture	32.8	0.056	32.1	Electronic components etc man.	22.9	0.745
72.60	Other computer activities	30.8	1.606	33.2	Testing,navigating etc eqt man.	30.5	0.637
33.20	Testing,navigating etc equipment manufacturing	30.5	0.637	11.2	Oil,gas services (not surveying)	35.0	0.474
33.30	Industrial process control equipment	30.2	0.164	11.1	Crude oil,gas extraction	38.6	0.400
85.20	Veterinary activities	29.9	0.370	74.3	Technical testing,analysis	37.3	0.387
32.30	TV,radio,hifi etc equipmentt manufacture	29.7	0.252	85.2	Veterinary activities	29.9	0.370
24.66	Other chemical products manufacture	29.6	0.294	23.201	Mineral oil refining	25.7	0.366
24.41	Basic pharmaceutical manufacture	29.1	0.322	24.41	Basic pharmaceutical anufacture	29.1	0.322
29.21	Furnace manufacture	29.1	0.059	24.66	Other chemical products man.	29.6	0.294

30.02	Computers, IT equipment manufacture	29.0	1.262	32.3	TV,radio,hifi etc eqt manufacture	29.7	0.252
24.13	Inorganic chemical manufacture	28.4	0.250	24.13	Inorganic chemical manufacture	28.4	0.250
24.42	Pharmaceutical preparations man.	28.2	1.195	23.3	Nuclear fuel processing	25.3	0.214
60.30	Transport via pipelines	27.7	0.148	30.01	Office mach manufacture	25.2	0.167
29.60	Weapons,ammunition manufacture	27.7	0.146	33.3	Industrial process control equipment	30.2	0.164
05.02	Fish hatcheries,farms	27.5	0.060	60.3	Transport via pipelines	27.7	0.148
80.30	First & post degree level education	27.4	4.511	29.6	Weapons,ammunition anufacture	27.7	0.146
23.20	Mineral oil refining	25.7	0.366	74.15	Managemnt activities,holding comps	25.1	0.137
23.30	Nuclear fuel processing	25.3	0.214	24.12	Dye,pigment manufacture	51.2	0.133
30.01	Office mach manufacture	25.2	0.167	72.1	Computer hardware consultancy	42.3	0.120
74.15	Managemnt activities,holding comps	25.1	0.137	24.14	Organic chemical manufacture	44.4	0.099
33.40	Optical precision eqt manufacture	25.0	0.056	24.11	Industrial gas manufacture	54.1	0.097
40.10	Elec generation,supply	24.3	1.085	24.2	Pesticides,etc manufacture	38.7	0.096
32.10	Electronic components etc man.	22.9	0.745	29.31	Agricultural tractors manufacture	37.5	0.095
35.30	Aircraft,spacecraft manufacture	22.9	1.441	26.24	Other technical ceramic man.	38.9	0.080
74.14	Business,management consultancy	22.5	1.340	5.02	Fish hatcheries, farms	27.5	0.060
80.21	Gen. secondary education, state, maintained	17.2	3.672	29.21	Furnace manufacture	29.1	0.059
75.22	Defence	15.2	1.583	21.24	Wallpaper manufacture	32.8	0.056
64.20	Telecommunications	15.1	1.736	33.402	Optical precision equipment	25.0	0.056
	Total		40.714			40.714	

Table A4 Selected Sectors – Core STEM (2011)

Code	Sector	Demand side ordering		Code	Sector	Supply side ordering	
		Density	Proportion			Density	Proportion
72.11	Research & experimental dev on biotech	65.6	0.2710	85.31	General secondary education	17.6	4.6680
71.11	Architectural activities	63.1	0.0957	71.12	Eng activities & related tech consultancy	52.3	4.4833
72.19	Other R&D on natural sciences & eng	57.7	1.4960	85.42	Tertiary education	29.6	4.0924
58.29	Other software publishing	55.9	0.2793	62.02	Computer consultancy activities	48.3	3.4359
20.13	Manu other inorganic basic chemicals	52.5	0.2271	62.01	Computer programming activities	48.2	3.1613
71.12	Eng activities & related tech consultancy	52.3	4.4833	70.22	Business and other management consultancy activities	25.1	1.8660
62.02	Computer consultancy activities	48.3	3.4359	84.22	Defence activities	22.1	1.6071
62.01	Computer programming activities	48.2	3.1613	72.19	Other R&D on natural sciences & eng	57.7	1.4960
75	Veterinary activities	45.0	0.8054	42.99	Constr other civil eng proj n.e.c.	37.5	1.3791
6.1	Extraction of crude petroleum	44.9	0.1960	30.3	Manu air & spacecraft & rel mchnry	32.4	1.2109
20.41	Manufacture of soap & detergents	43.8	0.0808	84.12	reg of actv providing social serv	15.1	1.1294
26.6	Manufacture of irradiation & electromed equipment	43.2	0.1475	85.59	Other education n.e.c.	16.3	1.0209
26.2	Manufacture of computers & peripheral equipment	42.8	0.6663	21.2	Manu of pharmaceutical preparations	42.4	0.9075
74.9	Other professional, scientific & technical activities, n.e.c.	42.7	0.6579	75	Veterinary activities	45.0	0.8054
21.2	Manufacture of pharmaceutical preparations	42.4	0.9075	61.2	Wireless telecommunications activities	28.0	0.8006
18.13	Pre-press and pre-media services	42.1	0.0946	35.11	Production of electricity	39.5	0.7884
62.03	Computer facilities management activities	42.0	0.1413	9.1	Supply activities petrol & natural gas extraction	38.2	0.6787
62.09	Other IT & computer service activities	40.9	0.4347	26.2	Manuf computers & peripheral equipment	42.8	0.6663
28.92	Manufacture of machinery for mining, quarrying & construction	40.2	0.1935	74.9	Other professional, scientific & technical activities, n.e.c.	42.7	0.6579

91.04	Botanical & zoological gardens & natural resource activities	40.1	0.1755
35.11	Production of electricity	39.5	0.7884
66.29	Other activities auxiliary to insurance & pension funding	39.3	0.1764
21.1	Manuf of basic pharmaceutical prod	38.6	0.4449
9.1	Support activities for petroleum and natural gas extraction	38.2	0.6787
20.3	Manu of paints & related products	37.6	0.1356
42.99	Constr other civil eng proj n.e.c.	37.5	1.3791
26.51	Manu instruments for measuring, testing & navigation	37.5	0.4780
46.12	Agents involved in the sale of fuels, ores, metals and industrial chemicals	37.0	0.0983
26.3	Manuf of communication equipment	36.6	0.2678
28.99	Man othr spec-purp mchnry n.e.c.	36.5	0.0933
28.49	Manufacture of other machine tools	36.1	0.0820
24.51	Casting of iron	36.1	0.0755
42.21	Construction of utility projects for fluids	35.2	0.1232
20.59	Manu of other chemical products n.e.c.	35.1	0.1256
2.4	Support services to forestry	34.4	0.1112
42.22	Construction of utility projects for electricity & telcom	34.0	0.1558
27.9	Manu of other electrical equipment	33.9	0.1736
19.2	Manu of refined petroleum products	33.6	0.3668
39	Remediation activities & other waste management services	33.5	0.2794

25.62	Machining	23.6	0.5761
66.12	Sec & commodity contrcts brokerage	20.8	0.5512
52.23	Service activities incidental to air transport	24.9	0.5349
26.51	Manu instruments for measuring, testing & navigation	37.5	0.4780
21.1	Manuf of basic pharmaceutical prod	38.6	0.4449
62.09	Other IT & computer service actv	40.9	0.4347
26.11	Manuf of electronic components	31.7	0.4171
71.2	Technical testing and analysis	28.3	0.4119
19.2	Manu of refined petroleum prod	33.6	0.3668
39	Remediation activities & other waste management services	33.5	0.2794
58.29	Other software publishing	55.9	0.2793
61.9	Other telecommunications activities	28.8	0.2755
33.16	Repair & maintenance aircraft & spacecraft	33.0	0.2735
72.11	Research & experimental development on biotech	65.6	0.2710
26.3	Manu of communication equipment	36.6	0.2678
28.29	Manu other gen-purp machinry n.e.c.	26.7	0.2382
20.13	Manu other inorganic basic chemicals	52.5	0.2271
6.1	Extraction of crude petroleum	44.9	0.1960
28.92	Manufacture of machinery for mining, quarrying and construction	40.2	0.1935
46.75	Wholesale of chemical products	32.0	0.1765

25.4	Manuf of weapons and ammunition	33.1	0.1073	66.29	Other activities auxiliary to insurance & pension funding	39.3	0.1764
33.16	Repair & maintenance aircraft & spacecraft	33.0	0.2735	91.04	Botanical & zoological gardens & nature research activities	40.1	0.1755
30.3	Manu air & spacecraft & rel mchnry	32.4	1.2109	27.9	Manu of other electrical eqmt	33.9	0.1736
46.75	Wholesale of chemical products	32.0	0.1765	42.22	Construction utility projects for electricity and telcom	34.0	0.1558
12	Manufacture of tobacco products	31.9	0.0837	63.11	Data proc, hosting & related actv	28.9	0.1501
26.11	Manuf of electronic components	31.7	0.4171	26.6	Manu irradiation & electromed eqmt	43.2	0.1475
42.91	Construction of water projects	31.6	0.0863	62.03	Computer facilities management activities	42.0	0.1413
94.11	Activities of business & employers membership org	31.2	0.0999	20.3	Manu of paints & related products	37.6	0.1356
30.2	Manu railway loco & rolling stock	30.6	0.1189	28.41	Manuf of metal forming machinery	28.6	0.1298
85.42	Tertiary education	29.6	4.0924	20.59	Manu of other chemical products n.e.c.	35.1	0.1256
63.11	Data proc, hosting & related actv	28.9	0.1501	42.21	Constructionof utility projects for fluids	35.2	0.1232
61.9	Other telecommunications activities	28.8	0.2755	42.12	Construction of railways & railways underground railways	26.5	0.1208
28.41	Manuf of metal forming machinery	28.6	0.1298	30.2	Manu railway loco & rolling stock	30.6	0.1189
71.2	Technical testing and analysis	28.3	0.4119	46.21	Wholesale of grain, unmanufactured tobacco, seeds and animal feeds	24.5	0.1157
61.2	Wireless telecommunication activities	28.0	0.8006	2.4	Support services to forestry	34.4	0.1112
28.29	Manu other general-purpose machinery n.e.c.	26.7	0.2382	25.4	Manuf of weapons and ammunition	33.1	0.1073
42.12	Construction of railways and underground railways	26.5	0.1208	32.99	Other manufacturing n.e.c.	26.0	0.1069
27.12	Man elctrcty dist & cont apparatus	26.3	0.0605	94.11	Activities of business & employers membership org	31.2	0.0999
32.99	Other manufacturing n.e.c.	26.0	0.1069	46.12	Agents involved in the sale of fuels, ores, metals and industrial chemicals	37.0	0.0983
70.22	Business and other management consultancy activities	25.1	1.8660	71.11	Architectural activities	63.1	0.0957
52.23	Serv actv incidental to air trans	24.9	0.5349	18.13	Pre-press and pre-media services	42.1	0.0946

25.62	Machining	23.6	0.5761
84.22	Defence activities	22.1	1.6071
66.12	Sec & commodity contracts brokerage	20.8	0.5512
85.31	General secondary education	17.6	4.6680
85.59	Other education n.e.c.	16.3	1.0209
84.12	Regulation of activities providing social services	15.1	1.1294
	Total		44.90

28.99	Manufacture of other special purpose machinery, n.e.c.	36.5	0.0933
42.91	Construction of water projects	31.6	0.0863
12	Manufacture of tobacco products	31.9	0.0837
28.49	Manufacture of other machine tools	36.1	0.0820
20.41	Manufacture of soap & detergents	43.8	0.0808
24.51	Casting of iron	36.1	0.0755
	Total		44.90

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