CENTRE ON SKILLS, KNOWLEDGE AND ORGANISATIONAL PERFORMANCE

Engineering graduates for UK Manufacturing:
Further confirmation of the evident minimal impact of possible workforce-planning policy responses to sectoral shortage reports

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Editor's Foreword

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ABBREVIATIONS

BEng	Bachelor of Engineering (First Degree)
CBI	Confederation of British Industry
CEE	Centre for the Economics of Education, LSE
CPI	Consumer Price Index
DLHE	Destinations of Leavers from Higher Education
E.C.	European Commission
EU	European Union
FD	First Degree (<u>not</u> – in this paper - *Foundation Degree*)
(GmbH	Gesellschaft mit beschränkte Haftung)
HE	Higher Education
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HESA	Higher Education Statistics Agency
HMG	Her Majesty's Government
ICT	Information and Communication Technologies
IEEE	(US) Institute of Electrical and Electronic Engineers
ISBN	International Standard Book Number
IT	Information Technology
JACS4	Joint Academic Coding System (Version 4.0)
LSE	London School of Economics and Political Science
MAC	Migration Advisory Committee
MEng	Master of Engineering (undergraduate degree)
MSc	Master of Science (Taught post-graduate degree)
n.e.c.	not elsewhere classified
SIC	Standard Industrial Classification
SOC	Standard Occupational Classification
STEM	science, technology, engineering, and mathematics
UKCES	(former) United Kingdom Commission for Employment and Skills

Abstract

This paper examines evidence from the HESA DLHE six-month Censuses and 3½ year ('longitudinal') surveys relating to three aspects of the flows of those who have left university with Higher Education Engineering qualifications, to test the robustness of the conclusions of SKOPE Research Paper No. 122 (Dixon, 2015), which showed strong evidence that most Engineering graduates do not go on to work in the sectors of the economy that might be expected, in particular in the 'natural' Manufacturing sub-sector.

Specifically, the paper examines three questions:

i) whether evidence of starting salary levels for those from particular disciplines going into particular sectors could explain the relative flows (on the assumption that higher salaries for graduate vacancies in a particular sector would attract more applications);

ii) whether evidence of sector destinations three years on from the (six-month after graduation) Census data analysed in Dixon (2015) would show up significantly different levels of 'leakage'; and

iii) whether those entering employment having completed Taught Masters (as opposed to First Degree) courses in particular Engineering disciplines would tend (in the light of their apparent greater interest and deeper understanding in the specific discipline) to enter the "expected" sectors more than their Bachelors colleagues.

The "bottom line" answers to these questions is that – with rather minor exceptions – none of the relevant broader evidence from HESA DLHE data over a ten-year period significantly questions the very considerable 'leakage', away from the 'natural' Manufacturing sub-sector, that was found and presented in Dixon (2015).

i) There is *some* correlation between the *average salaries offered* (by employers in each 'destination' sector to cohorts from each Engineering discipline examined) and the *size of the flows* from each discipline into each sector, but it is limited and rarely strong. While there might be reasons why average salary differences might not be large enough to provide a sufficient incentive for Engineering graduates to choose one sector over another, evidence of considerably greater correlation would have been helpful to justify the traditional response of classical economics to employers' concerns about shortages: "*offer more money*"!

ii) While there are sample size issues constraining the statistical precision of comparisons between the two DLHE surveys, these have been addressed, and comparisons of the "linear flows" of graduates from each discipline into the natural Manufacturing sub-sector show a) comparatively very small differences, and b) on balance, slightly *greater* 'leakage' three years on.

iii) More MSc's in *Automotive* and *Aerospace* Engineering have, over the ten years examined, then gone into the *Manufacture of Motor Vehicles...* and *Air and Space craft manufacture* (respectively) than BEng's from these disciplines. However, for the other disciplines compared, there is little difference, and – in terms of entry into Manufacturing as a whole, for the most recent year in the period - the

fraction of the disciplinary cohorts entering *any type of Manufacturing* is slightly *higher* for MSc's than First Degree (FD) graduates in <u>three</u> Engineering disciplines, though *lower* for MSc's than FD's in <u>four</u>!

This new evidence, therefore, only serves to *strengthen* the great importance of NOT assuming linear flows of Engineering graduates into the "natural" Manufacturing sub-sectors corresponding to their discipline, in particular in policy responses to reports of shortages from such sub-sectors.

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Preface: The Scope of Engineering work

Some readers of Dixon (2015) have raised questions, when considering the use of the word "leakage" (away from Engineering work) in relation to the first career steps of Engineering graduates, about precisely what is meant. From an economic classification point of view there are *two main characteristics* of employment:

- The *type of work* the individual carries out – the various functions s/he performs (for example a doctor, a cleaner, or an electrician): this is the **occupation**, and is tracked in labour market statistics in the UK using the *Standard Occupational Classification* (SOC); and
- The **sector** of the economy to which the individual's employer belongs (for example Agriculture, Mining, Transport, Construction – often referred to as the "industry", although in some cases - e.g. Public Administration, Health Care and Education - the employer's activity would not be considered to be "industrial". The **sector** is identified in UK economic statistics within the *Standard Industrial Classification* (SIC).

Thus any job can (and must, for meaningful statistical analysis) be specified in terms of a SOC category and a SIC category, indicating the occupation carried out *and* the sector in which the employer operates[1]. While the relation between the two is sometimes "obvious" – for example *Medical Doctors* generally work within the *Health Care* sector – this is not always so. For example Information Technology (IT) practitioners can work for IT companies (e.g. Computer Programmers working for *Microsoft* or *Google*) but a) often more IT practitioners work for IT *user* employers (in almost all other sectors), and b) Microsoft and Google employ many people who are not IT practitioners (for example accountants, marketing executives, Human Resources staff and of course senior managers who may or may not have a technical IT background).

It is therefore essential, when considering the first career steps of people with a particular education, to distinguish between the **occupation** they enter and the **sector** of their first employer.

The most obvious focus, when considering whether a graduate makes direct use of the knowledge they have acquired in their degree (particularly if a *vocational* course), is the **occupation**. It is natural to assume that occupations that would be viewed as Engineering occupations would be the 'natural' destination of those with an Engineering degree, in that the general assumption would be that the knowledge acquired in the three or more years within Higher Education would be relevant to, and therefore useful in, Engineering work. This assumption would also (although not validly) be made by most people about graduates of other "vocational" degrees: Medicine, Accountancy, the Law, etc.

In principle, therefore, the question of *how much of the technical knowledge gained in their degree course is used in graduate's first job* would be considered in terms of the **occupation** of that first job.

However, like any other labour market, the graduate recruitment market involves *two parties* – which embody the market's *supply* and its *demand*. In order to understand that market, therefore, and assess its *effectiveness*, it is necessary to consider the requirements of a common set of employers whose joint

[1] for the *self-employed*, the sector and occupation become the same

recruitment needs constitute the market demand. And in order to consider how policy might play a role, should such a labour market be felt to be failing, it is necessary to consider the perspectives, experience, and concerns, of employers in particular **sectors**. The realities and perspectives of employers in a particular sector, when considering the recruitment of graduates, will not be identical to the realities and perspectives of recruiting employers in a different sector. For example, some employers looking to recruit Computer Science graduates will be IT companies, but others may be Financial Service companies or Local Authorities. Among the differences that will affect the labour market will often be the *broader human characteristics and qualities sought for work in that sector*, the *attractiveness of work in the sector* and the *salaries that employers in the sector can offer to the fresh graduate* – an important, albeit not the only, consideration for new graduates.

And above all, from a *public policy* perspective, claims from employers that there are *shortages of good graduates for them to recruit* mostly emerge from **Sectoral** representative bodies and large *employers*. It is for this reason that Dixon (2015) and this paper focus on the fractions of Engineering graduates that, for whatever reason – maybe felt by others to be good, maybe felt to be misguided – choose not to go to work in Engineering **sectors**, and in particular choose not to go into *Manufacturing* engineering. As is recognised in both papers, Engineering is much more than just Manufacturing. However, Manufacturing is important not just because of the continuing political desire to *re-balance the UK economy*, but also because much of government's emerging Industrial Strategy is focused on Manufacturing sectors.

This 'leakage' from Engineering **sectors** is therefore completely independent from any 'leakage' from Engineering **occupations** (which will be different, and possibly different in scale). From the point of view of the 'return on the Higher Education investment' the 'leakage' from Engineering **occupations** is the more important measure, while from the point of view of the effectiveness of public policy, the 'leakage' from Engineering **sectors** is the important thing (after all, some Engineering graduates undoubtedly sometimes get recruited into *non-Engineering roles* – e.g Marketing – in Engineering firms).

Thus Dixon (2015) and this paper do not attempt to consider 'leakage' beyond Engineering occupations, but focus on Engineering sectors, in particular, sub-sectors within Manufacturing.

'Leakage' from Engineering sectors beyond Manufacturing

Dixon (2015) and the main body of this paper examine the flows, and the 'leakage', from the Manufacturing sub-sectors directly relevant to a number of Engineering disciplines into those sub-sectors. The reason for this focus is partly that this 'natural' or 'linear' initial career path would be expected to involve significant (the greatest?) direct use of the knowledge and understanding from the degree course in the work, and partly in case the supply of Engineering graduates into these sub-sectors were deemed to be inadequate.

However, as pointed out in Dixon (2015) there are elements within each such Manufacturing sub-sector of other Engineering systems requiring disciplines other than Aerospace Engineering. For example Aircraft contain a number of systems which draw on Engineering disciplines beyond aerospace: e.g. at least the Mechanical Engineering understanding needed for Aircraft engines, and many electronic systems requiring

Electronic Engineering skills. This naturally leads to demand for direct knowledge and understanding from other Engineering disciplines. And of course those with some (higher-level) engineering understanding are often valued, even if the graduate's degree was not in the "directly relevant" discipline for the particular Manufacturing subsector.

It is thus of interest to consider the flows of Engineering Graduates from any/all discipline(s) both into Manufacturing, and into other Sectors that might well be viewed as largely Engineering-based. The obvious additional candidates for this are (with their SIC (07) *Section* identifier):

- Professional, Scientific & Technical activities (M);
- Mining & Quarrying (B);
- Electricity, Gas, Steam and Air Conditioning Supply (D);
- Water Supply; Sewerage, Waste Management and Remediation Activities (E); and
- Construction (F)

Figure 1 shows the fractions of all employed Engineering graduates emerging each year across the ten year period who enter Manufacturing and these other five "Main Engineering Sectors", and Table 1 shows what business activities these additional sectors contain, to clarify their justification as Engineering sectors requiring higher level Engineering skills of the kind that Engineering graduates would expect (& be expected) to provide.

Figure 1: Engineering Graduates working in the *main Engineering Sectors* six months after graduation

(Source: HESA DLHE - discontinuity between 2006-7 and 2007-8 caused by change of SIC version)

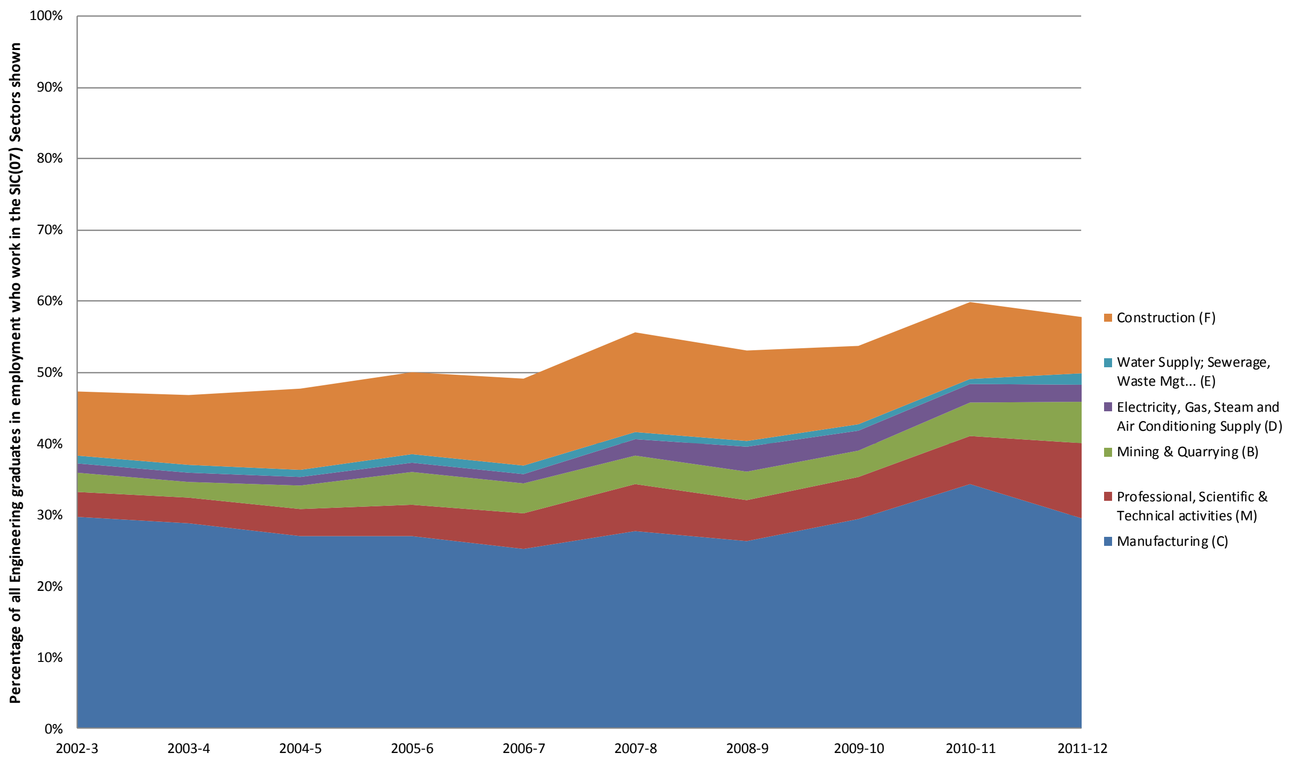


Table 1: Details of "Main Engineering Sectors"

SIC(07) '*Section*' Sectors	Industry/Sub-sectors	Non (higher-level) engineering sub-sectors within the *SIC (07) Section*
Manufacturing (C)	Manufacture of a wide range of products	(assume that higher-level engineering skills are needed in all production processes)
Professional, Scientific & Technical activities (M)	Consultancy and Professional services in Engineering and beyond	Legal and accounting activities; Activities of head offices; management consultancy activities; architectural activities; (non-engineering) technical testing and analysis; scientific research and development; advertising and market research; other professional, scientific and technical activities; and veterinary activities
Mining & Quarrying (B)	Coal and Lignite mining; Oil & Gas extraction industries; Mining of metal ores	Quarrying of stone, sand and clay
Electricity, Gas, Steam and Air Conditioning Supply (D)	Electric power generation, transmission and distribution; Manufacture of gas; Steam and air conditioning supply	Distribution of gaseous fuels through mains
Water Supply; Sewerage, Waste Management and Remediation Activities (E)	Water collection, treatment and supply; Remediation activities and other waste management services.	Sewerage; Waste collection, treatment and disposal activities; materials recovery
Construction (F)	Construction of buildings; Civil engineering;	Demolition and site preparation; Electrical, plumbing and other construction installation activities; Building completion and finishing; Roofing activities; Scaffold erection

Figure 1 confirms that, even if these five additional sectors were considered to be essentially (higher-level) Engineering sectors (which Table 1 shows they can *not*), then the total fraction of all Engineering graduates entering them was, over the ten-year period, **around a half**, albeit on what appears to be a slowly rising trend. In addition, since the flows into each Sector as a whole will include some Engineering Graduates going into non-Engineering sub-sectors, the meaningful percentages will, if anything, be lower.

1 Introduction

SKOPE Research Paper No. 122 (Dixon, 2015) examined the flows, over ten years[2], of graduates from a number of engineering disciplines into their first jobs in the different sectors of the economy, and in particular into the different relevant *'sub-sectors'* of UK Manufacturing.

The paper presented comprehensive evidence (with fewer than 50% of the employed graduates going into the 'natural' Manufacturing sub-sector for their discipline, and for some types of engineering fewer than 10% - see Figure 2) that the 'linear pipeline assumption' about sectoral destinations of graduates from engineering disciplines that has often been made (generally by default) thus far is fundamentally flawed, and examined the implications of this reality on the skills policy debate on the supply of engineering skills to different UK manufacturing sectors.

The evidence produced on these initial flows confirmed that public policy would be ill-advised to proceed assuming that the response to reported shortages of supply of engineering graduates in a particular subsector, where substantiated, could be to try to increase the numbers on the relevant engineering higher education courses. It should rather be to find ways of helping any sectors genuinely concerned about shortages to take much more seriously the need to significantly increase the attractiveness of their work to engineering students, and in particular to those in the last two years of their courses.

In addition the response to engineering employers' concerns about (possible) shortages of engineering graduates that straightforward application of classical economic theory would suggest – namely, for manufacturing employers to increase their starting salary offers – was shown to be over-simplistic. This is because employers' ability to increase pay depends on whether they can do so without jeopardising the price(s) of their product(s)/service(s). Average profitability levels in manufacturing industries are unequivocally lower than in some other sectors with which they compete for such graduates, thus limiting their ability to pay more. The paper also flagged significant issues about sectoral leadership, in response to skills supply concerns.

Evidence of the lack of 'tightness' of this recruitment market over recent years was presented, through the unemployment rates of engineering graduates from the various disciplines, which further questions default assumptions about the need for more people to enrol in engineering courses.

And, finally, the paper shed light on the answers to the question that naturally arises when it becomes clear that most graduates from engineering courses do not 'go on to work in the relevant engineering activity', showing in detail *where engineering graduates <u>do</u> go and work*, and clarifying other aspects of relevant employers' graduate recruitment.

The sometimes surprising realities that were uncovered by this investigation allow policy analysts to recognise, more clearly than before, the rather greater complexity in current graduate recruitment patterns than

[2] it is true that an additional three more years of DLHE data are now available. It is possible that subsequent data show certain changes to the first destination sectoral flows of Engineering graduates, but the absence of strong trends over the ten years to 2011/12 would suggest that major departures from the patterns found would be unlikely. Analysis of the flows since 2011/12 could easily clarify the question.

generally assumed, which will enable more valid insights into current behaviour, and so more soundly evidence-based, and thus more cost-effective, future policy responses.

However, one or two reservations expressed in response to the paper raised questions about the 'comprehensiveness' of the findings:

- "Six months after graduation may be too soon for us to know where graduates will *really* settle in their early careers";
- "Maybe employers in the 'natural sector' are not paying very attractive salaries"; and
- "With today's technologies, a *Bachelor*s degree may not be enough of a specialisation for a graduate entering a particular industry: perhaps 'leakage' from *Master*s degrees would be much less".

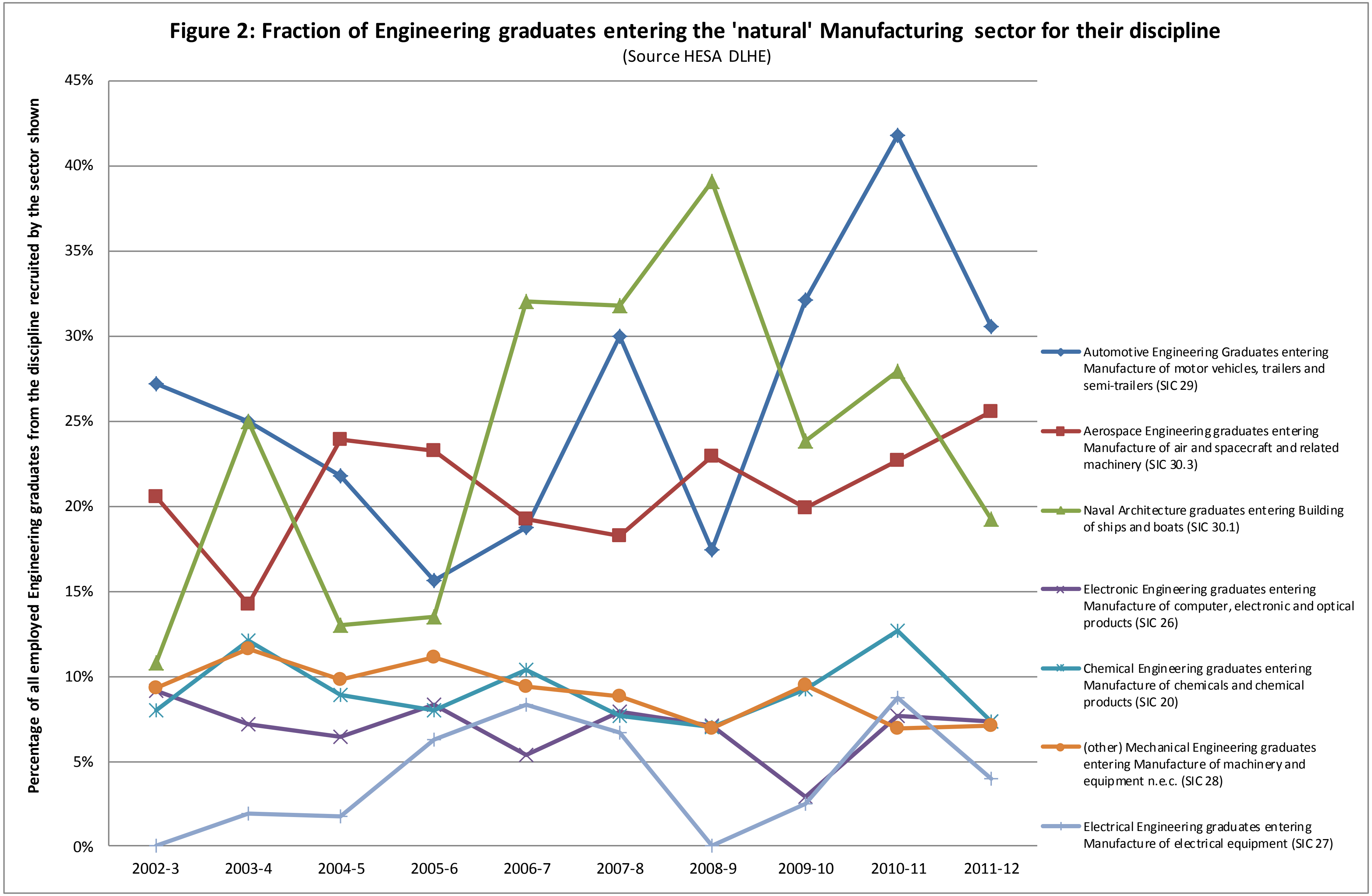


Figure 2: Fraction of Engineering graduates entering the 'natural' Manufacturing sector for their discipline
(Source HESA DLHE)
Percentage of all employed Engineering graduates from the discipline recruited by the sector shown
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
2002-3
2003-4
2004-5
2005-6
2006-7
2007-8
2008-9
2009-10
2010-11
2011-12
Automotive Engineering Graduates entering Manufacture of motor vehicles, trailers and semi-trailers (SIC 29)
Aerospace Engineering graduates entering Manufacture of air and spacecraft and related machinery (SIC 30.3)
Naval Architecture graduates entering Building of ships and boats (SIC 30.1)
Electronic Engineering graduates entering Manufacture of computer, electronic and optical products (SIC 26)
Chemical Engineering graduates entering Manufacture of chemicals and chemical products (SIC 20)
(other) Mechanical Engineering graduates entering Manufacture of machinery and equipment n.e.c. (SIC 28)
Electrical Engineering graduates entering Manufacture of electrical equipment (SIC 27)

This paper therefore considers further quantitative evidence for three related aspects of these initial flows of Engineering graduates from different disciplines, in order to deepen/broaden our understanding of the 'leakage' away from the natural Manufacturing sub-sector – in particular to understand better the answers to three questions:

1) **What were the average ('starting') salaries offered to graduates from the different disciplines by employers in the different sectors considered?** Dixon (2015) argued that employers in manufacturing sectors would be less able to offer starting salaries as high as some other sectors because of having to operate with considerably tighter profit margins. The Higher Education Statistics Agency's *Destinations of Leavers from Higher Education* (HESA DLHE) data asks about the average initial remuneration of each employed graduate responding, and so provides considerable evidence that could clarify whether the average salaries over the ten years in question might perhaps 'explain' the various flows and so throw more light on the reasons for very significant 'leakage'.

2) **How well do the six month 'first destinations' represent subsequent longer term sectoral destinations of Engineering graduates in their early careers?** It is generally argued that the DLHE *longitudinal surveys*, recording reported destinations 3½ years after graduation, show a more valid representation of 'sustained' early career sectoral 'homes' than can the 6-month DLHE census; and

3) **Whether the flows from (taught) *Masters'* degrees in each Engineering discipline have involved, over the ten years examined, notably *less* 'leakage' than is the case in flows from First Degrees**, as would perhaps be expected from the greater specialisation and more specific technical focus in Masters' courses.

2 Starting salaries in different sectors

2.1 Sample size considerations

As was pointed out in Dixon (2015), some of the flows of Engineering graduates into sectors of initial interest confirmed by the 6-month census were comparatively small: with only tens of graduates in total gaining employment rather than hundreds. The response rates of graduates to the question on *salary level* in the 6-month HESA/DLHE census appear to be lower than those on *which sector the respondent is working in*, and this results in lower statistical reliability for salary data than for destination sector data.

However, in most cases, average salary levels *are* available within the HESA rounding rules with adequate statistical confidence from the DLHE data for the 'natural' sectoral destination of particular interest, and a small number of other sectors, as well - of course - as the average over all sectors. This allows clarification of where, in the range of (initial) salary levels, the salaries 'achieved' in the 'natural' sector sit compared to others.

The other likely effect of the average being calculated over comparatively few samples (often tens rather than hundreds) is that there are often rather greater differences ('swings') between years than would be expected with larger samples. While this produces certain volatility over time for some flows, certain patterns do emerge, over the ten years, between sectors.

In considering the role of salary offer in the behaviour of this *market*, it is worth mentioning that there is an implicit assumption that the salary level given by each respondent was, indeed, the salary offered by the employer at the time of recruitment. In principle it is possible that, in a small number of cases, recruitment took place very soon after graduation, and the new recruit performed so well in the initial months that a rise in the salary has already taken place.

It is also worth noting that the *average salary* data provided by HESA are *arithmetic means*. In general representative earnings data from the labour market are provided as the ***median*** of the distribution, in order to eliminate the risk that a small number of very large salaries might distort the measure. However, the risk of a small number of very high earnings compromising the arithmetic mean is likely to be considerably less for initial graduate salaries than for earnings (for particular occupations) in the labour market as a whole.

2.2 The remuneration of Engineering graduates

The following charts show how the ***highest four*** average salaries paid by employers in a number of different sectors to graduates from each of the main Engineering disciplines categorised in the JACS 4 classification develop over ten years. The disciplines considered in the seven charts are (with JACS code):

Figure 3: (H2) Civil Engineering

Figure 4: (H3) Mechanical Engineering

Figure 5: (H4) Aerospace Engineering

Figure 6: (H6) Electrical and Electronic Engineering

Figure 7: (H7) Production and Manufacturing Engineering ("P&M Engineering")

Figure 8: (H8) Chemical, Process and Energy Engineering, and, for completeness:

Figure 9: (H1) General Engineering

Only the four sectors with the highest average salaries are shown for each discipline, in order to indicate which 'pay comparatively well'. For example, Figure 4 shows the development of average salaries from 2003 to 2012 of Mechanical engineering graduates entering work in:

- Mining and Quarrying (SIC (07) Section C)
- Manufacture of chemicals and chemical products (Division 20)
- Electricity, Gas and Water Supply (Sections D & E)
- Financial and Insurance Activities (Section K)

since it is *these sectors* that pay the highest average salaries for Mechanical Engineering graduates.

The reason for choosing the destination *sectors that pay best* is to compare this ranking with the ranking of the scale of the *flows into these sectors*, to see how they relate. Since graduates from each discipline enter a very wide range of other sectors (and since some of these flows are comparatively small the statistical reliability of many could be suspect), salary details of the *sectors below the top 4* are not shown.

The charts are all shown to the same vertical axis scale (from £15,000 to £35,000, with the exception of the *General Engineering* sector averages), in order to allow immediate visual comparisons between the salary levels and distributions of graduates from the different Engineering disciplines. The change in SIC classification between 2006/7 and 2007/8 results in significant changes in one or two sectors, in particular the *Engineering Consultancy* sub-sector, and this can, as for P&M Engineering (Figure 7), affect availability of data either before or after the change, arising from statistical reliability differences. Where there is substantive change to the scope of the SIC category, the line between the two years is suppressed. In addition, the absence of a data point for one or two years of the time series in these charts arises from data suppression by HESA in accordance with the published thresholds given sample size limitations.

It is worth noting the *often significant* movements of average salary levels between 2007/8 and 2008/9 (and in some cases 2009/10), presumably resulting from financial forces acting following the 2007/8 financial crisis.

And finally, it is worth recognising that there may be "Quality" aspects to Average Salary differences. It is possible that starting salaries for graduates from "Russell Group" universities would be higher than those from others – there is some evidence for this overall[3]. If, therefore, there happened to be particular sectoral destination preferences for Engineering graduates that were different between Russell Group Engineering departments and those of other universities, a perceived "quality premium" *might* influence the Average Salary differences between sectors.

Contribution to 'natural flows' of flows from *Production and Manufacturing Engineering*

As explained in Dixon (2015) it is necessary, when considering the 'natural' flows from each Engineering discipline into the corresponding sub-sector, to decide how to account for flows of graduates from production and manufacturing engineering courses. It could be argued that the natural destination of such graduates would be any kind of manufacturing. If the flows of these graduates into the specific subsectors were included in the flows from the other natural engineering source discipline (for example, electronic engineering for manufacturing of electronics products), the resulting leakage measure would inevitably be different from the fractions if such flows were not included[4].

[3] see, for example, Chevalier and Conlon (2003)

[4] The percentage of engineering graduates in employment in, say, automotive manufacturing from the 'natural' sources would, if production and manufacturing engineering were included, be a *combination* of the percentage of automotive engineering graduates who are recruited into automotive manufacture and the percentage of production and manufacturing engineering graduates recruited into that subsector. Since those graduating from production and manufacturing engineering courses will (in principle) 'supply' *all* the different subsectors of engineering manufacturing and manufacturing of non-engineering products (for example, food and beverages, or pharmaceuticals), it is likely that the fractions going into any one subsector would be comparatively low, so that, if the production and manufacturing fractions are included in the percentage figures, the combined fractions would be expected to be reduced, as compared with the fractions of those coming from the courses on the corresponding specific engineering discipline. The analysis in this paper therefore does not include those flows, but figures for the earlier years examined (2002–3 to 2006–7), with the P&M engineering flows included, confirm that the leakage is even greater.

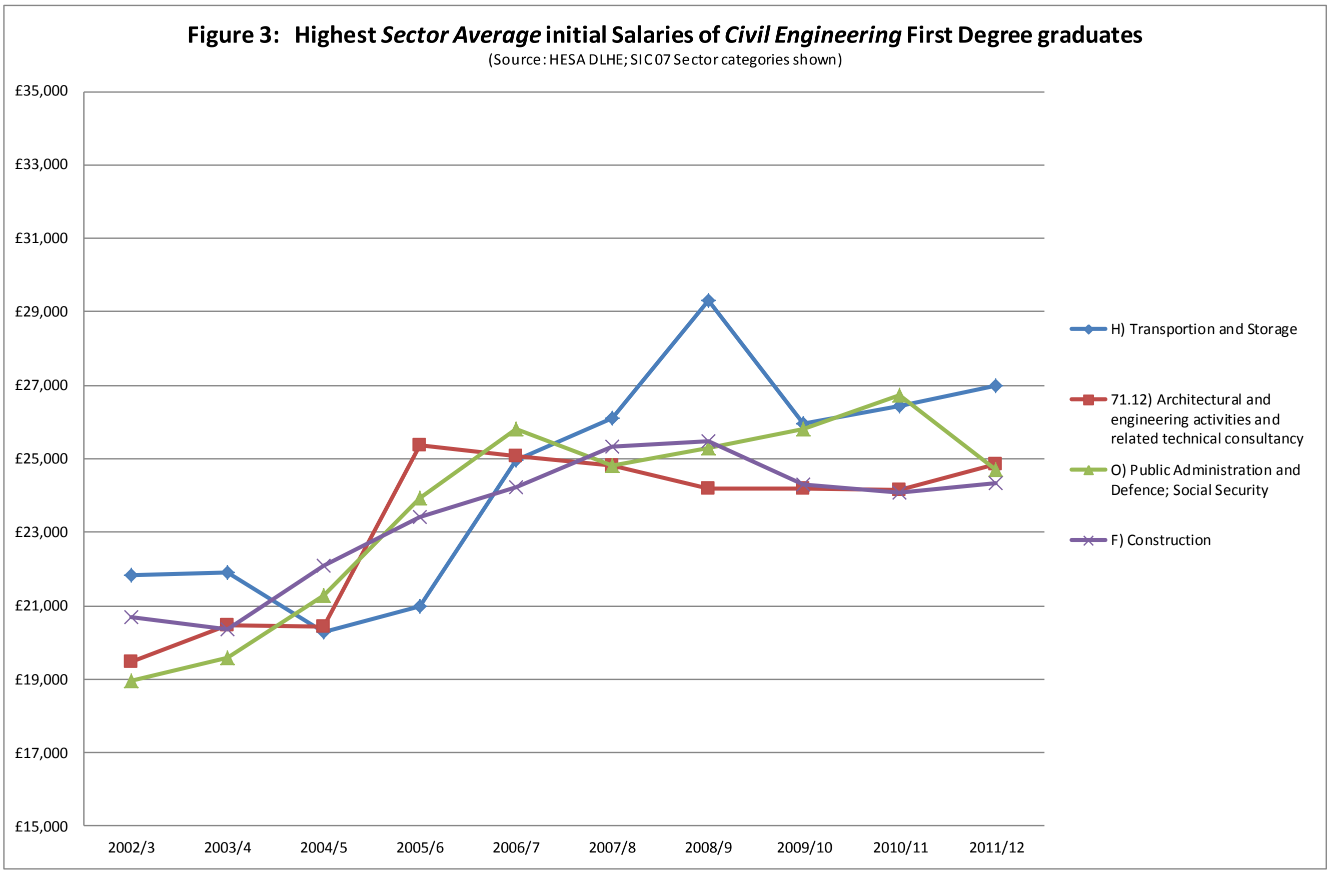


Figure 3: Highest Sector Average initial Salaries of Civil Engineering First Degree graduates
(Source: HESA DLHE; SIC07 Sector categories shown)
£35,000
£33,000
£31,000
£29,000
£27,000
£25,000
£23,000
£21,000
£19,000
£17,000
£15,000
2002/3
2003/4
2004/5
2005/6
2006/7
2007/8
2008/9
2009/10
2010/11
2011/12
H) Transportion and Storage
71.12) Architectural and engineering activities and related technical consultancy
O) Public Administration and Defence; Social Security
F) Construction

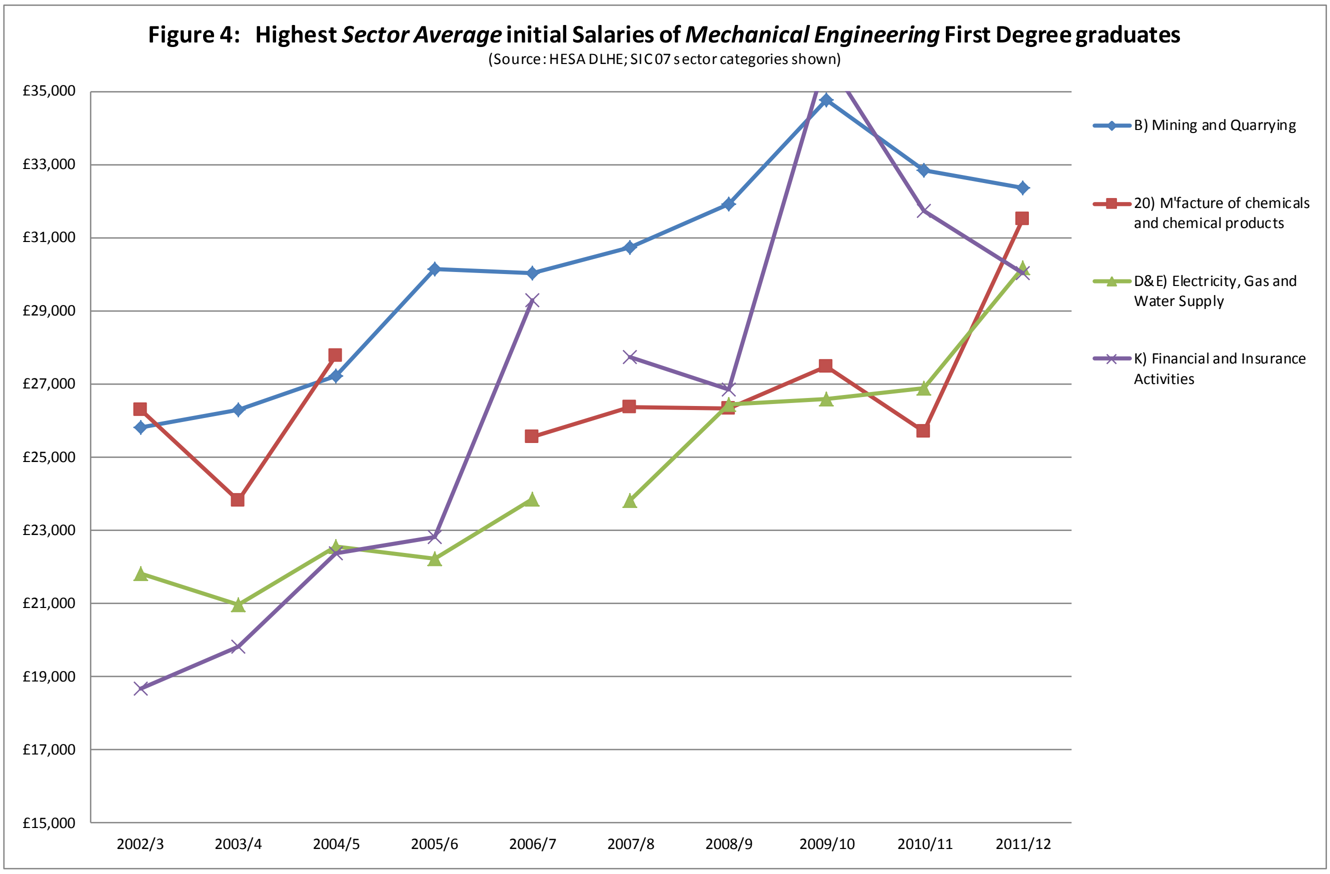


Figure 4: Highest Sector Average initial Salaries of Mechanical Engineering First Degree graduates
(Source: HESA DLHE; SIC07 sector categories shown)
£35,000
£33,000
£31,000
£29,000
£27,000
£25,000
£23,000
£21,000
£19,000
£17,000
£15,000
2002/3
2003/4
2004/5
2005/6
2006/7
2007/8
2008/9
2009/10
2010/11
2011/12
B) Mining and Quarrying
20) M'facture of chemicals and chemical products
D&E) Electricity, Gas and Water Supply
K) Financial and Insurance Activities

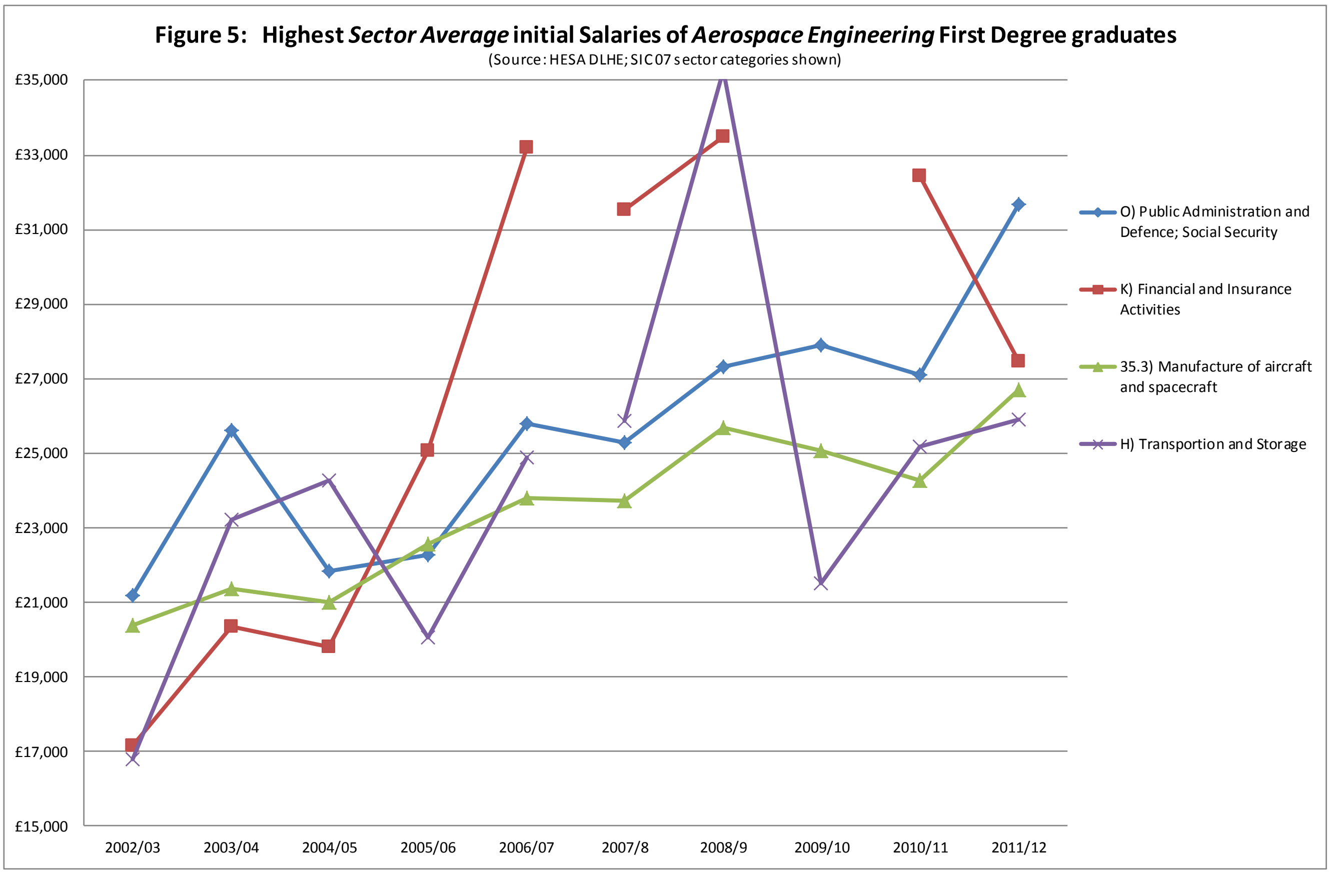


Figure 5: Highest Sector Average initial Salaries of Aerospace Engineering First Degree graduates
(Source: HESA DLHE; SIC07 sector categories shown)
£35,000
£33,000
£31,000
£29,000
£27,000
£25,000
£23,000
£21,000
£19,000
£17,000
£15,000
2002/03
2003/04
2004/05
2005/06
2006/07
2007/8
2008/9
2009/10
2010/11
2011/12
O) Public Administration and Defence; Social Security
K) Financial and Insurance Activities
35.3) Manufacture of aircraft and spacecraft
H) Transportion and Storage

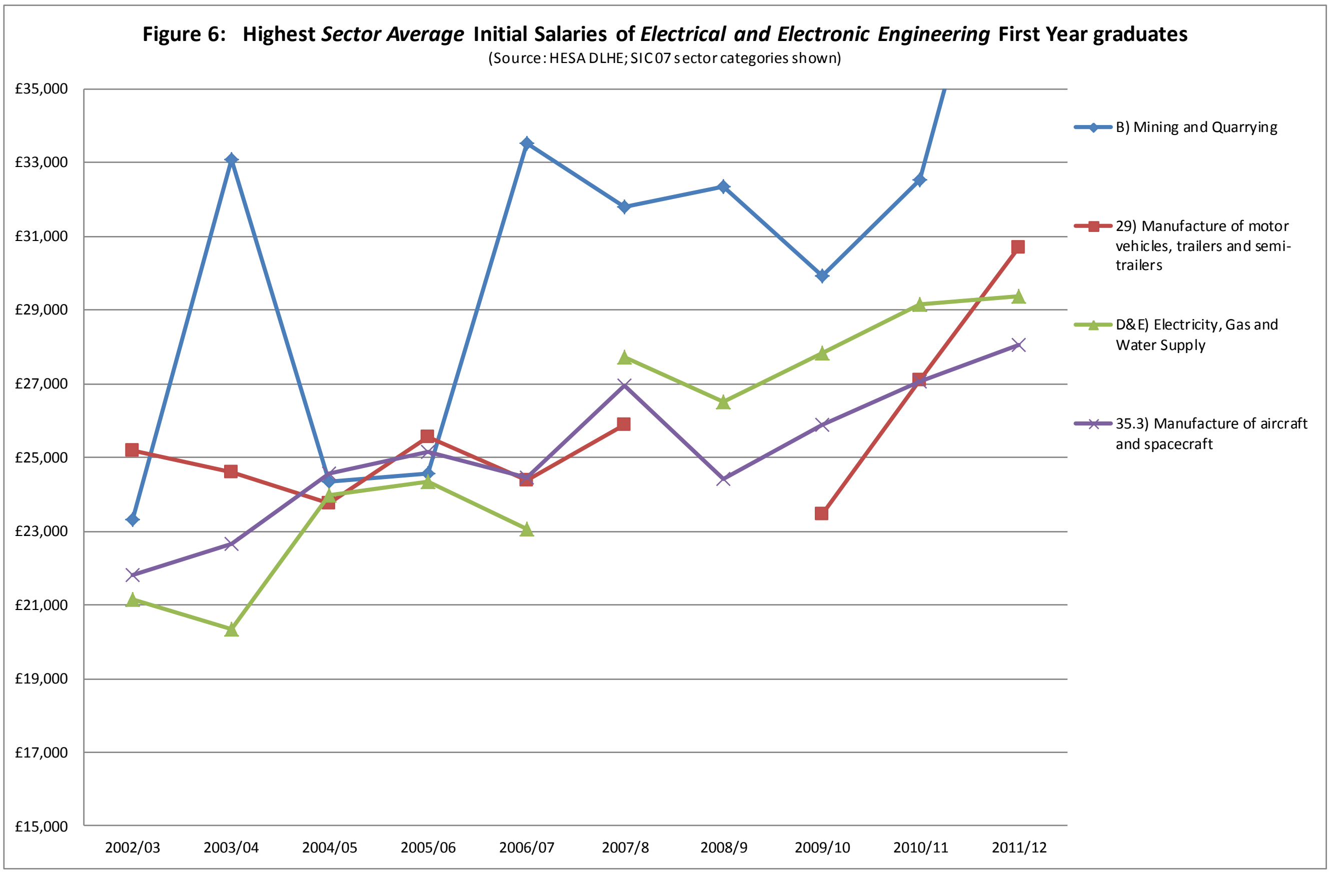
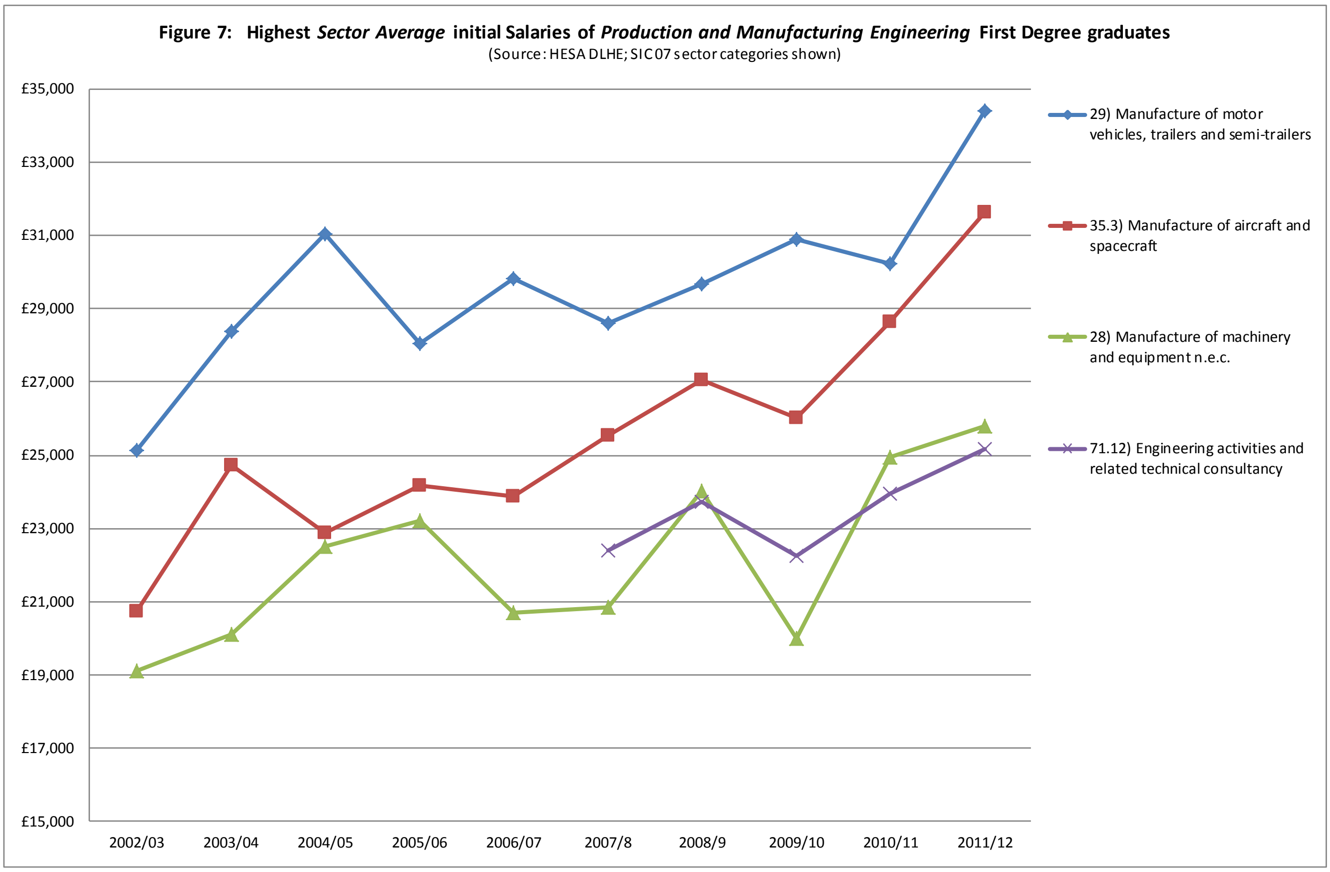
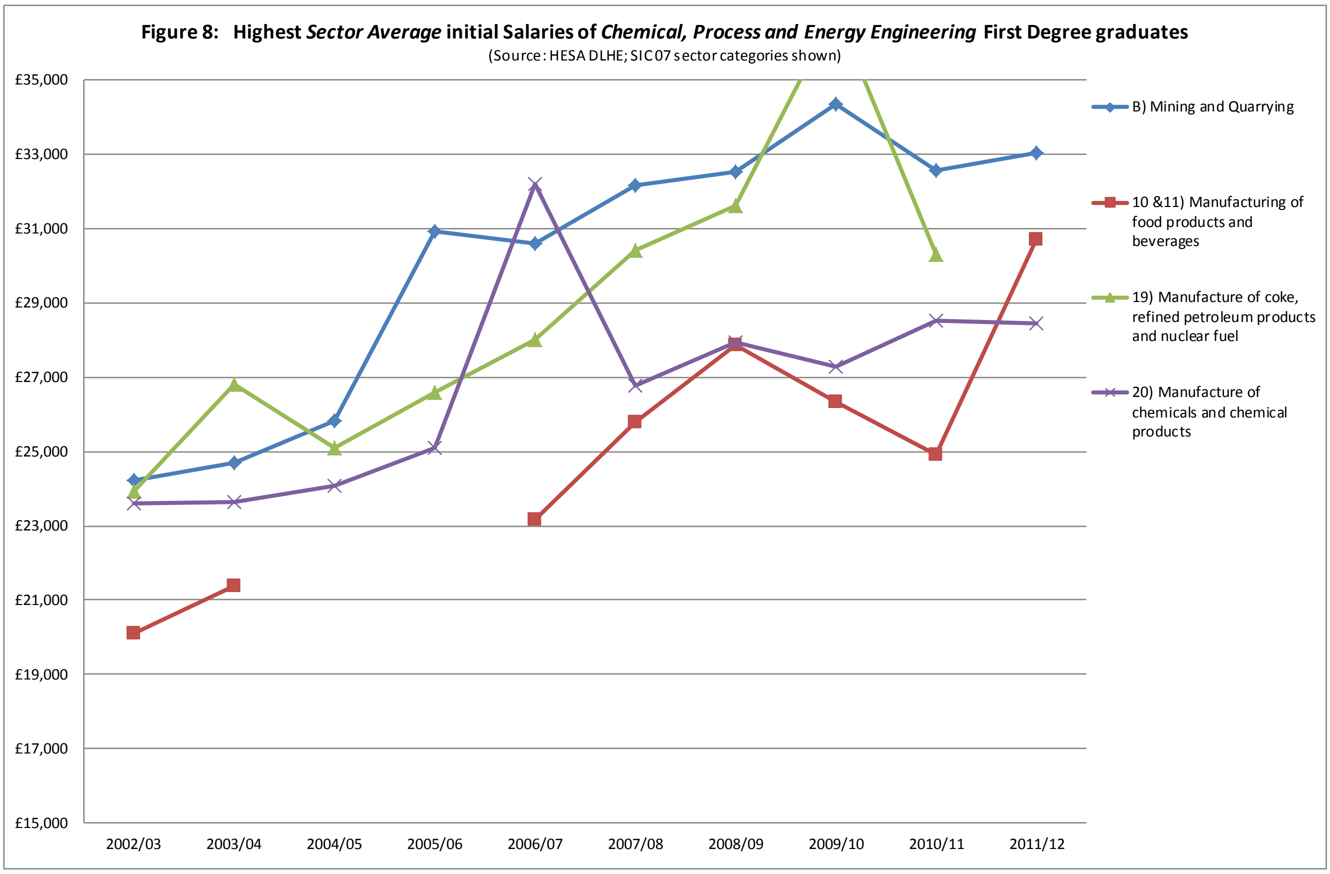
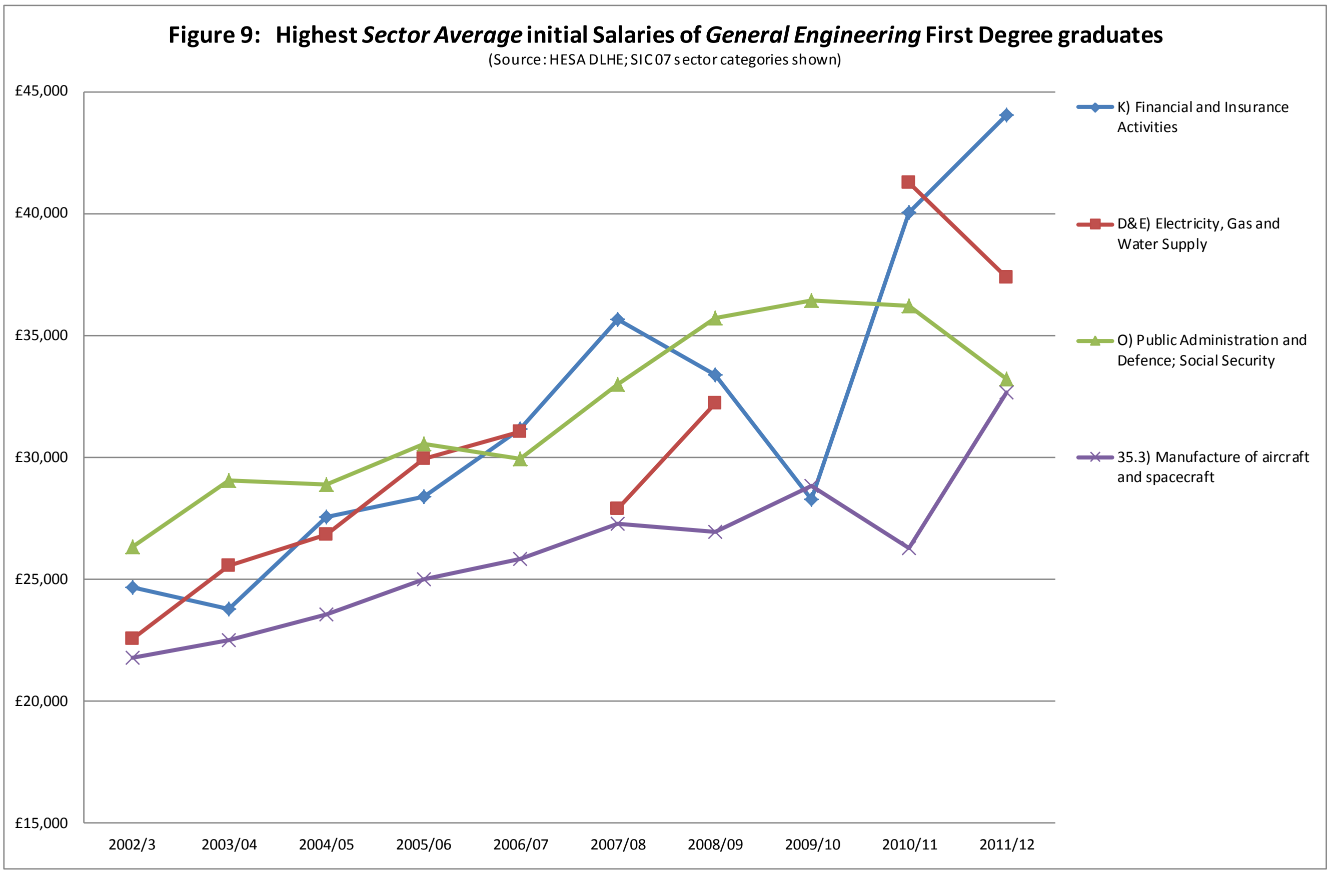


Figure 6: Highest Sector Average Initial Salaries of Electrical and Electronic Engineering First Year graduates
(Source: HESA DLHE; SIC07 sector categories shown)
£35,000
£33,000
£31,000
£29,000
£27,000
£25,000
£23,000
£21,000
£19,000
£17,000
£15,000
2002/03
2003/04
2004/05
2005/06
2006/07
2007/8
2008/9
2009/10
2010/11
2011/12
B) Mining and Quarrying
29) Manufacture of motor vehicles, trailers and semi-trailers
D&E) Electricity, Gas and Water Supply
35.3) Manufacture of aircraft and spacecraft





Note that *General Engineering* Sector Average salaries are shown between £15,000 and £45,000.



2.3 Correlation between Mean graduate Salaries in a sector and graduate Flows into the sector

The 10-year time series show quite a bit of volatility (presumably partly reflecting sample size issues) with few obvious trends, other than general growth from 2002/3 to 2006/7, followed by the fall of average salaries after 2007/8 or 2008/9, presumably reflecting responses to the financial crisis[5].

In order to examine the role of average salary levels in these flows, their *relationship with the flows* is of importance. As analysed in some depth in Dixon (2015), the graduate employment flows arise in a labour *market*, and – if ***price*** were as important in this marketplace as assumed in other labour markets – evidence of correlation between flows and average salaries would in principle be expected.

Dixon (2015) suggests and examines reasons why employers in many manufacturing sectors might not find it as easy as those in some other sectors to increase (starting) salary offers for 'fresh' graduates, should they suffer from recruitment difficulties.

However, the salary data from the "Early" (6-month) DLHE survey enables consideration of the role starting salary offers might be playing in this labour market. The tables on the following pages show, for each main Engineering discipline in turn, the rankings (the *top four*) of both the *flows* into the sectors that are most significant for that discipline, and the *average (starting) salaries* of the 'best paying' sectors. The tables therefore enable a straightforward examination of the *ranking correlation* between average salaries and flows.

[5] it is unfortunate that the financial crisis more or less coincided with the change of SIC version!

If there were perfect competition, and the overall valuation by each graduate from a particular discipline of work in each of the sectors considered were essentially the same, then – if 'normal' market mechanisms were operating - some direct correlation between flow and average salary level would be expected.

The *top four* rankings for these tables have been shown for three cohorts during the ten year period examined for RP122, and considered for six of the main JACS 4 groupings of engineering subjects, as follows:

(H2) Civil Engineering

(H3) Mechanical Engineering

(H4) Aerospace Engineering

(H6) Electrical and Electronic Engineering

(H7) Production and Manufacturing Engineering

(H8) Chemical, Process and Energy Engineering

This means that *Naval Architecture* (H5) is not considered, and nor are *Automotive Engineering* (a subset of Mechanical Engineering (H3)), or *Electrical Engineering* and *Electronic Engineering* separately. The reason for this is partly simplicity, and partly that those Engineering disciplines not considered involve comparatively small flows, which can result in questionable statistical reliability of the corresponding percentages.

The three cohorts considered, 2011, 2008 and 2004 include two sets of data with destination sectors defined by SIC 07, and one defined by SIC 92/03.

Highest *flows* and *average salaries* for Engineering graduates by discipline and significant sectors

(for three cohorts: most recent first)

(H2) Civil Engineering graduates

2011/12 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all CE grads	**Highest Four Average Salaries** Mean Salary
Professional, Scientific and Technical Activities (M) **40.2%**	Transportation & Storage (H) **£27.0K**
Construction (F) **25.3%**	Engineering activities and related technical consultancy (71.12) **£24.9K**
Public Administration and Defence (O) **5.2%**	Public Administration and Defence (O) **£24.7K**
Manufacturing (C) **4.2%**	Construction (F) **£24.3K**

2008/9 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all CE grads	**Highest Four Average Salaries** Mean Salary
Construction (F) **44.3%**	Transportation & Storage (H) **£29.3K**
Professional, Scientific and Technical Activities (M) **15.8%**	Construction (F) **£25.5K**
Public Administration and Defence (O) **11.2%**	Public Administration and Defence (O) **£25.3K**
Manufacturing (C) **4.4%**	Engineering activities and related technical consultancy (71.12) **£24.2K**

2004/5 (SIC 92/03 Sector Categories)	
Highest Four Flows %age of all CE grads	**Highest Four Average Salaries** Mean Salary
Construction (F) **43.7%**	Construction (F) **£22.1K**
Real Estate, Renting & Business Activities (K) **8.8%**	Public Administration and Defence (L) **£21.2K**
Public Administration and Defence (L) **5.6%**	Architectural and engineering activities and related technical consultancy (74.20) **£20.4K**
Manufacturing (D) **2.8%**	Transport, Storage and Communication (I) **£20.3K**

Features/Salary-Flow Correlations:

- The 'natural' destination sector (*Construction*) appears to have paid comparatively well over the period (for all 3 cohorts Construction average salaries are in the top four, and flows into Construction are in the top two);
- Higher recent average salaries in *Transportation and Storage* are not reflected in the top four flows; and
- Reasonably high average salaries in *the public sector* appear competitive and correspond to comparatively high flows.

(H3) Mechanical Engineering graduates

2011/12 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all ME grads	**Highest Four Average Salaries** Mean Salary
Professional, Scientific and Technical Activities (M) **16.2%**	Mining and Quarrying (B) **£32.4K**
Manufacture of motor vehicles, trailers and semi-trailers (29) **12.9%**	Manufacture of chemicals and chemical products (2O) **£31.5K**
Mining and Quarrying (B) **9.4%**	Electricity, Gas and Water Supply (D&E) **£30.2K**
Manufacture of machinery and equipment n.e.c. (28) **6.9%**	Financial & Insurance Activities (K) **£30.0K**

2008/9 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all ME grads	**Highest Four Average Salaries** Mean Salary
Professional, Scientific and Technical Activities (M) **13.0%**	Mining and Quarrying (B) **£31.9K**
Mining and Quarrying (B) **7.2%**	Financial & Insurance Activities (K) **£26.9K**
Manufacture of air and spacecraft and related machinery (30.3) **6.8%**	Electricity, Gas and Water Supply (D&E) **£26.4K**
Manufacture of machinery and equipment n.e.c. (28) **6.4%**	Manufacture of chemicals and chemical products (2O) **£26.3K**

2004/5 (SIC 92/03 Sector Categories)	
Highest Four Flows %age of all ME grads	**Highest Four Average Salaries** Mean Salary
Manufacture of machinery and equipment n.e.c. (29) **9.1%**	Manufacture of chemicals and chemical products (24) **£27.8K**
Manufacture of Motor Vehicles, trailers and semi-trailers (34) **8.1%**	Mining and Quarrying (C) **£27.2K**
Mining and Quarrying (C) **6.1%**	Electricity, Gas and Water Supply (E) **£22.6K**
Manufacture of air and spacecraft and related machinery (35.3) **4.4%**	Manufacture of machinery and equipment n.e.c. (29) **£22.6K**

Features/Salary-Flow Correlations:

- High average salaries in *Mining and Quarrying* are reflected in comparatively high flows (in top three for both);
- However, comparatively high average salaries in *Electricity, Gas and Water Supply*, *Chemicals Manufacture*, and *Financial & Insurance Activities* are not reflected in the highest flows; and
- The comparatively high flows into the Manufacture of *Motor vehicles*, of *Air and Spacecraft* and of *Machinery & Equipment* (the 'natural' Manufacturing sub-sector for Mechanical Engineering) in two of the years are also not reflected in higher salaries.

(H4) Aerospace Engineering graduates

2011/12 (SIC 2007 Sector Categories)		**2008/09** (SIC 2007 Sector Categories)		**2004/5** (SIC 92/03 Sector Categories)	
Highest Four Flows %age of all AE grads	**Highest Four Average Salaries** Mean Salary	**Highest Four Flows** %age of all AE grads	**Highest Four Average Salaries** Mean Salary	**Highest Four Flows** %age of all AE grads	**Highest Four Average Salaries** Mean Salary
Manufacture of air and spacecraft and related machinery (30.3) **25.6%**	Public Administration and Defence (O) **£31.7K**	Manufacture of air and spacecraft and related machinery (30.3) **18.2%**	Transportation and Storage (H) **£35.3K**	Manufacture of air and spacecraft and related machinery (35.3) **23.9%**	Transport, Storage and Communication (I) **£24.3K**
Professional, Scientific and Technical Activities (M) **11.4%**	Financial and Insurance Activities (K) **£27.5K**	Public Administration and Defence (O) **12.2%**	Financial and Insurance Activities (K) **£33.5K**	Transport, Storage and Communication (I) **11.1%**	Public Administration and Defence (L) **£21.8K**
Transportation and Storage (H) **7.6%**	Manufacture of air and spacecraft and related machinery (30.3) **£26.7K**	Professional, Scientific and Technical Activities (M) **11.0%**	Public Administration and Defence (O) **£27.3K**	Public Administration and Defence (L) **8.4%**	Manufacture of air and spacecraft and related machinery (35.3) **£21.0K**
Public Administration and Defence (O) **4.1%**	Education (P) **£26.5K**	Transportation and Storage (H) **7.0%**	Manufacture of air and spacecraft and related machinery (30.3) **£25.7K**	Real Estate, Renting & Business Activities (K) **3.8%**	Manufacture of machinery and equipment n.e.c. (29) **£20.8K**

Features/Salary-Flow Correlations:

- The *public sector* features among the highest average salaries and top four flows;
- The highest flows are into *Air and Space craft manufacture*, for which salary levels are in the *top four*;
- Flows into *Transportation & Storage* (mostly airlines?) are in the *top four* for all three cohorts, as are average salaries for two of the cohorts; and
- Flows into *Professional, Scientific and Technical activities* (and *Real Estate,...* for SIC 92/03) are significant, but salaries do not make the *top four*.

(H6) Electrical and Electronic Engineering graduates

2011/12 (SIC 2007 Sector Categories)		**2008/09** (SIC 2007 Sector Categories)		**2004/5** (SIC 92/03 Sector Categories)	
Highest Four Flows %age of all EE grads	**Highest Four Average Salaries** Mean Salary	**Highest Four Flows** %age of all EE grads	**Highest Four Average Salaries** Mean Salary	**Highest Four Flows** %age of all EE grads	**Highest Four Average Salaries** Mean Salary
Information and Communication (J) **21.8%**	Mining and Quarrying (B) **£42.4K**	Information and Communication (J) **22.2%**	Mining and Quarrying (B) **£32.4K**	72 Computer & Related activities and 6420 Telecomms. **17.5%**	Manufacture of air and spacecraft and related machinery (35.3) **£24.6K**
Professional, Scientific and Technical Activities (M) **11.5%**	Manufacture of motor vehicles, trailers and semi-trailers (29) **£30.7K**	Manufacture of computer, electronic and optical products (26) **7.5%**	Transportation and Storage (H) **£27.3K**	Real Estate, Renting and Business Activities (K) **13.1%**	Mining and Quarrying (C) **£24.4K**
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **7.5%**	Electricity, Gas and Water Supply (D&E) **£29.4K**	Public Administration and Defence (O) **7.4%**	Electricity, Gas and Water Supply (D&E) **£26.5K**	Public Administration and Defence (L) **8.1%**	Electricity, Gas and Water Supply (E) **£24.0K**
Manufacture of computer, electronic and optical products (26) **7.2%**	Manufacture of air and spacecraft and related machinery (30.3) **£28.0K**	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **7.1%**	Financial and Insurance Activities (K) **£25.8K**	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **7.3%**	Manufacture of motor vehicles, trailers and semi-trailers (28) **£23.8K**

Features/Salary-Flow Correlations:

- Flows into *Information and Communication* (J) are consistently the highest, *Public Administration* flows are third for two of the three cohorts, and flows into *Wholesale and Retail* are in the top four for all three years, though average starting salaries for all three are below the top four; and
- Average Salaries for *Electricity, Gas and Water Supply* are the third highest for all three cohorts, but the flows into this sector are not in the top four.

(H7) Production and Manufacturing Engineering graduates

2011/12 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all PME grads	**Highest Four Average Salaries** Mean Salary
Manufacture of Motor Vehicles, trailers and semi-trailers (29) **15.3%**	Manufacture of Motor Vehicles, trailers and semi-trailers (29) **£34.4%**
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **11.8%**	Manufacture of air and spacecraft and related machinery (30.3) **£31.6K**
Manufacture of air and spacecraft and related machinery (30.3) **7.2%**	Construction (F) **£25.8K**
Professional, Scientific and Technical Activities (M) **6.5%**	Manufacture of machinery and equipment n.e.c. (28) **£25.8K**

2008/09 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all PME grads	**Highest Four Average Salaries** Mean Salary
Manufacture of Motor Vehicles, trailers and semi-trailers (29) **12.3%**	Manufacture of Motor Vehicles, trailers and semi-trailers (29) **£29.7%**
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **9.2%**	Manufacture of air and spacecraft and related machinery (30.3) **£27.0K**
Manufacture of air and spacecraft and related machinery (30.3) **7.2%**	Manufacture of machinery and equipment n.e.c. (28) **£24.0K**
Professional, Scientific and Technical Activities (M) **6.5%**	Engineering activities & related technical consultancy (71.12) **£23.7K**

2004/5 (SIC 92/03 Sector Categories)	
Highest Four Flows %age of all PME grads	**Highest Four Average Salaries** Mean Salary
Manufacture of Motor Vehicles, trailers and semi-trailers (34) **13.5%**	Manufacture of Motor Vehicles, trailers and semi-trailers (34) **£31.1K**
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **9.3%**	Manufacture of air and spacecraft and related machinery (35.3) **£22.9K**
Manufacture of machinery and equipment n.e.c. (29) **6.8%**	Manufacture of machinery and equipment n.e.c. (29) **£22.5K**
Construction (F) **4.0%**	Construction (F) **£21.3K**

Features/Salary-Flow Correlations:

- The only case of ‘full correlation’ (for *Motor Vehicle manufacture*) where both average salaries and flows are highest for a single sector for all three cohorts;
- Flows into (*Wholesale & Retail*, covering) *Motor vehicle and Motorcycle repair* are consistently high, though salaries are not in the *top four* for any of the three years;
- Average Salaries for *Air- and Spacecraft Manufacturing* are second-highest for all three cohorts, while Flows into this sector are third highest for two;
- Flows into *Professional, Scientific and Technical activities* are among the *top four* for the more recent years, but the corresponding average salaries are not; and
- Average Salaries for *Manufacture of Machinery and Equipment n.e.c.* are in the top four, but not in any of the top flows.

(H8) Chemical, Process and Energy Engineering graduates

2011/12 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all ChE grads	**Highest Four Average Salaries** Mean Salary
Professional, Scientific and Technical Activities (M) **23.3%**	Financial & Insurance Activities (K) **£33.9K**
Mining and Quarrying (B) **21.0%**	Mining and Quarrying (B) **£33.0K**
Manufacture of chemicals and chemical products (20) **7.3%**	Manufacture of Food products and beverages (10 & 11) **£30.7K**
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **5.5%**	Engineering activities & related technical consultancy (71.12) **£28.5K**

2008/09 (SIC 2007 Sector Categories)	
Highest Four Flows %age of all ChE grads	**Highest Four Average Salaries** Mean Salary
Mining and Quarrying (B) **22.1%**	Mining and Quarrying (B) **£32.5K**
Professional, Scientific and Technical Activities (M) **12.2%**	Manufacture of coke, refined petroleum products and nuclear fuel (19) **£31.6K**
Manufacture of chemicals and chemical products (20) **7.0%**	Electricity, Gas and Water Supply (D&E) **£28.3K**
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G) **5.2%**	Manufacture of Food products and beverages (10&11) **£27.9K**

2004/5 (SIC 92/03 Sector Categories)	
Highest Four Flows %age of all ChE grads	**Highest Four Average Salaries** Mean Salary
Real Estate, Renting and Business Activities (K) **21.1%**	Mining and Quarrying (C) **£25.8K**
Mining and Quarrying (C) **16.7%**	Manufacture of coke, refined petroleum products and nuclear fuel (23) **£25.1K**
Manufacture of chemicals and chemical products (24) **8.9%**	Manufacture of chemicals and chemical products (24) **£24.1K**
Financial Intermediation (J) **4.5%**	Manufacture of pharmaceuticals, medicinal chemicals and botanical products (24.4) **£21.7K**

Features/Salary-Flow Correlations:

- Average salaries and flows into *Mining and Quarrying* are either top or second for all three cohorts;
- Although flows into the ‘natural’ manufacturing subsector (*Chemicals and Chemical products*) are, for all three cohorts, third highest, Average Salaries offered by the sector are only in the *top four* for the earliest cohort; and
- Flows into *Professional, Scientific and Technical* (& *Real Estate…* in SIC 92/03) are in the top two for all three years, but average salaries in the related SIC 71.12 (*...Engineering ... technical consultancy*) are only in the *top four* for one year.

2.4 Comparisons of the Cohort Flow and Average Salary rankings

While the above tables do not cover all of the ten years considered in Dixon (2015), it is clear from the considerable spread of evidence shown that there are *some* examples of correlation between average salary levels and flows for Engineering graduates' initial job choices, although these are limited. In some cases there appears to be *quite a range* of average salaries across the top four, in others much less so. Stronger correlation would presumably be expected where the top salaries are considerably higher than the others (in fact in the only case where a particular sector was highest both for average salaries and flow, the average salary was well above those paid by other sectors). In some cases the *second* highest flows represent less than 10% of the cohort, and in others the fraction dips below 10% into the sector with the *third* highest flow.

The only cases of comparatively **strong correlation of the rankings** are *high levels of both* for:

- *Manufacture of Motor Vehicles, trailers and semi-trailers* for *Production and Manufacturing Engineering* graduates, where both average salaries and flows are highest for a single sector in all three years;
- *Mining and Quarrying* for *Chemical**,** Process and Energy Engineering* graduates (presumably reflecting generally well-paid jobs in the Oil and Gas industry); and to a lesser extent
- *Construction* for *Civil Engineering* graduates.

This evidence, while analytically *broad-brush* rather than mathematically rigorous[6], is interesting, since it suggests that "price", while inevitably of importance, is not a *dominant* factor in influencing Engineering graduates' choices of which industry to (go and) work in for their first job. It could be argued that salary differences between sectors are not sufficiently great to overcome graduates' other considerations. While many market responses to price changes are recognised to be 'sticky', there are certain reasons why price is likely to be a less powerful factor for those considering their 'first real job' than in other labour markets. It is also worth recognising that the 'natural' sector that corresponds directly with the Engineering discipline only appears high up in the average starting salary rankings in two cases (for *Aerospace Engineering* graduates entering *Manufacture of air and spacecraft and related machinery*, and *Civil Engineering* graduates going into the *Construction* industry[7]). The average starting salaries for the *'linear flows into Manufacturing'* generally assumed by default are otherwise rarely within the *top four*.

It is interesting to note, given the arguments that good Engineering graduates are often 'lost' to Engineering because they go into *financial* businesses, that, in the tables above, of the 72 sectors in the four highest *average salary* sectors, Financial Services only appear 6 times, and of the 72 sectors with the top four *flows*, Financial Services do not appear once[8].

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[6] in principle a direct *correlation/regression analysis* – between *share of the total cohort flows* and *salary level* - could be explored

[7] although no comparison was made for *Automotive Engineering*

[8] although *Financial Services* do feature in the top four average salary sectors in *General Engineering* – the best paid type of Engineering degree

The fact that there is a certain amount of correlation between average salaries & flows might suggest that there remain *some* opportunities to influence behaviour by employers in the relevant Manufacturing (sub-) Sector by improving their starting salary offers. However, the main implication of the limited correlation between the two rankings is that, as long as starting salary remains just one factor - rather than the most important factor - for Engineering graduates making their first career step choices, *there is likely to be* ***a limit to the effectiveness of raising starting salaries*** as a response to possible 'shortages of good graduates' in that Manufacturing sub-sector, except of course *as between employers <u>within</u> a sector*.

Clearly the importance of starting salary level of first jobs for Engineering graduates (as for all graduates) will vary – these data inevitably reflect the sector choices made *on average*. However, salary level might well have lower priority for young people leaving university than it would later on in their career, when financial commitments and perceptions of remuneration comparabilities inevitably play a stronger role in career development choices. In practice, of course, starting salaries are likely to represent a step increase in most graduating students' disposable income levels – in general, graduate starting salaries, from whichever employer sector, are likely to seem attractive – not least as a token of graduate's *first real job*!

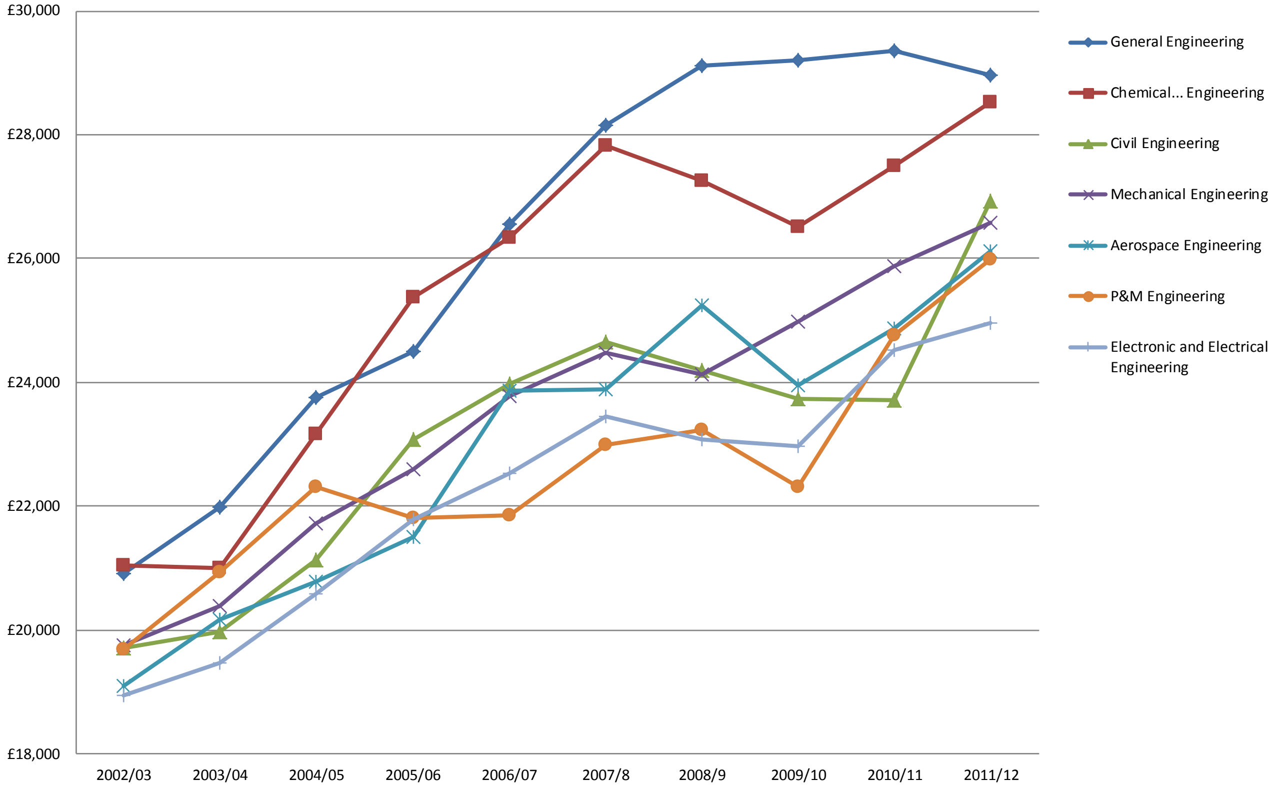
And finally, it is necessary to consider the *nature of the decision context* in considering the likely influence of salary in the Sector selection of the graduating Engineering student. Notwithstanding the wealth of the available HESA DLHE data on initial earnings, a student considering a number of possible sectoral destinations will rarely have unequivocal objective salary data at his or her disposal, and will probably have even less idea of what work in different sectors would really be like. With neither the *value proposition* not the '*price'* very clear to the person making the choice, informed, consistent decisions would not be expected...

Indeed students contemplating their first job are more likely to be trying to visualise and understand a choice between a number of possible *employers*, rather that of possible *sectors*. And, as already pointed out, salary will generally be only one of a number of key considerations in the student's mind. In general "price" (in this case *earnings*) is a much less straightforward indicator of the relative attractiveness of different options in a *labour* market than in a *product* market.

2.5 *Relative graduate starting salary levels of different Engineering disciplines*

For those considering, from a remuneration perspective, which HE Engineering course to apply for, the relative average salaries achieved over the ten years considered in Dixon (2015) would presumably be of interest, and these show certain differences between the different disciplines (see Figure 10).

Figure 10: Average (initial) Salaries (All Sectors) by discipline for First Degree Engineering graduates
(Source: HESA DLHE)



As can be seen, the notable fall in salaries for most disciplines after 2007/8, following steady growth - and the easing for *General Engineering* after 2008/9 - presumably arises from the 2007/8 financial crisis, but the growth generally picked up again after 2009/10.

Overall, the *remuneration ranking* for graduates from the different disciplines is as follows:

First Degree Course Discipline	Average (10 years)	Average (last 5 years)	Average (last 3 years)
General Engineering	£26,246	£28,956	£29,168
Chemical... Engineering	£25,450	£27,517	£27,505
Mechanical Engineering	£23,425	£24,643	£25,809
Aerospace Engineering	£22,948	£25,203	£24,981
Civil Engineering	£23,108	£24,815	£24,789
P&M Engineering	£22,586	£23,856	£24,356
Electronic and Electrical Engineering	£22,225	£23,789	£24,144

and the *growth over the ten years* would *rank* as follows, taking into account inflation (using the Consumer Price Index as shown):

First Degree Course Discipline	Increase over 9 years	Average Annual increase over 9 years	Increase over 9 years above CPI
General Engineering	38.5%	4.27%	2.73%
Aerospace Engineering	36.7%	4.08%	2.61%
Civil Engineering	36.6%	4.06%	2.59%
Chemical... Engineering	35.5%	3.94%	2.52%
Mechanical Engineering	34.6%	3.84%	2.45%
P&M Engineering	31.9%	3.55%	2.27%
Electronic and Electrical Engineering	31.7%	3.53%	2.25%

The differences in average starting salaries between the different disciplines of Engineering graduates are not enormous, although they do appear to be comparatively clear and consistent over the ten years. The consistently very high salary level offers of employers for *General Engineering* graduates is worth noting: while there is little evidence beyond the anecdotal as to possible reasons for this, it could be that employers (perhaps including some not directly involved in engineering) attach particular value to graduates with a broader understanding across a number of Engineering disciplines. Mention was made above of possible perceived "quality" differences between graduates from different Higher Education Institutions (HEIs): it is perhaps worth noting, in the light of the evident primacy of *General Engineering* average salaries, that both Oxford and Cambridge have had a strong tradition of 'Engineering Science' courses, which might possibly play a small role in this result.

3 'Sustainability' of initial sectoral destinations

3.1 The DLHE Longitundinal Surveys, and their relationship to the Annual DLHE Censuses

In addition to the (main) annual "Destinations of Leavers from Higher Education" (DLHE) *census* carried out by HESA, there is a separate "longitudinal" *survey* of leavers (carried out 3 years later) every two years. Over the ten-year period for which the main Annual Destinations data was analysed in Dixon (2015), there were therefore *five* such Surveys, of which (only) *four* can be directly compared with the results of the Annual Censuses without data beyond 2012 (See Table 2). As already indicated, it is generally argued that the longitudinal DLHE surveys, recording reported destinations 3½ years after graduation, are a better representation of 'sustained' early career situations (sectoral or otherwise) than the 6-month DLHE census ("graduates are more likely to 'stay' in the work they are in after 3½ years than in the job they have after six months"); and it is therefore of interest to examine whether the 'leakage' patterns observed in Dixon (2015) are confirmed, at least in broad terms, or not, in the findings of the relevant longitudinal surveys. It is in principle possible that the 'more meaningful' longitudinal data would show rather less 'leakage' than is evident from the early (6-month) census.

There is however a statistical issue with attempts to make this comparison. The longitudinal surveys are not Censuses, and the significantly smaller response samples therefore bring greater limits to the degree of granularity that can be interpreted from the results, in particular for the sectoral categories. However, given the reservations that are sometimes voiced in policy circles about the 'sustainability' of employment destinations only six months after graduation, it is nevertheless worth exploring the comparison to see what emerges.

Table 2 shows the *scheduling* of the DLHE surveys for the years covered in Dixon (2015) (source: HESA).

Table 2	**Year in which destination data gathered**									
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Year HE course completed:										
2002	6-m Census*	->	->	Longit. Survey*						
2003	->	6-m Census*								
2004		->	6-m Census*	->	->	Longit. Survey**				
2005			->	6-m Census*						
2006				->	6-m Census*	->	->	Longit. Survey**		
2007					->	6-m Census** ?				
2008						->	6-m Census**	->	->	Longit. Survey**
2009							->	6-m Census**		
2010								->	6-m Census**	
2011									->	6-m Census**

* sectoral destinations identified within SIC 92/03 classification; ** sectoral destinations identified within SIC 07 classification

This means that there can be *four* comparisons: for the 2002, 2004, 2006 and 2008 leaver cohorts. Table 3 shows more detail about the survey and response totals for these cohorts. As can be seen, the response datasets for the Annual (six-month) "early" Census are typically more than 300,000 (from over 400,000 Leavers approached), while the Longitudinal Survey responses are in the tens of thousands.

Table 3: Response characteristics of DLHE 6-month ('Early Survey') Census and 3½ year Longitudinal surveys
(Source: HESA)

Engineering graduate Datasets examined	**Graduation / initial DLHE Year:**	**Census Total**	**Cenus Response Total**	**Census Response Rate**		**3 years after 'Early DLHE'**		**Long. DLHE Survey Total**	**Long. Survey Response Total**	**Long. Survey Response Rate**		**Longitudinal Survey *Sample* characteristic**
1	2002/3	412,580	307,650	74.6%		2006		62,040	24,825	40.0%		
2	2004/5	430,290	319,260	74.2%		2008	Sample A	71,390	26,245	36.8%		(to over-sample Foundation Degree-, Research- and Non-White graduates)
							Sample B	89,605	15,155	16.9%		(remaining e-mail addresses)
							Total	**160,995**	**41,400**	**25.7%**		
3	2006/7	453,880	332,110	73.2%		2010	Sample A	70,960	29,340	41.3%		(to over-sample Foundation Degree-, Research- and Non-White graduates)
							Sample B	153,630	19,725	12.8%		(remaining e-mail addresses)
							Total	**224,590**	**49,065**	**21.8%**		
4	2008/9	470,940	354,730	75.3%		2012	Sample A	80,835	33,640	41.6%		(to over-sample Foundation Degree-, Research- and Non-White graduates)
							Sample B	192,745	28,565	14.8%		(remaining e-mail addresses)
							Total	**273,580**	**62,205**	**22.7%**		

3.2 Statistical considerations

Although the *HESA Rounding Methodology* requirements arise particularly from Data Protection considerations (to prevent disclosure of the identity of particular HE Institutions or individuals) – they also involve, for statistical reliability purposes, suppression of ratios/percentages based on a denominator (flow) of less than 22.5, and of averages based on fewer than 7 individuals (see HESA[9]). Since the percentage flows that are the core of this study are based on *ratios*, and since the Longitudinal DLHE totals are all *weighted*, errors arising from the oversampling carried out in the Longitudinal survey are expected to be negligible.

The Sectoral categories examined for Dixon (2015) focused particularly on the Manufacturing subsectors corresponding to the main engineering disciplines. These are (for SIC 07):

- Manufacture of chemicals and chemical products (SIC 20)
- Manufacture of computer, electronic and optical products (SIC 26)
- Manufacture of electrical equipment (SIC 27)

[9] https://www.hesa.ac.uk/component/content/article?id=146&limit=&start=0 (Accessed January, 2017)

- Manufacture of machinery and equipment *not elsewhere classified* (n.e.c.) (SIC 28)
- Manufacture of motor vehicles, trailers and semi-trailers (SIC 29)
- Building of ships and boats (SIC 30.1)
- Manufacture of air and spacecraft and related machinery (SIC 30.3)

In order to investigate whether the sample sizes of the four Longitudinal surveys are likely to be sufficient to allow the same level of analysis as the corresponding 6-month census data, it is worth comparing the relevant percentages for a *broader flow measure* – namely the flows for each of the 7 main Engineering disciplines that go into Manufacturing (as a whole). As is shown in Table 3, the total sample sizes for these 3½ year surveys increased steadily over the eight years involved (from just under 25,000 for the 2002/3 cohort to over 62,000 for the 2008/9). The percentages going into Manufacturing for the four cohorts are shown in Table 4. The percentages shown in the two datasets are notably closer for the last of the four cohorts than for the first, arising presumably from the fact that the sample size for the longitudinal survey of the last cohort was some 2.5 times the size of the first.

Table 4: Comparison of a broader measure of flows between the two surveys (source: HESA)

	Percentage of employed graduates from each Engineering Discipline working in (any kind of) Manufacturing							
	2002 cohort		**2004 cohort**		**2006 cohort**		**2008 cohort**	
Engineering Discipline	**6-month**	**3½ year**	**6-month**	**3½ year**	**6-month**	**3½ year**	**6-month**	**3½ year**
(Civil Engineering)	2.8%	0	2.8%	0.5%	2.6%	2.1%	4.4%	4.4%
Mechanical Engineering	40.5%	21.3%	39.3%	31.6%	37.4%	42.2%	36.2%	36.6%
Aerospace Engineering	36.9%	18.5%	36.0%	32.7%	33.7%	36.4%	39.9%	36.9%
Naval Architecture	29.7%	-*	21.7%	-*	31.6%	-*	43.5%	-*
Electronic and Electrical Engg.	26.8%	25.1%	22.1%	16.8%	22.2%	21.8%	23.5%	20.1%
Production and Manufacturing	45.6%	44.2%	44.7%	38.5%	36.5%	40.0%	46.1%	42.4%
Chemical, Process and Energy Engg.	39.5%	27.7%	34.7%	17.3%	33.2%	47.8%	30.5%	26.5%

* given the VERY small sample of *Naval Architecture* graduates picked up in the longitudinal surveys these results have been suppressed

As can be seen,

a) as the sample size gets larger, the correlation between the *early* and *longitudinal* survey results generally increases, and

b) correlation is weakest for the disciplines with the lowest flows, in particular for Chemical Engineering graduates, and above all for Naval Architecture graduates.

It is however noticeable that in all cases the percentages going into any kind of manufacturing do not exceed 50% of those who are in full time paid work. Given that those flows will then be further sub-divided into the different sub-sectors of Manufacturing (so that the percentages going into the 'natural' sub-sector will be distinctly, probably well- *below* those shown), this provides initial confirmation of the comparatively large scale of 'leakage' found from the early surveys and the longitudinal surveys.

It is, of course, in principle, not possible to say whether the difference in percentages between the two surveys *for each cohort* arise from differences in sample size or from differences in the movements in graduate employment during the three years between the two surveys[10]. However, we would presumably not expect substantial changes between the three year movement patterns for the first and fourth cohorts *in the intervening six years* (indeed the changes in the year-on-year patterns for the 6-month survey do not suggest any consistent substantial changes or trends over the ten years).

The highest sample size for the 2012 longitudinal survey of the 2008 cohort would be expected to give the most valid cross-comparison of destinations (between the two surveys conducted on the cohort) as compared with the earlier cohorts.

3.3 Comparison of flows for the 2008 Cohort

Considering, therefore, the last (2008) cohort within the ten year period, Tables 5 and 6 show the percentages of the cohort sampled working in the different *broad Sectors of the Economy* (upper matrix) and *Manufacturing Sub-sectors* (lower matrix) measured a) after 6 months, and b) after 3½ years.

The flows from *the seven Engineering disciplines which have a natural manufacturing sub-sector* into those sub-sectors are **highlighted**. (In these tables, Automotive Engineering data are not separated out from those of broader Mechanical Engineering, nor are Electrical Engineering & Electronic Engineering separated out).

[10] However, a perceived increase in risk to graduates' job/earnings security by moving when economic conditions are less favourable might be expected, following the 2007/8 financial crisis, to have reduced job moves during the three years following the DLHE "early" census.

Table 5: HESA 6-month DLHE for 2008 Cohort: Percentages

Sector=> ↓Discipline↓	Manu-facturing	Con-struction	Professional, Scientific and technical activities	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Information and Communication	Financial and Insurance activities	Public Administration and Defence; compulsory social security	Other Sectors (SIC sections N, P, Q, R, S, T, U)	Total (selected sectors)	Grand Total (all sectors)
Civil Engineering	4.4%	44.3%	15.8%	4.0%	3.5%	1.2%	1.8%	11.2%			(100%)
Mechanical Engineering	36.2%	4.0%	13.0%	7.7%	2.2%	2.2%	3.4%	5.2%			(100%)
Aerospace Engineering	39.9%	1.3%	8.0%	5.9%	7.2%	4.3%	4.0%	14.9%			(100%)
Naval Architecture	43.5%	0.0%	21.7%	0.0%	13.0%	0.0%	0.0%	13.0%			(100%)
Electronic and Electrical Engineering	23.5%	2.9%	6.6%	7.1%	3.5%	22.2%	2.9%	7.4%			(100%)
Production and Manufacturing Eng'g	46.1%	3.4%	6.5%	9.2%	2.4%	4.8%	1.7%	2.7%			(100%)
Chemical… Engineering	30.5%	2.3%	12.2%	5.2%	0.9%	1.9%	2.3%	2.8%			(100%)

⇩

Sector=> ↓Discipline↓	Manu-facturing		Manu-facture of Chemicals and Chemical products	Manufacture of computer, electronic and optical products	Manufacture of electrical Equipment	Manufacture of machinery and equipment nec	Manufacture of motor vehicles, trailers and semi-trailers	Building of ships and boats	Manufacture of air and spacecraft and related machinery	Total selected manu-facturing subsectors	Grand Total (all manu-facturing)
Civil Engineering	4.4%		0.1%	0.2%	0.0%	0.9%	0.2%	0.2%	0.0%	1.5%	4.4%
Mechanical Engineering	36.2%		0.7%	1.7%	1.3%	**6.4%**	**7.7%**	1.6%	6.8%	26.2%	36.2%
Aerospace Engineering	39.9%		0.0%	2.4%	0.8%	2.7%	4.0%	0.0%	**22.9%**	32.7%	39.9%
Naval Architecture	43.5%	and *within* Manu-facturing:	0.0%	0.0%	0.0%	0.0%	0.0%	**39.1%**	0.0%	39.1%	43.5%
Electronic and Electrical Engineering	23.5%		0.4%	**7.5%**	**1.9%**	1.9%	1.0%	0.1%	2.8%	15.5%	23.5%
Production and Manufacturing Eng'g	46.1%		2.0%	2.0%	3.1%	3.4%	12.3%	1.4%	7.2%	31.4%	46.1%
Chemical Engineering	30.5%		**7.0%**	0.0%	0.5%	0.9%	0.0%	0.0%	0.9%	9.4%	30.5%

Table 6: HESA Longitudinal DLHE for 2008 Cohort: Percentages

Sector=> ↓Discipline↓	Manufacturing	Con-struction	Professional, Scientific and technical activities	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Information and Communication	Financial and Insurance activities	Public Administration and Defence; compulsory social security	Other Sectors (SIC sections N, P, Q, R, S, T, U)	Total (selected sectors)	Grand Total (all sectors)
Civil Engineering	4.4%	29.2%	36.8%	2.3%	3.2%	1.2%	1.2%	9.1%			(100%)
Mechanical Engineering	36.6%	3.8%	24.1%	2.0%	3.0%	1.5%	3.0%	4.0%			(100%)
Aerospace Engineering	36.9%	3.2%	17.8%	4.5%	8.3%	5.7%	3.2%	12.1%			(100%)
Naval Architecture	50.0%	0.0%	16.7%	16.7%	0.0%	0.0%	0.0%	0.0%			(100%)
Electronic and Electrical Engineering	20.1%	2.7%	15.9%	5.7%	2.7%	23.4%	4.2%	5.7%			(100%)
Production and Manufacturing Eng'g	42.4%	2.4%	23.5%	4.7%	1.2%	5.9%	0.0%	2.4%			(100%)
Chemical… Engineering	26.5%	0.0%	27.7%	4.8%	1.2%	2.4%	2.4%	2.4%			(100%)

⇩

Sector=> ↓Discipline↓	Manufacturing		Manu-facture of Chemicals and Chemical products	Manufacture of computer, electronic and optical products	Manufacture of electrical Equipment	Manufacture of machinery and equipment nec	Manufacture of motor vehicles, trailers and semi-trailers	Building of ships and boats	Manufacture of air and spacecraft and related machinery	Total selected manu-facturing subsectors	Grand Total (all manu-facturing)
Civil Engineering	4.4%		0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.3%	4.4%
Mechanical Engineering	36.6%		0.3%	1.0%	2.3%	**8.8%**	**10.8%**	0.3%	2.8%	26.1%	36.6%
Aerospace Engineering	36.9%		0.0%	1.9%	1.3%	3.8%	6.4%	0.6%	**17.8%**	31.8%	36.9%
Naval Architecture	50.0%	and *within* Manu-facturing:	0.0%	0.0%	0.0%	33.3%	0.0%	**33.3%**	0.0%	66.7%	50.0%
Electronic and Electrical Engineering	20.1%		0.3%	**7.2%**	**1.8%**	1.5%	1.8%	0.6%	2.1%	15.3%	20.1%
Production and Manufacturing Eng'g	42.4%		0.0%	3.5%	1.2%	8.2%	9.4%	1.2%	3.5%	27.1%	42.4%
Chemical… Engineering	26.5%		**6.0%**	1.2%	1.2%	1.2%	0.0%	0.0%	0.0%	9.6%	26.5%

3.4 Differences in 'linear flow leakage'

As can be seen, there is generally close coherence in the percentages between the two datasets. The "linear flow percentages" from each discipline into the directly relevant Manfacturing sub-sectors in the two cases are as follows:

Table 7: 'Linear Flows' into 'natural' Manufacturing sub-sectors (SIC 07 categories) for 2008 cohort (source: HESA)**:**			**Percentage measured in 6-month census**	**Percentage measured in 3½ year survey**
Chemical (, process and energy) Engineering graduates	⇒	Manufacture of Chemicals and Chemical products (20)	7.0%	6.0%
Electronic Engineering graduates (Electronic Engineering is classified within Electronic and Electrical Engineering[11])	⇒	Manufacture of computer, electronic and optical products (26)	7.5%	7.2%
Electrical Engineering graduates (Electrical Engineering is classified within Electronic and Electrical Engineering[6])	⇒	Manufacture of Electrical equipment (27)	1.9%	1.8%
Mechanical Engineering graduates	⇒	Manufacture of machinery and equipment n.e.c. (28)	6.4%	8.8%
Automotive Engineering graduates *(Automotive Engineering is classified within Mechanical Engineering[6])*	⇒	Manufacture of Motor Vehicles, trailers and semi-trailers (29)	7.7%	10.8%
Naval Architecture graduates	⇒	Building of ships and boats (30.1)	39.1%	(33.3%)*
Aerospace Engineering graduates	⇒	Manufacture of air and space craft and related machinery (30.3)	22.9%	17.8%

* sample size very small

As can be seen, except in two cases, the percentage of the cohort sample entering the 'directly relevant' manufacturing sub-sector is *smaller* after three years (as are most of the figures for Manufacturing as a whole – Table 4), and in all cases the percentages are, at the very least, of the same order of magnitude as the findings from the "early" (6-month) survey. It is therefore evidently NOT the case that assessing sectoral destinations three years later makes any appreciable difference to the comparatively high scale of 'leakage' found in the census 6-months after graduation.

It is worth recognising that the sectoral destinations of graduates from a particular engineering discipline picked up in the Longitudinal DLHE do show graduates who are now in the sector being considered, whether or not they have worked anywhere else since graduation – i.e. the percentages include graduates who did not initially enter the relevant sector, but who subsequently moved into that sector. The analysis therefore validly picks up those who have entered the sector in question since the Census and omits those who have left the sector in the meantime.

[11] this may result in the percentages for the graduates from the specific disciplinary courses (Electronic Engineering, Electrical Engineering and Automotive Engineering) going into the directly-relevant Manufacturing sub-sectors being even lower.

Consideration of the likely *causes* of possible changes in 'leakage' over the three years might suggest that a net *decrease* in the percentage for a given sub-sector would probably be more likely than an *increase*. What happens in the three years cannot be known (and there will be a wide range of causes of different early career trajectories, involving, for each graduate, changes perhaps in desired location, housing, relationship status, friendship considerations, etc.). However, presumably the main reason for movement would be that the 'first destination' job/employer did not turn out to be all the graduate was hoping for (a realisation, after a while, that "this is not for me!"). It is certainly possible that a 'fresh graduate' from an Engineering discipline might initially try out something completely different, and conclude that **that** is not for them. Such graduates would however presumably (by virtue of their original decision) be more open-minded to other options than the "obvious" sector than other graduates so might well go on to another "non-obvious" occupation or sector. If these effects were a significant influence then a small *reduction* in percentages might indeed be expected over the three years.

4 'Leakage' levels in Taught Masters' course flows from each discipline

4.1 Expected Differences

University *Taught Postgraduate* courses in Engineering understandably 'probe deeper' into the relevant disciplinary Engineering 'Body of Knowledge', often involve considerable practical work, and are generally more narrow in scope, than Engineering First Degrees. As applied science and technological innovations continue to bring more specific technical approaches and systems to bear on tackling real-world engineering problems and enabling product and service innovation in technical businesses, it is natural to assume that a narrower, deeper focus would have value in preparing a graduate more directly for a significant contribution within certain specialist fields. It is therefore very natural to assume that those who have chosen Taught Masters courses in specific Engineering disciplines will go on to work in the relevant fields. However, the *flows* of leavers from such courses into employment will inevitably be lower than those of First Degree graduates. Table 8 shows the comparative numbers of leavers from First Degree (FD) and Taught Masters (MSc) courses who, after six months, are in full time paid employment.

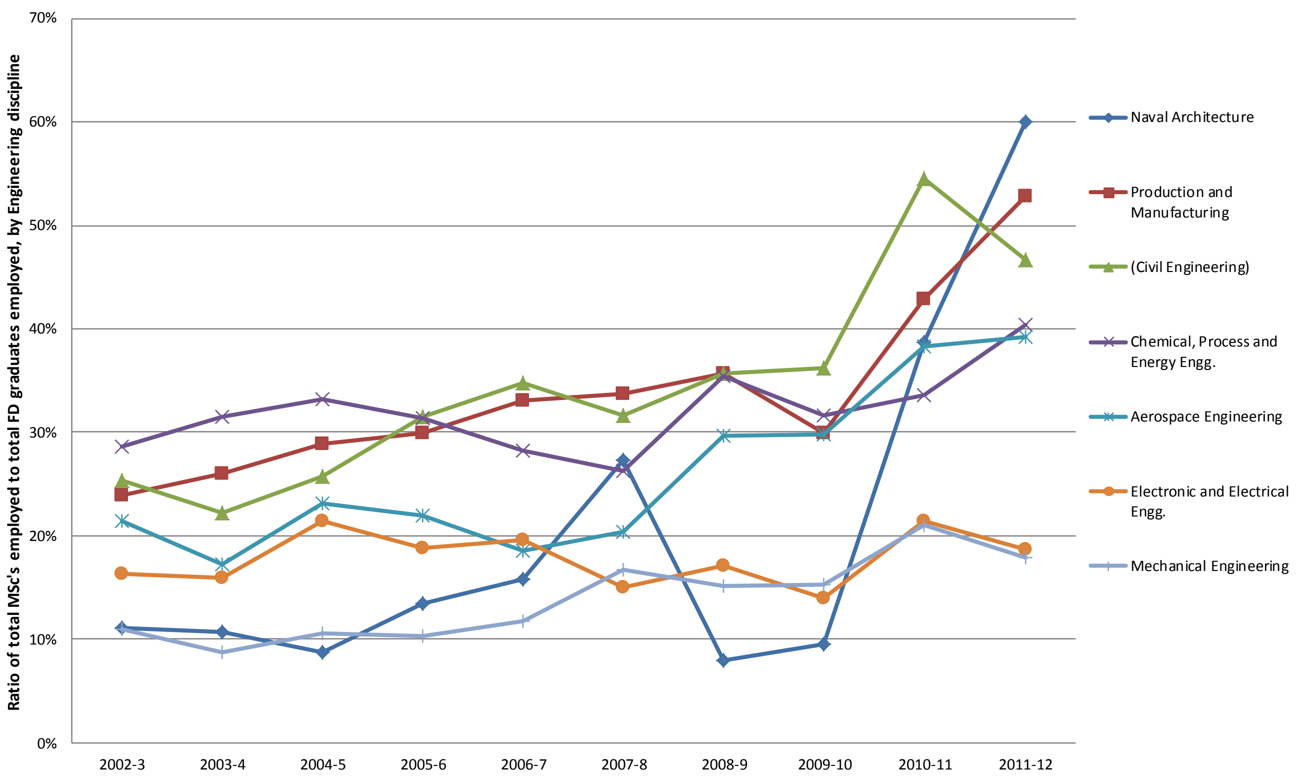
Table 8: Flows of Engineering graduates and post-graduates into employment

		Numbers graduating each year who enter employment									
Engineering Discipline	**Deg:**	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12
(Civil Engineering)	FD	891	961	1,122	1,074	1,213	1,231	1,200	1,316	1,368	1,651
	MSc	226	214	289	339	421	390	428	477	745	770
Mechanical Engineering	FD	1,347	1,373	1,377	1,458	1,482	1,391	1,335	1,465	1,622	1,894
	MSc	147	121	145	150	174	232	203	224	341	340
Aerospace Engineering	FD	401	448	441	474	459	456	412	403	481	545
	MSc	86	77	102	104	85	93	122	120	184	214
Naval Architecture	FD	36	28	23	37	38	22	25	42	44	30
	MSc	4	3	2	5	6	6	2	4	17	18
Electronic and Electrical Engg.	FD	1,807	1,772	1,570	1,494	1,486	1,446	1,072	1,232	1,274	1,462
	MSc	296	283	337	281	291	218	184	172	273	274
Production and Manufacturing	FD	609	610	502	477	451	347	322	344	375	345
	MSc	146	159	145	143	149	117	115	103	161	182
Chemical, Process and Energy Engg.	FD	238	238	244	261	258	282	229	303	384	418
	MSc	68	75	81	82	73	74	81	96	129	169

4.2 HESA Rounding Methodology requirements

The fraction of the First Degree labour market entrants represented by those with Taught Masters ranges between (an average over the 10 years of) some 17% (for Mechanical Engineering) and some 45% (Civil Engineering) – in fact the percentages vary considerably between disciplines and over time – see Figure 11. As in the last section, this will mean that the lower flows for MSc's would in general pose more problems with sample size and limitations of possible conclusion granularity than is the case with the First Degree flows. In particular the robustness of the percentages for Naval Architecture post-graduates will be very limited, and statistical reliability issues are more likely to emerge at least for Chemical Engineering post-graduates[12].

Figure 11: Fraction of total First Degree graduates employed represented by number of MSc's employed
(Source: HESA DLHE)



4.3 The Sectoral Flows from Taught Masters' courses in the different Engineering disciplines

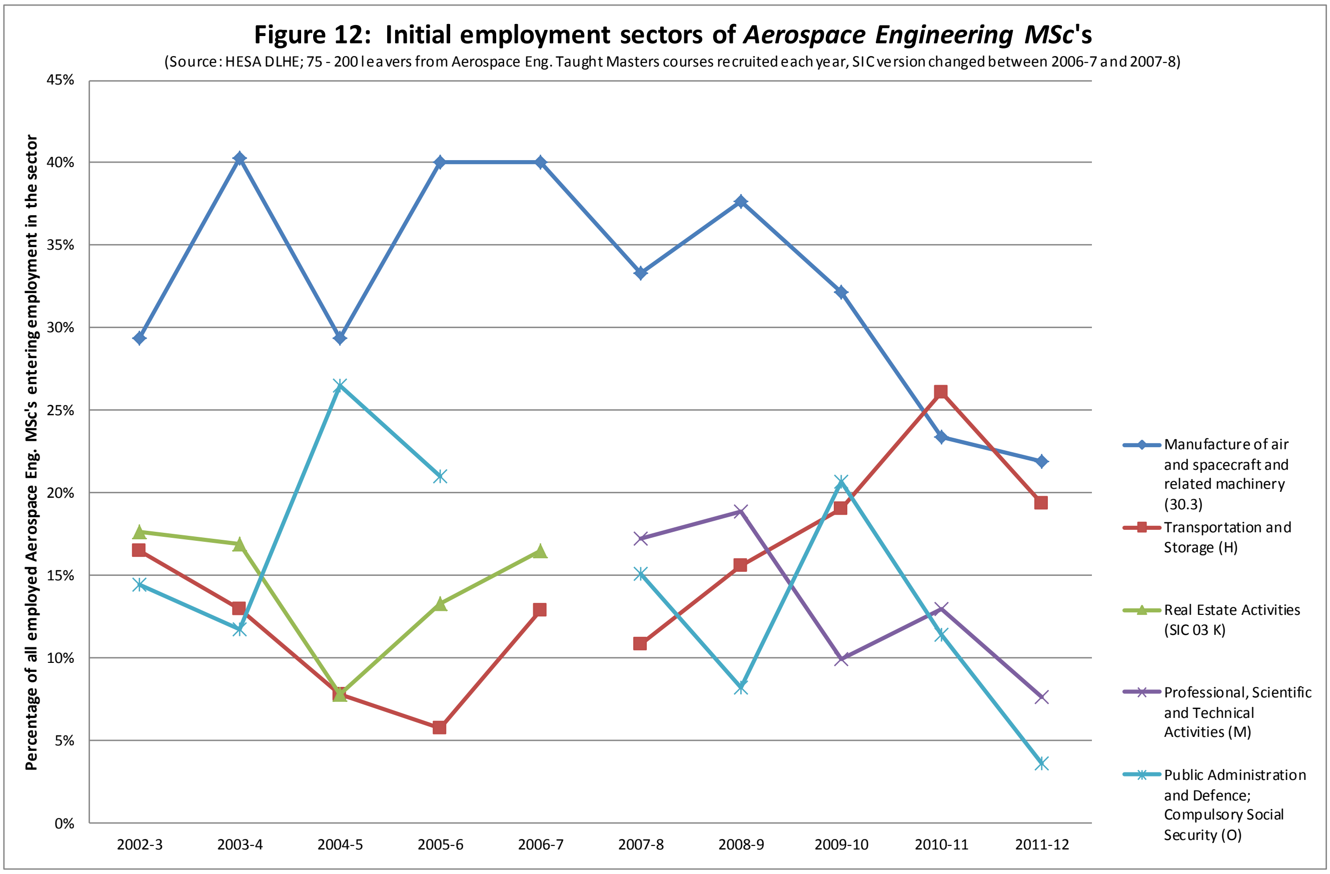
The flows into initial work in the different sectors for the Engineering disciplines that correspond directly to a sub-sector of Manufacturing were examined over the ten years, and the main results are show in Figures 12 - 16. No chart has been prepared for initial employment sectors of those graduating from Taught Masters courses (normally MSc courses) in *Naval Architecture* or *Electrical Engineering*, since numbers in employment six months after graduation were less than 25 (and often less than 10). The flows involving the other five disciplines (Aerospace, Automotive, Chemical, Electronic and Mechanical[13] Engineering) are shown below (although the sample sizes of many of the flows for the *Automotive Engineering* MSc flows are particularly low, resulting in suppression of a number of data points).

As with the time series for flows of First Degree graduates shown in Dixon (2015), there is in some cases considerable volatility over the ten years. As for the Average Salary time series charts in Section 2, the absence of a data point for one or two years of the time series in these charts arises from data suppression by HESA in accordance with the published thresholds in the light of sample size limitations. The larger swings are

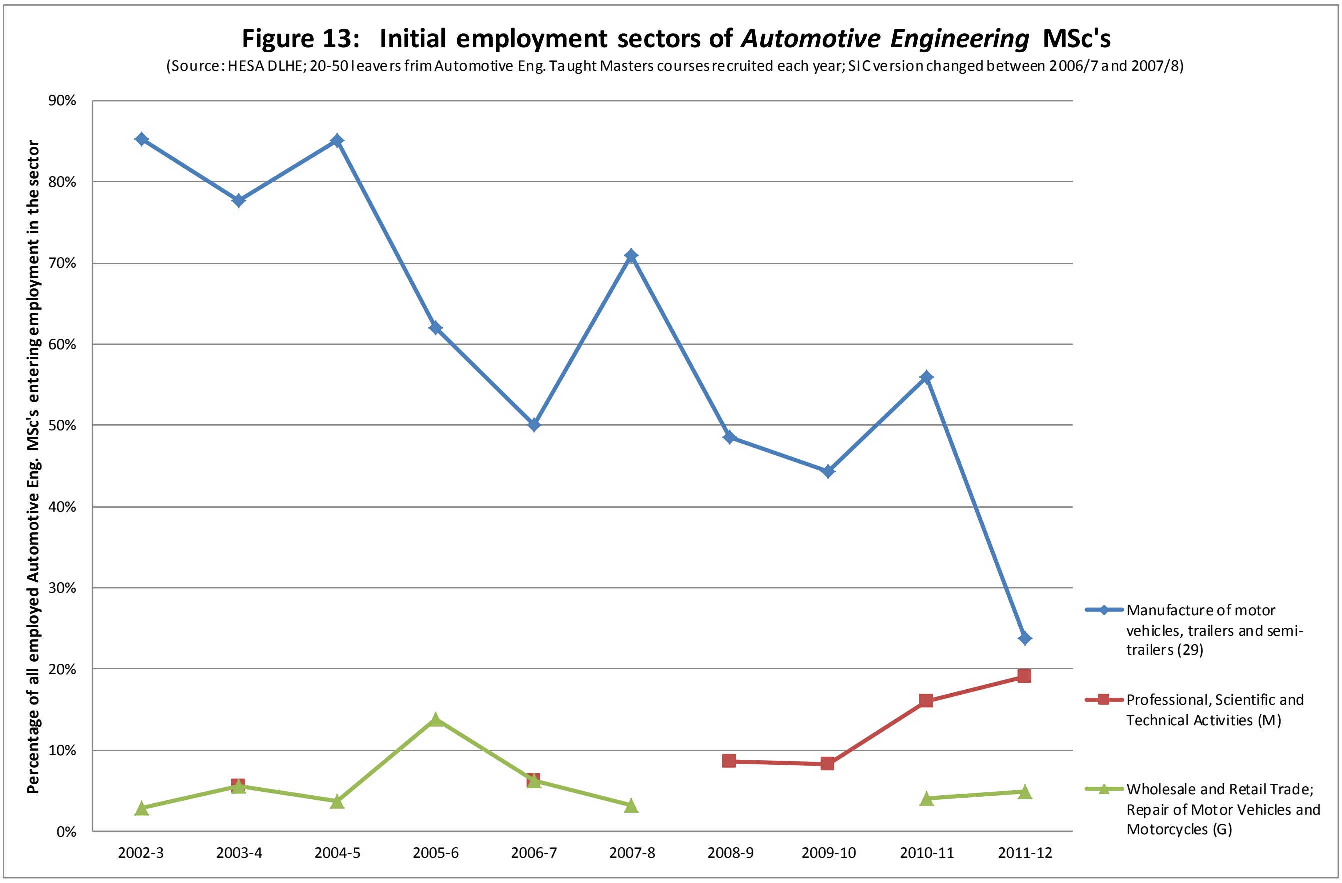
[12] after separating out data for Automotive Engineering from Mechanical Engineering, and separating *Electrical* and *Electronic* Engineering data, it emerges that employed numbers of Automotive and Electrical Engineering MSc's are also sufficiently small as to pose statistical limitations.

[13] without *Automotive* Engineering (normally included within *Mechanical Engineering*)

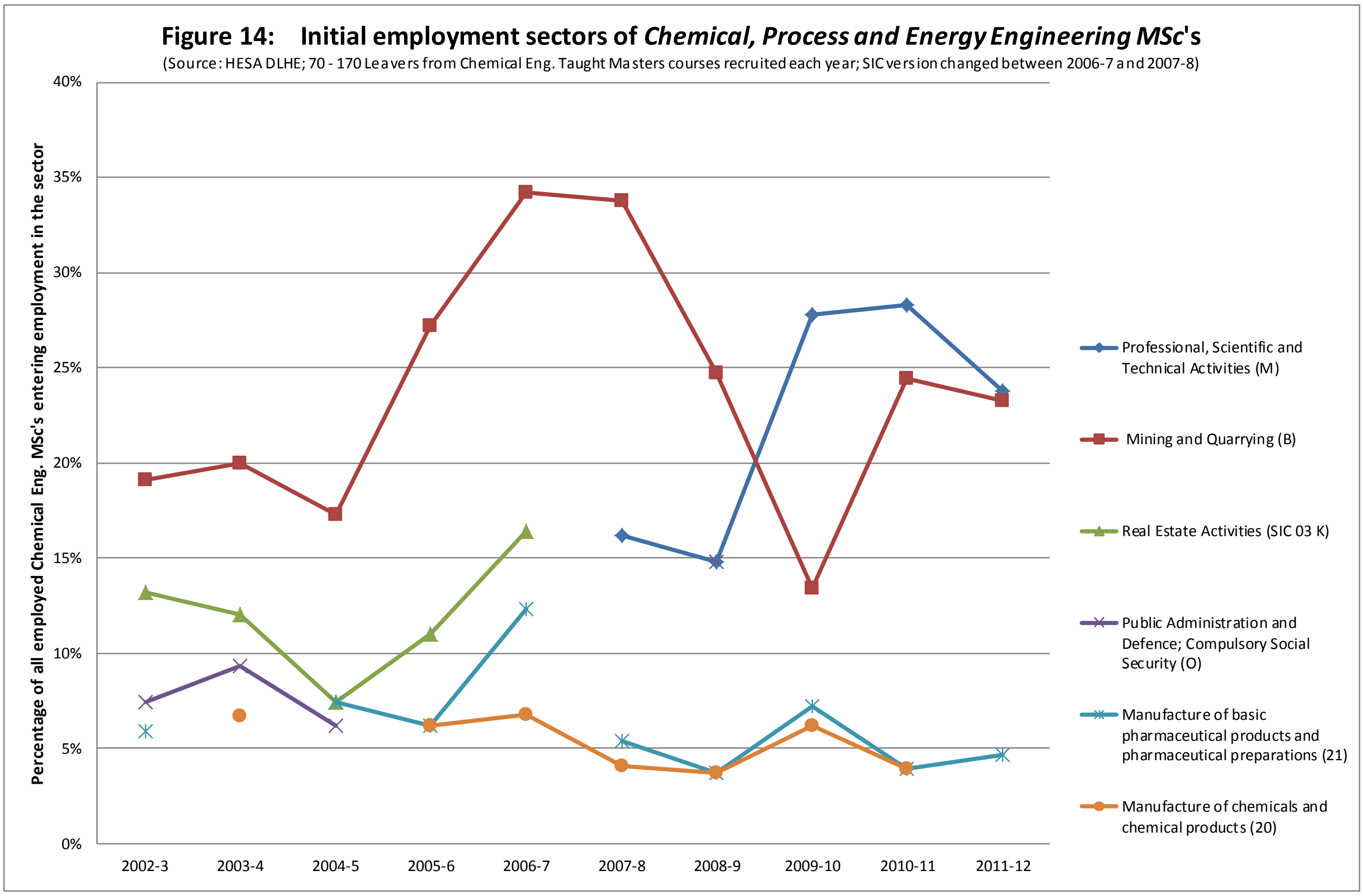
largely due to the smaller scale of the flows as compared with First Degree graduate flows, although significant changes over a small number of years may, in some cases, show up certain interesting trends. In particular, of course, the changes in flows following the financial crisis in 2007/8 are likely to show certain impacts of the subsequent recession – probably affecting some destination sectors more than others. This may, for example, account for the strong fall of graduates entering Aerospace Manufacturing by Aerospace Engineering MSc's (see Figure 12), and the sharp fall in the fraction of Electronic Engineering MSc's going into the ICT industry (Figure 15).



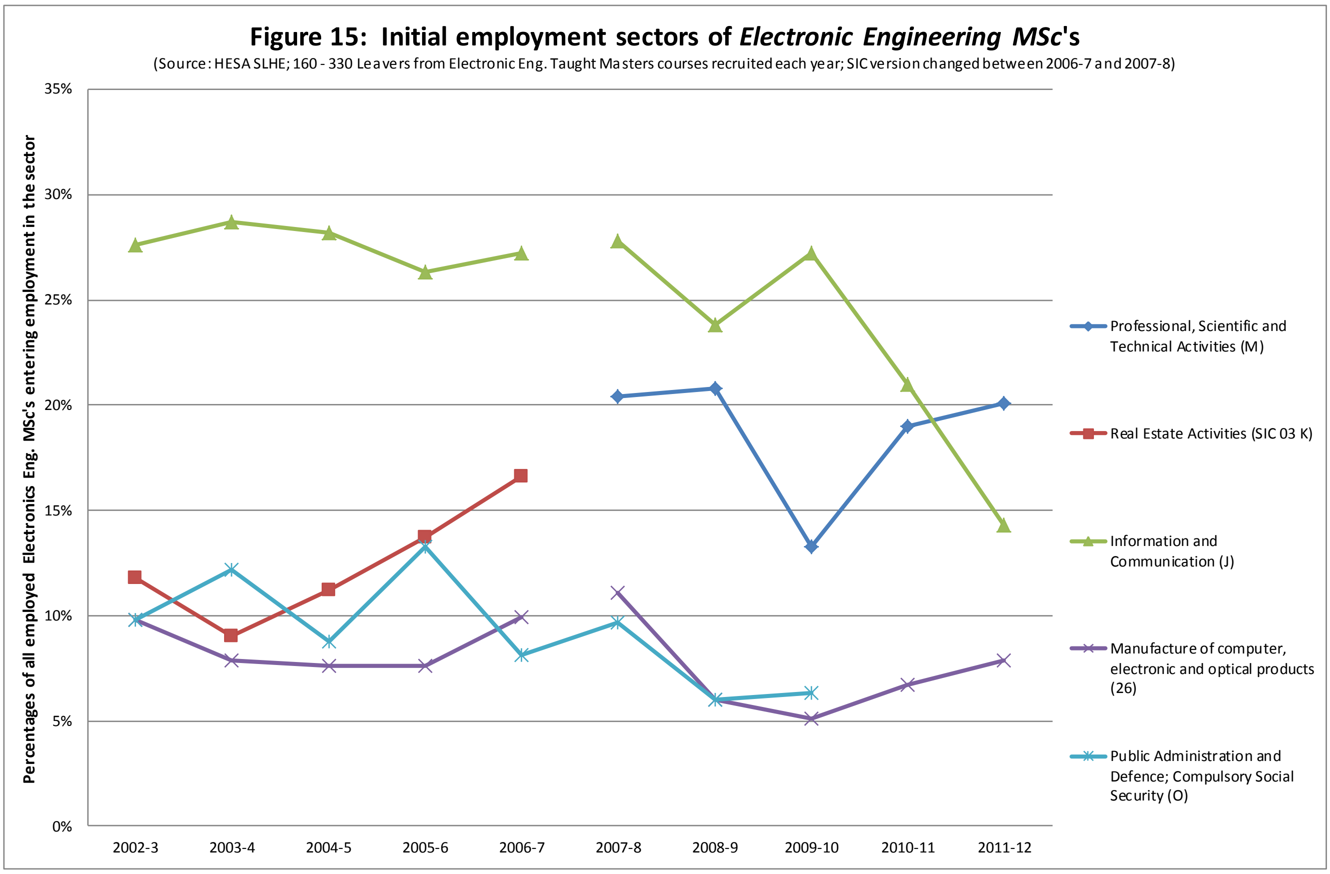
(Engineering Consultancy classified within SIC 03 Section **K**, and then within SIC 07 Section **M**)



(Comparatively low flows result in very small sample sizes for some year cohorts)



(Engineering Consultancy classified within SIC 03 Section **K**, and then within SIC 07 Section **M**)



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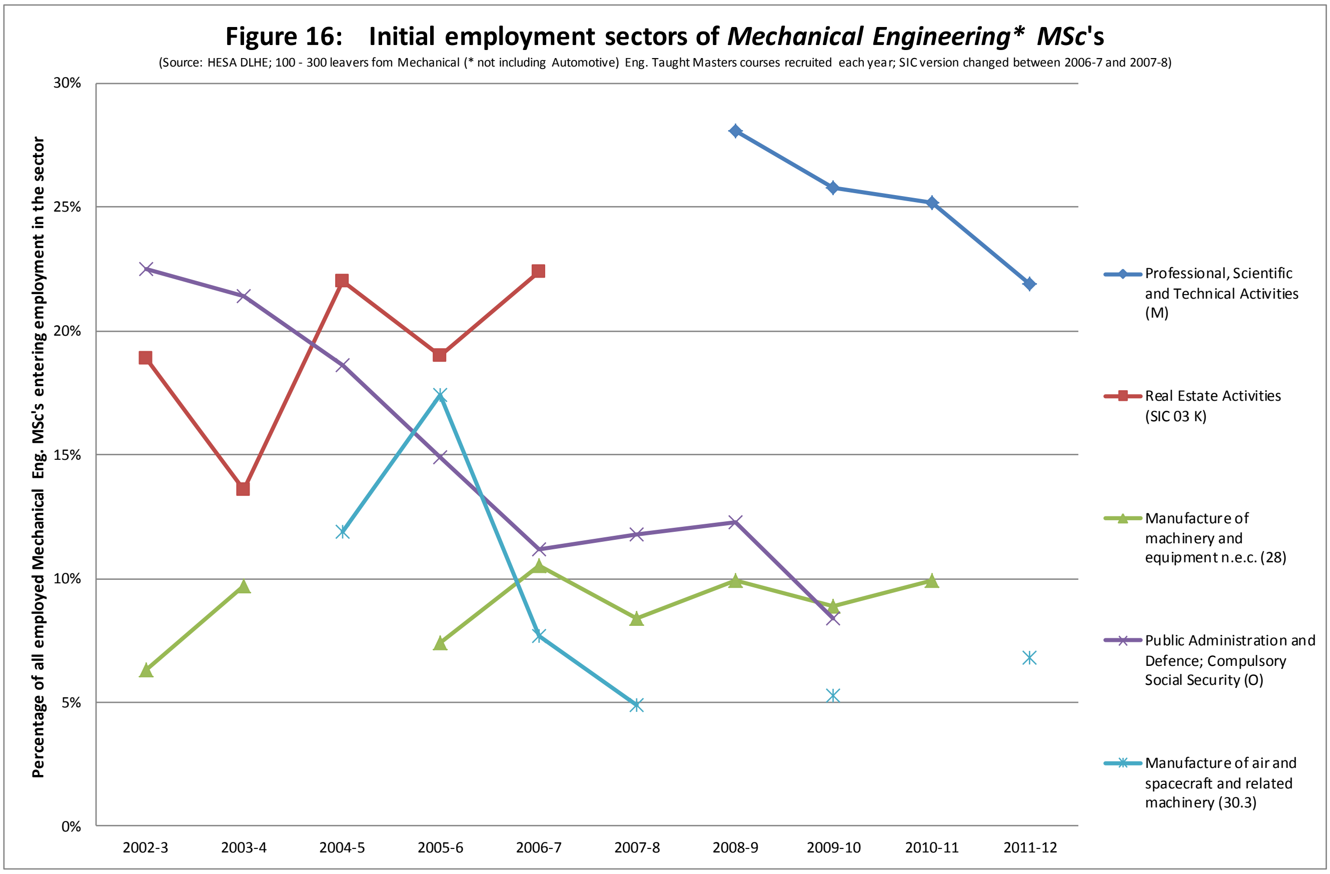


(Engineering Consultancy classified within SIC 03 Section **K**, and then within SIC 07 Section **M**)

4.4 Differences in 'linear flow leakage'

Intriguingly, comparisons of these charts with the relevant ones in Dixon (2015) show rather less difference in 'leakage' away from the 'natural' manufacturing sub-sector than might be expected: the only two disciplines for which the 'leakage' away from the relevant manufacturing sub-sector is unequivocally reduced are *Automotive* Engineering and *Aerospace* Engineering.

As can be seen from Figure 13, the vast majority of MSc graduates in *Automotive Engineering* enter the *Manufacture of Motor Vehicles...* sub-sector at the beginning of the ten-year period, though the fraction eases over the period and falls strongly towards the end.

Table 9 compares the fractions of those *Automotive Engineering* graduates from First and Taught Masters degrees flowing into the natural manufacturing sector over the ten years:

Table 9 Year	Fraction of *First Degree* Automotive Engineering graduates entering *Manufacturing of Motor Vehicles* sector	Fraction of *Taught Masters* Automotive Engineering graduates entering *Manufacturing of Motor Vehicles* sector
2002-3	27.2%	94.1%
2003-4	25.0%	83.3%
2004-5	21.8%	92.6%
2005-6	15.6%	69.0%
2006-7	18.7%	69.0%
2007-8	30.0%	69.0%
2008-9	17.4%	80.6%
2009-10	32.1%	61.1%
2010-11	41.8%	64.0%
2011-12	30.5%	40.5%

Likewise, although less dramatically, the fractions of *Aerospace Engineering* "MSc graduates" entering the *Manufacture of air and spacecraft...* sub-sector (Table 10) are notably higher than the fraction of First Degree graduates except at the end of the period:

Table 10 Year	Fraction of *First Degree* Aerospace Engineering graduates entering *Manufacturing of air and spacecraft*	Fraction of *Taught Masters* Aerospace Engineering graduates entering *Manufacturing of air and spacecraft*
2002-3	20.6%	29.4%
2003-4	14.2%	40.3%
2004-5	23.9%	29.4%
2005-6	23.2%	40.0%
2006-7	19.2%	40.0%
2007-8	18.2%	33.3%
2008-9	22.9%	37.7%
2009-10	19.9%	32.2%
2010-11	22.7%	23.4%
2011-12	25.6%	21.9%

However, apart from those two cases, there is broadly little significant difference between the fractions entering the *natural manufacturing sub-sector*:

- **Chemical Engineering MSc's:**
  While the "natural manufacturing sub-sector" for Chemical Engineers is the *manufacture of chemicals and chemical products*, they also work widely both within the *Pharmceuticals manufacturing* and *Oil & Gas* industries, and the latter confirms the comparatively significant fractions of the cohort recruited into the "Mining and Quarrying" sector.
- **Electronic Engineering MSc's:**
  With electronic devices more and more ubiquitous throughout the economy, it is understandable that opportunities for Electronic Engineers are widespread across the economy. Intriguingly, most leavers from both undergraduate and post-graduate courses have – over these ten years – opted to go and work in *the ICT industry*: this could be in hardware (often in Telecoms. System tailoring, installation and commissioning), but also the demand for engineers with an adequate understanding of software is significant. As already noted, the fall in the *Information and Communication* sector's share of MSc destinations since 2009 is striking. The fraction of the MSc cohorts that chose to enter *electronics manufacturing* was low – generally below 10% of those employed - as it was for first degree graduates. And finally it is interesting to note that *the public sector* ("Public Administration and Defence; Compulsory Social Security") featured more than for the first degree graduates.
- **Mechanical Engineering MSc's:**
  Although Mechanical Engineering graduates are valuable in many manufacturing sub-sectors and beyond, Dixon (2015) examined in particular the flows into the "machinery products" manufacturing industry: *Manufacture of Machinery and equipment not elsewhere classified*. The cohort fractions going into this sub-sector are not massively different between the "graduate" and "postgraduate" flows.

Other differences are intriguing: for example the flows of Aerospace MSc's into "Transportation and Storage" industries is notably greater than for first degree graduates. In principle this would represent recruitment into *airlines*, where considerable technical expertise is required for assessing, introducing and maintaining aircraft – perhaps the additional knowledge is particularly appreciated in that industry, as compared with in the manufacturing of aircraft.

4.5 Do Engineering MSc's go into Manufacturing more than BEng's?

And finally it is worth comparing, for the most recent cohort, the fractions of employed MSc's that entered ***any kind of Manufacturing***, as compared with those with their First (undergraduate) Degree (normally three year *Bachelor of Engineering* – BEng (Hons), or four year undergraduate *Master of Engineering* - MEng). This is shown in Table 11.

Total FD's in Employ-ment	***Total MSc's in Employ-ment***	**Discipline**	**FD's**	**MSc's**
302	42	**Automotive Engineering**	50.3%	40.5%
1,592	298	**Mechanical[14] Engineering**	42.9%	46.5%
545	214	**Aerospace engineering**	50.7%	58.9%
30	18	**Naval architecture**	30.8%	29.2%
50	20	**Electrical Engineering**	16.0%	10.0%
1,412	254	**Electronic Engineering**	25.2%	31.9%
418	169	**Chemical... engineering**	28.8%	17.4%

Table 11: Comparison (for 2011 Leavers) of fraction going into ANY Mfg. of First Degree and Taught Masters leavers

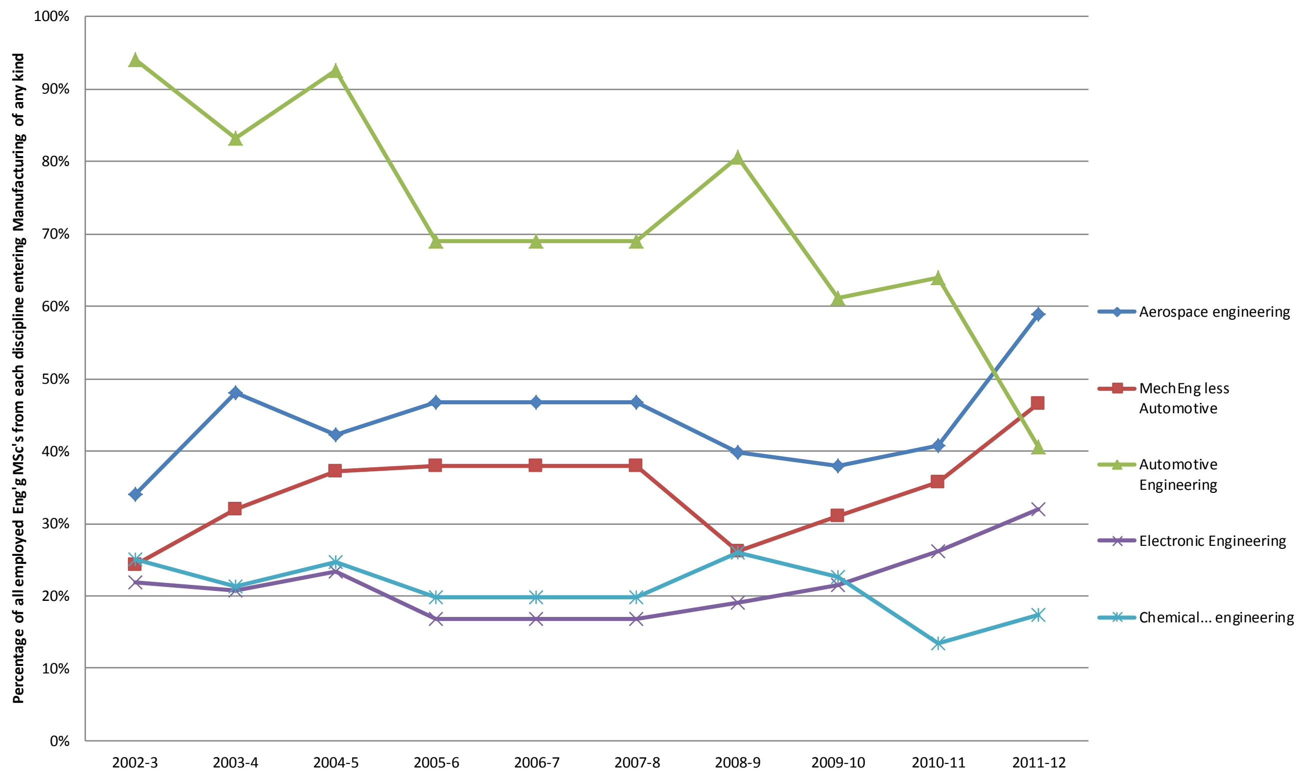
As can be seen, the fraction of the 2011 cohorts going into Manufacturing is *lower* for MSc's than FD's in *Automotive* Engineering, *Naval Architecture* (slightly), and *Electrical* and *Chemical*... Engineering, though *higher* for MSc's than FD's in *Mechanical*, *Aerospace*, and *Electronic* Engineering. As for the flows for leavers of each discipline into the 'natural' Manufacturing sub-sector, there is therefore ***no*** *clear, consistent pattern of 'leakage' reduction*.

Figure 17 shows how *the fraction of MSc's going into any kind of Manufacturing* developed over the 10 years:

[14] not including *Automotive Engineering*

Figure 17: Fraction of Engineering MSc's who enter (any) Manufacturing for their first job

(Source HESA DLHE data on Engineering Masters courses in the different disciplines)



Overall, over the 10 years, the ranking of MSc's going to work in Manufacturing is as follows:

- Automotive Engineering (*highest* flow into *any kind of Manufacturing);*
- Aerospace Engineering;
- Mechanical Engineering[15]
- Chemical... Engineering; and
- Electronic Engineering (*lowest* flow into *any kind of Manufacturing*).

Although there are falls in this fraction between 2007/8 and 2008/9 for *Aerospace* and *Mechanical* Engineering, and for *Automotive* Engineering the following year, there does not appear to be strong, consistent impact of the 2007/8 financial crisis**.**

[15] not including Automotive Engineering

5 Demand for STEM graduates more widely & the role of 'Leakage' in STEM skills policy

Dixon (2015) pointed out that 'leakage', from the 'expected destination sector' for a particular field, of graduates from courses in *Science, Technology, Engineering and Mathematics* (STEM) more broadly would also affect the effectiveness of policy responses to reports of skill shortages from employers in Sectors considered also to be "STEM industries", and that, because of the *very much greater breadth*, 'Leakage' from each distinct field to other STEM areas would be correspondingly higher.

STEM skills, including the role of supply of STEM graduates, continue to be of great interest in skills and economic policy considerations in the UK and beyond. The recent "*Green Paper*" from Her Majesty's Government on 'Building our Industrial Strategy': HMG (2017) asserts (p. 39):

> *Third, we face particular shortages in sectors that depend on science, technology, engineering and maths (STEM) skills. For example, nearly half of businesses report a shortage of STEM graduates as being a key factor in being unable to recruit appropriate staff[50]. The number of STEM undergraduates has been increasing over the last few years, but there remains unmet demand from employers. We must ensure the higher education sector is able to meet this need.*

and footnote 50 indicates:

> *[50] Engineering UK's report 'Engineering UK 2016: The State of Engineering' states that 46% of businesses reported a shortage of STEM graduates as being a key factor in being unable to recruit appropriate staff.*

Examination of "Engineering UK 2016" confirms (p. 262) that the 46% figure comes, in fact, from the CBI/Pearson 2014 'Education and Skills Survey: Gateway to growth'. While the annual CBI members' surveys are useful contributions to the skills debate, their Spring 2014 sample of 291 responding employers is massively less representative of employer realities than the 91,000 interviews of the *2015 Employer Skills Survey* carried out for the UK Commission for Employment and Skills.

More importantly, the UKCES commissioned over those years several studies looking directly at the supply and demand of high level STEM Skills. The 2013 study by the highly-respected Warwick Institute for Employment Research team (which has led the national "Working Futures" national forecasting studies for some years), found – as pointed out in Dixon (2015) - that:

> *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.*

In the light of this assessment, the UKCES 'Skills for the Future' briefing paper (UKCES 2014) admitted that "The UK is not forecast to have skill shortages for higher level STEM skills (between now and 2022)".

The UK Commission for Employment and Skills, perhaps with the encouragement of certain STEM interests (given this less convincing evidence in support of their lobbying), again reviewed the requirement for high level

STEM skills not much more than a year later (UKCES, 2015), in the light of the fresh evidence of the 2015 Employer Skills Survey. As well as recognising that employers reported *quality* issues with many STEM graduates and pointing out that the 2014 assessment

> *"estimated an adequate supply of STEM graduates in spite of an increasing dispersion of such graduates beyond Core STEM occupations and sectors",*

the review did not reject the 2014 report findings, and concluded that attempts to reconcile the apparent skill shortages reported by employers with an overall balance between supply and demand of individuals with high level STEM skills and knowledge suggested that:

> *"such shortages as there are relate to specific recruitment difficulties in some STEM-related areas where employers report insufficient UK candidates of suitable quality. This fits with our general understanding of skill shortages: that they are relatively few in number and in concentrated pockets, but with the potential to disrupt business performance to a disproportionate extent."*

Given this serious evidence, the continuing widespread assumption in public debate of significant shortages of STEM graduates on the UK labour market is both surprising and worrying.

Beyond the UK, the same realities are evident. A rather thorough report published by the European Commission in 2015 (E.C., 2015) reporting a detailed quantitative assessment by a consortium led by the Danish Technological Institute had asked: "Does the European Union need more STEM graduates?", and concluded:

> *4.1. Evidence about current STEM supply and demand Data analysed on current STEM skills supply and demand indicate that there are no overall quantitative shortages of STEM skills at the aggregate EU level.*

And, beyond Europe, the comprehensive analysis in 2014 by Teitelbaum (an acknowledged national expert on careers in Science and Engineering, and experienced Congressional expert witness) of STEM skills in the United States labour market that was flagged in Dixon (2015) provided a devastating critique[16] of Skill Shortage claims in this area. The book's assessment was summarised as follows:

- *If skill shortages exist, there should be evidence generally of a) rising relative wages for STEM occupations (which has not been present); b) faster than average employment growth (which has been present in some, but not all, occupations), and c) relatively low, and declining, unemployment rates (which has also not been present);*

[16] Teitelbaum (2014): 'Falling Behind? Boom, Bust, and the Global Race for Scientific Talent'; Princeton University Press; 2014; ISBN: 9780691154664

- *While there were no signs of broad STEM shortages, a) there was evidence of large variations within STEM; b) under-supply and over-supply coexisted in some specific fields at certain times, and situations in different fields change (rise and fall of activity in particular disciplines – for example, fading of demand for mechanical engineers as US automotive manufacturing declined; and growth in demand for petroleum engineers with the strong rise of fracking activity); c) geographical variations (local 'hot houses' – for example, Silicon valley – are atypical, there are booms and busts in specific occupations over time, but generalisations are perilous); Examples include i) computer/IT skills: high starting salaries, sub-degree qualified people common, some specific areas are 'hot', some not; ii) Engineers: high starting salaries, but slow increases, careers 'unstable'; iii) Biomedical: lengthy PhD + post-doc; low starting salaries; careers 'unstable'. Are STEM shortage claims over-generalisations?;*
- *Why then do shortage claims 'prevail'?: a) effective lobbying campaigns (led by IT employ-ers, emphasis on temporary visas), b) support from Higher Education (seeking increased funding for specific disciplines); c) substantial support from immigration lawyers (seeking more high-volume temporary visas paid for by employers); d) some Federal agencies (less now – for example, NSF in late 1980s). Opposition to shortage claims has been limited (some science and engineering associations – for example, IEEE – already international); and*
- *Science and engineering shortage claims have existed for decades: Quote from Arrow and Capron (1959): "Careful reading of such statements indicates that the speakers have in effect been saying: 'There are not as many engineers and scientists as this nation should have in order to do all the things that need doing such as maintaining our rapid rate of technological progress, raising our standard of living, keeping us militarily strong', etc. In other words they are saying (in the economic sense) demand for technically skilled manpower ought to be greater than it is – it is really a shortage of demand for engineers and scientists that concerns them".*

(Teitelbaum, 2014).

Reviews of, and comments on, Teitelbaum's book subsequently published by STEM-related professional associations and others in the United States do not appear to have attempted to question the essence of its analysis and conclusions.

Given the evident value, in the labour market, of graduates with a 'training' to degree level in a technical/scientific area plus broad understanding of, and familiarity - and confidence in working - with, mathematics, it is understandable that public policy has perceived the importance to employers, and so to the economy as a whole, of people with deeper knowledge and understanding of STEM subjects.

However, if the flows of people with STEM qualifications into work that will directly use the knowledge and understanding of that area of science and technology are to be seriously considered, as has been done for certain engineering disciplines in Dixon (2015), then, clearly, because of the *massively greater **breadth** of the* *scope* of the *bodies of knowledge* of STEM subjects as a whole[17], and because direct use of the technical knowledge acquired from each field will not be relevant to most other STEM occupations, the amount of *intra-STEM leakage* will be very considerable.

So, while STEM qualifications do provide undoubted potential labour market strengths to the holder, by bringing together all such qualifications across such a massively broad set of *bodies of knowledge*, the amount of potential heterogeneity (and so the amount of leakage from initial occupations that will directly use the technical body of knowledge acquired in the degree) in the subsequent 'graduate first destination flows' will be even (very considerably) greater than for just engineering.

While it is understandable that those in policy analysis value the importance of these fields to the economy, the prevailing assumption that there are widespread shortages of STEM graduates on the UK labour market should really not be accepted without question – as it appears to be.

Irrespective of a lack of robust evidence of any shortage of STEM graduates, policy should be mindful of three additional pitfalls of focusing (in response to reported sectoral skill shortages) on trying to increase the number of (young) people entering STEM degree courses:

1) The learning pipeline delay (labour market conditions are generally different when graduates emerge with their degrees and enter the labour market than when they start the course);
2) The fact that comparatively few *Small to Medium Enterprises* recruit "fresh graduates"; and
3) The fact that continuing MAC evidence points out that genuine specific technical skill shortages in the labour market can only rarely be filled by "fresh" graduates.

[17] UKCES (2013) acknowledged this heterogeneity, *inter alia*, by dividing the field into 'core STEM' and 'medical and related STEM'.

6 Conclusions

Dixon (2015) concluded, on the basis of ten years' worth of evidence of the flows of Engineering graduates into their initial employment, that the majority of graduates from Engineering undergraduate courses in the United Kingdom simply do **not** then go on to work in the industrial sectors that are generally assumed. In terms of flows in each case into the relevant *Manufacturing* industries - the fraction of graduates entering work in the sub-sector that corresponds to the Engineering discipline studied - the 'leakage' is not just more than 50%, it is in a number of cases more than 90%.

While such large 'leakage' may initially both be viewed as very surprising and raise concerns, given the often-reported skill needs of UK Manufacturing sub-sectors, the entry of Engineering *graduates*, as their first job, into 'less obvious' sectors is **not** something that should become a serious cause for concern. This is because the knowledge and understanding that Engineering graduates bring to other sectors, across the economy, are both valued by recruiting employers (they offered the graduate the job!) and can contribute to cost-effective production and achievement of the employers' goals, as well as usefully stimulating ideas for unexpected innovation. The real problem that arises is *the flawed assumption and argumentation (about flows being 'linear' – that these graduates largely go into the 'obvious' sectors) generally made in the analysis of related skills policy and publicly-funded action* – whether made by policymakers, relevant university departments, professional bodies, Engineering companies or relevant industry bodies, or other interested parties.

Dixon (2015) also showed, drawing on Migration Advisory Committee evidence, that the skill shortages actually reported by employers of engineers were simply not shortages that could be filled by Engineering graduates, since much more experienced engineers are needed. Where employers *do* recruit 'fresh' Engineering graduates, there might be an issue if *Engineering employers could not get enough*, good, graduates of the kind they are seeking. The Wakeham Review (HEFCE, 2016) investigated this question in the light of employer reports, and raised questions, and gathered evidence, that led to important recommendations relating to course content and management (in particular for *course accreditation*) and student choice. However, the Wakeham Review acknowledges:

> "...It remains possible that the attractiveness of offers of employment in some 'non-STEM' sectors is likely to deprive traditional STEM sectors of some of the best and brightest STEM graduates, but *it is neither feasible nor desirable for the UK to adopt a workforce-planning approach to all areas and aspects of the economy. It is for relevant industries and sectors to consider and address these issues directly, and it should not be the preserve of the HE system or Government to interfere with those dynamics."*

The key conclusion of Dixon (2015) was that attempts, whether encouraged by interested parties or considered by government in response to concerns that "something should be done", to respond to reported skills shortages in particular Manufacturing sub-sectors by attempting to get more (young) people to start HE courses in the relevant Engineering discipline would be fundamentally flawed, wasteful of time and public resources, and should not continue.

This paper has examined the broader context of the analysis in Dixon (2015) and confirms the essence of its conclusions. Having examined the subsequent destinations of Engineering graduates with evidence from the "longitudinal" DLHE survey (tracking destinations three years after the initial "6-month DLHE"), the paper confirms that 'leakage', if anything, increases over time, and adds two important considerations to the assessment:

1) it shows very limited evidence of significant influence of "price" in the recruitment market for Engineering graduates in the UK, and
2) it confirms that 'leakage' of the kind that dominates the first degree graduate recruitment market for Engineers *is in two cases less* in the recruitment of those leaving *post-graduate* (taught Masters') degrees, though otherwise not significantly different.

The limited correlation between the ranking of *flows of graduates from the different Engineering disciplines into different sectors of the economy* and the (average) *salary levels being offered by employers in those sectors* further questions the 'natural response of classical economic theory' to concerns raised by Engineering employers that "they can't recruit the graduates they need". The traditional response to such complaints (that such *employers should offer higher salaries*) makes assumptions about the working of this market that are not supported by this evidence.

This conclusion does however leave something of a natural remaining question: if a) trying to get more (young) people to sign-up for relevant degree courses will simply not, when these people emerge from the learning pipeline, provide more than a token additional supply to the relevant sub-sectors *(i.e. the 'obvious' policy response would not have very much effect*), and if b) employers' increasing the offer (salary) price would also make little difference (*the main response action employers could take would not work*), ***what, then, could be done in this situation?***

The answer requires us to stand back and consider more seriously than before ***what is the problem?*** In the light of the real behaviour in the labour marketplace, the understandable incentives of, and for, the market 'actors', and a *sensible reflection* of what's involved, several fundamental points become clear:

1) labour market entrants (even if bright, keen graduates) will very rarely - within a few months of completing Full-Time Education – be able to fill serious shortages of key technical skills (see various Migration Advisory Committee analyses – e.g. MAC, 2013);
2) the delay arising from the 'learning pipeline' of HE Engineering courses (even the twelve months of taught Masters' courses) will always prove too long to allow effective responses to employers' current needs, and labour market conditions as the graduates emerge will almost certainly have changed from those prevailing when the shortage assessment was made;

3) attempting to respond to current skill shortages by increasing flows through Higher Education programmes will therefore almost always prove inadequate and/or ineffective; and
4) while assertions and reports of serious skill shortages abound, consistent robust evidence of these is limited (see MAC labour shortage reports (2008 – 2014), based on a particularly thorough methodology (MAC, 2010)).

This suggests that:

a) the timing requirement realities of employer skill needs, particularly those competing in increasingly tough international product markets, are always likely to be so urgent that recruitment of *experienced* engineers is what is needed. In the absence of occasional good candidates who happen to be currently unemployed, achieving this would in principle mean "poaching" those already employed. Where a serious shortage really does pervade a whole UK sector, the only practical way to address the widespread urgent need for increased supply would therefore be recruitment from overseas; and
b) if manufacturing companies *really are* having significant problems recruiting (good) Engineering *graduates*, the only way for them of successfully securing more/better ones is to find a way of making the company as attractive as possible, in every way, to the candidates. As pointed out in Dixon (2015), however, there are rather fundamental challenges to attempting this for a sector (sub-sector) as a whole.

It is hoped that the analysis in this paper will further help to improve understanding in this area, and so improve the soundness, and so cost-effectiveness, of future policy thinking and public fund deployment.

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