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An Open and Data-driven Taxonomy of Skills Extracted from Online Job Adverts

Jyldyz Djumalieva and Cath Sleeman

ESCoE Discussion Paper 2018-13

August 2018

ISSN 2515-4664

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Contact Details
Economic Statistics Centre of Excellence
National Institute of Economic and Social Research
2 Dean Trench St
London SW1P 3HE
United Kingdom

T: +44 (0)20 7222 7665
E: escoeinfo@niesr.ac.uk

An Open and Data-driven Taxonomy of Skills Extracted from Online Job Adverts

Jyldyz Djumalieva[1,2] and Cath Sleeman[1,2]

[1] Nesta
[2] Economic Statistics Centre of Excellence

Abstract

In this work we offer an open and data-driven skills taxonomy, which is independent of ESCO and O*NET, two popular available taxonomies that are expert-derived. Since the taxonomy is created in an algorithmic way without expert elicitation, it can be quickly updated to reflect changes in labour demand and provide timely insights to support labour market decision-making. Our proposed taxonomy also captures links between skills, aggregated job titles, and the salaries mentioned in the millions of UK job adverts used in this analysis. To generate the taxonomy, we employ machine learning methods, such as word embeddings, network community detection algorithms and consensus clustering. We model skills as a graph with individual skills as vertices and their co-occurrences in job adverts as edges. The strength of the relationships between the skills is measured using both the frequency of actual co-occurrences of skills in the same advert as well as their shared context, based on a trained word embeddings model. Once skills are represented as a network, we hierarchically group them into clusters. To ensure the stability of the resulting clusters, we introduce bootstrapping and consensus clustering stages into the methodology. While we share initial results and describe the skill clusters, the main purpose of this paper is to outline the methodology for building the taxonomy.

Keywords: Skills, Skills taxonomy, Labour demand, Online job adverts, Big data, Machine learning, Word embeddings

JEL classification: C18, C38, J23, J24

Contact Details

Jyldyz Djumalieva
58 Victoria Embankment
London, EC4Y 0DS
United Kingdom

Email: jyldyz.djumalieva@nesta.org.uk, cath.sleeman@nesta.org.uk

This ESCoE paper was first published in August 2018.

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Introduction

In this work, we propose a data-driven taxonomy of skills mentioned by employers in online job adverts. We use the term "skills" to refer to all employer requirements including those relating to competences and knowledge. This is the first publicly available taxonomy we are aware of that does not rely on existing models and ontologies such as the Occupational Information Network (O*NET) and European Skills, Competences, Qualifications and Occupations (ESCO). It is also derived in an algorithmic way without expert elicitation, which means that it can be quickly updated to reflect changes in labour demand and provide timely insights to support labour market decision-making.

To generate the taxonomy we employ machine learning methods, such as word embeddings and network community detection algorithms. We model skills as a graph with individual skills as vertices and their co-occurrences in job adverts as edges. The strength of the relationships between the skills is measured using both frequency of actual co-occurrences of the skills in the same advert as well as their shared context, based on a trained word embeddings model. Once skills are represented as a network, we hierarchically group them into clusters. To ensure the stability of the resulting clusters, we introduce bootstrapping and consensus clustering stages into the methodology. While we share initial results and describe the skill clusters, the main purpose of this paper is to outline the methodology for building the taxonomy.

The remainder of the paper is organised as follows. We start by describing the motivation for developing a new skills taxonomy and relevant research. In the Methods section, we provide a detailed description of the methodology used to generate the skills taxonomy, followed by an overview of the initial results. The

limitations of the approach are reviewed in the Discussion section. We conclude with a summary of the contributions of the paper and suggestions for future research.

Motivation

A growing body of research predicts that the labour force will undergo substantial changes in the near future. Globalisation and technological developments, together with environmental and demographic trends, will reshape labour market structures. A recent study by Nesta and Pearson predicts with confidence that around 20% of occupations will shrink and 10% will grow, but for the remaining occupations the outlook is highly uncertain (Bakhshi, Downing, Osborne, and Schneider, 2017). The nature of work and the requirements for effective job performance are also likely to change with new skills, competences and knowledge areas emerging, while other requirements become redundant (World Economic Forum, 2018). In this context, policymakers, educators, businesses and individuals need timely information on both how the labour market is changing and what the potential pathways are for upgrading workers' skills and transitioning workers out of occupations at risk of decline. To generate such actionable insights we first, however, need a framework for measuring the similarity of skill requirements and grouping them in meaningful taxonomic groups. In this paper, we propose a methodology for discovering such a taxonomy in a data-driven way using non-traditional naturally occurring big data on the UK labour market.

Existing sources of information on occupational requirements have several limitations. Current publicly available models and taxonomies, such as O*NET (National Research Council, 2010) and ESCO (Directorate-General for Employment, Social Affairs and Inclusion, 2017) are expert-derived, which makes them expensive to update on an ongoing basis. As a result, there is a risk that information on skills might become outdated. Another limitation is that in their current state, the taxonomies do not fully capture the relationships between skills, competences and knowledge requirements. In ESCO, occupations are explicitly linked to skills, but the information on how the skills are connected to each other is only provided for *transversal* skills. Transversal skills refer to skills that are not specific to particular occupations, but rather are relevant to a broad range of occupations.

Alongside taxonomies like O*NET and ESCO, researchers in the private sector have also developed skills taxonomies using vast amounts of data from online job adverts and job seeker resumes. However, these are not open to the public. In addition, none of the existing taxonomies have been developed using UK data and therefore may be less suitable for the analysis and measurement of skill requirements in UK occupations. To fill the gap in the existing skills taxonomies and frameworks, we propose an empirically-driven taxonomy that is derived automatically from online job adverts. The proposed taxonomy offers a number of advantages over existing ones. First, it leverages naturally occurring data on millions of vacancies, which can be efficiently collected at scale and in real time. Using online job adverts also allows us to capture skills required by employers directly; in the adverts, employers are free to describe what they are looking for in candidates and are not constrained to select the requirements from a narrow number of skill groups. Another advantage of the taxonomy we propose is that we can enrich it with other information available in job adverts, such as offered salary and job title. Last, but not least, we are committed to making our taxonomy and methodology open to the public, which we think is important if the data are used to inform public policy.

We believe that our data-driven skills taxonomy can directly contribute to more responsive and evidence-based policy making. Timely information on the demand for, and salaries associated with, particular skills, competences and knowledge areas can help policymakers prioritise investment in skill development. The proposed taxonomy, together with the occupational classification we developed in a previous paper (Djumalieva, Lima, and Sleeman, 2017), can be combined to develop a recommender engine for identifying occupations that require similar skills. These insights could then inform policies for reskilling and supporting job transitions from occupations at risk of decline.

Related work

The systematic analysis of the occupational requirements has been a prominent area of labour market research for the past two decades. One of the most widely used models of occupational characteristics and worker attributes is O*NET, which was developed in late 1990s with support from the US Department of Labor and the Employment and Training Administration (Markowitsch and Plaimauer, 2009). For each occupation, O*NET provides detailed descriptions of worker characteristics and requirements, necessary levels of training, education and experience, job characteristics and occupational outlooks. O*NET is periodically updated using information from occupational experts and job holders as well as from job postings. The European Commission's ESCO represents another major public effort to systematise occupational information. ESCO is an ontology that maps relationships between skills, qualifications and occupations that are aligned with the International Standard Classification of Occupations (ISCO). Following several years of expert collaboration and public consultations, the first full version of ESCO was released in October 2017. Both O*NET and ESCO are open to the public.

With regards to data-driven skills taxonomies, research in this area has, of late, been concentrated in the private sector. In one such study, Zhao, Javed, Jacob, and McNair (2015) used data from 100 million resumes on CareerBuilder to generate a taxonomy of skills. In processing the resumes, the authors disambiguated and normalised 46 million unique skill phrases. This resulted in a taxonomy of 50,000 skills. However, the content and structure of the taxonomy was not made public. To date, as far as we are aware, there are no purely data-driven skills taxonomies in the public domain.

Most researchers in this field use data-driven approaches to extend ESCO instead of developing new taxonomies. For example, Sibarani et al. (2017) propose SARO - an ontology that connects information from job postings to ESCO skills. Authors tested automatically implementing SARO for extracting data from online vacancies for data scientists and performed a trend analysis for selected skills (Dadzie, Sibarani, Novalija, and Scerri, 2017). Boselli et al. (2017) also used relationships between ESCO occupations and skills to represent them in a bipartite knowledge graph, which enriches skills identified by experts for a given occupation with data from actual job adverts. It is likely that ESCO was chosen by researchers as a foundation due to its rich multilingual vocabulary of 13,485 skills as well as the availability of links between skills and occupations.

A methodology for the data-driven analysis of online job adverts was offered by Turrell et al. (forthcoming). The authors pursued a similar approach to the one we propose and implemented a bottom-up classification of jobs using vacancy descriptions in UK online job adverts. However, in their work Turrell et al. focused on identifying naturally existing occupational clusters and grouped individual jobs rather than employer requirements.

Within the context of the existing literature, our work contributes to the field in several ways. First, we offer a non-expert-driven taxonomy of skills required by employers that is independent of ESCO and O*NET. Since the taxonomy is created automatically, it's also easier to reproduce and keep up-to-date. And unlike taxonomies developed by the private sector, our taxonomy and methodology will be released to the public. Our proposed taxonomy also captures links between skills, aggregated job titles, and the salaries mentioned in the millions of UK job adverts used in this analysis.

Data

The online job advert dataset used in this paper was provided by Burning Glass Technologies, a labour market analytics company. Burning Glass collects data on active job postings from thousands of web-pages on a daily basis (Burning Glass Technologies, 2017). For each job posting, in addition to extracting job title, salary, education and experience requirements, Burning Glass identifies keywords from free text job descriptions. The full job descriptions are not available. We refer to the keywords as *skills*, which include skills, personal competences and knowledge required by employers. To develop the initial skills taxonomy

we use data on over 41 million adverts collected over a five-year period from January 2012 to December 2017. It is important to note that in our dataset there are many adverts with missing information: only 61% of adverts contain data on offered salary, and substantially fewer mention education (19% of adverts) and experience requirements (13% of adverts).

Methods

We use two approaches to measure the relationships between skills mentioned in Burning Glass job adverts (Figure 1). The first approach is based on the pairwise frequency of two skills appearing in the same job advert. The second approach is based on the distributed representation of skills. We generate the vector representations of skills by training a word2vec model, which learns the extent to which skills occur in the same context (i.e. together with other skills).

As a next step, we model the skills as a graph, where vertices represent individual skills. The vertices are joined by edges if they are mentioned in the same advert. The edges between vertices have attributes that describe the strength of the relationship, such as frequency (total number of pairwise skill mentions) and cosine similarity (similarity of the context in which the two skills occur across all adverts).

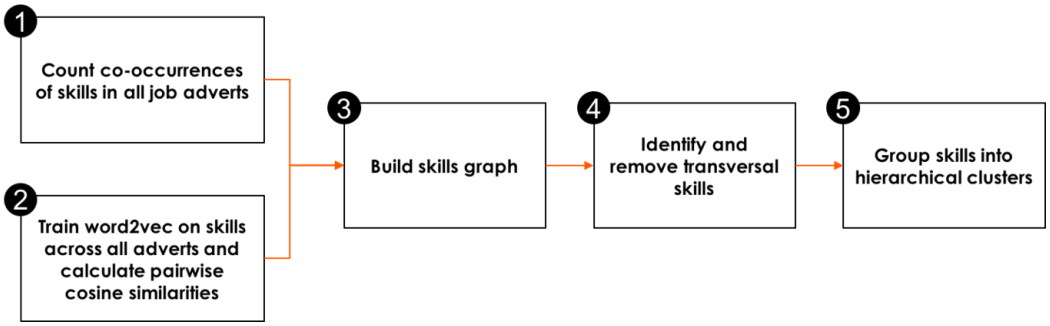

Figure 1: Process of discovering hierarchical skills taxonomy

Data Preparation

To prepare the data for the analysis, we first clean the skills removing any punctuation, special characters and numbers. We also exclude several groups of skills, which are: frequently inaccurate skills, phrases related to industry experience (that aren't related to skills) and skills mentioned three or fewer times over the six-year period. The 14 frequently inaccurate skills were identified in previous analysis of Burning Glass adverts and include acronyms which can refer to different sets of words when expanded (e.g. *CPR*: Cardiopulmonary resuscitation or Civil procedures rules) and irrelevant phrases scraped accidentally from web-pages (e.g. *"image processing"*, *"facebook"*). In total 891 skills are excluded. These account for 7.8% of all skills and comprise 3.1% of all skill mentions.

Building the Skills Graph

We use a graph approach to model the relationships between skills. Representing skills as a graph allows us to go beyond studying pairwise connections between skills and identify groups of skills that are densely connected to each other. To build the skills graph we traverse all job adverts and count the co-occurrences of skills. We then represent the counts as an *(N, N)* adjacency matrix, where N is the number of unique skills and the elements in the matrix indicate the number of skill co-occurrences. We then use the adjacency

matrix to generate an undirected graph, $G = (V, E)$, where vertices, V, are the skills, and edges, E, are the co-occurrences of the skills in the same advert.

To capture the strength of relationships in the network, we use two parameters for network edges: *f,* frequency and *c*, cosine similarity. Frequency refers to the most intuitive measure of skill relationships, and for two skills connected by an edge, it represents the total number of unique adverts that mention both skills. Put simply, the higher the frequency of the edge, the higher the co-occurrence of the skills and the stronger the relationship between them. However, this measure is flawed, since it will amplify the strength of the relationships between frequently occurring skills, such as *sales management* or *mechanical engineering*. This will make it more difficult to detect substantive relationships between skills that are mentioned less frequently. The decision on which metric to use for measuring the strength of edges has important implications for the community detection stage, since many algorithms use the edge-strength property as weights when partitioning the graph. In the case of skills, we are also likely to have situations where a skill (e.g. c*omputer-aided design*, *predictive modelling*, etc.) is mentioned in more than one domain and using frequency would result in assigning the skill to the largest domain.

As an alternative to a frequency-based measure of strength between skills, we trial context based vector representations. These distributed representations, also known as word embeddings, refer to a Natural Language Processing technique used to capture semantic similarities of terms based on their distribution in large text corpora (Jurafsky and Martin, 2017). Word embeddings convert terms, or in our case skills, into vectors that reflect the context in which the skills occur. The context refers to the probability that given terms or skills will be found together in a sentence or job advert. There is evidence in support of the higher accuracy of distributed representations of terms over frequency based approaches (Zhao, Javed, Jacob, and McNair, 2015). One of the leading methods for generating word embeddings is word2vec, which is based on shallow neural network language models (Mikolov, Sutskever, Chen, Corrado, and Dean, 2013). To compute distributed representations of skills in the online job adverts we use the *continuous bag of words* word2vec model as implemented in the python gensim library (Rehurek and Sojka, 2010). We train the word2vec model on 41 million online job adverts, ignoring adverts that mention 20 or more requirements. This filter is applied because the exploratory analysis showed that adverts with over 20 keywords typically combine descriptions of more than one vacancy. As demonstrated in Table 1, the trained word2vec model is able to uncover meaningful patterns in job adverts.

Table 1: Examples of the five most similar skills returned by trained word2vec model for select skills

Skill	Mechanical engineering	Machine learning	German	Google adwords
Top 5 most similar skills in the model	'Engineering support'	'Data science'	'Arabic'	'Keyword research'
	'Process engineering'	'Artificial intelligence'	'Spanish'	'Search marketing'
	'Manufacturing processes'	'Text mining'	'Dutch'	'Display campaigns'
	'Equipment design'	'Natural language processing'	'Swedish'	'Link building'
	'Technical drawings'	'Pattern recognition'	'Portuguese'	'Pay-per-click'

The resulting word2vec model outputs a set of unique skill vectors. The skills that occur in similar contexts (i.e. are often mentioned with the same skills in job adverts) will have similar vectors. We can then compute pairwise cosine similarity scores for all the skill vectors and use these to weight the edges in the skills graph.

Figure 2 shows a schematic representation of the skills graph, where two skills 'radiology' and 'diagnostic imaging' were mentioned together 1,585 times and the cosine similarity of their word2vec vectors is 0.66.

The summary of the steps taken to build the skills graph is provided in Appendix 2 (Figure 11).

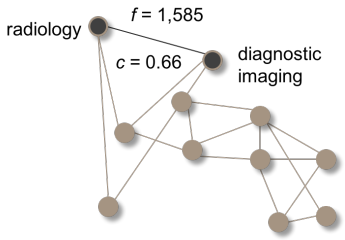

Figure 2: Schematic representation of the skills graph

Properties of the Skills Graph

The skills graph consists of 10,554 vertices and 4,015,549 edges. The properties of the graph resemble those of other real-life networks, where vertex degrees and centrality are very heterogeneous. From the highly positively skewed distributions of vertex degrees and eigenvector centrality shown in Figures 3 and 4, we can see that in the network there is a subset of highly central skills, which are connected to a large proportion of other skills in the network.

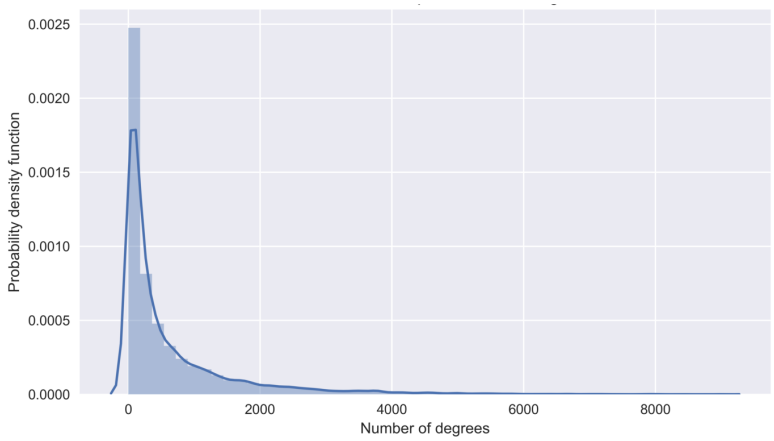

Figure 3: Distribution of skill degrees

This observation reflects the fact that, in our dataset, skills vary in how specific they are: some of the skills are very broad, or transversal. Examples of these transversal skills are *communication skills*, *problem solving* and *business management*. Other requirements are domain specific but still broad, such as *molecular biology*, *python* and *surgery*. Finally, there are very specific skills, such as *succession planning* and *visual merchandising*.

Identifying and Removing Transversal Skills

Our initial attempts to detect the naturally existing communities in the graph demonstrated that the presence of highly central skills engenders one giant community that contains most skills and very few specialised communities. This makes sense since we can imagine how transversal skills may connect vertices in the graph that have little else in common. To address this, we identify and remove highly transversal skills; we also use cosine similarity as the edge strength parameter.

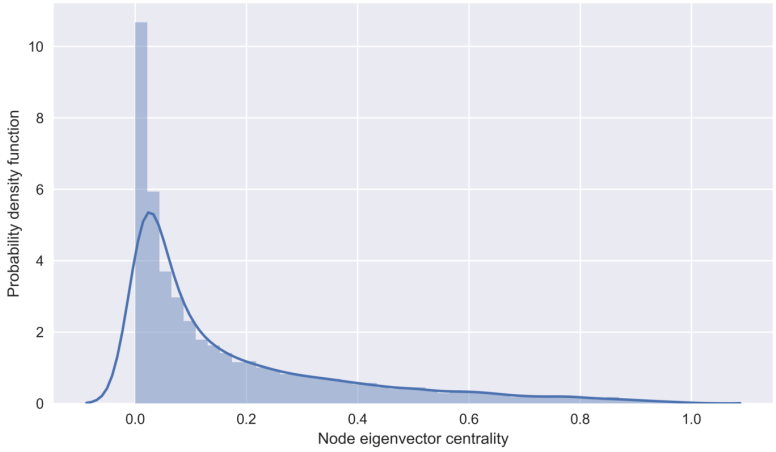

Figure 4: Distribution of skills' eigenvector centrality

In order to identify highly transversal skills, we consider two vertex properties: eigenvector centrality and the local clustering coefficient. Eigenvector centrality is a measure of vertex influence, so if a vertex is connected to vertices with a high number of degrees, its centrality will be high (Austin, 2006). The local clustering coefficient reflects how embedded the vertex is in its neighbourhood. If one vertex has a lower local clustering coefficient than another, it implies that fewer of that vertex's neighbours are connected to each other (Watts and Strogatz, 1998). We argue that a highly transversal skill is likely to have a high eigenvector centrality and a low local clustering coefficient, since the vertices they connect have relatively few other connections in common. We recognise that it is not simply the case that each skill is either transversal or not. Instead each skill will lie somewhere along a continuum with transversal skills at one end and specialist skills at the other. Similarly, in the ESCO taxonomy, skills are divided into transversal, cross-sector, sector specific and occupation specific categories. To explore whether the skill requirements in the Burning Glass data fall into similar categories, we fit a Gaussian mixture model (GMM) to skills' eigenvector centrality scores to explore naturally occurring concentrations of skills. After initial exploration, we identify 19 groups with varying levels of specialisation (Table 2).

Table 2: Skill groups identified using GMM with eigenvector centrality

Skill group	Number of skills	Local clustering coefficient	Eigenvector centrality
1	66	0.165	0.924
2	95	0.240	0.851
3	147	0.314	0.773
4	148	0.393	0.697
5	198	0.460	0.627
6	195	0.527	0.566
7	251	0.589	0.503
8	275	0.641	0.440
9	264	0.697	0.390
10	339	0.735	0.343
11	359	0.778	0.295
12	449	0.817	0.247
13	530	0.843	0.200
14	603	0.877	0.155
15	584	0.885	0.118
16	794	0.897	0.086
17	964	0.907	0.058
18	1434	0.912	0.031
19	2177	0.950	0.010

We can see that groups 1 and 2 are highly transversal: the skills requirements in these groups have the highest eigenvector centrality and very low local clustering coefficients (Figure 5). The top 10 skills in the first group are shown in Table 3.

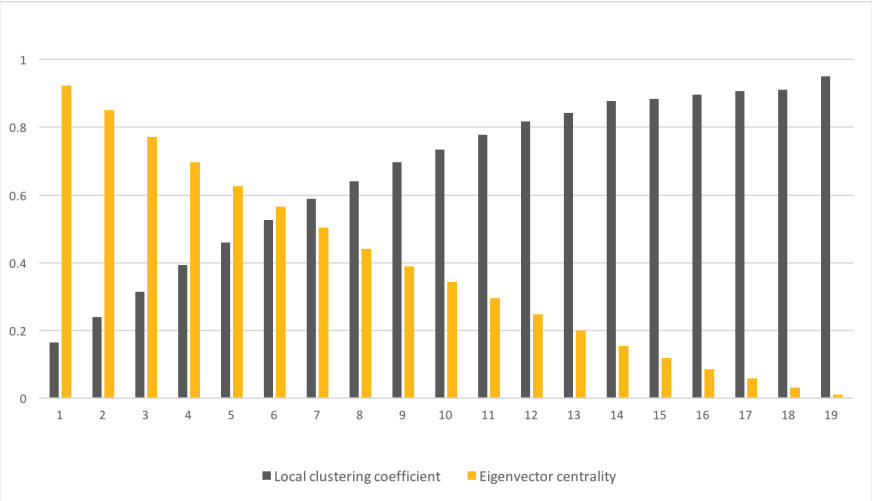

Figure 5: Characteristics of skill groups identified using GMM with eigenvector centrality

We discovered that the more highly transversal skill groups we removed, the more fragmented the skills network became. It appears that some broad skills serve as a *glue* connecting more niche skill clusters. Because of this and to preserve as much information as possible, we only remove group 1, which has the lowest specialisation and comprises 66 skills. While they represent only 0.6% of all vertices, the connections between these skills account for 11.15% of all edges in the graph.

Table 3: Top 10 highly transversal skills

Skill	Eigenvector centrality	Local clustering coefficient
Communication skills	1.000	0.076
Organisational skills	0.994	0.087
Team work/collaboration	0.988	0.096
Writing	0.987	0.097
Planning	0.986	0.099
Research	0.982	0.093
English	0.979	0.107
Problem solving	0.976	0.112
Project management	0.974	0.115
Microsoft Excel	0.971	0.118

Figure 11 in Appendix 2 summarises the steps taken to build the skills graph and prepare it for the community detection stage.

Detecting Communities

Prior to applying community detection algorithms, we reviewed the filtered graph and found that 38% of existing edges have cosine similarity of 0 or lower. This may be because some of the pairwise links reflect spurious co-occurrences and that even if two skills are mentioned together in a few adverts they are not

mentioned frequently enough in the same context. With this in mind, we remove any edges where the cosine similarity is equal to 0 or lower.

We have considered three different approaches to detecting communities in a graph: a method based on statistical inference (Stochastic Block Model), a method based on optimising the clustering quality parameter (Louvain) and a method based on exploring dynamical processes on the graph (Infomap).

A brief overview of algorithms is provided in Appendix 1. An initial comparative analysis of the three methods shows that they are all valid ways to partition the network. The non-hierarchical SBM identifies 283 communities, which appear to capture meaningful relationships between skills. However, the hierarchical implementation of SBM turns out not to be suitable because the clusters are grouped into higher levels based on the similarity of their connections (i.e. a similar number of edges) but ignore the subject domains. For example, computing- and medicine-related skills are placed in the same higher level group. The fact that only the non-hierarchical SBM clusters can be used for our purposes means that we need to identify a way to aggregate smaller clusters into broader groups.

We explore hierarchical clustering using the clusters' representative word embedding vectors. However, determining the appropriate way to generate representative vectors and selecting cutoffs for splitting the hierarchy into layers adds considerable subjectivity to the methodology. This is why we do not use the SBM in this analysis.

The broad groups identified by the Louvain algorithm are similar to those found by Infomap. However, Infomap detects a larger number of small, specialised employer requirement clusters; the algorithm appears to be *peeling off* more peripheral clusters at each iteration. For both algorithms, the cosine similarity property of edges is used. The Normalised Mutual Information (NMI) score for the top level of Infomap and the 2nd level of Louvain (chosen because they have a similar number of groups) is relatively high at 0.67, which indicates similar clustering (the maximum value of NMI is 1 for perfect correlation). Since Infomap identifies few large clusters and many very small clusters at each layer of the taxonomy, we decide to use Louvain as it produces more evenly distributed clusters.

Increasing robustness of clustering

We initially used the Louvain algorithm to detect communities with the highest corresponding modularity and iteratively split these communities if the new partition had a positive modularity value. However, some of the identified clusters, especially at the lower layers of the hierarchy, appeared to be driven by stochastic artefacts rather than meaningful differences. The fact that splitting a cluster improves graph modularity score doesn't mean that the resulting lower level clusters are well separated. The challenge is to identify an objective criterion for determining confidence in cluster partitioning. To ensure the stability of the resulting groups, we introduce bootstrapping and consensus clustering stages in the methodology. Bootstrapping refers to random sampling with replacement. This technique is used in machine learning to increase robustness of models since it allows for better exploration of biases and variation in the underlying dataset. Typically bootstrapping involves sampling of individual observations, which would be skills in our case. However, to preserve as many actual skills in the graph as possible, we follow an approach outlined by Rosvall and Bergstrom (2010) and instead of bootstrapping nodes we sample graph edges. We also assign to each edge a probability of being selected, which is proportional to the edge cosine similarity property. As a result we are more likely to select edges between nodes that are strongly related and less likely to sample spurious edges. As shown in Figure 6, once a bootstrapped sample is formed, we build a new graph using the edges in our sample and then apply the Louvain algorithm to detect communities with highest modularity. We repeat these steps 500 times, record node membership in resulting clusters and reconcile results from these runs using the cluster ensemble technique. The cluster ensemble method produces a single consensus partition and is performed using Hyper-graph partitioning (HGPA) and Meta-clustering algorithms (MCLA) (Strehl and Ghosh, 2002) as implemented in Cluster Ensemble python package (Giecold, Marco, Garcia, Trippa, and Yuan, 2016). The quality of clustering is determined based on the level of agreement, which is measured

as a weighted average NMI between all the runs and the resulting consensus cluster membership. We select the solution with the highest level of agreement. Once the top layer membership is finalised, the approach is repeated for each cluster at layer 2 and 3.

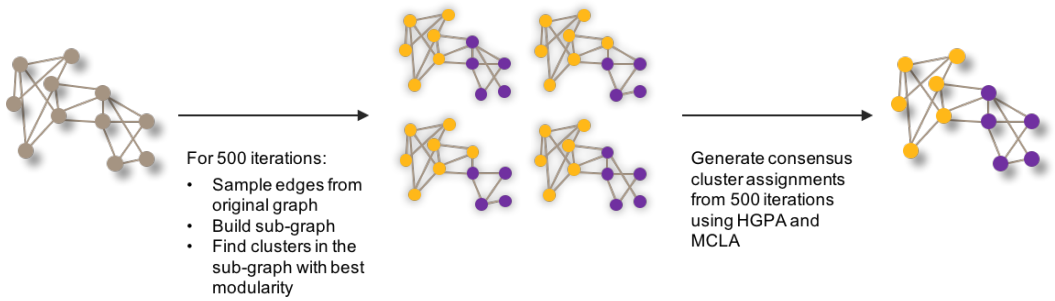

Figure 6: Process of generating consensus clustering across bootstrapped samples

The process for detecting hierarchical communities in the skills graph using bootstrapping is described in Figure 12 in Appendix 2.

Results

As illustrated in Figure 7, using the Louvain algorithm with bootstrapping, we generate consensus cluster assignments at three layers. It's possible to explore finer layers of the hierarchy. However, for the convenience of profiling clusters we stop at depth three where we find 143 clusters. The cluster labels are assigned manually after reviewing the most prominent skills as well as the most common job titles and SOC codes. In future work, we will aim to develop an automatic way of labelling the clusters at all levels.

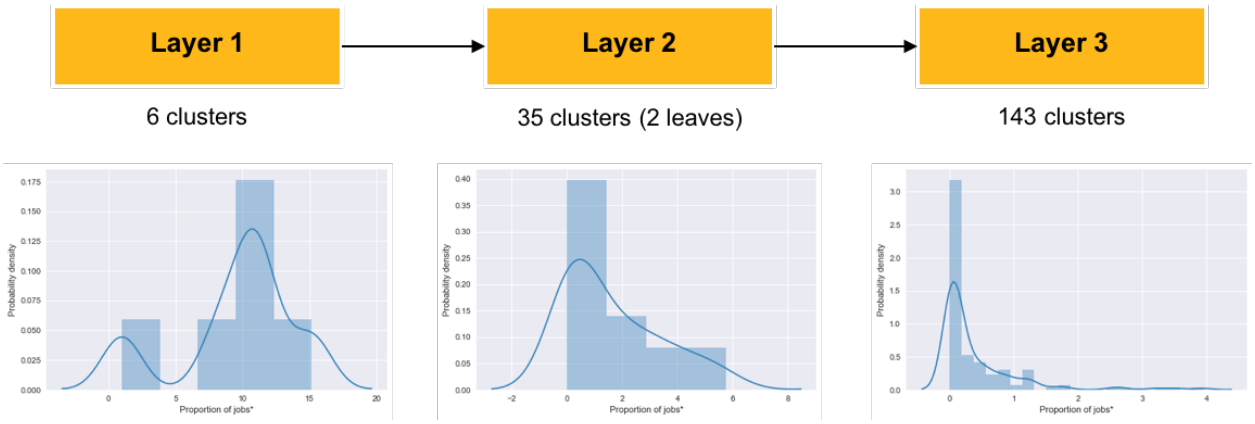

Figure 7: Number of clusters in each layer of the skills taxonomy

There are six broad clusters (Figure 8) at the top layer of the skills taxonomy. These are *Education, sales and marketing* (6 sub-clusters), Information technology (5 sub-clusters), *Science and research* (7 sub-clusters), *Engineering, construction and transport* (5 sub-clusters), *Health and social care* (7 sub-clusters) and *Business Administration* (5 sub-clusters).

There were some surprises in the skills groupings, such as education, languages and art skills being grouped together with marketing, design and sales. It is likely that this is explained by the connection between

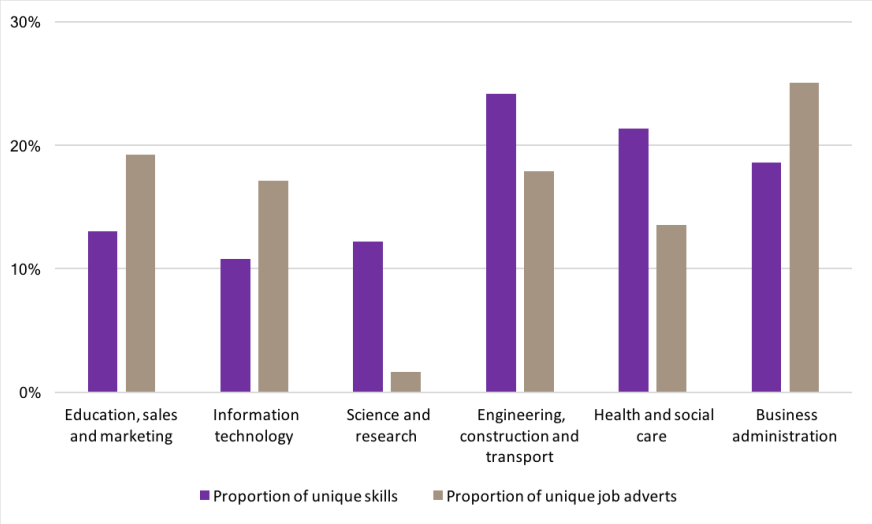

Figure 8: Distribution of skills and unique job adverts across top layer of taxonomy

teaching foreign languages and using them in sales roles. Medical device sales skills were also assigned to a health related group rather than to a sales cluster. This may reflect that a certain level of clinical experience is required in medical sales jobs.

To facilitate the exploration of the skills hierarchy, a prototype interactive data visualisation was developed (Figure 9, 10). The visualisation shows the three layers of the hierarchy but not the underlying individual skills. In the visualisation we also provide a brief description of each cluster, including average salary, the top five skills, the most common job titles and the proportion of unique job adverts that mention skills in the cluster.

Cluster robustness

The level of agreement varies for different layers of the skills taxonomy. At the top layer, across 500 bootstrapped samples, the weighted average NMI is equal to 0.85, which indicates a high level of agreement (weighted average NMI equals 1 for complete agreement). At the deeper layers, the level of agreement is lower for certain groups (Table 4). For instance, for *Science and research*, the average NMI is 0.60. This measure is also below 0.70 for *Engineering, construction and transport* and *Health and social care*. There are two possible explanations for the lower level of agreement on cluster membership between different iterations of the algorithm. First, it is likely that in some skill domains there is a substantial degree of complementarity between skills. So, in the *Health and social care* domain, skills related to nursing can be applied in primary care as well as in critical care. This means that during the bootstrapping and community detection stages, we may identify alternative combinations of skills that are often required together. The second explanation relates to the fact that certain skills are more transversal. While we remove the most prominent transversal skills early on, some remaining skills still demonstrate higher than average centrality. It is possible that these skills keep moving between clusters and lead to a lower level of agreement between clustering iterations. One example of such a skill is *biology*, which refers to a general knowledge applicable in molecular biology, infectious disease research and other areas of life science research. In the future we will aim to identify these domain-central skills to measure their impact on cluster robustness. But, more importantly, these skills might represent foundation-skills, which can widen the feasible set of job transitions for individuals.

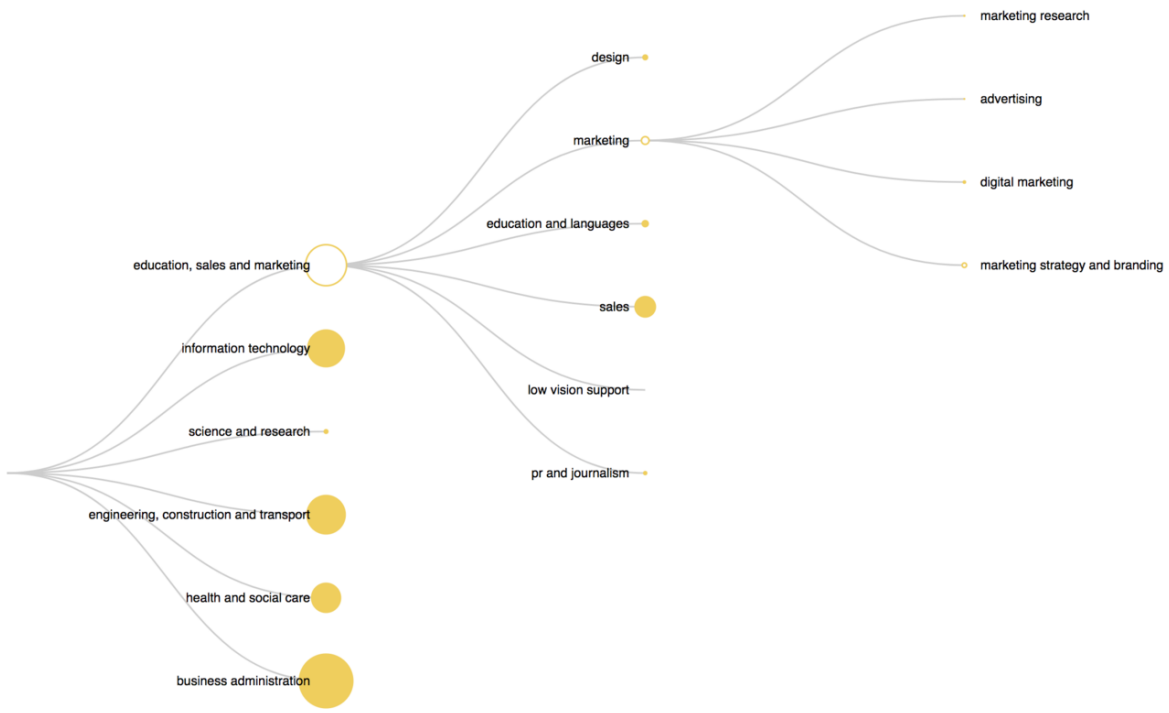

Figure 9: Screenshot of the interactive skills hierarchy showing sub-clusters for the marketing cluster

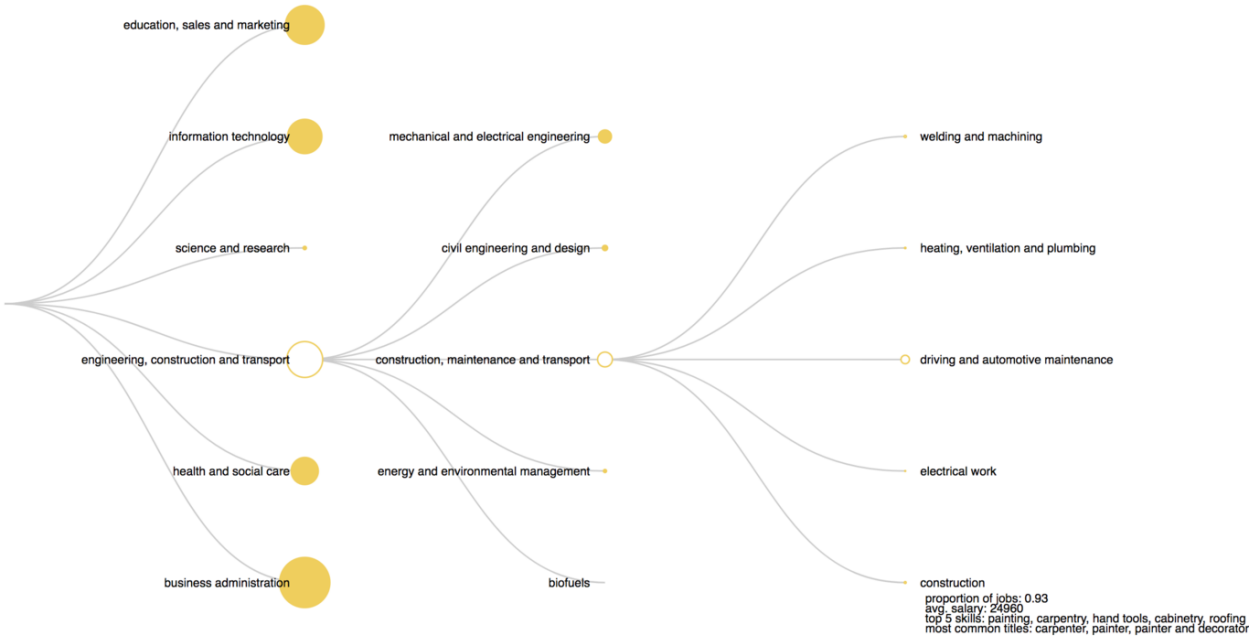

Figure 10: Screenshot of the interactive skills hierarchy showing layers of the hierarchy and additional information for the construction skill cluster

Discussion

While the skills taxonomy is generated entirely automatically without expert input, it appears to perform reasonably well in identifying distinct groups of skills, competences and knowledge. As shown in Tables 5 and 6 in Appendix 2, the cluster profiles, especially at the first and second layers of the taxonomy, reflect established occupational domains, such as *Education*, *Health*, *Information Technology* and *Business Administration*. The metadata on skill clusters, such as salary and job titles, also appear to be generally aligned with the data from official statistics. For example, the clusters with the highest average salary are located in *Securities trading* and *Data engineering*, while the lowest paid skill clusters are in *Medical* and *Office administration* (all of these clusters reside in the third layer of hierarchy).

Initial results demonstrate that the data-driven approach to grouping skills, competences and knowledge areas has its merits. At the same time, in its current state, the methodology for deriving the hierarchical taxonomy has several limitations. The first limitation is that we do not allow skills to exist in multiple parts of the taxonomy. The current hierarchical structure places a skill in the cluster in which it is most strongly connected to other members. However, it is likely that certain skills, competences and knowledge such as *cooking* and *data science* will have lateral links to other clusters. For example, *cooking* resides in *Social work and caregiving*, but can also be connected to food service in retail. Similarly, *data science*, which is currently in *Marketing research*, could also sit in *Data engineering*. To address the limitations of hard partitioning, we propose complementing the provided hierarchical structure with a simplified graph of skill clusters. In this graph, all the vertices will be contracted to their 3rd layer clusters. The links between the 143 clusters can then be aggregated and used to explore the lateral relationships between skill clusters.

The second limitation relates to the current lack of clarity on how to incorporate incoming information on job adverts. In future work, we would like to explore the advantages and disadvantages of running the analysis on the whole dataset, updated with new information, as opposed to generating the word embeddings and the taxonomy on temporal slices of the data. For further validation and to assess the extent to which the clusters are distinct, we will also collect text from Wikipedia articles on individual skills in each cluster. We will then analyse the extent to which article terms are associated with certain skill clusters using the mutual information method. Given the nested nature of the taxonomy, we expect the clusters at deeper hierarchy layers to be more similar and refer to the same subject domains. This is why the proposed analysis is likely to be more appropriate, as a validation method, if applied to first and second layers only.

Finally, the skill cluster labelling needs to be automated to enable regular re-running of the methodology. However, generating labels automatically is a challenging task. Our initial strategy involved using the three most demanded skills in the cluster as a label. This method did not produce satisfactory results as often these three skills did not communicate the broadness of the skills cluster and appeared to describe a relatively narrow segment of skills. Including more than three skills makes the label too long and difficult to read in tables and data visualisations. In future research, we plan to explore other strategies to automate labelling. One strategy is to search Wikipedia for the skills in the clusters and identify the most common terms and categories used to describe them. For example, a common term occurring in descriptions for *cardiology* and *oncology* could be *specialised medicine*.

While the data-driven approach used to generate the skills taxonomy offers significant advantages, the end users of the taxonomy might still perceive an expert curated taxonomy to have a higher quality. This may be due to the fact that expert curated taxonomies incorporate data from different sources and reflect input from relevant industry bodies. To increase the validity of the proposed skills taxonomy we intend to refine the resulting taxonomy using feedback from ONS occupational experts, career advice services, educators and professional associations. This will enable us to increase the utility of the taxonomy for users.

Conclusion

In this paper, we demonstrate how a taxonomy of employer skills, competence and knowledge requirements can be derived in a data-driven way. Using the initial results of the proposed method, we show that the automatically generated skills taxonomy performs reasonably well. The taxonomy contains three hierarchical layers, which are identified by applying a modularity optimisation community detection algorithm with bootstrapping and consensus clustering. The quality of the clustering is enhanced by using a word embeddings approach to capture the strength of relationships between the skills as opposed to relying only on a frequency-based measure.

In addition to generating the taxonomy, we also extract useful metadata on each skill cluster, mapping relationships between skill clusters and salary, occupations, and job titles. We also trial a method for determining the level of a skill specialisation by applying the Gaussian mixture model technique to the skill eigenvector centrality.

We make a number of contributions to the existing literature. The proposed skills taxonomy represents the first transparent non-expert-driven taxonomy that is independent from established frameworks such as ESCO or O*NET. The taxonomy is developed automatically and identifies meaningful patterns in the employer requirements without any pre-conditions for how requirements should be grouped. Because of this, the taxonomy minimises the risk that interrelationships between skills are overlooked because they don't fit a traditional view of how skills should be organised. For example, *machine learning* and *pattern recognition* are usually grouped with computing skills, while in our taxonomy, these reside in the *Physics and math* cluster. Even though these skills are often applied together with programming, they are grounded in knowledge of mathematics.

One of the important contributions of the proposed skills taxonomy is that it offers a possibility of describing occupations from the perspective of skills. This is why, in the upcoming applied analysis paper, we intend to map this skills taxonomy to ONS SOC codes. As an exploratory exercise, we have studied the composition of the 200 most popular job titles by the third layer skill clusters. The results listing each job title and the most prominent skill clusters are shown in Table 7 in Appendix 3. In future work, we will extend this approach from job titles to SOC codes. The resulting *crosswalk* between skill clusters and SOC codes will create a foundation for combining official labour market statistics with the skills taxonomy to produce novel measures of skills demand, supply and mismatch.

In future research, we also plan to extend the current hierarchical representation of the taxonomy into an ontology, where not just the direct, but also the lateral relationships between clusters are captured. The resulting ontology can then be implemented as a graph database accessible by the public. We would also like to study the evolution of employer requirements over time using the methodology described in Rosvall and Bergstrom (2010).

The resulting skills taxonomy as well as the algorithm for developing it and the interactive data visualisation will all be released to the public. We believe that these resources would benefit a wide audience and allow policymakers, educators and individuals to better understand the skill sets needed by employers and the associated salaries and job titles. The taxonomy also provides a foundation for measuring the similarity of jobs/occupations based on skills, competences and knowledge. These insights could be directly applied to inform policy on reskilling and identifying job transition opportunities for occupations at risk of decline.

Acknowledgements

The authors are grateful for the thoughts of colleagues at Nesta, the Economic Statistics Centre of Excellence and the Office for National Statistics on this work. Particular thanks are due to Hasan Bakhshi for his comments on early drafts.

Appendices

Appendix 1: Overview of community detection algorithms

Stochastic Block Modelling (SBM) involves fitting a generative model of a graph to data (Peixoto, 2017). Under SBM, nonparametric statistical inference is applied to partition the graph in such a way as to maximise the explanatory power of a fitted model given the observed edges. From the candidates, the minimum description length model (i.e. the simplest model) is selected to prevent overfitting. SBMs have been found to produce some of the best results on real-life networks and are capable of identifying several types of network structures in addition to communities. SBMs can also detect hierarchical structures in networks and can be extended to overlapping communities. For the purposes of our analysis, we use a degree-corrected SBM that employs a Markov chain Monte Carlo (MCMC) algorithm (Peixoto, 2014) as implemented in the python igraph library.

The Louvain multilevel community detection algorithm identifies communities in the network that maximise the quality of the partitioning (Blondel, Guillaume, Lambiotte, and Lefebvre, 2008). The established metric used to measure the quality of communities is modularity. Modularity varies between [-1,1] and refers to the concentration of edges within communities as opposed to the distribution of edges that would be observed in a random graph with the same vertex degree distribution. The Louvain algorithm is hierarchical; it starts with individual vertices belonging to their own communities and then iteratively groups the vertices in such a way as to increase the overall modularity score. This algorithm is intuitive and one of the most commonly used for identifying network communities. Louvain was found to be the second best-performing method in the comparative analysis of algorithms conducted by Lancichinetti and Fortunato (Fortunato and Hric, 2016). The criticism of the modularity optimisation algorithms focuses on the limitations of these methods in identifying an appropriate level of resolution. The algorithms may split large communities or merge smaller ones. They may also underperform as compared to other methods if the true number of clusters is not known.

Infomap is a dynamics based community detection algorithm, which identifies communities in the network by measuring the flow of information through the network using random walks (Rosvall and Bergstrom, 2008). The rationale behind the method is that due to the higher density of edges within communities, the random walkers will be trapped and spend a longer time inside communities. Infomap further improved the early implementations of the dynamics based algorithms by using information theory to define the most parsimonious way to describe graph community structure. Infomap is especially effective when applied to directed networks, where it can identify communities that would not be detected by modularity optimisation algorithms.

Stochastic Block Modelling (SBM) involves fitting a generative model of a graph to data (Peixoto, 2017). Under SBM nonparametric statistical inference is applied to partition the graph in such a way as to maximise the explanatory power of a fitted model given the observed edges. From the candidates the minimum description length model (i.e. the simplest model) is selected to prevent overfitting. SBMs have been found to produce some of the best results on real-life networks and are capable of identifying several types of network structures in addition to communities. SBMs can also detect hierarchical structures in networks and can be extended to overlapping communities. For the purposes of our analysis, we use a degree corrected SBM that employs a Markov chain Monte Carlo (MCMC) algorithm (Peixoto, 2014) as implemented in python igraph library.

Appendix 2: Flow charts

Figure 11 summarises the steps taken to first build the skills graph and then to prepare it for the community detection stage.

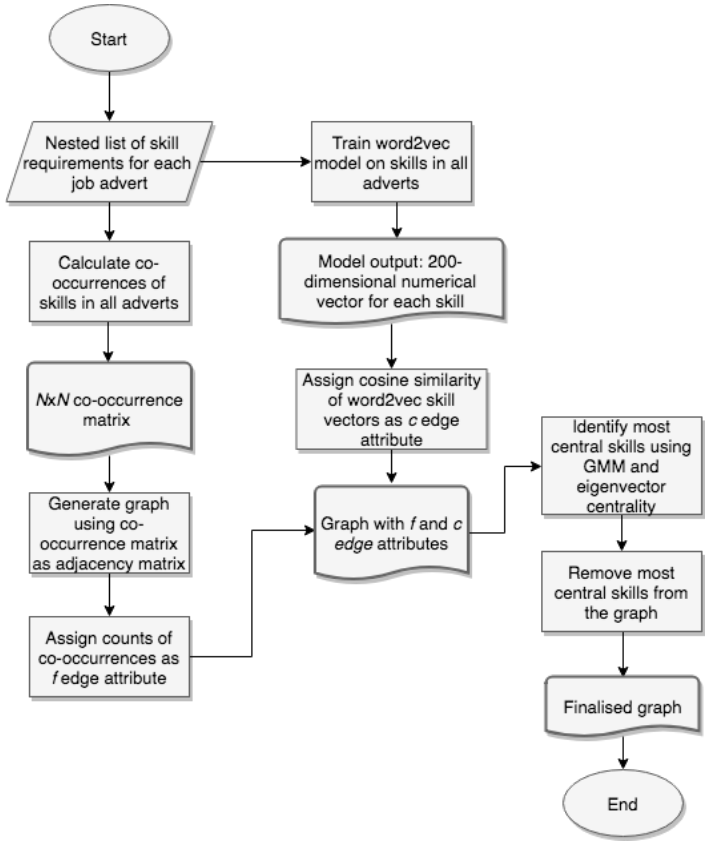

Figure 11: Flow chart for building and preparing the skills graph

Figure 12 provides an overview of the process used to detect hierarchical communities in the skills graph.

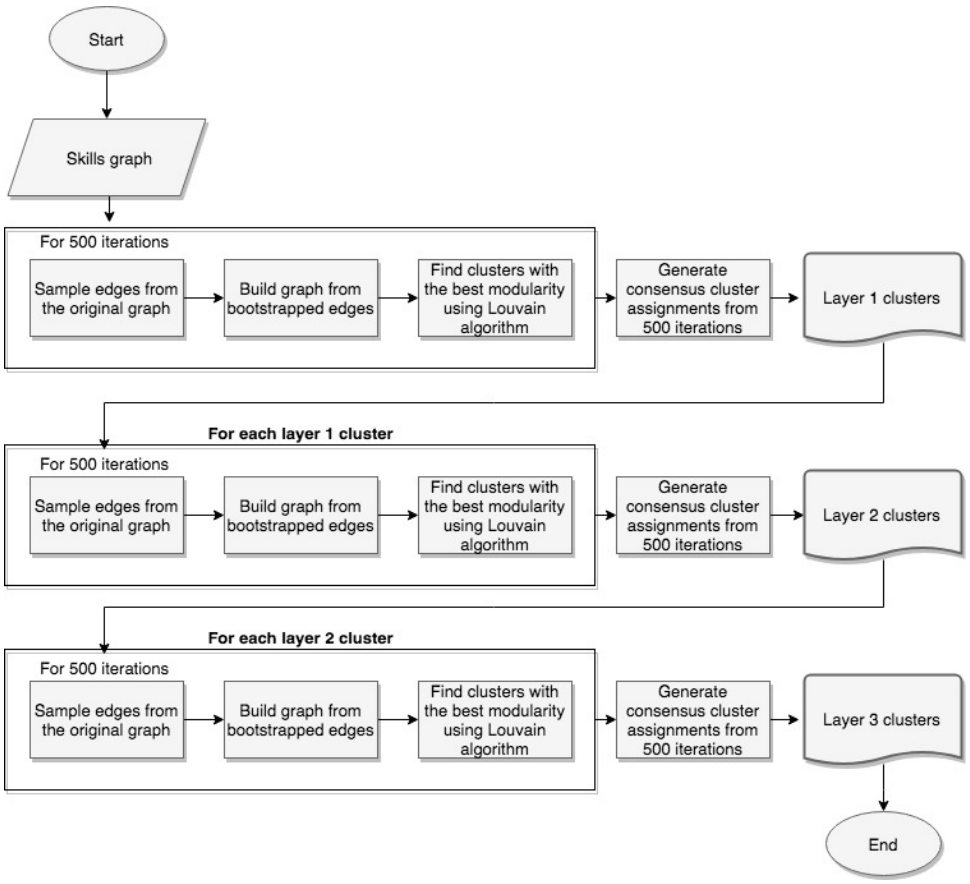

Figure 12: Flow chart for detecting hierarchical communities in the skills graph

Appendix 3: Tables

Table 4: Consensus clustering level of agreement

Level	Cluster above	Cluster label	Number of clusters below	Weighted average NMI
Top	None	All	6	0.85
Mid	All	Business Administration	5	0.76
Mid	All	Engineering, Construction and Transport	5	0.67
Mid	All	Health and Social Care	7	0.68
Mid	All	Information Technology	5	0.72
Mid	All	Science and Research	7	0.60
Mid	All	Education, Sales and Marketing	6	0.78
Bottom	Business Administration	Finance	4	0.66
Bottom	Business Administration	Logistics	4	0.71
Bottom	Business Administration	Accounting	4	0.60
Bottom	Business Administration	Administration and Law	4	0.73
Bottom	Business Administration	Management and Hr	5	0.72
Bottom	Engineering, Construction and Transport	Civil Engineering and Design	4	0.61
Bottom	Engineering, Construction and Transport	Biofuels	1	0.00
Bottom	Engineering, Construction and Transport	Energy and Environmental Management	7	0.67
Bottom	Engineering, Construction and Transport	Mechanical and Electrical Engineering	5	0.65
Bottom	Engineering, Construction and Transport	Construction, Maintenance and Transport	5	0.61
Bottom	Health and Social Care	Dentistry	5	0.66
Bottom	Health and Social Care	Ophthalmology and Dermatology	4	0.74
Bottom	Health and Social Care	Primary Care	6	0.55
Bottom	Health and Social Care	Caregiving and Rehabilitation	5	0.72
Bottom	Health and Social Care	Cardiovascular and Respiratory Healthcare	4	0.70
Bottom	Health and Social Care	Healthcare Administration	5	0.64
Bottom	Health and Social Care	Surgery and Internal Medicine	7	0.60
Bottom	Information Technology	Business Intelligence and IT Systems Design	4	0.76
Bottom	Information Technology	IT Security	4	0.63
Bottom	Information Technology	Windows Programming	2	0.50

Bottom	Information Technology	IT Systems and Support	3	0.69
Bottom	Information Technology	Software Engineering	5	0.70
Bottom	Science and Research	General Biology	4	0.41
Bottom	Science and Research	Autoimmunity	3	0.58
Bottom	Science and Research	Molecular Biology	7	0.27
Bottom	Science and Research	Physics, Math, Tomography and Structural Biology	5	0.47
Bottom	Science and Research	Research Methods	4	0.57
Bottom	Science and Research	Chromosome and Cell Examination	2	0.89
Bottom	Science and Research	Chemistry and Laboratory Technique	4	0.46
Bottom	Education, Sales and Marketing	Sales	3	0.61
Bottom	Education, Sales and Marketing	Design	4	0.65
Bottom	Education, Sales and Marketing	Marketing	4	0.76
Bottom	Education, Sales and Marketing	Pr and Journalism	4	0.62
Bottom	Education, Sales and Marketing	Education, Languages and Art	4	0.74
Bottom	Education, Sales and Marketing	Low Vision Support	1	0.00

Table 5: Metadata for second layer clusters

Second layer of taxonomy	Five most popular skills	Number of underlying unique skills	Proportion of unique job adverts	Average salary (Q1, Median, Q3)*	Ten most common job titles
Business Intelligence and IT Systems Design	business analysis, oracle, business process, project planning and development skills, data management	331	3.97	£39,562, £50,000, £70,000	business analyst, developer, project manager, java developer, solution architect, data analyst, consultant, business systems analyst, software engineer, software developer
IT Security	information security, information systems, cryptography, dv clearance, information assurance	69	0.28	£39,250, £50,750, £67,356	information security manager, information security analyst, business analyst, it security analyst, security analyst, information security consultant, security architect, project manager, software engineer, information security officer
IT Systems and Support	linux, itil, software use instruction, responding to technical questions, cisco	395	4.47	£30,000, £40,000, £55,000	network engineer, systems administrator, engineer, infrastructure engineer, it support engineer, devops engineer, software engineer, line support engineer, linux systems administrator, systems engineer

Software Engineering	sql, microsoft c#, java, .net programming, sql server	277	8.37	£37,500, £47,500, £63,063	developer, web developer, java developer, software developer, software engineer, php developer, .net developer, front end developer, c# developer, net developer
Windows Programming	delphi, visual c++, distributed component object model dcom, vxworks, win32 api	28	0.02	£35,000, £42,500, £50,000	software engineer, software developer, developer, embedded software engineer, c++ developer, c# developer, c++ software engineer, .net developer, web developer, engineer
Design	editing, website production, adobe photoshop, content management, graphic design	320	2.09	£25,000, £32,000, £40,000	graphic designer, digital designer, web designer, designer, web developer, marketing executive, user experience designer, front end developer, marketing manager, developer
Education, Languages and Art	french, german, tutoring, teaching english, teaching mathematics	248	2.74	£21,500, £28,000, £36,000	teacher, science teacher, english teacher, teaching assistant, nanny, tutor, teacher of english, geography teacher, teacher of science
Low Vision Support	kinesthetic learning, braille writing, dog guides, human guides, electronic travel aids etas	15			low vision therapist, vision rehabilitation therapist, mobility specialist, certified low vision therapist, certified mobility specialist, sen teaching assistant, learning support assistant, learning support worker higher level teaching assistant, sen classroom teacher, primary teacher
Marketing	marketing, social media, e-commerce, market strategy, campaign management	293	3.59	£27,500, £35,000, £45,710	marketing manager, marketing executive, digital marketing executive, digital marketing manager, marketing assistant, brand manager, account manager, business development manager, marketing coordinator, analyst
PR and Journalism	marketing communications, fundraising, promotional support, copy writing, event planning	124	1.33	£23,000, £29,120, £37,500	marketing executive, marketing manager, marketing assistant, digital marketing executive, public relations manager, communications manager, event manager, communications officer, copywriter, marketing coordinator
Sales	product sale and delivery, sales recruiting, sales management, account management, sales goals	333	9.49	£23,000, £30,900, £42,500	sales executive, business development manager, sales manager, account manager, area sales manager, telesales executive, business development executive, recruitment consultant, sales consultant, marketing manager
Accounting	invoicing, financial accountancy, contract accountancy, forecasting, spreadsheets	448	6.06	£24,091, £32,500, £45,000	management accountant, accounts assistant, finance manager, financial accountant, accountant, financial controller, assistant accountant, finance analyst, bookkeeper, finance assistant

Administration and Law	secretarial skills, file management, office administration, administrative support, typing	222	5.78	£19,000, £23,500, £34,000	administrator, legal secretary, administrative assistant, office administrator, receptionist, administration assistant, sales administrator, executive assistant, personal assistant, secretary
Finance	business communications, portfolio management, risk management, asset management, contract preparation	363	3.74	£32,548, £45,000, £62,500	business analyst, project manager, internal auditor, analyst, manager, quantity surveyor, business development manager, compliance manager, audit manager, finance manager
Logistics	sap, negotiation skills, order and invoice processing, enterprise resource planning erp, logistics	482	4.07	£25,000, £32,880, £45,000	buyer, supply chain manager, project manager, quantity surveyor, procurement manager, sales administrator, administrator, production planner, sap consultant, warehouse operative
Management and HR	store management, change management, listening, business planning, performance management	382	5.41	£26,875, £35,000, £50,000	store manager, project manager, human resource adviser, human resource manager, assistant manager, programme manager, manager, business analyst, operations manager, finance manager
Cardiovascular and Respiratory Healthcare	critical care, cardiology, radiology, physiology, radiography	334	0.59	£29,303, £34,320, £40,000	radiographer, staff nurse, cardiac physiologist, consultant, nurse, sonographer, clinical fellow, registered nurse, sister charge nurse, consultant radiologist
Caregiving and Rehabilitation	cooking, mental health, caregiving, care planning, social work	623	8.61	£23,605, £30,458, £36,000	support worker, care assistant, chef, staff nurse, registered nurse, care worker, healthcare assistant, occupational therapist, chef de partie, home manager
Dentistry	dentistry, x-rays, condition hepatitis b, ensuring patients comfort, patient family education and instruction	124	0.34	£20,509, £28,083, £37,554	associate dentist, dental nurse, dentist, dental associate, apprentice dental nurse, dental hygienist, healthcare assistant, dental nurse apprentice, dental assistant, trainee dental nurse
Healthcare Administration	patient care, word processing, pharmacist, welsh, triage	285	0.87	£20,565, £27,000, £35,327	staff nurse, pharmacy technician, pharmacist, registered nurse, clerical assistant, administrator, nurse, healthcare assistant, medical secretary, receptionist
Ophthalmology and Dermatology	therapy, optometry, ophthalmology, dermatology, skin care	124	0.32	£25,437, £31,071, £39,625	optometrist, beauty therapist, consultant, occupational therapist, physiotherapist, speech and language therapist, spa therapist, consultant dermatologist, therapist, staff nurse
Primary Care	occupational health and safety, primary care, infection control, public health and safety, immunisations	278	1.27	£25,107, £30,763, £37,929	practice nurse, occupational health adviser, registered general nurse, nurse, healthcare assistant, registered nurse, staff nurse, nurse practitioner, advanced nurse practitioner, support worker

Surgery and Internal Medicine	surgery, pediatrics, oncology, condition cancer, medical sales	411	1.54	£30,000, £36,018, £42,148	staff nurse, nurse, consultant, veterinary surgeon, theatre practitioner, registered nurse, dental nurse, clinical fellow, specialist registrar, territory manager
Biofuels	biofuel production, biofuels processing, biofuels processing equipment, biofuels production equipment, biofuels plant inspection	12			processing technician, biomass plant technician, production manager, biomass manager, simulation of chemistry the first mechanic, technician production, research fellow, operations manager fuel plant, research technician experimental officer, research officer life cycle and energy analysis of
Civil Engineering and Design	civil engineering, engineering consultation, estimating, microsoft project, architectural engineering	293	2.57	£30,500, £40,000, £50,000	project manager, quantity surveyor, structural engineer, estimator, engineer, civil engineer, site manager, project engineer, design engineer, mechanical design engineer
Construction, Maintenance and Transport	cleaning, inspection, machinery, forklift operation, computer numerical control cnc	858	7.37	£21,330, £26,500, £31,500	cleaner, electrician, maintenance engineer, carpenter, plumber, technician, warehouse operative, field service engineer, maintenance electrician, cleaning operative
Energy and Environmental Management	report writing, workplace health and safety, environmental consultancy, sustainability, transportation planning	656	1.51	£26,938, £33,866, £43,529	project manager, geotechnical engineer, transport planner, engineer, planner, environmental consultant, ecologist, manager, consultant, landscape architect
Mechanical and Electrical Engineering	computer aided draughting design cad, mechanical engineering, concept development, product development, product research	646	6.45	£30,000, £37,500, £46,000	mechanical design engineer, design engineer, engineer, mechanical engineer, electronics engineer, quality engineer, manufacturing engineer, project engineer, electrical engineer, electrical design engineer
Autoimmunity	condition cardiovascular disease, autoimmunity, immunoglobulin, immunodeficiency, th2	32	0	£29,301, £33,560, £40,000	consultant, research nurse, research associate, area healthcare lead, research fellow, research assistant, clinical nurse specialist, practice nurse, consultant immunologist, nurse
Chemistry and Laboratory Techniques	chemistry, biology, good manufacturing practises gmp, medical device, biochemistry	310	0.53	£25,000, £30,500, £36,400	scientist, science teacher, analytical chemist, laboratory technician, analyst, qc analyst, chemistry teacher, biology teacher, microbiologist, research associate
Chromosome and Cell Examination	light microscopes, fine needle aspirations fna, cell examination, specimen quality evaluation, chromosomal staining	23	0	£17,500, £27,335, £32,000	technologist, cytology manager, asbestos analyst, scientist, specialty doctor, field service engineer microscope, material scientist, asbestos laboratory analyst, specialist

General Biology	pathology, immunology, bioinformatics, condition infectious disease, genomics	175	0.09	£28,040, £34,168, £38,489	biomedical scientist, bioinformatician, scientist, research associate, research fellow, medical laboratory assistant, research assistant, building surveyor, research technician, research scientist
Molecular Biology	molecular biology, dna, genetics, cell biology, histology	299	0.08	£27,552, £33,162, £36,445	research associate, scientist, research technician, research assistant, research fellow, research scientist, postdoctoral scientist, biomedical scientist, bioinformatician, technician
Physics, Math, Tomography and Structural Biology	physics, lecturer, experiments, machine learning, design of experiments doe	141	0.44	£28,688, £33,914, £38,422	lecturer, data scientist, science teacher, teacher, software engineer, engineer, research associate, scientist, teacher of science
Research Methods	data collection, research reports, statistics, clinical research, clinical trials	264	0.48	£30,000, £36,233, £43,935	clinical research associate, paraplanner, research nurse, regulatory manager, project manager, statistician, research assistant, medical writer, manager, analyst

*Average salary Q1, Median and Q3 values are calculated using data for 2015-2017 (inclusive).

Table 6: Metadata for third layer clusters

Third layer of taxonomy	Most popular skills*	Number of underlying unique skills	Proportion of unique job adverts	Average salary (Q1, Median, Q3)**	Ten most common job titles
App Development	objective c, swift, android, mobile application design, mobile applications, xcode, android software development kit sdk, ios software development kit sdk, sqlite	22	0.17	£35,000, £45,000, £60,000	developer, android developer, mobile application developer, mobile developer, software developer, software engineer, web developer, php developer, application developer, front end developer

BI and Data Warehousing	oracle, data management, business intelligence, data warehousing, visual basic, sql server reporting services ssrs, extraction transformation and loading etl, microsoft sql, oracle pl sql, microsoft access, businessobjects, data modelling, data architecture, cognos impromptu, qlikview, crystal reports, data integration, informatica, online analytical processing olap, microsoft sql server integration services ssis, oracle business intelligence enterprise edition obiee, unix shell scripting, sql server analysis services ssas	100	1.37	£39,000, £50,000, £70,000	developer, data analyst, sql developer, business intelligence developer, business analyst, java developer, data architect, consultant, analyst, oracle developer
Business Analysis and IT Projects	business analysis, business process, project planning and development skills, microsoft sharepoint, process testing, technical writing editing, microsoft dynamics, prince2, lifecycle management, business systems analysis, system architecture, systems integration, systems analysis, microsoft visio, systems development life cycle sdlc, unified modelling language uml, full life cycle, business solutions, document management, data migration, microsoft crm, middleware, business requirements documentation, systems development, user acceptance testing uat, it management, ibm websphere, requirements analysis, solution architecture, it strategy, information architecture	112	2.54	£40,000, £50,000, £70,000	business analyst, project manager, developer, solution architect, business systems analyst, java developer, software engineer, it project manager, dynamic crm developer, sharepoint developer
Data Engineering	python, optimisation, big data, ruby, nosql, kanban, software as a service saas, apache hadoop, mongodb, chef, postgresql, data structures, trading systems, amazon web services aws, enterprise software, scaling, data visualisation	52	0.72	£42,500, £55,000, £72,500	developer, java developer, devops engineer, software engineer, data scientist, python developer, software developer, web developer, php developer, engineer
Intelligence	dv level, intelligence analysis, geospatial intelligence, signals intelligence, human intelligence, imagery intelligence, counter intelligence	14	0.01	£37,500, £50,000, £60,000	intelligence analyst, project manager, analyst, chief engineer, systems engineer, software engineer, engineer, manager, network engineer

IT Security Implementation	dv clearance, information assurance, security implementation, iso iec 27001	11	0.03	£40,000, £50,000, £71,250	project manager, consultant, security architect, information assurance consultant, information security consultant, security consultant, information security manager, engineer, systems engineer, business analyst
IT Security Operations	information security, cryptography, computer engineering, arcsite, arcsight	28	0.17	£38,750, £53,750, £69,856	information security manager, information security analyst, it security analyst, information security consultant, security analyst, security architect, information security officer, security consultant, software engineer, it security manager
IT Security Standards	information systems, certification accreditation	16	0.07	£41,493, £52,500, £65,000	business analyst, project manager, developer, administrator, solution architect, human resource adviser, human resource administrator, systems engineer, management accountant, business systems analyst
IT Support	software use instruction, it support, computer hardware hardware knowledge, basic internet skills, printers, microsoft exchange, application support, troubleshooting technical issues, network hardware software maintenance, dynamic host configuration protocol dhcp, hardware and software configuration, microsoft operating systems, network hardware, help desk support, microsoft networking, network support, computer installation and setup, lotus notes, software installation, microsoft vista, workstations, macintosh os, phone systems, problem analysis	148	1.31	£23,500, £30,381, £44,148	it support engineer, it support technician, it support analyst, software engineer, application support analyst, line support engineer, service desk analyst, network engineer, engineer, infrastructure engineer
Legacy Mainframe	rpg, linc, uniface, os 400, rpg400, rpg iv, lansa	17	0.01	£35,000, £40,000, £50,000	developer, analyst programmer, software developer, programmer, application support analyst, business analyst, support analyst, analyst

Mainframe Programming	mainframe, cobol, customer information control system cics, mqseries, test director, winrunner, job control language, job control language jcl, rapid application development, structured programming, as 400, staff augmentation, icl vme, mainframe systems, mvs, powerbuilder, ibm resource access control facility racf, quick test professional qtp, rexx, pro c, adabas, esql, db2, ibm mq series, virtual storage access method vsam, microfocus	102	0.05	£39,562, £52,500, £81,753	developer, test analyst, software engineer, solution architect, analyst programmer, java developer, engineer, consultant, business analyst, project manager
Networks	responding to technical questions, cisco, network administration, wide area network wan, network engineering, switches, network installation, virtual private networking vpn, network security, internet services, broadband, ethernet, avaya, video conferencing, ospf, 3g, internet service provider isp, global system for mobile communications gsm, cisco routers, computer networking	112	1.08	£30,000, £42,500, £56,960	network engineer, engineer, infrastructure engineer, systems engineer, project manager, network security engineer, it support engineer, line support engineer, network support engineer, systems administrator
Servers and Middleware	apache webserver, soap, extensible stylesheet language xsl, tomcat, relational database management system rdbms, java server pages jsp, jboss, junit, weblogic, sybase, java message service jms, hibernate, integrated development environment ide, struts, servlets, jdbc, spring framework	53	0.32	£40,000, £50,000, £70,000	java developer, developer, software engineer, web developer, php developer, software developer, java engineer, devops engineer, solution architect, .net developer
Software Development	sql, microsoft c#, java, .net programming, sql server, asp, software engineering, software development, c++, scrum, extensible markup language xml, unix, agile development, transact-sql, object-orientated analysis and design ooad, perl, visual studio, relational databases, version control, software architecture, database design, software testing	88	5.29	£35,000, £45,000, £57,500	developer, software developer, software engineer, .net developer, java developer, c# developer, web developer, php developer, c# .net developer

System Administration	linux, itil, it recruiting, windows server, firewalls, database administration, system and network configuration, transmission control protocol internet protocol tcp ip, citrix, domain name system dns, configuration management, system administration, disaster recovery planning, microsoft powershell, hyper-v, red hat linux, systems administration, bash, solaris, shell scripts, clustering, puppet, web servers, ssl, network attached storage nas, symantec packages, raid, vbscript, capacity management, vmware esxi, systems management, internet hosting	135	2.08	£35,000, £45,000, £62,398	systems administrator, devops engineer, network engineer, infrastructure engineer, linux systems administrator, engineer, systems engineer, developer, software engineer, line support engineer
Web Development	web site development, hypertext preprocessor php, jquery, mysql, web application development, git, web development, css, front-end development, ajax, user interface ui design, json, angularjs, web applications, prototyping, xhtml, model-view-controller mvc, drupal, html5, zend framework	62	1.87	£32,500, £42,000, £55,000	web developer, php developer, front end developer, developer, php web developer, java developer, front end web developer, software developer, .net developer, software engineer
Windows Programming Methods	delphi, distributed component object model dcom, common object model, activex, pascal	14	0.01	£33,565, £41,250, £46,250	developer, software developer, software engineer, c# developer, .net developer, web developer, sales manager, analyst programmer, c++ developer
Windows Programming Tools	visual c++, vxworks, win32 api, windows ce, tickit, windows programming, microsoft visual c	14	0.01	£37,500, £42,500, £55,000	software engineer, embedded software engineer, software developer, c++ developer, c++ software engineer, developer, c# developer, software engineer c++, c++ software developer, software development engineer

Accounting Admin	invoicing, spreadsheets, billing systems, account closing, bank reconciliation, invoice payment, bookkeeping, accounts payable and receivable, customer accounts, accountancy systems, account opening, invoice coding, invoice processing, bank transaction processing, credit debit card processing, kerridge, vlookup, cash deposits and receipts	168	2.12	£19,492, £23,000, £30,000	accounts assistant, purchase ledger clerk, credit controller, administrator, bookkeeper, finance assistant, assistant accountant, management accountant, accounts payable clerk, accountant
Accounting and Financial Management	financial accountancy, contract accountancy, forecasting, budget forecasting, account reconciliation, account analysis, financial reporting, balance sheet, financial analysis, cost analysis, financial planning, financial controls, accruals, cash flow forecasting, statutory accounts, budget analysis, international financial reporting standards, calculation, pivot tables, financial statements, management reporting, generally accepted accountancy principles gaap, variance analysis, general ledger, cost review, cash management, job costing, data manipulation, corporate reporting, macros, ad hoc reporting, cash flow analysis, hyperion, sarbanes-oxley sox audit, financial transactions	145	2.89	£30,000, £40,000, £52,500	management accountant, financial accountant, finance manager, financial controller, accountant, assistant accountant, finance analyst, accounts assistant, financial analyst, assistant management accountant
Accounting Software	accountancy software, navision, system implementation, agresso, jd edwards, oracle financials, netsuite, report maintenance, pegasus	35	0.16	£28,500, £40,000, £52,500	accounts assistant, management accountant, accountant, finance manager, financial controller, finance assistant, bookkeeper, consultant, assistant accountant, developer

Audit and Compliance	contract preparation, internal auditing, risk assessment, legal compliance, outsourcing, audit planning, compliance management, external auditing, corporate governance, contract auditing, audit reports, risk management framework, money management, cobit, compliance reporting, prevention of criminal activity, compliance auditing, audit processes	89	0.84	£32,500, £42,500, £58,500	internal auditor, quantity surveyor, compliance manager, audit manager, quality engineer, internal audit manager, project manager, auditor, manager
Business Management	change management, business planning, performance management, budget planning, strategic management, process improvement, staff coordination, financial management, facility management, service level agreements, business strategy, team management, business acumen, trend analysis, strategic planning, service improvement, cost management, environmental remediation, staff management, programme management, strategic development, conflict management, staff development, vendor relations, succession planning, performance appraisals, regional planning, business operations, policy development, facility improvement, workforce management	143	2.91	£28,290, £38,375, £53,529	project manager, programme manager, manager, business analyst, operations manager, finance manager, human resource adviser, human resource manager, management accountant, account manager
Claims Administration	case management, property management, preparing reports, claims adjustments, claims knowledge, instruction, claims service, settlement negotiation	35	0.62	£20,000, £26,000, £35,360	claims handler, property manager, occupational health adviser, motor claims handler, legal secretary, administrator, human resource adviser, case manager, claims administrator, quantity surveyor
Employee Development	training programmes, training, leadership development, corporate training, management training, sales automation software, learning management system, training packages, leadership training	37	0.19	£25,000, £32,500, £45,000	trainer, training manager, human resource manager, human resource adviser, it trainer, training coordinator, care assistant, learning and development manager, project manager, manager

Financial Asset Management	business communications, portfolio management, risk management, asset management, business modelling, professional services marketing, economics, due diligence, management consultancy, mergers and acquisitions, financial consultancy, corporate finance, acquisitions, investment management, wealth management, financial modelling, corporate recruiting, pricing strategy, investment strategy, pricing, policy analysis, critical thinking, financial advising, international business, investment planning, investor relations	123	2.06	£34,000, £45,250, £64,500	business analyst, project manager, business development manager, analyst, pricing analyst, manager, account manager, corporate solicitor, finance manager, management accountant
HR Management	employee relations, benefits management, human resource management, benchmarking, benefits analysis, employee engagement, tupe, benefits administration, organisational analysis, hr consultancy, hris, hr strategy, hr policies, job evaluation	94	0.54	£29,000, £39,750, £52,500	human resource adviser, human resource manager, human resource administrator, human resource officer, human resource business partner, human resource assistant, project manager, manager, business analyst, analyst
Insurance and Lending	insurance underwriting, credit risk, cemap, credit assessment, credit analysis	68	0.25	£30,000, £44,000, £60,000	mortgage adviser, credit risk analyst, credit controller, underwriter, credit analyst, commercial underwriter, business analyst, credit risk manager, commercial account handler, risk analyst
Legal Services	litigation, legal support, commercial litigation, intellectual property, legal documentation, dictation, mediation, civil litigation, bill preparation, arbitration, estate planning, legal research, document review, case preparation, prosecution	103	0.74	£24,480, £35,000, £47,150	legal secretary, commercial litigation solicitor, paralegal, litigation solicitor, solicitor, property litigation solicitor, private client solicitor, legal counsel, quantity surveyor

Logistics Administration	order and invoice processing, stock control, order management, eftpos, merchandise labelling, order correction, processing item returns, electronic data interchange, sales order processing, delivery unload and breakdown, expediting orders, resolving shipping delivery problems, customer complaint resolution, order entry	78	0.81	£17,500, £21,000, £26,500	sales administrator, administrator, customer service adviser, customer service administrator, warehouse operative, chef, buyer, accounts assistant, customer service representative, stock controller
Office Administration	secretarial skills, file management, office administration, administrative support, typing, contract administration, calendar management, data entry, telephone skills, scanners, advertising copywriting, record keeping, cash handling, general office duties, business administration, travel arrangements, sorting, initiative, office skills, note taking	76	4.41	£17,000, £20,000, £27,000	administrator, administrative assistant, office administrator, receptionist, legal secretary, administration assistant, sales administrator, executive assistant, personal assistant, secretary
Payroll and Tax Accounting	account auditing, payroll processing, vat returns, payroll administration, tax preparation, tax returns, payroll reports, tax compliance, payroll preparation, tax planning, general ledger maintenance, peoplesoft, audit management, audit supervision, payroll taxes, corporate tax returns, data validation, tax accountancy, companies house	100	0.9	£24,000, £31,200, £43,500	payroll administrator, accountant, accounts assistant, management accountant, finance manager, financial accountant, audit, payroll manager, financial controller, payroll assistant
Premises Security	access and or egress control, security patrol, alarm system monitoring, prevention of unauthorised entry, security camera monitoring	8	0.01	£16,367, £17,680, £18,720	security officer, retail security officer, relief security officer, dedicated relief security officer, security officer distribution, dedicated relief officer, security officer distribution support, relief retail security officer, security area relief officer, retail security officer driver

Procurement	negotiation skills, logistics, cost control, supply chain management, supplier management, costing, contract negotiation, contract review, procurement contracts, category management, sourcing requirements, supplier identification, procurement strategies, purchasing functions, request for information rfi, strategic sourcing, sourcing strategies, supplier review, operating margin maximisation, supplier selection, price negotiation, supply chain improvement, commodity management	148	1.45	£31,500, £42,250, £55,000	buyer, quantity surveyor, project manager, procurement manager, supply chain manager, category manager, commercial manager, contract manager, business development manager, purchasing manager
Recruitment	listening, contract recruitment, candidate sourcing, candidate interviewing, rpo, workforce planning, talent pool, permanent placement, taleo, recruiting	56	0.5	£25,500, £35,000, £45,000	recruitment consultant, customer service adviser, trainee recruitment consultant, recruiter, sales executive
Retail Management	store management, food safety, faculty training, employee training, retail management, restaurant management, store operations, loss prevention, retail operations, asset protection, disciplinary procedures, performance analysis, health and safety compliance	52	1.26	£19,330, £25,500, £35,875	store manager, assistant manager, assistant store manager, restaurant manager, retail store manager, chef, supervisor, deputy manager, shop manager, retail manager
Securities Trading	front office, derivatives, onboarding, capital markets, investment banking, equities, securities trading, visual basic for applications vba, reengineering, foreign exchange, operations analysis, transaction processing, stress management, trading floor, commodities, risk system, securities	83	0.59	£37,500, £55,000, £73,875	business analyst, project manager, analyst, developer, operations analyst, java developer, data analyst, risk analyst, manager
Shipping and Warehouse Operations	transportation logistics, logistics analysis, warehouse management, logistics management, haulage, freight forwarding, warehouse operations, sap implementation, warehouse management systems, shipping, efficient transportation, shipping and receiving, air freight, export compliance	114	0.84	£22,500, £30,000, £40,000	warehouse manager, warehouse operative, logistics manager, operations manager, project manager, driver, warehouse supervisor, hgv driver, transport planner

Supply Chain Management	sap, enterprise resource planning erp, materials planning, supply chain knowledge, supply chain, product delivery, inventory management, inventory control, product availability, demand forecasting, demand planning, manufacturing resource planning mrp, production planning, supply chain solutions, inventory maintenance	142	0.95	£26,000, £33,150, £45,000	supply chain manager, production planner, sap consultant, buyer, project manager, supply chain coordinator, management accountant, supply chain planner, business analyst, material planner
Automotive Engineering	original equipment manufacturer oem, electric vehicle, vehicle systems, braking, fuel efficiency, hybrid vehicle	48	0.09	£30,863, £38,197, £49,968	engineer, project engineer, systems engineer, sales engineer, auto electrician, quality engineer, hgv technician, vehicle technician, sales manager, apprentice service technician
Aviation	fortran, civil aviation, meteorology, aviation safety, civil aviation authority, flight safety, flight planning, aviation regulations, general aviation, helicopter operations, flight training, business aviationauthority, flight safety, flight planning, aviation regulations, general aviation, helicopter operations, flight training, business aviation	35	0.01	£27,438, £36,750, £47,750	engineer, software engineer, software developer, systems engineer, quantitative analyst, project manager, aeronautical engineer, cabin crew, analyst, developer
Biofuels	biofuel production, biofuels processing, biofuels processing equipment, biofuels production equipment, biofuels plant inspection, biofuels production management, biofuels quality assessment, biomass - fuelled generators, biomass feedstock mixing, biomass feedstock quality assessment	12			processing technician, biomass plant technician, production manager, biomass manager, technician production, research fellow, operations manager fuel plant, research technician
Civil Engineering	civil engineering, surveys, traffic management, structural design, transport planning, microstation, ceng, masonry, drainage design, ole, bridge engineering, highways agency, traffic engineering, civil 3d, motorway maintenance, traffic maintenance, land survey, foundation design, bridge design	97	0.7	£30,500, £40,000, £50,000	structural engineer, civil engineer, quantity surveyor, engineer, site engineer, transport planner, project manager, design engineer, bridge engineer, structural design engineer

Construction	painting, carpentry, hand tools, cabinetry, roofing, power tools, insulation, materials moving, renovation, woodwork, gloss, door installation, concrete mixing, concrete finishing, guttering, basic carpentry, construction labour, fascia, plasterboard, pipe laying	194	0.93	£20,540, £26,000, £31,200	carpenter, painter, painter and decorator, labourer, handyman, roofer, painter decorator, joiner, cscs carpenter, shuttering carpenter
Construction Engineering	estimating, microsoft project, architectural engineering, commercial construction, home building, construction management, revit, progress reports, cost estimation, feasibility studies, interior design, site surveys, survey design, design software, site inspection, primavera, demolition, project design, design and construction, set design, fall protection, building inspection, sketchup	100	1.51	£30,000, £39,760, £50,000	project manager, quantity surveyor, estimator, site manager, project engineer, structural engineer, planner, architectural technician, engineer, architect
Design and Process Engineering	computer aided draughting design cad, mechanical engineering, concept development, product development, mechanical design, materials design, process design, product design, product lifecycle management plm, engineering projects, catia, engineering activities, autodesk, 3d modelling design, materials science, package design, pro engineer, mechanical draughting	130	1.92	£32,500, £40,000, £50,609	mechanical design engineer, design engineer, mechanical engineer, engineer, project engineer, project manager, cad technician, manufacturing engineer, product manager, structural engineer
Driving and Automotive Maintenance	cleaning, inspection, machinery, forklift operation, automotive repair, preventive maintenance, labeling, equipment ordering, work area maintenance, health and safety standards, vehicle maintenance, shipping through ups, lift trucks, paint sprayer, heavy large goods vehicle driving, maintenance scheduling, transporting, equipment cleaning, hoisting equipment, equipment maintenance, delivery driving	275	4.21	£18,761, £23,810, £29,500	cleaner, maintenance engineer, cleaning operative, warehouse operative, vehicle technician, technician, field service engineer, hgv technician, electrical maintenance engineer

Electrical Engineering	electrical engineering, sales engineering, wiring, electrical design, hydraulics, siemens nixdorf hardware, installation planning, technical training, electrical systems, technical assistance, schematic diagrams, scada, robotics, power generation, low and high voltage, technical recruiting, technical services marketing, hydraulic engineering, hmi, rolling stock, hazop, switchgear, flow testing, inverters, electrical control, programmable logic controller plc programming, electrical diagrams, transformers, power distribution, wiring diagrams, electrical schematics, professional engineer, instrument calibration, circuit diagrams, telemetry	155	1.45	£29,062, £35,000, £44,165	electrical engineer, electrical design engineer, maintenance engineer, engineer, sales engineer, field service engineer, electrical maintenance engineer, project engineer, control systems engineer, electrician
Electrical Work	electrical work, cabling, facility maintenance, blueprints, electrical wiring, industrial electrical work, wiring installation, multimeters	100	0.43	£25,000, £29,000, £34,320	electrician, maintenance electrician, maintenance engineer, auto electrician, industrial electrician, electrical engineer, electrician mate, electrical maintenance engineer, engineer, data engineer
Electronics	validation, product testing, systems engineering, electronic design, simulation, system design, matlab, test equipment, analogue design, computer programming, field programmable gate array, circuit design, electronic circuits, hardware design, vhsic hardware description language vhdl, electronic engineering, microcontrollers, schematic design, microprocessors, pcb layout and design, rf design, verilog, data acquisition, labview, power supplies, environmental testing, circuit testing	134	1.09	£35,000, £42,500, £50,000	electronics engineer, systems engineer, engineer, design engineer, electronics design engineer, software engineer, hardware engineer, electronic design engineer, embedded software engineer, test engineer

Energy	sustainability, renewable energy, chemical engineering, energy engineering, energy efficiency, energy management, energy conservation, biomass, carbon reduction, energy supply, energy consumption, energy reduction, energy consultancy, alternative energy, energy services, energy systems, economic analysis, energy products, economic models, sustainability consultancy, energy markets, carbon footprint, natural gas, building performance, energy saving products, environmental sustainability, energy management system, energy business development, waste-to-energy, power plants, green energy, energy solutions	162	0.29	£27,500, £35,000, £45,000	sustainability consultant, project manager, process engineer, energy manager, energy consultant, engineer, mechanical engineer, business development manager, electrical engineer, energy engineer
Environmental Planning	transportation planning, geographic information system gis, impact assessment, town planning, community planning, landscape architecture, land planning, urban design, natural resources, environmental studies, landscape design, arcgis, land management, environmental education, city planning, agricultural research, landscape planning, town management, community relations, archaeology, transport policies, ecological consultancy, space management, town development, biodiversity, preparation of appeals, local planning authorities, land use, farm management, agronomy, conservation planning, greenhouse	133	0.32	£25,829, £32,500, £42,495	transport planner, planner, landscape architect, ecologist, planning officer, project manager, land manager, business analyst, principal transport planner, urban designer

Health, Safety and Environment	report writing, workplace health and safety, environmental consultancy, proposal writing, iso 14001 standards, water treatment, environmental management, environmental policy, environmental health and safety, geology, environmental protection, environmental science, condition legionella, geotechnical engineering, environmental engineering, site investigations, water sampling, hazard identification, permitting, environmental regulations, environmental compliance, air quality control	190	0.8	£25,625, £32,500, £40,666	geotechnical engineer, project manager, engineer, environmental consultant, manager, consultant, environmental engineer, paraplanner, risk assessor, health and safety manager
Heating, Ventilation and Plumbing	plumbing, hvac, ventilation, boilers, heating systems, pipefitting, water testing, drainage, commercial plumbing, cooling towers, liquefied petroleum gas lpg, hvac engineering, ventilation systems, home repair, fuel meters, centrifugation	146	0.69	£26,062, £30,695, £36,387	plumber, commercial gas engineer, gas engineer, pipe fitter, heating ventilation and air conditioning engineer, mechanical engineer, engineer, maintenance engineer, domestic gas engineer, area sales manager
Hydrology	hhydrology, wastewater treatment, water quality, water engineering, water distribution, coastal engineering, water reuse, erosion control, wastewater engineering, environmental models, watershed management	61	0.03	£30,207, £36,875, £42,500	hydrologist, engineer, civil engineer, water engineer, environmental restoration planner, flood risk consultant, mechanical engineer, process engineer, hydraulic modeller, electrical engineer

Manufacturing Methods	product research, packaging, lean methods, iso 9001 standards, machining, engineering management, manufacturing processes, root cause analysis, six sigma, calibration, process engineering, new product development, lean manufacturing, technical drawings, surveillance, failure modes and effects analysis fmea, engineering support, injection moulding, logistics engineering, lean processes, process control, waste reduction, computer aided manufacturing cam, machine tools, capability maturity model cmm, product improvement, kaizen, bill of materials, production management, coordinate measuring machine cmm, six sigma green belt, industrial engineering, lean six sigma, iso 9000, process equipment, value stream mapping	179	1.91	£28,854, £35,000, £43,797	quality engineer, manufacturing engineer, process engineer, engineer, engineering manager, quality manager, production engineer, production manager, mechanical design engineer, design engineer
Oil and Gas Extraction	brownfields, liquefied natural gas, liquefied natural gas lng, decision analysis, well control, geophysics, pipeline design, logging, facility design, petrel, offshore drilling, well design, petrophysics, workover, talisman, well testing, drill engineering, gas exploration, reservoir simulation, corrosion control systems, well completion, reservoir management, wireline, coiled tubing, pigging, artificial lift, water injection	69	0.05	£30,000, £40,000, £62,500	engineer, drilling engineer, reservoir engineer, geophysicist, process engineer, project engineer, project manager, geologist, drilling supervisor, production engineer
Solar and Wind Energy	wind power, wind turbines, solar energy, solar panels, site selection, solar sales, photovoltaic pv systems, renewable energy systems, hydropower, solar farm, renewable sales, solar energy systems, solar products, solar photovoltaic installation, wind farm construction, renewable energy consultation, solar thermal systems	75	0.05	£29,000, £36,250, £43,300	field sales executive, solar energy systems engineer, solar energy installation manager, wind turbine technician, project manager, wind energy engineer, electrical engineer, electrician, engineer

Structural Engineering	engineering consultation, engineering design, structural drawings, engineering software	27	0.31	£32,500, £38,250, £50,636	structural engineer, engineer, mechanical design engineer, design engineer, project engineer, mechanical engineer, civil engineer, electrical engineer, electrical design engineer, project manager
Welding and Machining	computer numerical control cnc, welding, machine operation, lathes, soldering, mig and tig welding, grinders, milling cutters, sewing, micrometers, computerised numerical control lathes, machine setting, press materials, welding equipment, boring tools, calipers, pressure testing, colour matching, paint shop pro	143	1.1	£20,900, £26,000, £30,160	cnc machinist, cnc turner, welder, cnc miller, fabricator welder, welder fabricator, mig welder, machine operator, cnc programmer, cnc setter operator
Autoimmune Cardiovascular Disease	condition cardiovascular disease, neuroimmunology	11		£29,502, £34,490, £39,376	area healthcare lead, research nurse, research fellow, practice nurse, research associate, research assistant, research technician, nurse, clinical research associate, nurse adviser respiratory
Autoimmune Conditions	autoimmunity, immunoglobulin, immunodeficiency, th2, asthmatic, allergist, allergy and immunology, allergen immunotherapy	21		£28,852, £33,000, £40,000	consultant, consultant immunologist, clinical nurse specialist, respiratory staff nurse, product specialist, staff nurse, research associate, scientist, biomedical scientist, immunologist
Biochemistry	biology, biochemistry, proteins, cell culturing, assay development, mass spectrometry, protein purification, protein analysis	131	0.14	£26,688, £31,553, £35,327	scientist, science teacher, biology teacher, research associate, teacher of biology, research assistant, research technician, biomedical scientist, research scientist, laboratory technician
Biomedical Research	pharmacology, neuroscience, biomarkers, biomedical research, medical technology, metabolism, biomarker, veterinary medicine, clinical testing, cognitive science, diagnostic technologies, condition rheumatoid arthritis, bayesian methods, sle, disease treatment, fmri	79	0.03	£27,781, £33,901, £39,856	scientist, research associate, research assistant, research fellow, optometrist, clinical research fellow, research technician, research scientist, project manager, staff nurse

Biotechnology Manufacturing	chemistry, good manufacturing practises gmp, medical device, aseptic, biologics development	55	0.24	£28,500, £35,000, £47,500	science teacher, chemistry teacher, scientist, analytical chemist, laboratory technician, quality engineer, qc analyst, quality assurance officer, teacher of chemistry, analyst
Cell Biology	cell biology, confocal, laboratory research, medical research council, condition neurodegenerative disease, stem cell biology, neurobiology, drosophila, mrna, circadian, cell cycle, fret fluorescence resonance energy transfer, dna repair, digestive system, apoptosis, histochemistry, ubiquitin, cell death, dna cloning, phosphorylation, ataxiadisease, stem cell biology, neurobiology, drosophila, mrna, circadian, cell cycle, fret fluorescence resonance energy transfer, dna repair, digestive system, apoptosis, histochemistry, ubiquitin, cell death, dna cloning, phosphorylation, ataxia	69	0.01	£27,741, £33,044, £34,975	research associate, research fellow, research technician, research assistant, scientist, postdoctoral scientist, postdoctoral research associate, research scientist, postdoctoral research fellow, postdoctoral research assistant
Cell Examination	fine needle aspirations fna, cell examination, specimen quality evaluation, chromosomal staining, papanicolaou pap smear, fine needle aspiration fna biopsies, abnormal condition detection	10			cytology manager, specialty doctor, advanced practitioner, specialty doctor surgery, postdoctoral researcher, consultant pathology, biomedical scientist, radiographer
Chromosome Examination	light microscopes, karyotype, photomicroscopes, karyotypes, amniotic fluids, inverted microscopes, mitotic arrestants, standard genetics laboratory practises, cell releasing agents, condition chorionic villi, cell fixatives	13		£17,500, £27,335, £32,000	technologist, asbestos analyst, scientist, field service engineer microscope, material scientist, field service engineer, sales specialist light microscope, laboratory technician

Clinical Research	clinical research, clinical trials, regulatory affairs, good clinical practices gcp, drug development, clinical development, pharmacovigilance, clinical study, clinical research management, biostatistics, medical writing, drug discovery, regulatory documents, clinical data management, clinical trial management, clinical data interchange standards consortium cdisc, clinical study reports, pharmaceutical development, protocol development	98	0.23	£31,500, £40,457, £60,000	clinical research associate, regulatory manager, research nurse, medical writer, clinical project manager, clinical research nurse, project manager, biostatistician, regulatory associate, clinical research fellow
Developmental Biology	genetics, developmental biology, molecular cloning, gene identification	18	0.01	£27,500, £33,364, £35,000	research associate, research fellow, research assistant, research technician, bioinformatician, genetic technologist, postdoctoral scientist, clinical scientist, consultant clinical genetics
Flow Cytometry	flow cytometry, fluorescence-activated cell sorting facs, immunotherapy, condition lymphoma, immune system, cell sorting, autologous, cellular immunology, cytokine, gene expression analysis, tissue collection, immunology research, tumour immunology	34	0.01	£29,869, £33,558, £37,752	scientist, research associate, research assistant, research technician, research fellow, research scientist, postdoctoral scientist, postdoctoral research fellow, consultant haematology, postdoctoral research associate
Genomics and Dna Sequencing	bioinformatics, genomics, dna sequencing, sequence analysis, deoxyribonucleic acid dna analysis, molecular genetics, metabolomics, genome sequencing, genome analysis, cytogenetics, functional genomics, genetic analysis	60	0.02	£30,017, £34,569, £38,122	bioinformatician, research associate, scientist, research fellow, research assistant, software developer, research technician, bioinformatics scientist, data scientist, software engineer
Histology	histology, tissue culture, transfection, high throughput screening hts, real-time polymerase chain reaction, immunofluorescence, in situ hybridisation, western blot analysis, cell differentiation, rna isolation, quantitative real time pcr qrt-pcr	31	0.01	£26,751, £31,263, £35,000	biomedical scientist, research technician, scientist, research associate, research assistant, technician, medical laboratory assistant, consultant histopathologist, research fellow, research scientist

Infectious Diseases	immunology, condition infectious disease, virology, disease control, vaccine development, condition influenza, food security, condition malaria	59	0.03	£28,185, £34,498, £39,970	scientist, biomedical scientist, research associate, registrar infectious disease, research fellow, research assistant, consultant infectious disease, research scientist, specialist registrar infectious disease
Laboratory Techniques	food science, good laboratory practises glp, high performance liquid chromatography, analytical chemistry, laboratory equipment, sample preparation, microbiology, chemical analysis, chromatography, toxicology, sample collection, analytical testing, organic chemistry, wet chemistry, forensic science, laboratory procedures, reagent preparation, instrumental analysis, laboratory information management system lims, animal husbandry	90	0.14	£20,843, £26,000, £32,625	analytical chemist, laboratory technician, analyst, qc analyst, scientist, microbiologist, analytical scientist, laboratory analyst, chemist, technical manager
Microfluidics	experiments, design of experiments doe, microfluidics, microfabrication	15	0.25	£29,500, £35,000, £45,000	lecturer, scientist, science technician, research associate, research fellow
Molecular Biology Of Cancer	condition breast cancer, proteomics, condition prostate cancer, cancer biology, condition leukaemia, condition brain tumour, cancer genetics, somatic, condition pancreatic cancer, stem cell research, her2, condition ovarian cancer, metastasis, carcinoma, shrnaleukaemia, condition brain tumour, cancer genetics, somatic, condition pancreatic cancer, stem cell research, her2, condition ovarian cancer, metastasis, carcinoma, shrna	46	0.01	£29,833, £34,404, £38,987	clinical nurse specialist, research associate, research fellow, bioinformatician, research assistant, research technician, scientist, clinical research fellow, postdoctoral scientist, specialist nurse
Molecular Biology Processes	molecular biology, dna, genome, gene expression, microarrays	40	0.04	£28,429, £34,083, £37,166	scientist, research associate, research technician, research assistant, research fellow, bioinformatician, biologist, research scientist, postdoctoral scientist

Nanotechnology	catalysis, nanotechnology, crystals, polymer synthesis, metamaterials, nanofabrication, graphene, novel materials, solar cell, quantum dots, green chemistry, nanotechnology engineering	30		£27,403, £32,854, £36,733	engineer, engineering technician, research associate, engineering technologist, research fellow, scientist, research scientist, research assistant associate, research assistant, polymer chemist
Pathology	pathology, bacteriology, zoology, medical microbiology, parasitology	56	0.04	£22,500, £30,875, £35,184	biomedical scientist, building surveyor, medical laboratory assistant, specialist biomedical scientist, phlebotomist, consultant pathologist, anatomical pathology technician, consultant pathology, consultant, chartered building surveyor
Pathophysiology	receptor, animal models, pathophysiology, microrna, homoeostasis, gfp, fibrosis, lymphatic, nucleotide, endothelial, clinical features, condition hypoxia, steroid, ion channel, angiogenesis, innate immunity, cardiovascular system, atherosclerosis, extracellular matrix ecm, adipose, epithelium, inflammatory response, insulin resistance, leukocyte, reperfusion, protease, neutrophil	61		£27137, £33,058, £35,837	research associate, research fellow, research technician, research assistant, scientist, clinical research fellow, postdoctoral scientist, postdoctoral research assistant, postdoctoral research associate, postdoctoral research fellow
Physics and Math	physics, machine learning, mathematical modelling, high-performance computing, experimental design	28	0.17	£32,979, £36,839, £50,000	data scientist, science teacher, teacher, software engineer, engineer, teacher of science, software developer, systems engineer, developer
Research Methods and Statistics	data collection, research reports, statistics, grant writing, policy research, peer review, healthcare research, epidemiology, grant applications, medical research	87	0.22	£30,000, £35,746, £42,682	paraplanner, analyst, data analyst, research assistant, statistician, manager, research fellow, administrator, data scientist, research associate
Synthetic Biology	medicinal chemistry, toxicity, structural biology, synthetic biology, x-ray crystallography, inhibitor, drug design, biological chemistry, protein structure, molecular modelling	34		£29,973, £34,253, £38,047	scientist, research associate, research fellow, medicinal chemist, computational chemist, research assistant, postdoctoral research associate, postdoctoral research fellow, research technician, postdoctoral research assistant

Tissue Culture	aseptic technique, biosafety, tissue preparation, cryopreservation, biological material, histocompatibility, microscopic techniques, polymerase chain reaction pcr, cell requirements, formalin, oocyte, calorimeters, cryostat, flame photometers, microtomes, microscopic examination	34		£24,936, £30,000, £35,669	microbiologist,microbiologist, technician, scientist, laboratory technician, research technician, medical technician, research assistant, medical technologist, medical laboratory technician, clinical laboratory scientist
Tomography and Microscopy	microscope, fluorescence, electron microscopy, magnetic resonance imaging mri, tomography, chemical reactions, deformation, irradiation, tissue engineering	34	0.01	£22,250, £31,961, £38,374	research associate, scientist, laboratory technician, research fellow, technician, engineer, science technician, research assistant, research technician, electrical maintenance engineer
Anesthesiology	anesthesiology, anesthetic, theatre practitioner, perioperative, operating department practitioner, pain management, postoperative care, cosmetic surgery, surgical services, surgical instruments	49	0.2	£26,500, £30,763, £37,455	theatre practitioner, theatre practitioner anaesthetic, operating department practitioner, anaesthetic practitioner, anaesthetic nurse, scrub nurse, theatre nurse, theatre practitioner scrub, staff nurse, nurse
Cardiac Surgery	cardiothoracic surgery, cardiac surgery, recovery units, thoracic surgery, ecmo, condition organ failure, intensivist	27	0.02	£30,611, £37,665, £42,898	registrar surgery, clinical fellow surgery, consultant surgery, staff nurse, specialist registrar surgery, consultant, house officer surgery, consultant surgeon
Cardiology	cardiology, exercise testing, catheterisation, condition cardiac disorders, echocardiography, defibrillation, condition heart failure, angiography, cardiac rehabilitation, aorta, invasive procedures, angioplasty, condition chest pain, condition arrhythmia, cardiac services	82	0.11	£28,846, £33,662, £39,364	cardiac physiologist, staff nurse, consultant, consultant cardiologist, clinical fellow, specialist cardiac physiologist, nurse, registered nurse, specialist registrar, chief cardiac physiologist
Clinical Information Systems	information governance, healthcare management, ehealth, healthcare information, clinical information systems, clinical information technology, medical software, meditech, health information technology hit, decision support systems	36	0.03	£27,868, £35,689, £44,932	information governance manager, information governance officer, project manager, registered nurse, administrator, receptionist, business analyst, information governance lead, information analyst

Treatment of Aneurysms	condition aortic aneurysm, vascular medicine, eecp, abdominal aneurysm	7			project manager, clinical vascular scientist, screening technician, clinical support specialist vascular medicine, vascular nurse practitioner, clinical research nurse, vascular scientist, screening and immunisation coordinator, consultant radiologist, vascular medicine
Critical Care	critical care, emergency medicine, acute care, emergency care, mrcp, paediatric intensive care unit picu, geriatrics, advanced life support certificate, ambulatory care, internal medicine, neonatal intensive care unit nicu, critical care nursing, neonatology	65	0.24	£29,923, £35,000, £41,526	staff nurse, consultant, nurse, consultant emergency medicine, critical care nurse, charge nurse, clinical fellow, specialty doctor, registered nurse, consultant medicine
Dental Assistance	oral hygiene, dental assistance, equipment instrument sterilisation, bedside manner, dental instruments, patient recall system, treatment preparation, dental histories, dental supply inventory, plaque control, study cast polishing, temporary restorations, removable appliance polishing	24	0.01	£15,393, £19,360, £28,425	dental nurse, dental assistant, certified dental assistant, surgical dental assistant, healthcare assistant, orthodontic assistant, registered dental assistant, certified registered dental assistant, dental hygienist
Dermatology	therapy, dermatology	43	0.21	£25,437, £31,071, £38,000	beauty therapist, occupational therapist, physiotherapist, speech and language therapist, spa therapist, consultant dermatologist, consultant, trainee beauty therapist, therapist, therapy assistant
Diagnostic Imaging	radiology, radiography, ultrasound, patient monitoring, medical imaging, diagnostic imaging, mammography, medical physics, radiation protection, computed tomography ct, nuclear medicine, single photon emission computed tomography spect, fluoroscope c-arm, digital imaging, x-ray radiography equipment, ionising radiation	90	0.16	£28,471, £33,250, £42,296	radiographer, sonographer, consultant radiologist, staff nurse, mri radiographer, consultant radiology, mammographer, general radiographer, diagnostic radiographer, consultant

Endodontics and Dental Appliances	oral healthcare, teeth examination, educational materials, endodontics, root canal	21	0.01	£22,970, £30,500, £49,473	dental associate, dental nurse, dentist, associate dentist, general dental practitioner, dental nurse apprentice, associate, civilian dental nurse, apprentice dental nurse
Gastroenterology	endoscopy, gastroenterology, endocrinology, hepatology, colorectal surgery, endoscopic procedure, endoscope, condition inflammatory bowel disease, colonoscopy, hepatobiliary, therapeutic procedures, endoscopic retrograde cholangiopancreatography, condition liver disease, bariatric surgery, decontamination units, condition colorectal cancer	78	0.1	£30,458, £36,378, £43,595	nurse, staff nurse, consultant gastroenterology, consultant, consultant gastroenterologist, registered nurse, clinical fellow, technician, specialist registrar, specialist registrar gastroenterology
General Practice	general practise, nursing, medication prescription, health checks, urgent care, wound management, condition chronic disease, health education, paramedics	48	0.29	£28,471, £33,800, £40,500	practice nurse, nurse practitioner, registered nurse, nurse, advanced nurse practitioner, registered general nurse, staff nurse, support worker, gp, healthcare assistant
Gynecology and Urology	urology, gynecology, obstetrics, obstetrics gynaecology, biopsy	59	0.1	£30,414, £36,559, £43,558	consultant, clinical fellow, specialist registrar, staff nurse, specialty doctor, registrar, sonographer, trust doctor
Medical Admin	word processing, clerical duties, medical terminology, calculator, clerical support, booking, medical records accuracy	39	0.15	£16,450, £17,823, £23,083	clerical assistant, administrator, medical secretary, administrative assistant, receptionist, legal secretary, clerical officer, administration assistant, secretary, office administrator
Medical Coding	medical coding, clinical documentation, medical records, icd-10, medical records review	63	0.04	£20,000, £26,468, £33,800	clinical coder, medical record clerk, developer, staff nurse, software engineer, registered nurse, support worker, software developer, administrator, dental nurse
Medical Device Sales	medical sales, medical device sales, hospital sales, medical equipment sales, laparoscopy	25	0.06	£34,140, £39,500, £43,750	territory manager, medical sales representative, territory sales manager, account manager, hospital sales specialist, business development manager, sales specialist, hospital sales representative, sales representative

Mental Health	mental health, psychology, occupational therapy, learning disability, process adjustment, clinical leadership, psychiatry, clinical psychology, criminal justice, condition mental illness, condition attention deficit hyperactivity disorder adhd	136	1.5	£25,437, 31,071, 38,000	occupational therapist, support worker, clinical psychologist, staff nurse, registered mental health nurse, registered nurse, consultant psychiatrist, nurse, healthcare assistant, assistant psychologist
Nephrology	dialysis, nephrology, haemodialysis, condition acute renal failure, condition end stage renal disease esrd, end stage renal disease esrd knowledge, renal dialysis, peritoneal	20	0.04	£25,092, £29,482, £36,420	registered nurse, staff nurse, dialysis nurse, registered nurse dialysis unit, renal dialysis nurse, staff nurse renal dialysis, renal nurse, renal healthcare technician, staff nurse dialysis, consultant nephrologist
Neurological Disorders	stroke, condition brain injury, neurology, condition spinal cord injuries, condition neurological injury, condition parkinson's disease, cognitive impairment, condition sclerosis, condition neurological disorders, electroencephalography eeg, electroencephalography	85	0.15	£26,000, £31,356, £36,741	support worker, physiotherapist, occupational therapist, staff nurse, registered nurse, care assistant, consultant, speech and language therapist, registered general nurse, nurse
Nutrition and Diabetes Management	primary care, condition diabetes, diabetes management, insulin, weight loss	33	0.18	£25,495, £32,295, £37,974	practice nurse, nurse practitioner, advanced nurse practitioner, specialist nurse, nurse, gp, account manager, consultant, registered general nurse, community nurse
Oncology	pediatrics, oncology, condition cancer, hematology, patient treatment, patient safety, chemotherapy, rheumatology, intravenous procedures	99	0.5	£29,323, £35,756, £42,826	staff nurse, nurse, paediatric nurse, consultant, clinical nurse specialist, registered nurse, biomedical scientist, physiotherapist, sister charge nurse
Ophthalmology	optometry, ophthalmology, refraction, eye care, early diagnosis, retinopathy, cataract surgery	50	0.11	£25,180, £33,373, £43,648	optometrist, consultant, consultant ophthalmologist, specialist registrar, specialty doctor, dispensing optician, staff nurse, orthoptist, optical adviser, optical assistant
Patient Assistance and Care	patient care, welsh, triage, medical assistance, patient contact, patient direction, patient assistance, patient transportation and transfer, patient flow, patient evaluation, body mass index bmi	95	0.52	£21,648, £28,250, £36,018	staff nurse, registered nurse, nurse, healthcare assistant, registered general nurse, physiotherapist, clinical support worker, nurse practitioner, theatre practitioner, advanced nurse practitioner

Patient Support	patient family education and instruction, treatment explanation, breathing exercises, prescription information provision	13	0.01	£26,968, £40,861, £45,628	dental associate, physiotherapist, registered nurse, staff nurse, registered general nurse, nurse, specialist nurse, paediatric nurse, dental nurse, occupational therapist
Pharmacy	pharmacist, pharmacy technician, prescription filling, dispensing patients medication, drug preparation, pharmaceutical services	52	0.14	£22,418, £25,865, £34,410	pharmacy technician, pharmacist, clinical pharmacist, apprentice pharmacy assistant, pharmacy manager, dispensing assistant, relief pharmacist, trainee pharmacy assistant, specialist pharmacist
Phlebotomy	infection control, physical demand, phlebotomy, wound care treatment, life support, patient advisement, blood pressure checking, injections, informed consent, chaperoning, blood samples	75	0.26	£18,410, £27,040, £33,058	healthcare assistant, staff nurse, phlebotomist, registered nurse, nurse, registered general nurse, care assistant, practice nurse, dental nurse
Physiotherapy and Beauty	treatment planning, physiotherapy, rehabilitation, clinical reasoning, hairstyling, anatomy, podiatry, rehabilitation services, massage therapy, therapy services, massage, hydrotherapy, condition sports injuries, aromatherapy, exercise programmes, patient rehabilitation, physiotherapist assistance, pilates, prognosis, injury prevention, physical therapy, patient visitation, orthotics, condition arthritis, condition management, group fitness, condition fractures, reflexology	167	0.33	£20,715, £28,250, £35,859	physiotherapist, hair stylist, staff nurse, occupational therapist, podiatrist, nurse, physiotherapy assistant, massage therapist, dental associate, trainee massage therapist
Prosthodontics and Orthodontics	dentistry, x-rays, condition hepatitis b, ensuring patients comfort, orthodontics, dental hygiene, dental care, medical emergencies, condition gum disease	66	0.31	£20,400, £29,500, £38,270	associate dentist, dentist, dental nurse, dental associate, apprentice dental nurse, dental hygienist, dental nurse apprentice, healthcare assistant, hygienist, radiographer
Public Health Programmes	public health education, prevention programmes, environmental medicine, food service sanitation, preventive health reports	9		£26,432, £35,074, £44,141	public health officer, safety specialist, occupational medicine physician, preventive medicine physician, practice lead early years, nursery nurse, public health engineer, public health facilitator, public health director, health visitor

Reproductive Health	public health and safety, midwifery, sexual health, children's health, cytology, family planning, smoking cessation, condition sexually transmitted infections, reproductive health, health programmes	69	0.16	£25,718, £30,917, £38,247	practice nurse, midwife, sexual health nurse, health visitor, public health engineer, school nurse, nurse, staff nurse, community midwife, registered nurse
Respiratory Disease	physiology, condition chronic obstructive pulmonary disease copd, condition cystic fibrosis, condition lung cancer, condition respiratory conditions, continuous positive airway pressure cpap, bronchoscopy, respiratory therapy, pleural, condition mesothelioma, interstitial, lung function tests, respiratory failure, condition pulmonary disease, respiratory care procedures, cardiopulmonary function evaluation	63	0.06	£26,688, £32,000, £38,000	cardiac physiologist, respiratory physiologist, practice nurse, clinical physiologist, specialist cardiac physiologist, physiologist, physiotherapist, staff nurse, chief cardiac physiologist
Screening and Immunisation	occupational health and safety, immunisations, health promotion programmes, health screening, measles mumps rubella mmr, vaccination, condition varicella	44	0.38	£23,755, £30,763, £42,640	occupational health adviser, practice nurse, registered general nurse, healthcare assistant, occupational health nurse, specialist registrar, registrar, nurse, consultant, registered nurse
Social Work and Caregiving	cooking, caregiving, care planning, social work, home management, nursing home, condition learning disabilities, child protection, condition dementia, social services, community development, condition autism, laundry, housekeeping, home care, medication administration, elder care, condition physical disability, meal preparation, nurse management, toileting, senior care, palliative care, emergency services, home health, ironing, needs assessment, patient progress evaluation, child development, supportive care	165	6.53	£18,720, £25,185, £32,253	support worker, care assistant, chef, care worker, chef de partie, healthcare assistant, registered nurse, staff nurse, home manager, registered general nurse

Speech and Hearing Therapy	audiology, condition dyslexia, speech therapy, dysphagia, condition severe disability, condition cerebral palsy, condition physical impairment, deafness, condition dyspraxia, swallowing problems, down syndrome, communication disorders, sensory integration, differential diagnosis, developmental delay, cochlear	70	0.1	£24,980, £30,763, £36,250	speech and language therapist, audiologist, support worker, teaching assistant, speech therapist, adult speech therapist, specialist speech and language therapist, adult speech and language therapist, learning support assistant, sen teaching assistant
Surgery	surgery, trauma, general surgery, orthopaedic surgery, neurosurgery, plastic surgery	81	0.54	£30,878, £38,588, £46,403	veterinary surgeon, dental nurse, staff nurse, gp, consultant, receptionist, nurse, clinical fellow, apprentice dental nurse, vet
Surgical Procedures	microdermabrasion, chemical peels, condition melanoma, skin surgery, liposuction, dermabrasion	31		£23,475, £26,000, £34,250	beauty therapist, therapist, dermatologist, spa therapist, nurse, staff nurse, consultant dermatologist, medical aesthetician, consultant, specialist
Advertising	media planning, web analytics, google adwords, advertising, online advertising, ad campaigns, digital advertising, keyword research, search marketing, link building, a b testing, search engine marketing sem, internet marketing, media buying, ad operations, campaign performance analysis, mobile marketing, ad serving, webtrends, acquisition campaigns	60	0.19	£25,500, £32,500, £42,300	digital marketing executive, digital marketing manager, marketing manager, marketing executive, advertising executive, seo executive, advertising manager, account manager, advertising sales executive, seo manager
Animation	adobe aftereffects, 3d animation, 3d studio max, game development, maya, cinema 4d, motion graphics, fine art, graphics software, unity, v-ray, animation, colour theory, computer-generated imagery cgi	45	0.06	£27,695, £35,000, £42,500	motion graphic designer, animator, graphic designer, designer, digital designer, artist, 3d designer, technical artist, developer, software engineer
Archiving and Libraries	library research, art history, integrated library systems, library resources, document delivery, metadata standards, information literacy, digital preservation, library programming, digital curation, modern art, marc21, dublin core, public libraries, library reference, electronic resources	49	0.01	£22,248, £27,500, £35,672	library assistant, librarian, assistant librarian, information assistant, school librarian, project manager, archivist, research assistant, researcher

Complex Sales	business consultancy, sales forecasting, salesforce, persuasion, account strategy, territory management, description and demonstration of products, business writing, technical sales, seminars, business research, vertical integration, sales cycle, business presentations, request for proposal rfp, sales strategy, account development, sales training, international sales, value proposition, channel development, sales development, sales administration, pharmaceutical sales, healthcare marketing, presenting solutions, channel management, client management	95	1.57	£27,500, £37,500, £50,000	business development manager, sales executive, account manager, sales manager, business analyst, business development executive, sales engineer, territory manager, area sales manager, project manager
Digital Content Authoring	training materials, proofreading, actionscript, desktop publishing, frontpage, graphics editing, adobe flash, instructional design, copy editing, filemaker pro, online help, interactive media, framemaker	58	0.15	£25,000, £32,240, £40,000	technical author, marketing executive, graphic designer, administrator, marketing assistant, developer, business analyst, web developer, trainer, instructional designer
Digital Marketing	social media, e-commerce, online marketing, digital marketing, online research, google analytics, social media tools, search engine optimisation seo, social media platforms, linkedin, media strategy, media campaigning, online communications	60	0.96	£21,750, £27,500, £35,000	marketing executive, digital marketing executive, marketing manager, digital marketing manager, marketing assistant, social media manager, web developer, digital marketing apprentice, social media executive, e-commerce manager
Event Planning	marketing communications, fundraising, promotional support, copy writing, event planning, marketing materials, newsletters, website management, internal communications, press releases, promotional materials, marketing copy, marketing event planning	36	1.07	£22,500, £28,000, £35,000	marketing executive, marketing manager, marketing assistant, event manager, digital marketing executive, marketing coordinator, copywriter, communications manager, communications officer, business development manager
Extracurricular Activities and Childcare	babysitting, teaching music, singing, teaching dance, guitar, football, piano, dog walking, gymnastics, yoga, drama, tennisguitar, football, piano, dog walking, gymnastics, yoga, drama, tennis	53	0.23	£18,000, £25,470, £36,400	nanny, music teacher, teacher of music, dance teacher, football coach, teacher, dog walker, nanny babysitter, singing teacher, occasional nanny

General Sales	product sale and delivery, sales recruiting, sales management, account management, sales goals, telesales, client base retention, prospective clients, energetic, customer relationship management crm, advertising sales, lead generation, inside sales, cold calling, self-motivation, sales support, cross sell, appointment setting, direct sales, new business development, prospecting, telemarketing, outbound sales, outside sales	137	5.82	£20,000, £26,000, £37,500	sales executive, business development manager, sales manager, account manager, telesales executive, area sales manager, recruitment consultant, business development executive, sales consultant, sales adviser
Graphic and Digital Design	editing, website production, adobe photoshop, content management, graphic design, adobe acrobat, adobe indesign, content management systems cms, interactive advertising, brand design, web site design, digital design, print production, print advertising, microsoft publisher, adobe illustrator, ux wireframes, creative design, illustration, adobe dreamweaver, typesetting, macromedia dreamweaver, visual design, proofing, brand identity, art direction, wordpress, hypertext markup language	124	1.38	£25,000, £30,000, £40,000	graphic designer, web designer, digital designer, designer, web developer, user experience designer, marketing executive, front end developer, marketing manager, developer
Journalism and Writing	blogging, newspaper, media training, creative writing, news editing	31	0.07	£21,427, £27,175, £34,250	marketing executive, digital marketing executive, marketing manager, marketing assistant, copywriter, digital marketing apprentice, public relations manager, recruitment consultant, editor
Languages	french, german, italian, spanish, bilingual, dutch, chinese, polish, russian, portuguese, japanese	54	0.88	£21,000, £27,020, £35,000	customer service adviser, sales executive, teacher, interpreter, account manager, credit controller, foreign language teacher, french teacher, nanny
Low Vision Support	kinesthetic learning, braille writing, dog guides, human guides, electronic travel aids etas, reading stands, adaptive mobility devices amds, low vision devices, adaptive eating, two - point touches, braillers, long canes	15			low vision therapist, vision rehabilitation therapist, mobility specialist, certified low vision therapist, sen teaching assistant, learning support assistant, sen classroom teacher, primary teacher

Marketing Research	market analysis, sas, tableau, data mining, spss, consumer research, r, data science, consumer behaviour, consumer segmentation, quantitative research, marketing analytics, predictive models, qualitative research, predictive analytics	74	0.36	£35,000, £47,500, £60,000	analyst, data scientist, data analyst, marketing analyst, marketing manager, developer, business analyst, customer analyst, product manager, credit risk analyst
Marketing Strategy and Branding	marketing, market strategy, campaign management, brand management, market research, marketing management, brand marketing, advertising design, marketing effectiveness, channel marketing, email marketing, direct marketing, branding strategy, advertising management, market planning, branding communication, competitive analysis, database marketing, brand planning, brand enhancement, marketing strategy development	99	2.08	£26,187, £35,000, £45,000	marketing manager, marketing executive, marketing assistant, brand manager, digital marketing manager, digital marketing executive, account manager, business development manager, head of marketing, marketing coordinator
Media Relations	public relations, media relations, corporate communications, messaging strategy, media coverage, pr strategy, communications programmes, pr agency, press coverage, print media, pr events	38	0.13	£26,750, £32,750, £43,750	public relations manager, public relations executive, marketing manager, communications manager, press officer, communications officer, marketing executive, public relations account manager, public relations account executive, public relations officer
Multimedia Production	video production, music, broadcast, video editing, media production, multimedia, photography, audio production, digital photography, television production, final cut pro, comedy, adobe premiere, script writingproduction, multimedia, photography, audio production, digital photography, television production, final cut pro, comedy, adobe premiere, script writing	93	0.49	£24,000, £30,179, £39,831	product tester, music teacher, graphic designer, marketing executive, marketing manager, photographer, teacher of music, digital designer, software engineer, producer

Retail	strategic marketing, retail setting, product promotion, product knowledge, merchandising, product management, retail sales, sales analysis, promotional marketing, promotional planning, market trend, visual merchandising, trade shows, profit targets, trade marketing, sales reporting, sales planning	101	2.1	£24,000, £32,500, £45,000	marketing manager, product manager, store manager, sales assistant, sales executive, assistant manager, business development manager, marketing executive, sales manager, account manager
Teaching	tutoring, teaching english, teaching mathematics, teaching science, lesson planning, graduate teaching, course development, creative problem solving, teaching geography, teaching information and communication technology, teaching pe, teaching history, teaching physics, teaching chemistry, teaching biology, teaching art, curriculum development, teaching speakers of other languages	92	1.62	£25,135, £30,548, £36,389	teacher, science teacher, english teacher, teaching assistant, tutor, teacher of english, geography teacher, teacher of science
Web Content Management	content development, web communications, web content management, really simple syndication rss, web content editing, web writing, web content development	19	0.06	£22,500, £29,899, £40,000	marketing executive, web developer, marketing manager, digital marketing executive, web content editor, developer, web content manager, digital marketing manager, marketing assistant, content designer

*Shown are the skills that in total account for at least 90% of all skill mentions in the corresponding cluster.

** Average salary Q1, Median and Q3 values are calculated using data for 2015-2017 (inclusive).

Table 7: Most prominent skill clusters in top 200 job titles*

Job title	Most prominent skill clusters (per cent)**
.net developer	(software development, 84.9), (web development, 11.5)
account administrator	(office administration, 45.2), (accounting admin, 25.0), (accounting and financial management, 8.0), (general sales, 5.4), (logistics administration, 4.8), (payroll and tax accounting, 1.7)
account assistant	(accounting admin, 40.1), (accounting and financial management, 32.0), (office administration, 9.5), (payroll and tax accounting, 5.9), (accounting software, 5.0)

account executive	(general sales, 27.2), (complex sales, 18.6), (marketing strategy and branding, 12.5), (accounting and financial management, 7.8), (office administration, 6.5), (event planning, 5.9), (accounting admin, 3.3), (business management, 2.5), (medical device sales, 2.4), (digital marketing, 2.1), (retail, 1.6)
account manager	(general sales, 35.5), (complex sales, 19.9), (marketing strategy and branding, 11.8), (accounting and financial management, 8.5), (business management, 5.5), (retail, 2.4), (accounting admin, 1.9), (office administration, 1.9), (event planning, 1.4), (financial asset management, 1.2)
accountant	(accounting and financial management, 84.1), (payroll and tax accounting, 12.6)
accounts payable administrator	(accounting admin, 72.4), (accounting and financial management, 22.2)
administration assistant	(office administration, 84.6), (accounting admin, 2.9), (general sales, 1.6), (accounting and financial management, 1.5)
administrative assistant	(office administration, 95.4)
administrator	(office administration, 75.5), (accounting admin, 5.0), (accounting and financial management, 3.0), (general sales, 2.7), (logistics administration, 2.1), (accounting software, 1.0), (business management, 0.9)
analyst	(bi and data warehousing, 15.5), (accounting and financial management, 14.0), (marketing research, 13.4), (financial asset management, 8.7), (business analysis and it projects, 4.1), (business management, 4.0), (securities trading, 3.2), (laboratory techniques, 3.2), (marketing strategy and branding, 3.1), (system administration, 2.8), (software development, 2.6), (hr management, 2.6), (accounting admin, 2.1), (office administration, 2.0), (design and process engineering, 1.7), (general sales, 1.0), (advertising, 1.0), (data engineering, 1.0), (electronics, 0.9), (complex sales, 0.8), (supply chain management, 0.8), (audit and compliance, 0.8), (retail, 0.7)
architect	(construction engineering, 38.1), (software development, 9.9), (business analysis and it projects, 9.0), (system administration, 7.9), (bi and data warehousing, 4.7), (graphic and digital design, 3.7), (design and process engineering, 3.5), (business management, 3.1), (data engineering, 3.0), (complex sales, 2.6), (web development, 2.2), (servers and middleware, 1.4), (office administration, 1.2)

architectural technician	(construction engineering, 74.6), (graphic and digital design, 5.3), (design and process engineering, 5.2), (business management, 2.0), (office administration, 1.9), (manufacturing methods, 1.4)
area sales manager	(general sales, 64.9), (complex sales, 30.0)
assistant accountant	(accounting and financial management, 92.9)
assistant management accountant	(accounting and financial management, 97.9)
assistant quantity surveyor	(construction engineering, 29.1), (accounting and financial management, 28.3), (procurement, 15.6), (business management, 8.2), (office administration, 5.7), (civil engineering, 3.8)
assistant store manager	(retail management, 55.3), (retail, 34.5), (business management, 7.1)
bar team member	(general sales, 94.2)
bookkeeper	(accounting and financial management, 47.1), (accounting admin, 26.4), (payroll and tax accounting, 22.5)
branch manager	(business management, 25.6), (general sales, 21.9), (retail, 11.9), (complex sales, 9.7), (accounting and financial management, 5.7), (office administration, 3.6), (retail management, 3.1), (accounting admin, 2.9), (procurement, 2.3), (system administration, 1.7), (supply chain management, 1.6)
brand manager	(marketing strategy and branding, 88.5), (retail, 4.9)
building surveyor	(construction engineering, 40.1), (business management, 11.1), (office administration, 9.6), (procurement, 8.5), (claims administration, 3.3), (financial asset management, 3.3), (audit and compliance, 3.0), (general sales, 2.9), (accounting and financial management, 2.4), (driving and automotive maintenance, 2.1), (complex sales, 1.9), (health, safety and environment, 1.8)
business analyst	(business analysis and it projects, 64.8), (bi and data warehousing, 6.6), (financial asset management, 6.4), (accounting and financial management, 5.5), (business management, 3.5), (securities trading, 3.3)
business development executive	(general sales, 54.1), (complex sales, 35.5), (marketing strategy and branding, 5.8)
business development manager	(complex sales, 66.5), (general sales, 24.8)
business manager	(complex sales, 39.8), (business management, 23.2), (general sales, 11.8), (accounting and financial management, 5.4), (retail, 4.4), (marketing strategy and branding, 4.3), (financial asset management, 2.7)

buyer	(procurement, 69.5), (retail, 6.9), (supply chain management, 5.4), (logistics administration, 3.0), (business management, 2.6), (accounting and financial management, 1.9), (office administration, 1.6)
c# developer	(software development, 88.9), (web development, 6.9)
cad technician	(design and process engineering, 39.3), (construction engineering, 36.6), (electrical engineering, 5.8), (civil engineering, 4.7), (structural engineering, 4.1)
care assistant	(social work and caregiving, 91.9)
care worker	(social work and caregiving, 93.8)
carpenter	(construction, 81.8), (construction engineering, 6.9), (driving and automotive maintenance, 5.8)
catering assistant	(retail management, 42.1), (driving and automotive maintenance, 17.2), (general sales, 10.7), (social work and caregiving, 9.6), (office administration, 7.0), (logistics administration, 3.0), (business management, 2.6)
chef	(retail management, 87.6), (retail, 3.2)
chef de partie	(retail management, 89.4), (business management, 2.6)
cleaner	(driving and automotive maintenance, 66.9), (retail management, 13.6), (social work and caregiving, 3.5), (office administration, 3.4), (business management, 2.9)
commercial manager	(procurement, 23.1), (business management, 20.5), (accounting and financial management, 16.0), (construction engineering, 9.5), (complex sales, 8.2), (retail, 4.7), (general sales, 3.6), (marketing strategy and branding, 3.1), (financial asset management, 2.3)
commercial property solicitor	(financial asset management, 35.3), (complex sales, 26.0), (general sales, 10.4), (legal services, 7.6), (procurement, 2.9), (office administration, 2.6), (business management, 2.0), (claims administration, 1.9), (construction engineering, 1.8)
commis chef	(retail management, 90.6)
contract manager	(business management, 52.7), (construction engineering, 17.1), (procurement, 16.1), (accounting and financial management, 4.9)

coordinator	(office administration, 24.8), (business management, 10.3), (accounting admin, 4.9), (accounting and financial management, 4.7), (general sales, 4.4), (event planning, 3.6), (social work and caregiving, 3.4), (teaching, 2.6), (logistics administration, 2.2), (manufacturing methods, 2.1), (supply chain management, 1.9), (procurement, 1.8), (patient assistance and care, 1.8), (graphic and digital design, 1.7), (oncology, 1.7), (audit and compliance, 1.6), (complex sales, 1.5), (construction engineering, 1.5), (medical admin, 1.3), (research methods and statistics, 1.1), (marketing strategy and branding, 1.1), (health, safety and environment, 1.0), (mental health, 1.0), (financial asset management, 0.9), (hr management, 0.9), (design and process engineering, 0.9), (shipping and warehouse operations, 0.8), (business analysis and it projects, 0.7), (retail, 0.6), (civil engineering, 0.6), (general practice, 0.6), (critical care, 0.6), (securities trading, 0.6), (software development, 0.5), (it support, 0.5)
credit controller	(accounting admin, 41.6), (accounting and financial management, 39.1), (office administration, 6.5), (general sales, 3.8)
customer adviser	(general sales, 54.9), (office administration, 11.2), (retail, 8.3), (accounting admin, 6.7), (complex sales, 6.2), (business management, 2.3), (logistics administration, 1.3)
customer assistant	(general sales, 46.2), (retail, 28.4), (retail management, 19.2)
customer service administrator	(office administration, 47.5), (general sales, 24.3), (logistics administration, 13.6), (accounting admin, 10.4)
customer service adviser	(general sales, 55.7), (office administration, 17.9), (logistics administration, 6.8), (accounting admin, 6.5), (retail, 3.8)
customer service assistant	(general sales, 56.7), (accounting admin, 13.4), (office administration, 10.0), (retail management, 7.0), (logistics administration, 6.3)
customer service executive	(general sales, 54.2), (office administration, 18.5), (logistics administration, 10.7), (accounting admin, 7.5)
customer service manager	(general sales, 30.1), (retail, 20.5), (business management, 17.6), (logistics administration, 6.5), (retail management, 5.8), (office administration, 5.3), (accounting admin, 3.5), (accounting and financial management, 1.8)
customer service representative	(general sales, 46.1), (office administration, 20.8), (logistics administration, 14.5), (accounting admin, 9.5)

data analyst	(bi and data warehousing, 40.8), (marketing research, 28.6), (accounting and financial management, 8.5), (data engineering, 2.8), (office administration, 2.7), (financial asset management, 2.4), (marketing strategy and branding, 1.7), (software development, 1.7), (accounting admin, 1.0)
data scientist	(data engineering, 48.4), (marketing research, 31.5), (physics and math, 6.6), (bi and data warehousing, 3.4), (software development, 2.9)
design engineer	(design and process engineering, 57.0), (electronics, 11.5), (construction engineering, 7.0), (manufacturing methods, 5.9), (electrical engineering, 5.2), (civil engineering, 3.1), (structural engineering, 2.4)
designer	(graphic and digital design, 57.8), (design and process engineering, 9.4), (marketing strategy and branding, 6.6), (construction engineering, 5.8), (event planning, 1.8), (electronics, 1.4), (web development, 1.4), (retail, 1.3), (business management, 1.3), (manufacturing methods, 1.2), (office administration, 1.0), (software development, 0.9), (complex sales, 0.8)
developer	(software development, 40.5), (web development, 23.5), (bi and data warehousing, 15.0), (data engineering, 3.6), (app development, 3.5), (business analysis and it projects, 2.7), (system administration, 1.2)
devops engineer	(system administration, 41.5), (software development, 39.8), (data engineering, 7.3), (web development, 3.1)
digital marketing executive	(digital marketing, 48.3), (marketing strategy and branding, 44.5)
digital marketing manager	(marketing strategy and branding, 72.2), (digital marketing, 24.8)
driver	(driving and automotive maintenance, 23.0), (shipping and warehouse operations, 20.6), (general sales, 13.9), (logistics administration, 6.3), (office administration, 5.1), (procurement, 4.3), (business management, 2.8), (retail, 2.7), (complex sales, 1.8), (social work and caregiving, 1.8), (construction engineering, 1.5), (manufacturing methods, 1.5), (retail management, 1.3), (accounting admin, 1.1), (health, safety and environment, 1.0), (civil engineering, 0.9), (construction, 0.7)
electrical design engineer	(electrical engineering, 66.3), (construction engineering, 17.1), (design and process engineering, 7.1)
electrical engineer	(electrical engineering, 75.4), (construction engineering, 8.6), (electronics, 3.7), (design and process engineering, 3.5)

electrical maintenance engineer	(electrical engineering, 61.7), (manufacturing methods, 19.4), (heating, ventilation and plumbing, 3.9), (driving and automotive maintenance, 3.6), (electrical work, 2.8)
electrician	(electrical work, 67.4), (electrical engineering, 23.6)
electronics engineer	(electronics, 93.9)
embedded software engineer	(software development, 70.7), (electronics, 27.4)
engineering manager	(manufacturing methods, 43.7), (business management, 23.7), (electrical engineering, 10.3), (design and process engineering, 7.6), (construction engineering, 3.5), (structural engineering, 2.1)
english teacher	(teaching, 99.6)
estimator	(construction engineering, 54.4), (procurement, 7.9), (accounting and financial management, 7.2), (business management, 3.6), (general sales, 3.6), (driving and automotive maintenance, 3.5), (office administration, 3.3), (manufacturing methods, 2.4), (civil engineering, 1.8), (complex sales, 1.7), (logistics administration, 1.6)
executive assistant	(office administration, 94.1)
field sales executive	(general sales, 90.3)
field service engineer	(electrical engineering, 43.2), (driving and automotive maintenance, 15.3), (it support, 9.2), (manufacturing methods, 7.6), (logistics administration, 3.3), (heating, ventilation and plumbing, 2.6), (general sales, 2.4), (design and process engineering, 2.1), (office administration, 1.5), (electrical work, 1.4), (business management, 1.4)
finance administrator	(accounting admin, 33.0), (office administration, 28.9), (accounting and financial management, 27.5), (payroll and tax accounting, 4.1)
finance analyst	(accounting and financial management, 96.3)
finance assistant	(accounting and financial management, 50.3), (accounting admin, 34.6), (office administration, 8.2)
finance business partner	(accounting and financial management, 82.8), (business management, 7.2), (financial asset management, 3.9)
finance manager	(accounting and financial management, 88.2), (business management, 4.4)
financial accountant	(accounting and financial management, 99.4)
financial analyst	(accounting and financial management, 95.3)
financial controller	(accounting and financial management, 92.9)
front end developer	(web development, 89.5), (software development, 5.3)

general manager	(business management, 37.6), (complex sales, 10.2), (retail, 8.7), (accounting and financial management, 7.4), (general sales, 6.7), (retail management, 6.0), (marketing strategy and branding, 5.3), (office administration, 3.0), (event planning, 1.6), (design and process engineering, 1.4), (manufacturing methods, 1.4), (social work and caregiving, 1.3)
geography teacher	(teaching, 99.9)
graphic designer	(graphic and digital design, 90.5)
head chef	(retail management, 80.3), (business management, 5.9), (retail, 3.7), (accounting and financial management, 1.7)
healthcare assistant	(social work and caregiving, 73.2), (phlebotomy, 4.3), (patient assistance and care, 3.5), (mental health, 2.8), (general practice, 2.6), (screening and immunisation, 2.1), (business management, 1.4), (office administration, 1.1)
hgv driver	(shipping and warehouse operations, 30.4), (driving and automotive maintenance, 27.1), (general sales, 13.1), (procurement, 5.5), (logistics administration, 4.2), (complex sales, 3.6), (office administration, 3.5), (retail, 1.7), (manufacturing methods, 1.1)
hgv technician	(driving and automotive maintenance, 70.2), (logistics administration, 9.6), (electrical engineering, 7.9), (automotive engineering, 2.0), (procurement, 1.4)
home manager	(social work and caregiving, 73.5), (business management, 23.2)
housekeeper	(retail management, 64.2), (social work and caregiving, 28.1)
human resource administrator	(office administration, 72.1), (hr management, 9.7), (payroll and tax accounting, 5.0), (accounting and financial management, 2.4), (business management, 2.4)
human resource adviser	(hr management, 53.7), (business management, 24.8), (office administration, 8.5), (complex sales, 1.6), (accounting and financial management, 1.5)
human resource assistant	(office administration, 53.9), (hr management, 18.8), (payroll and tax accounting, 6.4), (business management, 5.7), (accounting and financial management, 2.4), (employee development, 1.5), (accounting admin, 1.3)
human resource manager	(hr management, 45.3), (business management, 42.3), (office administration, 3.0)
infrastructure engineer	(system administration, 67.2), (civil engineering, 6.9), (construction engineering, 4.3), (structural engineering, 4.2), (it support, 3.9), (software development, 3.7)
internal sales executive	(general sales, 98.1)

it project manager	(business analysis and it projects, 38.4), (business management, 32.3), (system administration, 6.9), (software development, 2.6), (complex sales, 2.0), (accounting and financial management, 2.0), (procurement, 1.8), (accounting software, 1.5), (financial asset management, 1.4), (bi and data warehousing, 1.2)
it support analyst	(it support, 70.2), (system administration, 23.3)
it support engineer	(it support, 61.8), (system administration, 33.6)
java developer	(software development, 69.6), (servers and middleware, 11.3), (web development, 9.8)
key account manager	(complex sales, 39.5), (general sales, 24.6), (retail, 7.8), (business management, 4.6), (marketing strategy and branding, 3.7), (medical device sales, 3.3), (accounting and financial management, 2.9), (dermatology, 1.6), (oncology, 1.3), (nutrition and diabetes management, 1.0)
key stage teacher	(teaching, 89.4), (business management, 8.5)
kitchen team member	(general sales, 92.7)
labourer	(driving and automotive maintenance, 26.7), (construction, 20.7), (construction engineering, 14.0), (business management, 6.8), (logistics administration, 6.0), (health, safety and environment, 5.2), (welding and machining, 2.1), (office administration, 2.1), (electrical work, 1.5), (heating, ventilation and plumbing, 1.4), (manufacturing methods, 1.4), (civil engineering, 1.3), (insurance and lending, 1.1)
learning support assistant	(teaching, 61.0), (social work and caregiving, 17.1), (office administration, 7.1), (business management, 4.2), (mental health, 2.5)
legal secretary	(office administration, 82.4), (legal services, 17.2)
maintenance engineer	(electrical engineering, 50.3), (manufacturing methods, 28.0), (driving and automotive maintenance, 5.6), (heating, ventilation and plumbing, 3.2), (business management, 2.3), (welding and machining, 2.0)
maintenance technician	(electrical engineering, 43.2), (manufacturing methods, 19.4), (heating, ventilation and plumbing, 9.8), (driving and automotive maintenance, 9.0), (business management, 3.6), (electrical work, 3.4), (welding and machining, 2.6)
management accountant	(accounting and financial management, 98.3)
manufacturing engineer	(manufacturing methods, 83.1), (design and process engineering, 5.2), (electrical engineering, 1.8)
marketing assistant	(marketing strategy and branding, 46.9), (event planning, 36.0), (digital marketing, 10.5)

marketing executive	(marketing strategy and branding, 68.2), (event planning, 18.8), (digital marketing, 10.4)
marketing manager	(marketing strategy and branding, 91.1)
mechanical design engineer	(design and process engineering, 85.1), (construction engineering, 4.3), (electrical engineering, 3.4)
mechanical engineer	(design and process engineering, 50.3), (manufacturing methods, 14.8), (electrical engineering, 14.6), (construction engineering, 7.0), (structural engineering, 4.5)
mechanical fitter	(electrical engineering, 33.9), (manufacturing methods, 23.3), (welding and machining, 11.3), (driving and automotive maintenance, 9.1), (electrical work, 4.2), (design and process engineering, 4.1), (heating, ventilation and plumbing, 3.9), (business management, 2.1)
nanny	(extracurricular activities and childcare, 38.3), (social work and caregiving, 29.8), (retail management, 11.4), (teaching, 8.4), (general sales, 3.4)
network engineer	(networks, 57.8), (system administration, 39.5)
nurse	(social work and caregiving, 38.7), (general practice, 10.8), (patient assistance and care, 10.4), (anesthesiology, 5.1), (oncology, 5.0), (critical care, 4.5), (mental health, 4.3), (business management, 2.7), (phlebotomy, 2.0), (screening and immunisation, 1.6), (gastroenterology, 1.4), (office administration, 1.4), (surgery, 1.0), (neurological disorders, 1.0), (cardiology, 1.0)
nursery nurse	(teaching, 39.9), (social work and caregiving, 27.5), (office administration, 9.0), (business management, 6.8), (general sales, 2.1), (extracurricular activities and childcare, 2.0), (retail management, 1.6), (event planning, 1.4)
occupational therapist	(mental health, 63.9), (social work and caregiving, 11.2), (neurological disorders, 7.3), (patient assistance and care, 4.9), (physiotherapy and beauty, 3.3)
office administrator	(office administration, 95.6)
office manager	(office administration, 76.9), (business management, 7.6), (accounting admin, 3.7), (accounting and financial management, 3.4)
operations manager	(business management, 74.2), (manufacturing methods, 5.5), (retail management, 3.0), (supply chain management, 2.2), (accounting and financial management, 1.8), (procurement, 1.6), (office administration, 1.5), (shipping and warehouse operations, 1.4)
pa	(office administration, 90.7)

paraplanner	(financial asset management, 40.6), (accounting and financial management, 24.7), (office administration, 8.9), (general sales, 5.6), (research methods and statistics, 4.3), (health, safety and environment, 3.1), (marketing strategy and branding, 1.5), (payroll and tax accounting, 1.2), (business management, 1.2)
payroll administrator	(payroll and tax accounting, 91.1)
personal assistant	(office administration, 77.9), (social work and caregiving, 12.5)
personal trainer	(general sales, 30.4), (marketing strategy and branding, 15.8), (multimedia production, 14.0), (event planning, 9.7), (claims administration, 5.5), (nutrition and diabetes management, 4.1), (driving and automotive maintenance, 3.9), (employee development, 3.2), (complex sales, 2.8), (molecular biology processes, 2.7)
php developer	(web development, 82.9), (software development, 13.5)
physiotherapist	(physiotherapy and beauty, 32.2), (patient assistance and care, 20.6), (neurological disorders, 7.3), (mental health, 6.7), (social work and caregiving, 5.7), (office administration, 4.2), (general practice, 3.8), (oncology, 3.3), (patient support, 1.9), (business management, 1.8), (screening and immunisation, 1.7), (dermatology, 1.5)
planner	(environmental planning, 30.5), (construction engineering, 17.2), (business management, 10.0), (supply chain management, 6.3), (office administration, 6.2), (procurement, 5.5), (accounting and financial management, 3.7), (business analysis and it projects, 3.1), (marketing strategy and branding, 2.1), (civil engineering, 1.3), (logistics administration, 1.3), (retail, 1.2), (financial asset management, 1.1), (shipping and warehouse operations, 1.1)
plumber	(heating, ventilation and plumbing, 88.7), (construction, 2.9)
primary school teacher	(teaching, 89.8), (business management, 8.4)
procurement manager	(procurement, 87.4), (business management, 7.3)
product manager	(marketing strategy and branding, 39.5), (complex sales, 18.9), (retail, 13.0), (data engineering, 3.7), (business analysis and it projects, 3.5), (software development, 2.9), (business management, 2.7), (financial asset management, 2.0), (design and process engineering, 1.9), (web development, 1.6), (marketing research, 1.4)

production manager	(manufacturing methods, 39.5), (business management, 30.7), (supply chain management, 5.7), (procurement, 3.0), (retail, 2.7), (retail management, 2.1), (accounting and financial management, 1.9), (logistics administration, 1.7), (marketing strategy and branding, 1.6), (biotechnology manufacturing, 1.2)
production operative	(manufacturing methods, 26.1), (driving and automotive maintenance, 15.4), (logistics administration, 11.3), (welding and machining, 8.3), (office administration, 6.0), (business management, 4.6), (retail management, 4.2), (electrical work, 3.6), (construction, 2.6), (retail, 1.9), (shipping and warehouse operations, 1.8), (electrical engineering, 1.7), (general sales, 1.5), (procurement, 1.3)
programme manager	(business management, 69.6), (business analysis and it projects, 9.6), (complex sales, 2.6), (procurement, 1.8), (design and process engineering, 1.4), (manufacturing methods, 1.4), (financial asset management, 1.4), (accounting and financial management, 1.3), (marketing strategy and branding, 1.2)
project coordinator	(office administration, 27.9), (business management, 12.7), (accounting and financial management, 9.1), (business analysis and it projects, 5.7), (general sales, 4.3), (construction engineering, 3.9), (procurement, 3.8), (accounting admin, 3.7), (event planning, 3.1), (logistics administration, 2.9), (networks, 2.0), (complex sales, 1.9), (retail, 1.3), (design and process engineering, 1.2), (manufacturing methods, 1.2), (financial asset management, 1.1), (marketing strategy and branding, 1.0), (accounting software, 0.9), (supply chain management, 0.9), (research methods and statistics, 0.7), (it support, 0.6), (clinical research, 0.5)
project engineer	(design and process engineering, 20.5), (manufacturing methods, 14.7), (construction engineering, 12.5), (electrical engineering, 10.9), (business management, 8.4), (procurement, 5.5), (accounting and financial management, 3.2), (electronics, 3.2), (structural engineering, 2.6), (civil engineering, 2.0), (business analysis and it projects, 1.9), (system administration, 1.9), (automotive engineering, 1.4), (office administration, 1.1), (complex sales, 1.0)

project manager	(business management, 37.0), (business analysis and it projects, 11.5), (construction engineering, 10.1), (procurement, 5.5), (accounting and financial management, 4.7), (complex sales, 2.5), (office administration, 2.4), (financial asset management, 2.0), (general sales, 1.8), (manufacturing methods, 1.6), (design and process engineering, 1.6), (electrical engineering, 1.5), (software development, 1.4), (marketing strategy and branding, 1.2), (networks, 1.1), (system administration, 0.9), (civil engineering, 0.7), (bi and data warehousing, 0.7), (accounting software, 0.7), (retail, 0.7), (securities trading, 0.6)
property manager	(business management, 25.7), (office administration, 18.9), (claims administration, 14.7), (financial asset management, 8.1), (accounting admin, 7.6), (accounting and financial management, 5.6), (driving and automotive maintenance, 5.3), (general sales, 4.1)
purchase ledger clerk	(accounting admin, 64.9), (accounting and financial management, 27.2)
python developer	(software development, 37.3), (data engineering, 32.2), (web development, 26.2)
quality engineer	(manufacturing methods, 69.5), (audit and compliance, 7.1), (business management, 4.9), (procurement, 2.5), (design and process engineering, 1.7), (electronics, 1.2), (biotechnology manufacturing, 1.0), (office administration, 1.0), (electrical engineering, 0.9), (general sales, 0.8)
quality inspector	(manufacturing methods, 56.6), (welding and machining, 13.5), (business management, 4.0), (office administration, 3.7), (logistics administration, 2.4), (electronics, 1.9), (electrical engineering, 1.7), (health, safety and environment, 1.6), (driving and automotive maintenance, 1.6), (audit and compliance, 1.5), (procurement, 1.3), (electrical work, 1.2)
quality manager	(manufacturing methods, 46.1), (business management, 15.6), (audit and compliance, 12.0), (procurement, 3.1), (retail management, 2.4), (biotechnology manufacturing, 2.4), (office administration, 1.6), (laboratory techniques, 1.1), (accounting and financial management, 1.1), (complex sales, 1.0), (general sales, 1.0), (business analysis and it projects, 0.8), (health, safety and environment, 0.8), (employee development, 0.7), (design and process engineering, 0.7)

quantity surveyor	(construction engineering, 26.7), (accounting and financial management, 26.2), (procurement, 20.1), (business management, 12.7), (civil engineering, 3.2), (office administration, 2.4)
receptionist	(office administration, 73.9), (general sales, 9.2), (accounting admin, 2.3), (retail management, 1.4), (business management, 1.2), (securities trading, 1.1), (retail, 1.1)
recruitment administrator	(office administration, 72.8), (recruitment, 4.1), (general sales, 3.8), (event planning, 3.2), (digital marketing, 2.1), (business management, 1.6), (payroll and tax accounting, 1.6), (accounting and financial management, 1.6)
recruitment consultant	(general sales, 47.5), (complex sales, 20.3), (recruitment, 5.4), (marketing strategy and branding, 3.1), (business management, 2.9), (office administration, 2.4), (accounting and financial management, 2.1), (digital marketing, 1.7), (accounting admin, 1.7), (procurement, 1.4), (system administration, 1.4), (financial asset management, 1.2)
registered general nurse	(social work and caregiving, 58.0), (patient assistance and care, 8.1), (screening and immunisation, 7.3), (general practice, 6.0), (mental health, 3.7), (phlebotomy, 3.5), (business management, 2.5), (critical care, 2.1)
registered nurse	(social work and caregiving, 57.2), (patient assistance and care, 12.7), (mental health, 4.4), (general practice, 4.2), (business management, 3.0), (oncology, 2.4), (phlebotomy, 2.0), (anesthesiology, 1.9), (critical care, 1.2), (pharmacy, 1.1)
restaurant manager	(retail management, 85.7), (business management, 6.5)
sales account manager	(general sales, 87.9), (complex sales, 10.0)
sales administrator	(general sales, 71.0), (office administration, 20.5)
sales adviser	(general sales, 95.1)
sales assistant	(general sales, 85.6), (retail, 10.8)
sales consultant	(general sales, 86.5), (complex sales, 7.1)
sales coordinator	(general sales, 86.6), (office administration, 6.1)
sales engineer	(complex sales, 45.4), (general sales, 39.1), (electrical engineering, 5.9)
sales executive	(general sales, 93.7)
sales manager	(general sales, 57.6), (complex sales, 31.9), (retail, 4.7)
sales negotiator	(general sales, 97.6)
sales representative	(general sales, 90.1)
school teacher	(teaching, 90.5)
science teacher	(teaching, 94.5)
sen teaching assistant	(teaching, 82.3), (social work and caregiving, 9.9)

service adviser	(general sales, 46.2), (accounting admin, 17.2), (driving and automotive maintenance, 10.4), (logistics administration, 10.1), (office administration, 6.8)
service desk analyst	(it support, 46.4), (system administration, 26.6), (office administration, 5.9), (business management, 4.6), (general sales, 4.5), (networks, 2.2)
service engineer	(electrical engineering, 43.3), (driving and automotive maintenance, 13.3), (manufacturing methods, 8.3), (heating, ventilation and plumbing, 6.6), (it support, 4.4), (electrical work, 3.4), (general sales, 3.2), (logistics administration, 2.4), (business management, 2.2), (office administration, 1.4), (design and process engineering, 1.1), (networks, 0.9)
service manager	(business management, 41.1), (social work and caregiving, 14.4), (general sales, 4.9), (retail, 3.6), (system administration, 3.6), (accounting and financial management, 3.4), (mental health, 3.2), (business analysis and it projects, 2.6), (office administration, 2.4), (complex sales, 2.1), (electrical engineering, 1.9), (accounting admin, 1.1), (manufacturing methods, 1.1), (procurement, 0.9), (financial asset management, 0.9), (driving and automotive maintenance, 0.9), (logistics administration, 0.8), (heating, ventilation and plumbing, 0.8), (general practice, 0.7)
site engineer	(construction engineering, 33.0), (civil engineering, 25.6), (electrical engineering, 8.3), (business management, 6.6), (design and process engineering, 3.9), (health, safety and environment, 3.7), (manufacturing methods, 3.1), (structural engineering, 2.8), (procurement, 1.9), (office administration, 1.6)
site manager	(business management, 36.4), (construction engineering, 33.9), (procurement, 5.5), (office administration, 2.7), (health, safety and environment, 2.1), (civil engineering, 2.0), (accounting and financial management, 1.9), (general sales, 1.7), (construction, 1.6), (retail management, 1.3), (supply chain management, 1.1)
social worker	(mental health, 49.3), (social work and caregiving, 41.5)
software developer	(software development, 89.6), (web development, 6.5)
software engineer	(software development, 81.4), (electronics, 6.3), (web development, 3.6)

solution architect	(business analysis and it projects, 36.4), (software development, 17.9), (system administration, 6.9), (complex sales, 5.7), (data engineering, 4.8), (bi and data warehousing, 3.8), (business management, 3.7), (web development, 3.0), (networks, 3.0), (servers and middleware, 1.8), (accounting software, 1.2), (general sales, 1.1), (financial asset management, 1.1)
staff nurse	(social work and caregiving, 45.0), (patient assistance and care, 7.8), (mental health, 6.7), (general practice, 5.8), (oncology, 4.7), (critical care, 4.6), (anesthesiology, 3.3), (business management, 2.6), (office administration, 2.0), (neurological disorders, 1.7), (gastroenterology, 1.4), (gynecology and urology, 1.4), (phlebotomy, 1.3), (surgery, 1.1), (ophthalmology, 1.0)
store manager	(retail management, 50.8), (retail, 32.1), (business management, 9.0)
structural engineer	(structural engineering, 37.2), (construction engineering, 29.6), (design and process engineering, 13.0), (civil engineering, 10.8)
support worker	(social work and caregiving, 75.9), (mental health, 5.9), (business management, 3.4), (general sales, 2.5), (office administration, 1.7), (teaching, 1.4)
systems engineer	(electronics, 37.2), (system administration, 23.7), (software development, 8.6), (business analysis and it projects, 6.0), (electrical engineering, 5.7), (design and process engineering, 5.4), (networks, 2.7), (complex sales, 2.1)
teacher	(teaching, 94.9)
teacher of english	(teaching, 99.9)
teaching assistant	(teaching, 89.2), (social work and caregiving, 4.0)
technical manager	(business management, 16.4), (construction engineering, 16.1), (manufacturing methods, 12.3), (retail management, 6.8), (design and process engineering, 4.6), (audit and compliance, 4.3), (procurement, 3.8), (complex sales, 2.8), (general sales, 2.3), (laboratory techniques, 2.3), (biotechnology manufacturing, 2.1), (it support, 2.0), (retail, 2.0), (electrical engineering, 2.0), (system administration, 1.7), (structural engineering, 1.6), (business analysis and it projects, 1.4), (accounting and financial management, 1.4), (office administration, 1.3), (software development, 1.1), (civil engineering, 1.0), (electronics, 0.9)

technician	(driving and automotive maintenance, 31.7), (electrical engineering, 10.2), (manufacturing methods, 5.6), (it support, 3.4), (general sales, 3.4), (construction engineering, 3.2), (office administration, 2.9), (laboratory techniques, 2.5), (business management, 2.1), (accounting and financial management, 1.9), (heating, ventilation and plumbing, 1.6), (electrical work, 1.4), (civil engineering, 1.4), (logistics administration, 1.3), (welding and machining, 1.3), (electronics, 1.3), (design and process engineering, 1.1), (teaching, 1.1), (networks, 1.0), (system administration, 1.0), (claims administration, 1.0), (automotive engineering, 0.9), (procurement, 0.9), (biotechnology manufacturing, 0.9), (anesthesiology, 0.8), (software development, 0.7), (accounting admin, 0.6), (audit and compliance, 0.6), (financial asset management, 0.6), (gastroenterology, 0.6), (multimedia production, 0.5), (patient assistance and care, 0.5), (biochemistry, 0.5), (microfluidics, 0.5), (health, safety and environment, 0.5), (phlebotomy, 0.5)
telesales executive	(general sales, 97.7)
test analyst	(software development, 64.0), (business analysis and it projects, 12.8), (bi and data warehousing, 3.8), (accounting and financial management, 2.7), (business management, 2.0), (web development, 1.8), (system administration, 1.6), (electronics, 1.2), (securities trading, 1.1)
test engineer	(software development, 53.4), (electronics, 19.5), (electrical engineering, 5.2), (manufacturing methods, 4.6), (business analysis and it projects, 1.8), (design and process engineering, 1.7), (system administration, 1.5), (automotive engineering, 1.3), (networks, 1.3)
trainee recruitment consultant	(general sales, 55.7), (complex sales, 18.0), (recruitment, 3.9), (marketing strategy and branding, 2.8), (office administration, 2.5), (financial asset management, 2.3), (digital marketing, 2.0), (procurement, 1.8), (business management, 1.6)
transport planner	(shipping and warehouse operations, 53.7), (civil engineering, 22.7), (office administration, 5.4), (business management, 5.0), (environmental planning, 4.2)
tutor	(teaching, 93.1)
user experience designer	(graphic and digital design, 60.3), (web development, 23.2), (software development, 2.7), (design and process engineering, 1.9), (business analysis and it projects, 1.6), (marketing strategy and branding, 1.3)

vehicle technician	(driving and automotive maintenance, 81.7), (electrical engineering, 3.0), (general sales, 2.9), (logistics administration, 2.8)
veterinary surgeon	(surgery, 78.9), (diagnostic imaging, 4.2), (prosthodontics and orthodontics, 4.0), (patient assistance and care, 2.6), (phlebotomy, 1.7)
warehouse operative	(logistics administration, 23.7), (office administration, 21.0), (shipping and warehouse operations, 19.3), (driving and automotive maintenance, 13.9), (procurement, 4.1), (manufacturing methods, 3.0), (general sales, 2.6), (supply chain management, 2.5)
web developer	(web development, 77.4), (software development, 17.0)

*The top 200 job titles were selected based on the frequency of unique job titles (after cleaning and pre-processing) in adverts collected in 2017.

**Shown are the skill clusters that in total account for at least 90% of job title composition by third layer clusters.

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