USING LINKEDIN TO ESTIMATE THE EMPLOYMENT OF THE UK CALIBRATION AND TESTING SECTOR

This study attempts to estimate the size of the segment of the UK labour supply whose primary job function is to provide calibration and testing (measurement) services by utilising employment data collated by members of the professional social networking service LinkedIn (linkedin.com) whom self-report their employment status on the website. It provides an alternative method of estimating the employment of the calibration and testing sector to that detailed in the Quantifying Measurement Activity in the UK study which is founded on official national statistics. Both methods yield similar estimates thereby enhancing their validity. This document begins by introducing the context and motivation behind this piece of research, followed by an in-depth description of the dataset which includes the capabilities of its search tools and its limitations. This is followed by a step-by-step breakdown of the methodology for calculating the estimate of employment before presenting the results. Lastly, it is briefly speculated how this research could be expanded upon by harnessing more advanced search filters offered by LinkedIn to obtain further insights into the calibration and testing sector.

1 INTRODUCTION

Measurement products and services are used frequently by both producers and consumers at almost every stage of the supply chain and across a broad range of industries. Accurate, traceable measurements ease trade frictions by demonstrating the quality and quantity of products to consumers and suppliers, plus, improved measurement capabilities facilitate the development of innovative products and processes. In each instance, individuals with the knowledge to calibrate and/or test are employed to carry out measurements to an appropriate degree of accuracy. Examples of these occupations include Calibration Technicians, Quality Assurance Engineers and Analytical Chemists. These employees form the labour input of what is referred to in this analysis as the calibration and testing sector.

1.1 CONTEXT ON THE UK CALIBRATION AND TESTING SECTOR

Calibration is the comparison of an instrument against a reference or standard to identify and correct for errors in the instrument readings. Instrument users wanting to make good quality measurements or ensure that industry specifications are met will need their instruments to be calibrated with an accuracy and precision that fits their intended purpose.

But who determines the accuracy of a measurement? Alongside five other core laboratories, NPL sits atop of a chain of measurements that uphold national standards – the UK National Measurement System (NMS).[1] The NMS is the technical and organisation infrastructure which ensures a consistent and internationally recognised basis for measurement in the UK.[2] Its central objectives are:

1 The six NMS labs are: National Physical Laboratory (the UK's National Measurement Institute), National Measurement Laboratory at LGC (chemical and biometrology), National Engineering Laboratory (fluid flow metrology), Office for Product Safety and Standards (legal metrology), National Gear Metrology Laboratory (gears metrology), National Institute for Biological Standards and Control (bioactivity metrology).

2 (Department of Trade and Industry, 1989)

- to enable individuals and organisations in the UK to make measurements competently and accurately;
- to demonstrate the validity of such measurement;
- and to coordinate the UK's measurement system with the measurement systems of other countries.

The NMS labs have the capacity to support metrology in several fields, from mass and nuclear metrology to chemical analysis, fluid flow and biometrology. They underpin the UK's technical infrastructure by supplying services to commercial calibration laboratories, who then go on to calibrate the instruments of their own customers, diffusing measurement accuracy through a chain of linked calibrations. This 'fan-out' of national measurement standards extends the reach of the NMS to thousands of organisations across the UK. Consequently, once an instrument user receives one calibration, they may use that knowledge as reference to calibrate any number of their own similar instruments or products – this is referred to as 'in-house' calibration. In-house calibration is not specific to any particular industry because instrumentation is useful in multiple sectors, hence why there are no available national statistics that quantify the scale of these activities.

The testing sector uses measurement tools and theories to test the characteristics and performance of products. Their services assure consumers, businesses and government institutions of the safety and quality of the products they buy and sell with specific regard to British, European and International standards. Companies whose primary service is to provide testing services are conveniently grouped into one SIC 07 code, ***72.1*** *Technical Testing and Analysis*. It is a sub-category of section M in the SIC classification, *Professional, scientific and technical activities*. Businesses in the industry offer a wide range of services including acoustics and vibration testing, testing of composition and purity of minerals (etc.), testing of physical characteristics and performance of materials. However, within many sectors, testing is often a vital stage in the production process and can also occur in-house.

1.2 MOTIVATION

The pervasive nature of measurement poses a challenge for those who wish to survey the landscape for measurement activities.[3] As measurement products and services are crucial inputs in the activities of many industries, from Manufacturing to Telecommunications to Health, standard national industrial data collection praxis often absorbs their value into these industries' output. Existing evidence that attempts to unpick the true value of measurement within a 21st Century economy is sparse. As the UK's National Measurement Institute, it seems logical that NPL should provide some impetus for such research in the UK; as well as shoring up our evidence to justify the impact of internal activities, the benefits of a comprehensive analysis of the market for measurement would extend to all agents who operate within networks that depend on the supply of measurement goods or services by allowing for better informed forecasting and investment decisions.

The parent study to this piece of analysis, *Quantifying UK Measurement Activity*, is our first venture into this area of research – it divides measurement activity into four key elements (labour input, investment, intermediate demand, and research and development) and dissects spending on each element with the assistance of a variety of open data sources. Within the chapter on labour input, an analysis of the segment of the labour supply whose occupations require the use of instruments, some space is given to estimating the even smaller subset of workers who are employed specifically for their knowledge of calibration and testing with the use of instruments. We identify this group of employees as the operational arm of the calibration and testing sector and, through a thorough analysis of Standard Occupational Classification 2010 (SOC 10) codes combined with some key assumptions, are able to reveal

3 Measurement activities are defined in *Quantifying UK Measurement Activity* (Fennelly, 2021)

the size of this sector, the value it generates and even the industries that are most dependent on their services. It is estimated that there were 162,000 employees providing calibration and testing (measurement) services in the UK in 2017.

Given the value of such information, this analysis seeks to validate the aforementioned estimate by arriving at a similar estimate using an alternative method. The method devised is founded on data collated by members of the professional networking service, LinkedIn. LinkedIn members self-report their employment history in as much detail as they choose, publicly providing their specific job titles, thus, overcoming a major obstacle in measurement activity research being that we are attempting to analyse a niche area of economic activity that is not captured by most large datasets. Utilising built in search tools designed for recruiters to identify potential job candidates, we can filter through LinkedIn members to find the number of individuals with a LinkedIn account employed in a calibration or testing occupation in a specific location. This method could be more advantageous than the method outlined in *Quantifying UK Measurement Activity* because LinkedIn boasts rich employment data from millions of contributors across the globe and goes further than to just state the number of individuals employed for a specific task but can also be disaggregated by industry, age, skills, and level of education for further analyses.

2 DATA

LinkedIn is the world's largest professional social network with more than 700 million members worldwide, with new members joining at a rate of roughly two per second.[4] Combining interactive features of traditional social networking sites such as Twitter and Facebook with a built-in jobs board, LinkedIn provides and online forum that draws together candidates and clients seeking professional opportunities. LinkedIn member profiles serve as an online curriculum vitae, allowing individuals to broadcast their employment history, their education, their skills and their interests which has the potential to be lifted and analysed to produce voluminous data on international labour markets.

2.1 LINKEDIN PROFILES

Upon signing up to LinkedIn, members are required to provide personal and geographical details including their full name, country, post code and location within that area, plus occupational details including most recent job title (or educational institution/qualification if they are a student), most recent company and, optionally, employment type (e.g. full-time/part-time). When entering their job title and company, LinkedIn standardises the responses by mapping member inputs against a comprehensive taxonomy of more than 22,000 job titles and a community of more than 50 million listed companies.[5] Although, members can bypass this function and instead opt to input any string of text they please.

Following the initial creation of a profile, LinkedIn encourages members to increase the strength of their profiles by issuing prompts to add work dates for all current and previous jobs, universities or schools attended, at least five skills and a summary of their expertise and interests. Members can choose to divulge further information including any licenses and certifications, volunteer experience, and personal accomplishments such as publications, test scores and honours.

4 (Juni Zhu, Fritzler, & Orlowski, 2018)

5 (LinkedIn, 2021)

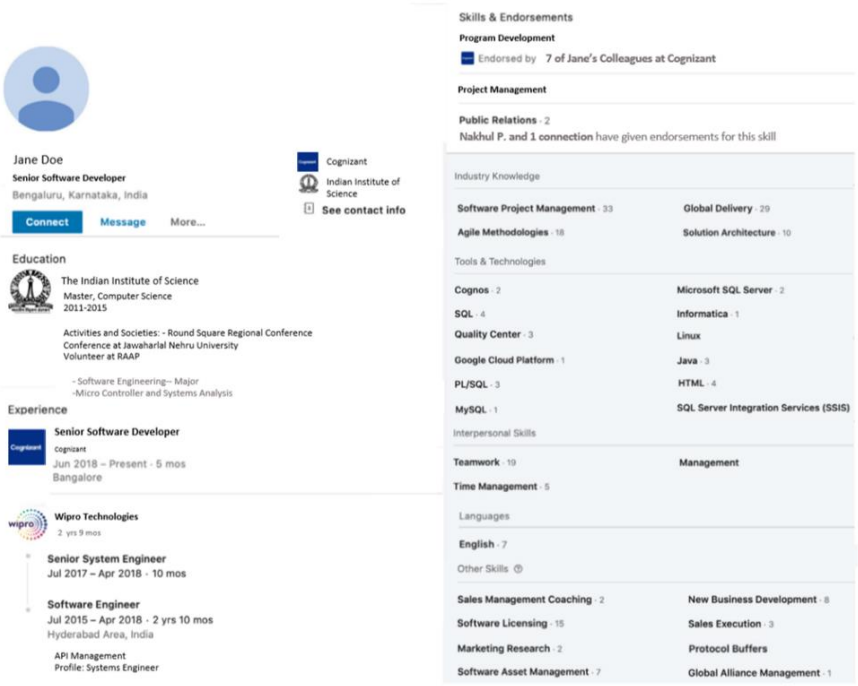

Figure 1: Sample LinkedIn profile

2.2 SEARCH TOOLS

Standard LinkedIn members have restricted capabilities to search for other members on the website, limited to a certain number of searches per month, using a basic set of search filters, which only return an approximate number of members (of which results will stop displaying after 1,000 profiles).

To capture the wealth of labour market data offered by LinkedIn, we acquired a subscription to LinkedIn's Recruiter Lite product. Aimed at employers seeking to target prospective hires, Recruiter Lite offers a range of additional features designed to allow users to home in on talent, including unlimited people browsing with more than 20 search filters.

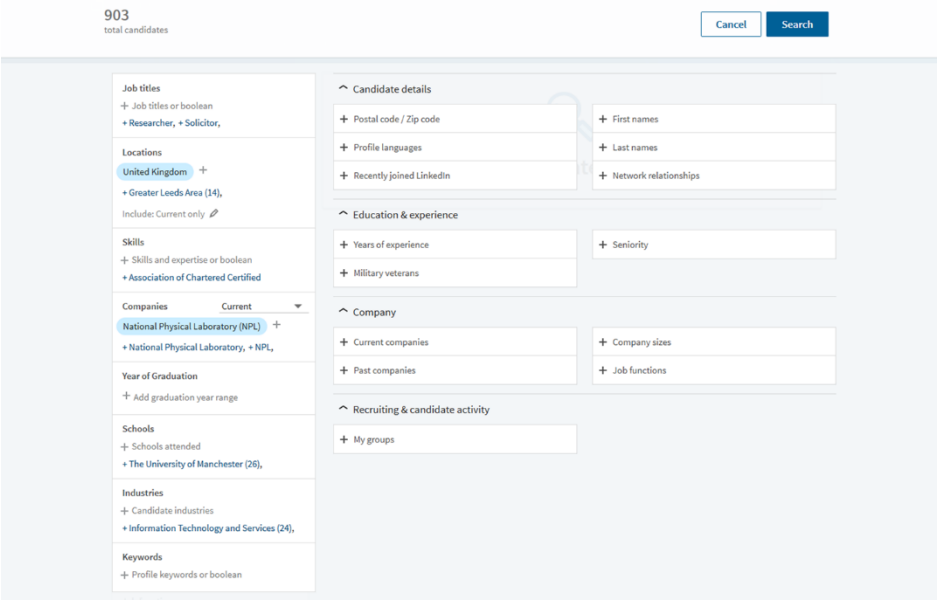

Figure 2: LinkedIn Recruiter Lite search for employees currently at NPL in the UK. Returns 903 candidates

Crucially, search filters include job titles, locations and companies. The latter can be further disaggregated by current and past companies, company size and job function. Job functions provide broad groupings of common job roles based on the job title the member inputs. The classification of the job title in LinkedIn's title taxonomy determines the function a member performs in their job. Additionally, Recruiter Lite offers a selection of filters based on education and experience which could be useful for further analyses of the labour market.

Users can combine as many filters as they require to return a list of "candidates" (LinkedIn members) profiles that match the search criteria. These profiles can then be sorted through manually with full visibility of candidate profiles who are in the user's first, second or third degree networks. For the purposes of this analysis, we are only concerned with the aggregate number of candidates returned from each search.

2.3 ADVANTAGES

Granularity

With a comprehensive taxonomy of more than 22,000 job titles, populated by more than 28 million members in the UK, LinkedIn offers a rich source of data on small sectors of the economy that are not captured by national statistics. Traditional labour market data collection methods are based on surveying a small proportion of the population meaning that occupations have to be grouped up into broader categories in order to produce accurate findings; in the UK labour statistics by occupation are based on the Standard Occupation Classification (SOC) which disaggregates all occupations in the economy into a maximum of 369 categories.

Moreover, LinkedIn occupation classification is far less rigid than SOC, which undergoes significant reform every 10 years. Thus, the creation of relatively new careers such as social media specialist may not appear in national statistics for years but are immediately accounted for by LinkedIn's ever-growing taxonomy of job titles.

Timeliness

LinkedIn provides near real-time analytics on labour markets, as changes to the data are initiated by members updating their profiles which are instantaneously visible to other members. In contrast, traditional national labour market statistics suffer significant time lags between data collection and data publication.

Single data structure

LinkedIn facilitates comparisons between countries by having a single data structure and taxonomy. Whereas individual countries have their own methodologies and practices for publishing national labour market statistics, sometimes obstructing one-to-one international comparisons (particularly within highly specific markets such as calibration and testing), LinkedIn profile criteria are completely uniform no matter the location of the member and all inputs are mapped to a central classification.

2.4 LIMITATIONS

Selection bias

Unlike national labour market statistics which are based on randomised samples of the population, LinkedIn members select themselves into the sample resulting in a sample that is likely to be non-representative of the population. This analysis considers two key types of bias that LinkedIn data is particularly prone to: industry bias and occupational bias.

Industry bias is where members working within a certain industry are overrepresented or underrepresented in a sample compared to the actual population. The greatest industry coverage by LinkedIn data is in the knowledge-intensive and tradable sectors; the professional, scientific and technical activities sector has the second highest global industry coverage (behind ICT) representing approximately 26% of the actual population and an even greater

proportion within high income economies (e.g. the UK).[6] Occupational bias is where members with certain occupations are overrepresented or underrepresented in a sample compared to the actual population. 'Support' occupations, such as managers and analysts, are typically better represented on LinkedIn than 'delivery', manual labour-intensive occupations. Occupational bias drives some industry bias where in some industries, such as agriculture, support occupations make up a smaller portion of the occupational pool compared to other industries, such as finance. Both biases arise due to individuals experiencing varying degrees of necessity of being a LinkedIn member in order to advance in their chosen career.

Other forms of bias to consider include age and sex. The distribution of LinkedIn members by age is skewed towards capturing a younger sample of the workforce and slightly overrepresents men.

Spam and inactive profiles

This analysis relies on self-reported labour market data, which may not always be accurate for several reasons. For example, individuals may become LinkedIn members in order to be considered for a certain position, after which, LinkedIn has served its main purpose and they may neglect to update their profile as they advance through their career. This offsets some of the benefit of LinkedIn being a timely source of data.

Furthermore, anyone can create a LinkedIn profile if they provide a unique email address. Thus, individuals may generate spam accounts that do not represent real members of the population, either for research purposes or otherwise.

Without the same unfettered access to the LinkedIn database that LinkedIn data scientists have, there is no knowledge of how many spam and inactive profiles appear within searches of LinkedIn profiles.

Incompleteness

Although encouraged to provide as much information as possible, there is no requirement for LinkedIn members to input any personal information beyond their name, location and current job title and company (or education status). Members choosing not to fill out their profiles results in an incomplete dataset which must be taken into consideration during estimation with LinkedIn data. For the purposes of this analysis, we only extract data on three required variables (location, job title, current company) and so do not need to account for incomplete data.

3 METHODOLOGY AND RESULTS

This section provides a step-by-step explanation of the method devised to estimate the employment of the calibration and testing sector using LinkedIn data before presenting the results. It includes a description of the search filters employed to extract the data and accounts for industry and occupational bias and adjusts the findings accordingly.

All LinkedIn data was gathered via a LinkedIn account generated to be as non-descript as possible in order to minimise the impact of any potential search bias.[7] Data was collected in August 2020.

6 (Juni Zhu, Fritzler, & Orlowski, 2018)

7 As mentioned in chapter 2, some personal information is required to register a LinkedIn account. The account created to conduct this research was given the following details. Location: London, UK. Job title: None. Company: Nope. At the time of writing, it is unclear whether LinkedIn algorithms recommend candidates based on connections to an individual, but this precaution was taken to maximise the validity of the findings. Furthermore, data was gathered in as few searches as possible to avoid the possibility of LinkedIn learning what we are searching for, so to ensure the reproducibility of this analysis.

3.1 LINKEDIN DATA EXTRACTION

Using LinkedIn Recruiter Lite, a list of keywords relating to known calibration and testing occupations (e.g. metrology, calibration, test) were input in the job title field in order to gather a comprehensive list of calibration and testing occupations in LinkedIn taxonomy:

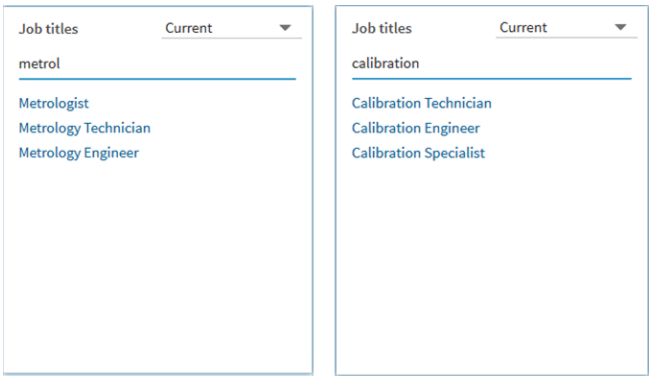

Figure 3: Example of LinkedIn job title filters

This produced a list of 61 job titles, plus a Boolean search for "Measurement Technician" OR "Measurement Analyst" OR "Measurement Scientist". Conducting a combined search for members who currently have any one of the 62 job titles AND currently live in the UK returned a total of 91,647 candidates.[8] These individuals represent the portion of the UK calibration and testing sector who are members of LinkedIn.

3.2 ACCOUNTING FOR SELECTION BIAS

To estimate the portion of the UK calibration and testing sector that are not LinkedIn members we require an industry specific solution. This method takes a random sample of UK companies who either require or provide calibration and testing services and compares the number of LinkedIn members who claim to be currently employed by each company with the most recent official company total employment figures. The corporate structure of these companies is likely to be similar and it is assumed that the overwhelming majority of calibration and testing employees will work for companies with these characteristics. Therefore, the fraction of each companies' employment that is visible on LinkedIn can represent a probability for the likelihood of a worker with a calibration or testing occupation being a LinkedIn member.

The sample of companies consists of UK companies with more than 100 employees, listed on LinkedIn and with a Manufacturing (10-33) or Technical Testing and Analysis (71.2) SIC 07 code – 34 observations in total.[9]

Searching LinkedIn for members currently employed by each company, separately, AND currently living in the UK then dividing the returned number of candidates by the actual employment of each respective company generates the distribution seen in *Figure 4*.[10] It is negatively skewed with a mean of 64% and a median of 63%. We take the median because we expect that the mean estimate is inflated by the presence of inactive accounts. Therefore, we estimate that, given that they are employed by a company that requires or provides calibration and testing services, a UK employee is a LinkedIn member with a probability of 63%.

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8 Refer to Table A1 for full list of job titles.

9 Refer to Table A2 for full list of companies.

10 The data in *Figure 4* excludes two outliers with unusually low staff coverage on LinkedIn: Goodwin PLC and Spectris PLC. Both these companies own several subsidiaries which could explain the low LinkedIn representation; staff may be self-reporting their company on LinkedIn for the subsidiaries but appearing in the employment data for the main company.

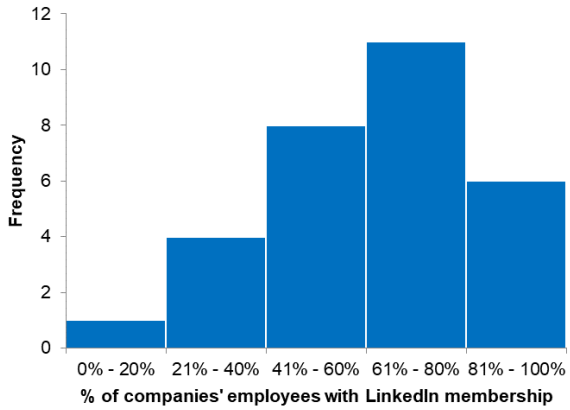

Figure 4: Distribution of LinkedIn representation of employees within testing and analysis and manufacturing companies

3.3 FINAL EQUATIONS AND RESULTS

LinkedIn's rich employment data with a highly granular classification of job titles allows us to view a segment of the UK's total calibration and testing employees. The purpose of this analysis is to estimate the remainder of that total which is not visible in any labour market data.

First, we define the following variables:

- **Measurement:** An employee having a calibration or testing occupation (i.e. any one of the 62 job titles found on LinkedIn).
- **LinkedIn:** An employee who is a LinkedIn member.
- **Industry:** An employee of a company that requires or provides testing and calibration services.

Probability formulae can be used to express our findings. We know the following:

$$Measurement \cap LinkedIn = 91{,}647 \qquad \textit{[Eq.1]}$$

The number of UK employees with a calibration and/or testing occupation who are members of LinkedIn is 91,647. Also:

$$P(LinkedIn|Industry) = 0.63 \qquad \textit{[Eq.2]}$$

The probability that a UK employee is a LinkedIn member, given that they are employed by a company that requires or provides testing and calibration services is 63%.

We want to capture $Measurement$. Using the multiplication rule for dependant events, we can express $Measurement$ as in *[Eq.3].*

$$Measurement = \frac{Measurement \cap LinkedIn}{P(LinkedIn|Measurement)} \qquad \textit{[Eq.3]}$$

We can express the denominator in *[Eq.3]* as in *[Eq.4].*

$$P(LinkedIn\,|Measurement) = [P(LinkedIn|Industry)\cdot P(Industry|Measurment)] + [P(LinkedIn|Industry^{C})\cdot P(Industry^{C}|Measurment)] \quad \textit{[Eq.4]}$$

Where $Industry^{C}$ denotes the complement of $Industry$. By definition, the probability that an employee works for a company that does not require nor provide testing and calibration services, given that they have a calibration or testing occupation, is 0. Therefore, $P(Industry^{C}|Measurment) \approx 0$ and $P(Industry|Measurment) \approx 1$. These are only approximations because, due to the pervasive nature of measurement, there will occasionally be roles for calibration and testing employees outside of the representative industrial company that frequently engages in calibration and testing activities. Hence, Eq(4) simplifies to become Eq(5).

$$P(LinkedIn|Measurement) \approx P(LinkedIn|Industry) \quad \textit{[Eq.5]}$$

Thus, *[Eq.5]* is approximately equal to *[Eq.2]*. Finally, substituting *[Eq.1]* and *[Eq.2]* into *[Eq.3]* arrives at a lower bound estimate for the total number of UK employees with calibration and testing occupations.

$$Measurement \approx \frac{91{,}647}{0.63} \approx 146{,}000 \quad \textit{[Eq.6]}$$

We find that there are at least 146,000 employees in calibration and testing occupations in the UK. This is only a lower bound estimate because, in reality, $P(Industry|Measurment)$ is less than 100%, meaning that the actual denominator in *[Eq.6]* is slightly smaller causing the final result to be slightly greater.[11] Nonetheless, 146,000 is only 10% less than the most recent figure for the same variable reported in *Quantifying UK Measurement Activity*.

4 CONCLUSION

This analysis increases confidence in the estimate of the number of employees with calibration and testing occupations reported in *Quantifying UK Measurement Activity* by devising an alternative method to arrive at a similar figure. Overall, there is a 10% discrepancy between the two figures, but it is acknowledged that the result reported in this analysis is a lower bound estimate. The degree to which the result reported in this analysis is underestimated is dependant on how strongly the assumption holds that all employees with calibration and testing occupations are employed by companies with a similar corporate structure, and that these companies can be accurately represented by the chosen sample. Ultimately, a comprehensive list of companies that require staff for calibration and testing does not exist, thus, the sample must be based on companies which we know are most likely to employ to majority of calibration and testing employees.

11 Additionally, there may be a slight occupational bias that drives the actual figure upwards. Even within companies that are likely to employ calibration and testing staff, it is expected that there will be greater representation of support staff rather than delivery staff (of whom we assume calibration and testing employees are a subset of). However, most of this is captured by accounting for industry bias, hence why global LinkedIn industry coverage is far greater in ICT (48%) than it is in manufacturing (3%).

There are numerous advantages to using LinkedIn data in labour market analysis which could be exploited further in future iterations of this analysis. With the use of advanced search filters, it may be possible to disaggregate the total number of employees with calibration and testing occupations by industry, education and experience. Furthermore, LinkedIn's single data structure and taxonomy allows for such analysis to be repeated in multiple countries for cross country comparisons or even for analysis on talent migration.

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ANNEX

Analytical chemist	Senior Analytical Chemist
Calibration engineer	Senior Electrical and Instrumentation Engineer
Calibration specialist	Senior Instrumentation Control Engineer
Calibration technician	Senior Instrument Engineer
Electrical and Instrumentation Engineer	Senior Instrumentation Engineer
Electrical and Instrumentation Inspector	Senior Instrument Technician
Electrical and Instrumentation Technician	Senior Quality Assurance Automation Engineer
Electrical Instrument Engineer	Senior Quality Assurance Engineer
Electronic Test Technician	Senior Quality Assurance Engineer Lead
Final Test Technician	Senior Quality Assurance Lead
Instrument Engineer	Senior Quality Assurance Quality Control Engineer
Instrumentation Engineer	Senior Quality Assurance Specialist
Instrument Specialist	Senior Quality Assurance Test Engineer
Instrumentation Specialist	Senior Test Engineer
Instrument Supervisor	Senior Testing Engineer
Instrument Technician	Senior Test Technician
Instrumentation Technician	Technical Test Analyst
Instrumentation and Control Engineer	Technical Test Lead
Laboratory Technician	Test Analyst
Lead Electrical and Instrumentation Engineer	Testing Analyst

Lead Instrument Engineer	Test Engineer
Metrologist	Testing Engineer
Metrology Engineer	Test Engineering Specialist
Metrology Technician	Test Engineering Technician
Nondestructive Testing Engineer	Test Lead
NDT Technician	Testing Lead
Quality Assurance Automation Engineer	Test Specialist
Quality Assurance Engineer	Testing Specialist
Quality Assurance Lead	Test Technician
Quality Assurance Specialist	Testing Technician
Quality Assurance Test Lead	

Table A1: List of LinkedIn job titles for calibration and testing occupations

Company Name	LinkedIn Company
AIRBORNE ENVIRONMENTAL CONSULTANTS LIMITED	AEC - Airborne Environmental Consultants Ltd.
AIRBUS GROUP LIMITED	Airbus
ANTHONY BEST DYNAMICS LIMITED	AB Dynamics
AUGHTON AUTOMATION LIMITED	Aughton Automation Ltd.
BAE SYSTEMS PLC	BAE Systems
BESPAK EUROPE LIMITED	Bespak
BMT GROUP LIMITED	BMT
BRITISH ENGINEERING SERVICES LIMITED	British Engineering Services
CAMBRIDGE CONSULTANTS LIMITED	Cambridge Consultants
CARNELL SUPPORT SERVICES LIMITED	Carnell
DELTA-SIMONS ENVIRONMENTAL CONSULTANTS LIMITED	Delta-Simons Environmental Consultants
DISPLAYLINK (UK) LIMITED	Displaylink
ENVIRONTEC LIMITED	Environtec Limited
GENUS PLC	Genus PLC
GOODWIN PLC	Goodwin PLC
HORIZON DISCOVERY GROUP PLC	Horizon Discovery
INEOS GROUP LIMITED	Ineos (Europe)
INSTITUTE OF CANCER RESEARCH: ROYAL CANCER HOSPITAL (THE)	The Institute of Cancer Research

INTERTEK GROUP PLC	Intertek
IRISNDT LIMITED	Irisndt
JAGUAR LAND ROVER LIMITED	Jaguar Land Rover
LIVERPOOL SCHOOL OF TROPICAL MEDICINE	Liverpool School of Tropical Medicine
NPL MANAGEMENT LIMITED	National Physical Laboratory (NPL)
ORCHID CELLMARK LTD	Orchid Cellmark
PHARMARON UK LIMITED	Pharmaron
RENISHAW PLC	Renishaw
RICARDO-AEA LIMITED	Ricardo Energy & Environment
ROLLS-ROYCE PLC	Rolls-Royce
SPECTRIS PLC	Spectris PLC
THE BINDING SITE GROUP LIMITED	The Binding Site
VECTURA GROUP PLC	Vectura Group PLC
VERTEX PHARMACEUTICALS (EUROPE) LIMITED	Vertex Pharmaceuticals

Table A2: Names of companies sampled for industry bias analysis

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