

**ASSESSING THE REACH AND IMPACT OF THE NMS
LABORATORIES ON UK PRIVATE SECTOR BUSINESSES**

DHARANI REDDY KATANGURU, MIKE KING

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Dharani Reddy Katanguru, Mike King
Analysis & Evaluation Team, Partnerships Directorate

ABSTRACT

This report presents an analysis of a survey that was conducted in 2023 for the National Measurement System (NMS) programme. The data was collected through a telephone survey of customers who work with three NMS laboratories: NPL, NML-LGC, and NEL. By this means, the NMS programme aims to understand its private sector users and demonstrate the extensive reach of the NMS labs in the UK economy. The respondents belong to defined segments of the population and the poststratification method adjusts the sampling weights to account for underrepresented segments in the sample. The methodology used for this report involved survey analysis techniques, such as, multiple imputation to fill in missing values. The key findings from this report are that: (1) users in the private sector are concentrated in technologically important parts of the UK's economy; and (2) mostly they are satisfied with the services delivered through the NMS labs. Moreover, some of these users attributed their new or improved products to the support provided by the NMS labs. As there is a huge scope for further analysis, two additional reports will be generated to delve deeper into the measurement and innovation activities of private sector users.

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National Physical Laboratory
Hampton Road, Teddington, Middlesex, TW11 0LW

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Approved on behalf of NPL by
David Skelton, Head of Strategic Programmes

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EXECUTIVE SUMMARY

The UK National Measurement System (NMS) is the nation's technical infrastructure which underpins trade, industry, and regulation. The NMS is supported by the Department for Science, Innovation, and Technology (DSIT) and delivered through measurement laboratories who are dedicated to world-class measurement science. These labs deliver services to underpin the certification of calibrations; and they play a vital role in supporting innovation and growth in the UK.

Every three years, the NMS commissions a survey of customers who use one or more of the following labs: NPL; NML at LGC; and NEL. This report will refer to these as the 'NMS labs', although the NMS programme also provides limited funding to a few other organisations that are not included in this study.

In 2023, Team Telemarketing interviewed a sample of the NMS labs' customers from the private sector. The survey was designed to allow the NMS labs to :

- better establish the reach of their customers.
- understand the impact of NMS support on the users' sales of new and improved products.
- benchmark satisfaction.

This survey is part of the NMS evaluation plan, designed to maintain accountability for the public investment and to enable future funding to be allocated based on evidence of what worked well.

This is a "first-findings" report that highlights the headline numbers that are important for the NMS labs to monitor. This report was written and led by economists at NPL. Two additional reports will be generated shortly to delve deeper into individually understanding the measurement and innovation customers.

The NMS labs have an extensive private sector customer base of approximately 3000 sites in the UK. The site-level approach allows the NMS labs to better understand the direct impact that the NMS has on businesses. Therefore, the customers were asked about their place of work (e.g., a division of their company) rather than for the whole enterprise. This report refers to 'businesses' but it should be understood that this refers to 'business sites'.

TOP FINDINGS

1. ***By supplying calibration services and reference materials, the NMS labs reach into important parts of the UK's private sector, and their direct userbase is of an economically significant scale.***

The businesses that work with the NMS make great contributions to the UK's economy. These businesses employ **~711,500 people in the UK**. The business sites that have worked with the NMS labs have **an aggregate turnover of £154 billion**. **The revenue per employee for the sites that work with the NMS is ~£216,450**. Around half of these businesses operate within the UK's manufacturing sector, and these businesses account for **13% of employment in UK manufacturing**.

Almost a fifth of the private businesses identify themselves as commercial calibration laboratories. **The NMS labs work with 35% of all the United Kingdom Accreditation Service (UKAS) accredited calibration labs in the UK**. By providing support to these labs, the reach of the NMS labs is extended. This survey found that **the NMS labs indirectly supported ~75,500 organisations in the UK through the**

“fanout” of calibration services (UKAS labs provide calibrations that are traceable to measurement standards maintained by the NMS labs) provided by the customers.

2. ***Many new or improved products would not have existed without support from the NMS labs, and such products currently generate considerable sales revenue for customers.***

Around **88% of the users introduced new or improved products / processes as a result of working with the NMS on innovation projects. Three quarters of them are product innovations and a quarter of them are process innovations.** Moreover, **18% of the NMS users claim to have affected their industry through “disruptive innovations”.**

Revenue impact is the calculated headline number that represents the sales income generated by private businesses from developing or improving new products and reaching new markets using NMS support. Together, around 2870 of the UK based businesses that engaged with the NMS labs, generated **£1.56 billion in revenue from sales of new and improved products.**

So, what fraction of the aggregate revenue from sales of these new and improved products can be attributed to the NMS labs? **A third of users from the private sector believe that their new and improved products would not exist without the support they received from the NMS labs.** Therefore, each year, around 920 of the UK-based businesses who’ve used the NMS labs, collectively attribute **£500 million** in sales revenue to innovations that wouldn’t have succeeded without the NMS labs.

3. ***The NMS labs most strongly provide support to innovations amongst businesses that share a connection to environmental protection and/or could affect human health. The labs are also starting to play a role for a small group of customers who are developing Quantum Technologies.***

49% of the userbase has a line-of-business (or activity) that’s connected to improving environmental protection. Moreover, 37% of these businesses attributed innovations to support from the NMS labs.

44% of the userbase has a line-of-business that’s connected to security / defence. Moreover, 34% of these businesses attributed innovations to support from the NMS labs.

47% of the userbase has a line-of-business that feeds into the provision of healthcare services or connects to the fields of public health. Moreover, 31% of such businesses attributed innovations to support from the NMS labs.

Most of the businesses that receive support from the NMS are connected to more than one challenge area. The national challenge areas aim to align with the UK’s current and future requirements. **85%** of the userbase has a line-of-business that’s connected to **at least one national challenge area.** Moreover, **52%** of these businesses attributed innovations to support from the NMS labs.

7% of the userbase has a line-of-business connected to the development of quantum technologies. Moreover, 38% of these businesses attributed innovations to support from the NMS labs. (In this case, the sample-size is rather small but these conditional probabilities are noticeably higher than for most other technological areas.)

Most of the businesses that receive support from the NMS are connected to more than one technological area. 72% of the userbase has a line-of-business that's connected to **at least one significant technological area**. Moreover, **45%** of these businesses **attributed innovations to support from the NMS labs**.

4. *Customers are satisfied with the NMS labs.*

To deliver greater impact in the future, it is important to understand how the businesses in the userbase view their relationship with the NMS labs. To measure satisfaction, a Net Promoter Score (NPS) was calculated. The **overall NPS given to the NMS labs is 47** which is considered 'good' and indicates that there are more "happy" customers than "unhappy" ones. However, this also suggests that the NMS labs need to reflect on their current ways of working and strive to deliver the best value for their users. It was also noted that the NMS users are **most satisfied with the quality and least satisfied with price**.

1 INTRODUCTION

1.1 THE ROLE OF THE NMS LABORATORIES

The UK National Measurement System (NMS) is the nation's technical infrastructure which exists to provide the nation with dependable measurements. The top layer of the NMS is comprised of six core laboratories, known as the NMS labs, which underpin measurement accuracy in the UK. The NMS labs are responsible for maintaining the UK's national measurement standards and associated facilities. They then make the benefits of this available to users through a wide range of services and knowledge transfer activities.

Table 1 Details of the six core NMS labs

NPL	National Physical Laboratory	The UK's National Measurement Institute
NML at LGC	National Measurement Laboratory, at LGC (formerly Laboratory of Government Chemist)	Designated for chemical and biometrology
NEL	National Engineering Laboratory	Designated for fluid flow metrology
DSIT	Office for Product Safety and Standards (part of the Department for Science, Innovation, and Technology)	Designated for legal metrology
NGML	National Gear Metrology Laboratory	Designated for gears metrology
NIBSC	National Institute for Biological Standards and Control	Designated for bioactivity metrology

The core NMS labs have the capacity to support metrology in a range of fields, from mass and nuclear metrology to chemical analysis, fluid flow, and bio-metrology. The NMS labs underpin the UK's technical infrastructure by supplying services to the commercial calibration laboratories, who then go on to calibrate the instruments of their own customers, diffusing measurement accuracy through a chain of linked calibrations. The benefits coming from this second layer of the infrastructure is not discussed in this report, as customers of the commercial calibration laboratories were not interviewed in the survey.

The NMS labs are funded by the Department for Science, Innovation, and Technology (DSIT). DSIT invests ~£100m annually into the NMS so that it can maintain the national measurement standards needed to supply traceable calibration services, as well as undertake research and development (R&D) into new measurement techniques. The NMS laboratories sell products and services to companies to generate additional revenue for the labs, which is then reinvested into the system to increase the impact of the NMS¹.

¹ [NMS Customer Survey Report 2018](#)

1.2 THE NMS SURVEY

The NMS survey is a telephone survey of customers who work with the National Physical Laboratory (NPL), the National Measurement Laboratory at LGC (NML; formerly The Laboratory of Government Chemist) and the National Engineering Laboratory (NEL). The survey was commissioned by the NMS and run by an independent survey company, Team Telemarketing. Between May and September in 2023, Team Telemarketing contacted 3087 sites who use the NMS, and 788 of those contacted responded, achieving a response rate of ~26%.

The NMS survey is a site-based survey, specifically looking at sites for medium and large companies. This survey consists of three question sets :

- Question set 1 – Questions on context & feedback
- Question set 2 – Measurement related questions
- Question set 3 – Innovation related questions

The first question set will be answered by all the respondents, and every site was pre-tagged on a random basis to answer either measurement or innovation related questions. At the beginning of the fieldwork, the total number of sites for the survey were 3087, where 1546 sites were randomly allocated to answer the measurement question set and 1541 sites were allocated to answer the innovation question set.

However, multiple duplicate surveys (more than one survey from the same site) were identified in the final survey responses extract. To fix this complication, sites were redefined using the company account number and postcode. This process resulted in 736 unique sites. The duplicate survey responses from the same site were deleted on a random basis in Stata. For the purpose of analysis, this has resulted in a total of 736 survey responses, where the measurement question set has 393 responses and the innovation question set has 343 responses.

1.2.1 Focus of the report

The first findings report aims to :

- 1. Establish the reach of the NMS laboratories in the UK private sector and identify how economically important their private sector customers are.**

The NMS is interested in the scale of economic activity amongst the private organisations the labs work with to enable an understanding of the size and importance of its userbase among the wider population of businesses.

- 2. Understand the impact of the NMS labs on their users' sales of new and improved products.**

Customers who use the NMS labs are often active innovators, using the support they receive to create and improve products and processes. The survey aims to quantify the annualised revenue generated from the sale of products which business customers think would not exist without the support they received from the NMS labs.

3. Capture satisfaction.

The NMS labs calculate a Net Promoter Score to capture satisfaction. This is designed to identify what should be improved in order to increase uptake and deliver greater impact in future.

1.2.2 Segmentation and weights

The NMS users that were supported in between the years 2018 to 2022 were segmented based on the size of their firm and the level of support received.

The size of the firms is defined by the number of people employed in the organisation :

- Micro (M) refers to the firms that have 1 to 9 employees.
- Small and medium (SME) refers to the firms that have 10 to 249 employees.
- Large (L) refers to the firms that have 250 or more employees.

The level of support received by the firms that work with the NMS can be broken down by the number of times they have been supported :

- Engaged (E) refers to low-intensity support such as classroom trainings, e-learnings, events, and free downloads i.e., anything that is not an invoice or a collaboration.
- Supported (S) refers to the support provided for 1 to 4 years in a 6 year moving window.
- Regulars (R) refers to the support provided for at least 5 years in a 6 year moving window.

The NMS users were segmented in such a way that they represent both the size of their firm and the level of support received. For example, 'M-E' in the table below refers to users that are micro and engaged. The weights have been calculated for each segment using the poststratification method. Poststratification is a method to adjust the sampling weights to account for underrepresented segments in the population to decrease bias. This involves adjusting the sampling weights so that they sum to the population sizes within each stratum. It should be noted that the analyses conducted throughout the report are representative of the entire population of the survey, correcting for the differences in response rates within various segments of the population (unless specified in the report).

Table 2 Poststratification weights

Segment	Sample	Population	Weight
M-E	63	241	3.8
SME-E	130	475	3.7
L-E	52	341	6.6
M-S	52	131	2.5
SME-S	174	482	2.8
L-S	86	440	5.1
SME-R*	97	246	2.5
L-R	82	514	6.3
Total	736	2870	

**This segment includes micro sites as well because there are very few micro regulars.*

2 DEMOGRAPHIC PROFILE OF PRIVATE BUSINESS USERS

2.1 PROFILE OF THE NMS USERS

The private sector is very important to the NMS labs and it represents the largest proportion (80%) of their userbase, excluding commercial calibration laboratories. Calibration labs have been self-identified by the survey respondents and form the remaining 20% of the userbase. 42% of the private businesses are small and medium-sized enterprises (SMEs).

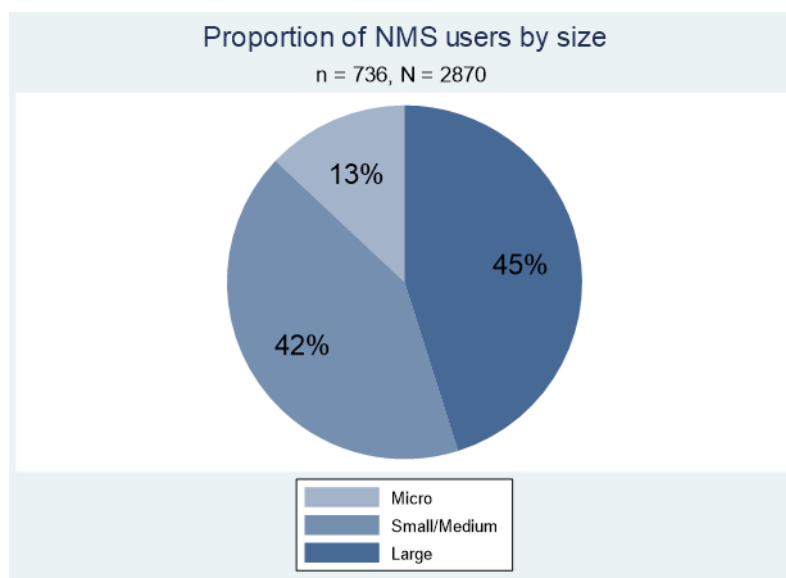


Figure 1 Proportion of NMS users by size of organisations

The largest proportion of NMS users is represented by the manufacturing sector, accounting for almost half (48%) of the customer base. This is followed by firms associated with professional, scientific, and technical activities, which accounts for 39% of the NMS users².

Table 3 Count and proportion of users broken down by industries

Standard Industrial Classifications	Sample	Population	Proportion
Manufacturing sector	347	1364	48%
Professional, scientific, and technical activities	303	1128	39%
Utilities	22	98	3%
Distribution and transportation	11	52	2%
Construction	5	27	1%
Primary sector	2	9	0%
Other	46	192	7%
Total	736	2870	100%

² It should be noted that all the proportions in the tables throughout the report have been rounded to the nearest whole number and therefore might not add up to a 100%.

The highest proportion of large firms operate in the manufacturing sector (50%) and the industry of professional, scientific, and technical activities (33%).

Table 4 Count of large firms broken down by industries

Standard Industrial Classifications	Sample	Population	Proportion
Manufacturing sector	111	653	50%
Professional, scientific, and technical activities	72	421	33%
Utilities	11	63	5%
Distribution and transportation	6	36	3%
Construction	3	20	2%
Primary sector	1	7	1%
Other	16	95	7%
Total	220	1295	100%

2.2 CATEGORIES OF JOB ROLES

The respondents were asked about the broad category of their job role. Since more than three quarters of them fit into either technical or production roles, this reassures that this survey has reached the right audience who carry the expertise to answer measurement and innovation related questions.

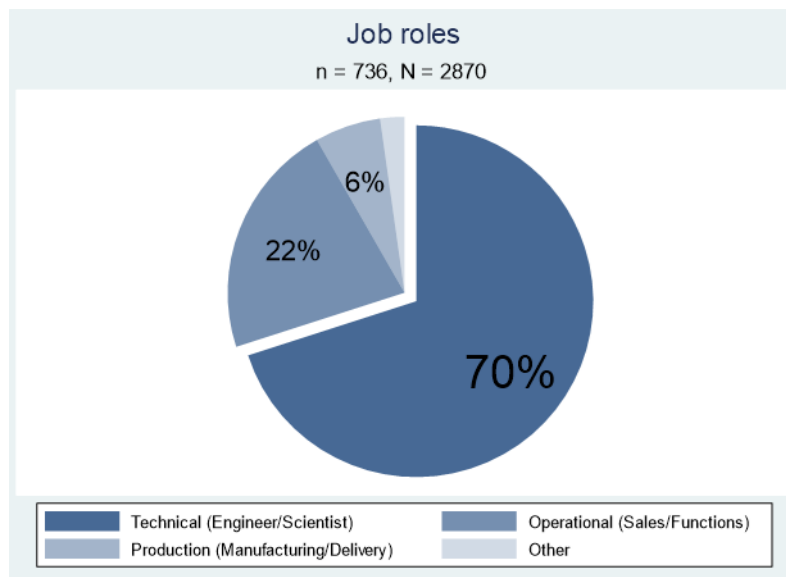


Figure 2 Proportion of respondents within broad job categories

2.3 MEASUREMENT ACTIVITY IN SCIENTIFIC AREAS

The respondents were asked to choose a scientific area in which they conduct most of their measurement activity. It can be observed that mass and dimensional, material properties, and thermal and radiometric metrology account for more than half (56%) of the measurement activity that occurs within all the scientific areas.

As the broad scientific area 'Materials & Mechanical Metrology' has a large proportion of the NMS users, it has been split into three sub-sections : Mass & Dimensional, Material Properties, and Other Engineering Metrology.

Table 5 Count and proportion of users for scientific areas in measurement

Scientific areas for measurement activities	Sample	Population	Proportion
Mass & Dimensional	180	725	25%
Material Properties	149	566	20%
Thermal & Radiometric Metrology	92	326	11%
Electromagnetic & Electrochemical Technologies	63	228	8%
Other Engineering Metrology	42	170	6%
Chemical & Biological Sciences	39	158	6%
Medical, Marine & Nuclear	40	155	5%
Atmospheric Environmental Science	36	148	5%
Time & Frequency	11	41	1%
Quantum Metrology	. ³	8	<1%
Other	82	345	12%
Total	736	2870	100%

³ The count in this category is below 5 and therefore is not statistically significant. It is therefore represented using the period.

2.4 GEOGRAPHICAL SPREAD

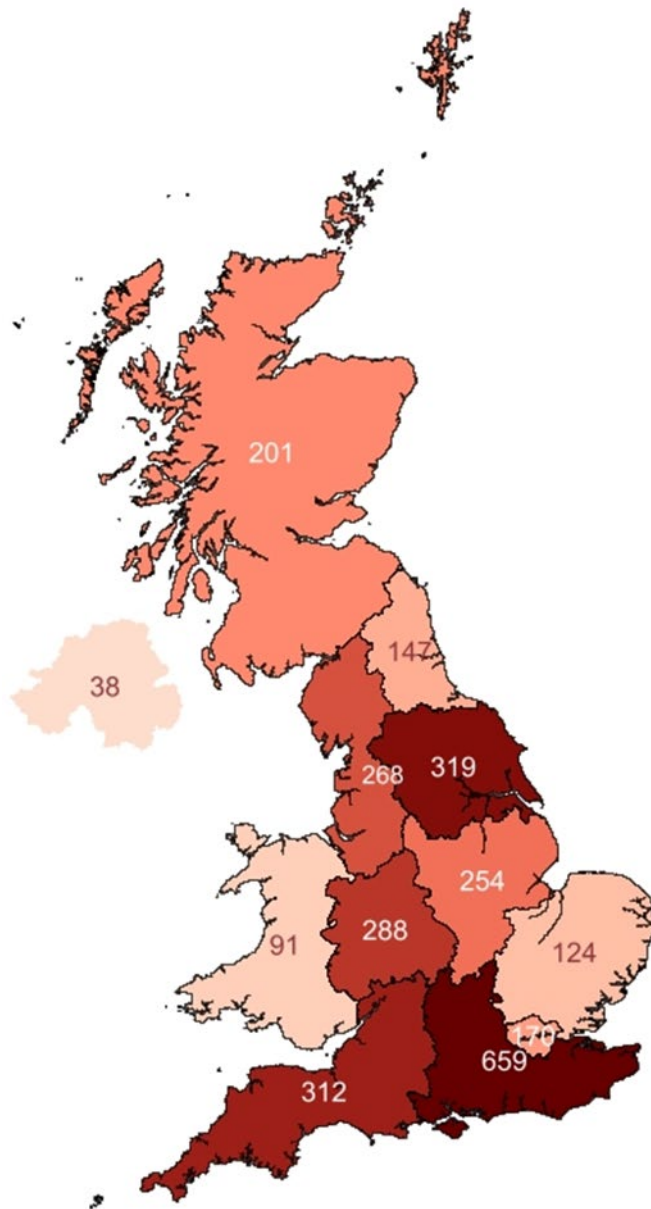


Table 6 Count of NMS users in NUTS regions

NUTS Region	Sample	Population
North East	35	147
North West	72	268
Yorkshire and the Humber	77	319
East Midlands	64	254
West Midlands	71	288
East of England	32	124
London	43	170
South East	172	659
South West	87	312
Wales	24	91
Scotland	50	201
Northern Ireland	9	38
Total	736	2870

Figure 3 Count of NMS users in NUTS regions

A site-based survey is a better measure to analyse the geographical spread because the headquarters of an organisation is mostly located in a major city, for e.g., London, but the technical work would ideally be conducted at sites which are situated away from the headquarters. This explains why the numbers for London could be lower when compared to areas such as the Midlands.

South East England, South West England, and Yorkshire and the Humber are three most populated areas with NMS customers in the United Kingdom (UK). **The Greater South East (GSE) region, comprising the South East England; London; and East of England, amounts to 33% of the NMS users.** NMS regularly supported firms in comparison with GDP proportions

2.4.1 NMS regularly supported firms in comparison with GDP proportions

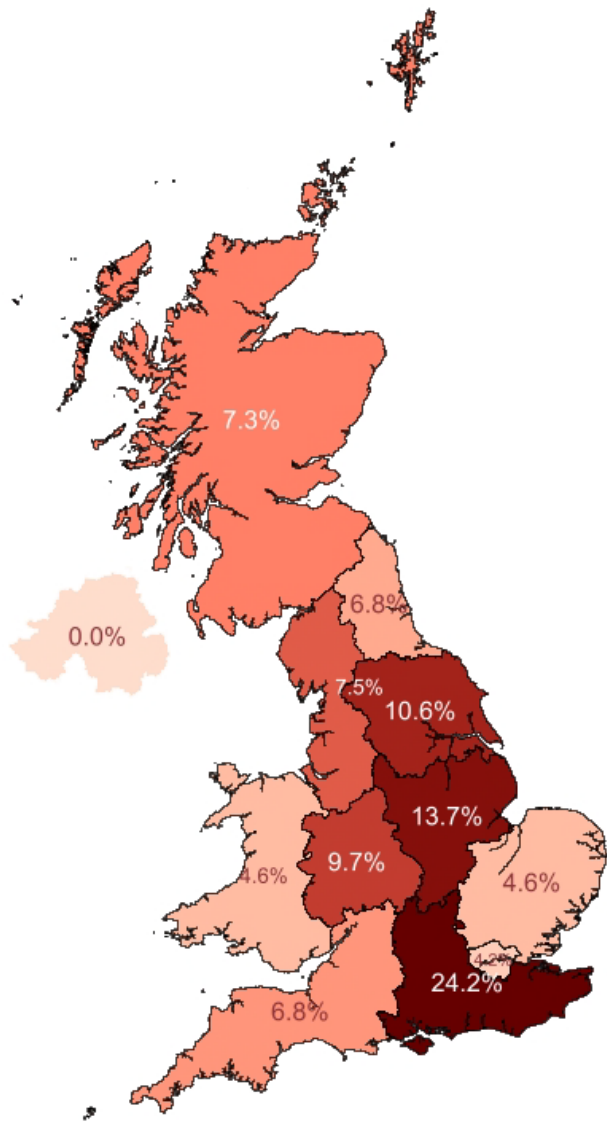


Table 7 Proportion of NMS regularly supported firms Vs. GDP proportions

NUTS Region	Regularly supported	GDP Proportion
North East	7%	3%
North West	7%	10%
Yorkshire and the Humber	11%	7%
East Midlands	14%	6%
West Midlands	10%	7%
East of England	5%	8%
London	4%	23%
South East	24%	15%
South West	7%	7%
Wales	5%	4%
Scotland	7%	7%
Northern Ireland	0%	2%
Total	100%	100%

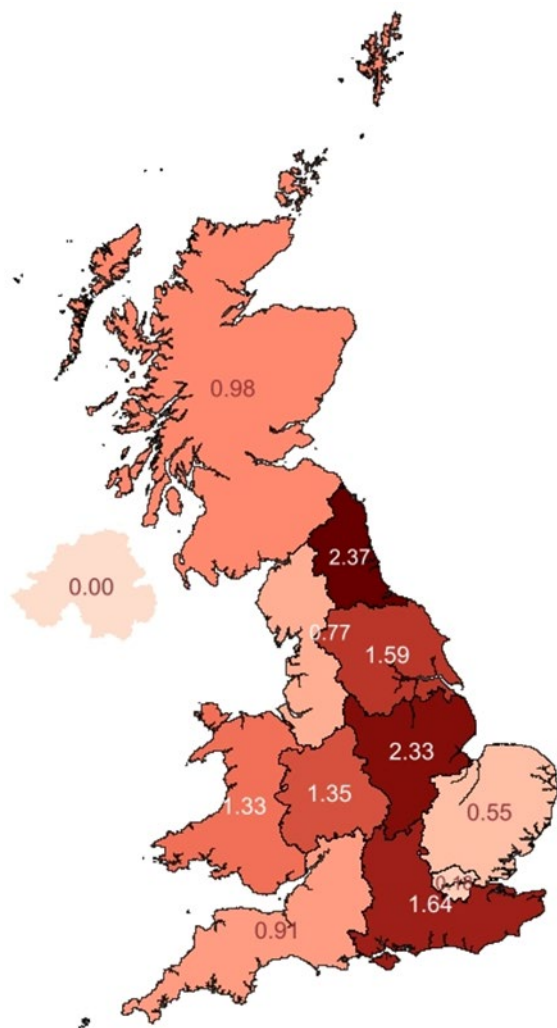
Figure 4 Proportion of NMS regularly supported firms in NUTS regions

The above map shows the proportion of NMS regularly supported firms in each NUTS region. The GSE region amounts to 33% for the NMS regularly supported firms in the UK. Similarly, when the regional product in the UK is computed, the GSE region amounts to 46%. Comparatively, this shows that the NMS regularly supported firms operate in regions outside of the GSE area, accounting for widespread business activity. It is important for the NMS labs to have beneficiaries scattered all over the UK rather than focusing on and around the “Golden Triangle”.

2.4.2 Quotient analysis

Table 8 Quotient analysis for NMS regularly supported firms in the UK

NUTS Region	Regularly supported	GDP Proportion	Quotient	% change
North East	7%	3%	2.4	137%
North West	7%	10%	0.8	-23%
Yorkshire and the Humber	11%	7%	1.6	59%
East Midlands	14%	6%	2.3	133%
West Midlands	10%	7%	1.3	35%
East of England	5%	8%	0.5	-45%
London	4%	23%	0.2	-82%
South East	24%	15%	1.6	64%
South West	7%	7%	0.9	-9%
Wales	5%	4%	1.3	33%
Scotland	7%	7%	1.0	-2%
Northern Ireland	0%	2%	0.0	-100%

**Figure 5 Regional quotients**

This is a quotient analysis modelled on regional or location quotients. To compute the quotient for each NUTS region, the proportion of NMS regularly supported firms is divided by the GDP proportions. The quotient shows the presence of NMS regularly supported firms across the NUTS region in comparison to the respective regional products. North East England, East Midlands, South East England, and Yorkshire & the Humber hold a higher concentration of the NMS regularly supported firms, thereby contributing to more business activity in those respective regions, in contrast to the regional products. On the other hand, there is room to strengthen our userbase in Northern Ireland.

2.5 NATIONAL CHALLENGE AREAS

The national challenge areas aim to align with the UK’s current and future requirements. The private businesses that the NMS works with connect to four strategic areas : Prosperity, Environment, Health, and Security & resilience.

- **Prosperity** aims to shift the UK’s industrial landscape towards achieving net-zero carbon emissions, prioritizing societal wellbeing, driving the need for innovation and investment in measurement infrastructure to unlock market opportunities and ensure economic growth, and align with government strategies such as the Industrial Strategy and the Clean Growth Strategy.
- **Environment** aims to minimise environmental damage caused by greenhouse gas emissions, utilize national science and metrology to aid the transition to a net-zero emissions economy, ensure sustainability, and align with government strategies such as the Net-zero Strategy and Climate Change Act.
- **Health** aims to enhance and provide metrology expertise to support faster disease detection, sustainable bioeconomy development, reliable data for early diagnosis and precision medicine, and align with government strategies and global life sciences & health sector trends.
- **Security & resilience** aims to deliver a robust digital measurement infrastructure, support innovation, ensure a resilient infrastructure, and foster public trust in transformative technologies like self-driving vehicles, quantum computing, and Artificial Intelligence.

In the following chart, the lightest shade represents micro firms; the medium shade represents SMEs, and the darkest shade represents large firms.

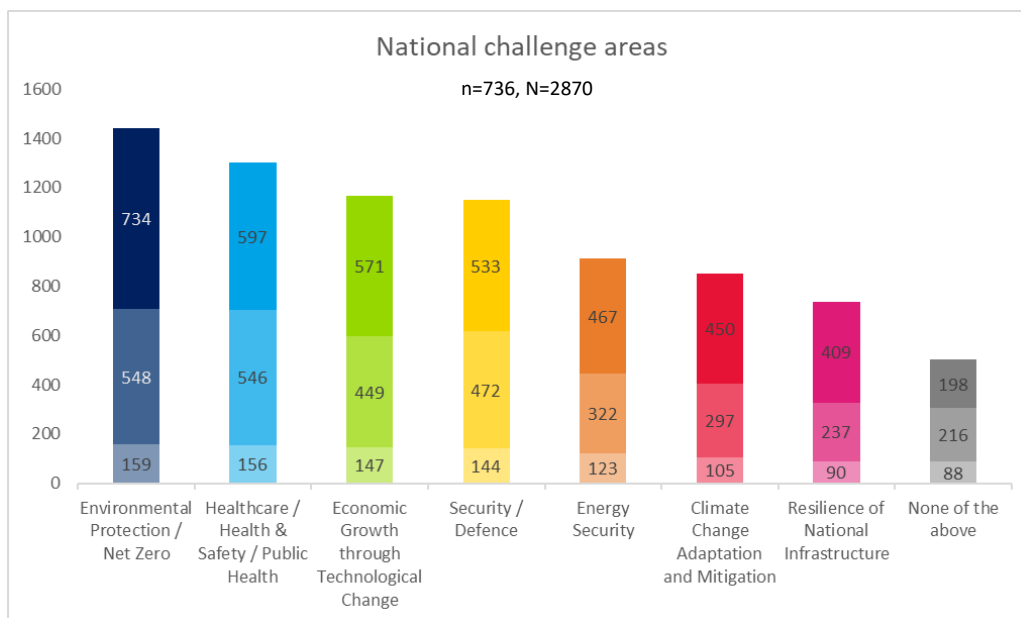


Figure 6 Count of the NMS users that connect to national challenge areas by size of sites⁴

⁴ The firm’s line-of-business can connect to more than one national challenge area.

2.5.1 Attribution to the NMS support

This section details on attribution to the NMS through conditional probabilities. The Venn diagram sets the context for the analysis to follow :

- Set A – refers to a firm’s connection to a technological or challenge area⁵.
- Set B – refers to the attribution to the NMS for an innovation project⁶.
- Intersection ($A \cap B$) – refers to the firms that work in a technological or challenge area and have attributed their innovation project to the NMS.

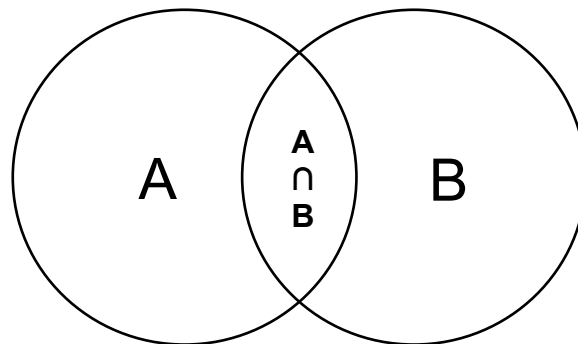


Figure 7 Venn diagram for conditional probabilities

In this case, the conditional probability of attributing the innovation project to the NMS (event B) is the probability that it will occur, given the knowledge that the firm’s line-of-business lies in that particular challenge area or technological area (event A). This probability is written as $P(B|A)$, notation for the probability of B given A.

The equation for condition probability is as follows :

$$P(B|A) = \frac{P(A \cap B)}{P(A)}$$

In economic terms, the above equation can be re-written as :

$$\textit{Criticality of NMS support in an area} = \frac{\textit{Impact attributed in an area}}{\textit{Relevance of an area to users}}$$

Alternatively, it could also be said that the impact of the NMS labs on the attributed innovations is the multiplicative combination of the relevance of a particular challenge / technological area to the userbase and the criticality of the NMS support to advances in innovations in that a particular challenge / technological area.

<i>Impact attributed in an area</i>	=	<i>Criticality of NMS support in an area</i>	×	<i>Relevance of an area to users</i>
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It should be noted that the sampling weights are not assigned in the following analysis i.e., it is not representative of the entire population of the survey.

⁵ This question has been answered by all the 736 survey respondents.

⁶ This question appears in the innovation question set and is only answered by 343 respondents. This complexity might result in small sample sizes for certain challenge or technological areas. The sample sizes (n) that are lower than 30 are mentioned in the tables.

49% of the userbase has a line-of-business (or activity) that's connected to improving environmental protection. Moreover, 37% of these businesses attributed innovations to support from the NMS labs.

44% of the userbase has a line-of-business that's connected to security / defence. Moreover, 34% of these businesses attributed innovations to support from the NMS labs.

47% of the userbase has a line-of-business that feeds into the provision of healthcare services or connects to the fields of public health. Moreover, 31% of such businesses attributed innovations to support from the NMS labs.

Table 9 Conditional probabilities for national challenge areas

National Challenge Areas	$P(A \cap B)$	$P(A)$	$P(B A)$
Environmental Protection / Net Zero	18%	49%	37%
Security / Defence	15%	44%	34%
Healthcare / Health & Safety / Public Health	15%	47%	31%
Economic Growth through Technological Change	11%	41%	28%
Climate Change Adaptation and Mitigation ($n=29$)	10%	29%	36%
Energy Security ($n=24$)	9%	32%	28%
Resilience of National Infrastructure ($n=19$)	7%	25%	26%
Any national challenge area	44%	85%	52%
None of the above ($n=19$)	8%	15%	53%

In the above table, the row highlighted in bold showcases the values for respondents who have selected at least one of the mentioned national challenge areas as their response. 85% of the userbase has a line-of-business that's connected to at least one national challenge area. Moreover, around half (52%) of these businesses attributed innovations to support from the NMS labs.

This can be explained in simple terms using an analogy of a ball in a bucket. For example, let's consider that a **green** ball represents **environmental protection**, and a **red** ball represents **security**. In this case, *only* the **green** ball can fall into the **environmental protection** bucket and *only* a **red** ball can fall into the **security** bucket. However, *both* the **red and green** ball can fall into the "**any national challenge area**" bucket. Therefore, the probabilities for belonging to any national challenge area are much higher than probabilities for specific national challenge areas.

2.6 SIGNIFICANT TECHNOLOGICAL AREAS

The respondents were asked if their firm’s line-of-business connects to any significant technological areas. It can be observed that a high number of respondents chose areas that broadly connect to ‘Environment’ and ‘Health’.

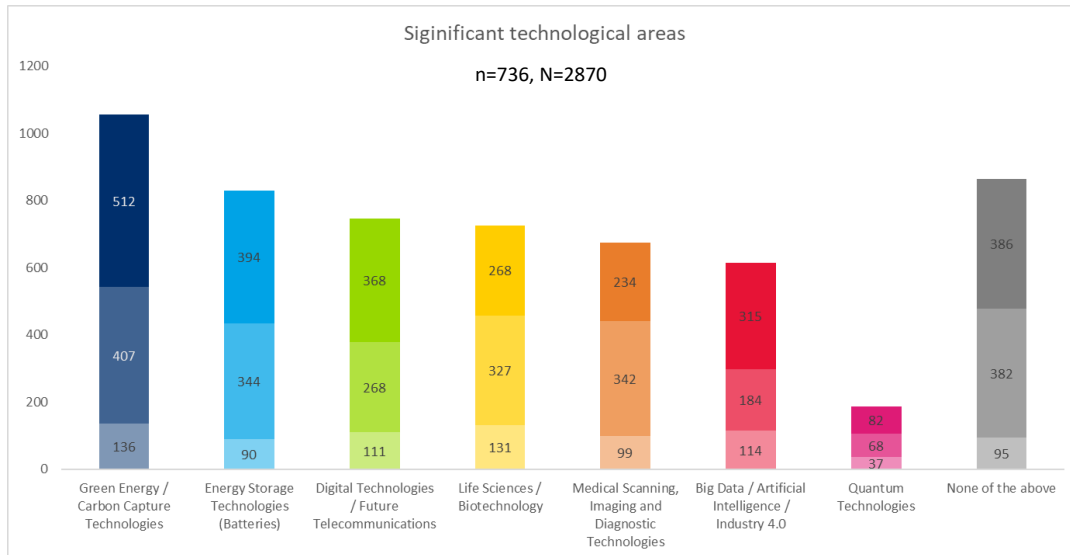


Figure 8 Count of the NMS users that connect to significant technological areas by size of sites⁷

The below figure compares the proportion of the technological areas that function in the GSE region and the other regions in the UK. The most striking observation is that the businesses that connect to nascent areas such as quantum technologies and artificial intelligence seem to work more in the GSE region in comparison to other existing technological areas.

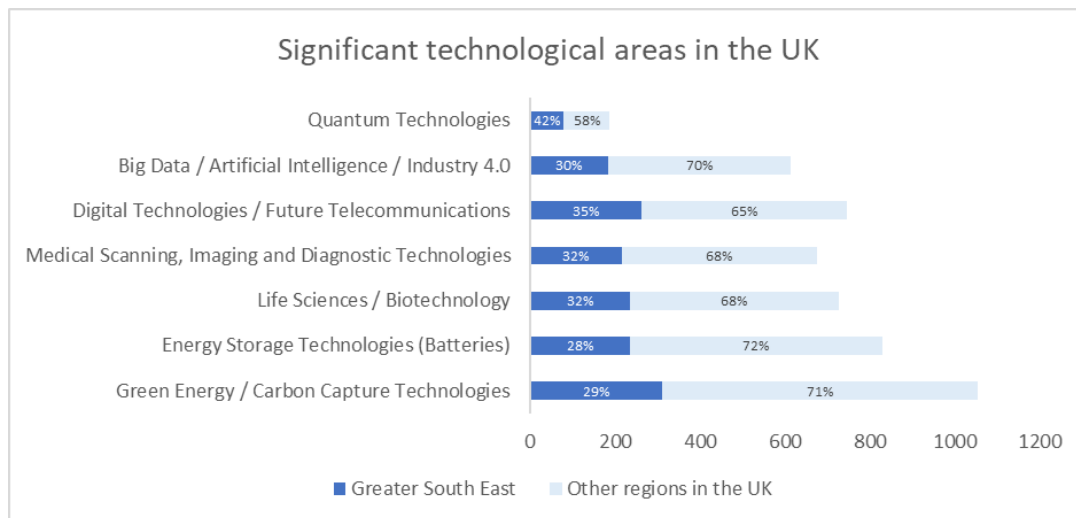


Figure 9 Proportion of regions in the UK broken down by technological areas

⁷ The firm’s line-of-business can connect to more than one significant technological area.

2.6.1 Attribution to the NMS support

It is important to note that sampling weights are not assigned in this analysis i.e., it is not representative of the entire population of the survey.

7% of the userbase has a line-of-business connected to the development of quantum technologies. 28% of the userbase has a line-of-business connected to the development of biotechnology. Moreover, ~38% of these businesses attributed innovations to support from the NMS labs. However, it is important to exercise caution while interpreting technological areas with very low sample sizes.

Quantum technologies has a small impact because it is a nascent area, but the support from the NMS labs is of long-term importance. Future impact is driven by the growth in quantum. Therefore, if the NMS labs continue to play a critical role by providing support, they will remain vital to growth in this area.

Table 10 Conditional probabilities for significant technological areas

Significant technological areas	$P(A \cap B)$	$P(A)$	$P(B A)$
Green Energy / Carbon Capture Technologies	12%	38%	30%
Life Sciences / Biotechnology ($n=26$)	11%	28%	39%
Energy Storage Technologies / Batteries ($n=21$)	9%	29%	30%
Digital Technologies / Future Telecommunications ($n=21$)	8%	26%	32%
Medical Scanning, Imaging and Diagnostic Technologies ($n=19$)	7%	27%	26%
Big Data / Artificial Intelligence / Industry 4.0 ($n=16$)	6%	20%	29%
Quantum Technologies ($n=9$)	3%	7%	38%
Any significant technological area	33%	72%	45%
None of the above	18%	28%	66%

In the above table, the row highlighted in bold showcases the values for respondents who have selected at least one of the mentioned significant technological areas as their response. 72% of the userbase has a line-of-business that's connected to at least one significant technological area. Moreover, 45% of these businesses attributed innovations to support from the NMS labs.

It is notable that 28% of the respondents chose 'None of the above', with the remaining 72% of respondents declaring that their line-of-business connects to at least one of our selected technological areas. In other words, more than one quarter of the respondents have a line-of-business that doesn't connect to any of our selected technological areas.

This suggests that there are other up-and-coming technological areas that the NMS should be looking into so that it can better support its userbase. Some of these might be 'whizzy' technological areas that are not yet established and have not acquired a commonly used label. On the other hand, it is possible that traditional areas in manufacturing (where a large fraction of the userbase lies) may have become so mature that they are better classified as an industry rather than as a technological area.

Refer to Appendix A for additional analysis performed to show attribution to the NMS.

2.7 CUSTOMERS' VIEW ON THEIR WORKING RELATIONSHIP WITH THE NMS

To understand why customers choose to work with the NMS, they were asked about the benefits of working with the NMS labs over other suppliers. A substantial proportion of our customers (65%) trust that the NMS helps increase confidence in measurements, which highlights the key role that is played by the NMS in the field of measurement in the UK economy. Many also choose to work with the NMS labs over other suppliers as they are convinced that it helps expand the capabilities of their businesses and also increase the satisfaction of their customers.

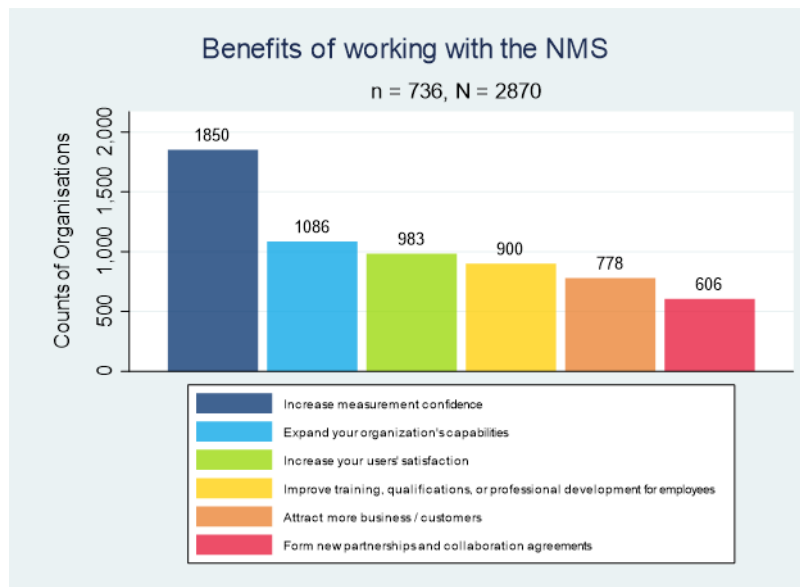


Figure 10 Perceived benefits of working with the NMS

3 ECONOMIC ACTIVITY OF THE NMS USERS

The respondents were asked questions relating to the employment and turnover at their business sites⁸. This helps the NMS labs understand the contribution that their customers make to the UK economy.

3.1 EMPLOYMENT STATISTICS

The total number of employees that work at the sites that are supported by the NMS labs amounts to **~711,490 people⁹ and this accounts for around 2.15% of the UK's labour force¹⁰**. When this number is broken down by industries, it can be observed that more than 85% of the private sector customers operate within profession, scientific, and technical activities, or the manufacturing sector. The employment at manufacturing sites that are supported by the NMS labs account for **13% of the manufacturing sector workforce in the UK¹¹**.

3.2 FINANCIAL STATISTICS

The business sites that use the NMS labs have **an aggregate turnover of £154 billion¹²**. It is noteworthy to mention that the sites that work with the NMS labs are hold great importance as they create considerable economic value. It is possible that some proportion of this economic activity could be at risk if they do not continue receiving support from the NMS labs.

Furthermore, **the revenue per employee for the sites that work with the NMS is ~£216,450**. This roughly measures the revenue generated by each employee for the site. The sites that use the NMS labs have a higher revenue per employee when compared to the national average of £136,843 for the professional, scientific, and technical activities industry; and a lower revenue per employee when compared to the national average of £263,328 for the manufacturing sector¹³.

3.3 COMPARISON TO THE 2018 NMS SURVEY

In 2018, the business sites that used the NMS labs collectively employed just under 1 million people in the UK and had an aggregate turnover of around £188 billion. Even though a decrease can be observed in the employment and turnover figures within the last 4 years, it is important to recollect that this period experienced economic shocks.

⁸ Currently, how many employees are present at the site that you work at?

Of the site that you work at, what was your financial turnover/revenue in tax year ending in 2022?

⁹ 95% confidence interval [~622,125, ~800,854]

¹⁰ [UK labour market statistics](#)

¹¹ [UK manufacturing sector workforce](#)

¹² 95% confidence interval [~128 billion, ~181 billion]. Respondents who could not provide financial information based on a site-level, around 20% of the total survey respondents, were asked to provide information on company-level. The aggregate turnover for companies that use the NMS labs is ~£152 billion.

¹³ The benchmark figures for revenue per employee are calculated from the [Annual Business Survey](#) and the [Business Register & Employment Survey](#) in the UK in 2022.

4 FANOUT OF TRACEABILITY IN THE UK ECONOMY

The NMS labs recognise that it is important to understand the number of commercial calibration labs that they work with to estimate how far their direct reach extends. This survey shows that a fifth of the total survey respondents are commercial calibration labs. It has been estimated that **the NMS labs work with 564¹⁴ calibration labs in the UK.**

Among the customers who are commercial calibration labs :

- **The NMS labs work with 35% of all the accredited calibration labs in the UK¹⁵.**
- 83% of the labs that work with the NMS are UKAS accredited for testing and analysis or calibration and reference materials.
- A majority of the customers use the NMS labs to increase their confidence in measurements and maintain accuracy of their instruments, so that it makes it possible for them to reliably calibrate instruments for their own customers.

4.1 INDIRECT REACH : BEYOND DIRECT CUSTOMERS

The direct reach of NMS labs could be extended to calculate the fanout of calibration services provided by our customers. The accuracy in the firsthand calibrations provided by the NMS is in-turn transferred through follow on calibration services provided to other firms by the NMS users, and this effect spreads out across the economy. The calculation of fanout as a headline number is valuable as it helps monitor the indirect impact generated by the NMS labs. Refer to Appendix B to gain a detailed understanding on the calculation of fanout.

The 151 firms that self-identified as commercial calibration labs were asked to provide the number of firms to which they provide calibration services or reference materials¹⁶. All the respondents were able to provide a reasonable answer to this question. The analysis found that **the calibration services provided by the NMS labs have a fanout to ~75,500 organisations¹⁷.**

It should be noted that this estimate represents the 'first level' of fanout where the NMS labs provide services to their direct users, and they in turn provide services to their own customers. It does not include the services that are further provided by these recipients. It is within reason to assume that the 'second level' fanout would be significantly higher. The following table shows the split between UKAS and non-UKAS accredited labs. The previous NMS survey conducted in 2018, the NMS labs had a fanout to 74,000 organisations. Therefore, it can be observed that there is an increase of ~1500 organisations within the last 4 years.

Table 11 Number of labs that the NMS users provide traceability to

	Sample	Population	Fanout
UKAS accredited	127	465	62,313
Non-UKAS accredited	24	99	13,209
Total	151	564	75,522

¹⁴ The population estimate (N) amounts to 564 calibration labs. The sample size (n) is 151 calibration labs.

¹⁵ There are 364 [UKAS accredited calibration laboratories](#) in the UK.

¹⁶ To understand the fanout of traceability in the economy, how many laboratories do you provide calibration services/reference materials to?

¹⁷ It should be noted that this is an upper estimate as it does not account for the overlap of labs that receive calibration services/reference materials from the NMS userbase.

5 REVENUE IMPACT

Revenue impact is the calculated headline number that represents the sales income generated by private businesses from developing or improving new products and reaching new markets using NMS support. Quantifying the revenue that the NMS helps generate for their customers allows the labs to understand the amount and expanse of this impact.

5.1 DATA

The revenue impact number from the previous survey included data collected from surveys conducted in the years 2012, 2015, and 2018. However, the following analysis only uses the data collected from this survey. The respondents were asked to choose one option from the set revenue bands. This shift in the revenue impact analysis allows the NMS labs to track this metric in future surveys.

5.2 METHODOLOGY

The NMS users who have used the labs to make an innovation change were asked questions about their recent economic impact of this innovation¹⁸. The revenue impact estimate is calculated from the following components :

- The sale of new products or services
- The sale of improved products or services
- The sale of existing products or services reaching new global markets

Estimates are calculated separately for each component and are later summed up to devise the final revenue impact number. As this survey was designed for sites that have worked with the labs on measurement related activities, it is likely that the respondents would provide answers for the revenue from products or services that are dependent on measurement. Customers were also asked if the innovation changes made would have been possible in the absence of support from the NMS¹⁹. If the customers reported that the support provided by the NMS was essential and unavailable elsewhere, that revenue was attributed to the NMS labs.

However, it is essential to note that approximately 25% of the respondents have told that they do not know or they prefer not to answer these questions, and we consider those responses as 'missing' values. Therefore, to deal with non-response bias in the analysis, **multiple imputation**²⁰ technique has been used to fill in the missing values. For all the components, fifty imputations have been performed such that every imputation represents the proportion of population that would fall in each revenue band. It was then observed that this data best fits a **pareto distribution**.

The pareto distribution is a power-law probability distribution which can be described by two parameters, alpha (α) and x_m . The value of α determines the slope of the distribution, and x_m represents the minimum possible value for the distribution which helps determine the spread of the distribution. When this function is plotted across a range of x ²¹ values, it can be observed that the distribution slopes downward as x increases. In simple terms, as observed

¹⁸ As a result of the innovation you worked on with NMS in financial year 2022, what were the annual sales of your product or service?

¹⁹ Would the changes made have been possible without the support of NMS? If 'yes', where could you have obtained this alternative support?

²⁰ Multiple imputation represents several sets of plausible values. It helps reduce bias and overcome incorrect estimates of standard errors and tests of statistical significance.

²¹ In this instance, 'x' values are the highest points of each revenue band.

in the following figure, the majority of the distribution's density is concentrated on the left-hand side near x_m with only a small proportion of the density on the right-hand side.

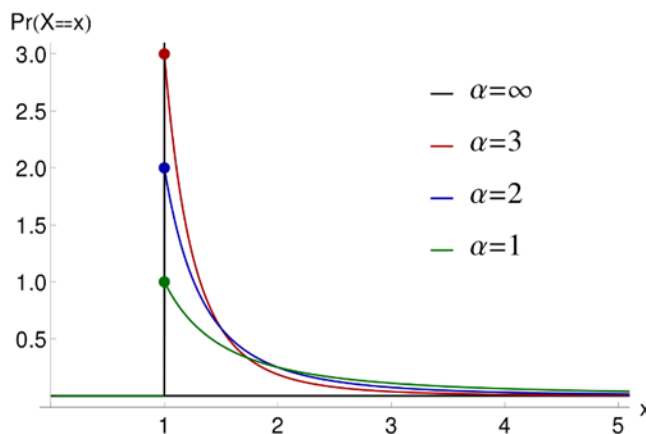


Figure 11 Pareto distribution with various α values²²

Applying the calculated values of α and x_m , revenue numbers for the missing values have been generated at random using inverse transform sampling. For each component, the revenue estimates for each individual site in the population are calculated and summed up at the end to represent the total revenue number. This process was repeated and ordered such that the total values are represented as percentiles. **The 50th percentile, also known as the median, is used to compute the headline number.** The 25th and the 75th percentiles form the lower and upper bounds of the confidence intervals, respectively.

5.3 RESULTS

In the year 2022, 2870 private businesses in the UK that interacted with the NMS collectively created a **total annual revenue impact of £1.56 billion before accounting for attribution.** It is important to note that these numbers have been restricted to a certain level of *innovation change*²³ and to the *real values*²⁴ provided by the respondents. It is noteworthy to mention that **88% of the NMS users made a change to their products or processes. Three quarters of them are product innovations and a quarter of them are process innovations. Moreover, 18% of the customers have reported that they disrupted or transformed the industry through an innovation change.** When the NMS survey was last conducted in 2018, the total revenue impact number was £1.4 billion before accounting for attribution²⁵. Therefore, it can be observed that there has been an increase of £160 million for total revenue impact within the last 4 years.

²² [Danvildanvil, CC BY-SA 3.0](#), via Wikimedia Commons

²³ On a scale of 0-10, the customers were asked what level of innovation change was achieved by their project. The respondents who have selected zero were excluded in the calculation of the total revenue impact number.

²⁴ Customers who have selected N/A were classified as the sites that had not made any sales in the year 2022. Therefore, they were excluded in the calculation of the total revenue impact number.

²⁵ The real value (after adjusting for inflation) of this revenue impact number is ~£1.8 billion.

Table 12 Total annual revenue impact without attribution to the NMS

<i>All values in £m</i>	Total revenue	Lower bound	Upper bound
New product or service	432	403	641
Improved product or service	637	533	1740
Reaching new markets	421	407	818
Total	1564	1413	3390

Even though it is important to be informed on the above figure, it however does not account for attribution. This would mean a few customers hold the opinion that some of the revenue benefits would have been possible to achieve without the support provided by the NMS labs. Therefore, it is necessary to calculate another headline number that accounts for attribution. As a consequence of excluding the non-attributed revenue numbers, the score would be necessarily lower.

The results show that about **32% of the revenue benefits has been attributed to the NMS labs**. This shows that the NMS labs contribute to a significant proportion of income for its customers. Though the attribution level for each component does not vary excessively, it should be noted that sales from new products or services hold the highest level of attribution of 34.3% and sales from improved products or services hold the lowest level of attribution of 30.6%.

In the year 2022, **when accounting for attribution, the annual revenue impact of ~£500 million**. In the previous NMS survey, the attributed revenue impact number was £539 million²⁶. Even though a decrease of £39 million can be observed within the last 4 years, it should be recalled that this period witnessed a series of economic shocks such as the covid crisis.

Table 13 Total annual revenue impact attributed to the NMS

<i>All values in £m</i>	Attributed revenue	Lower bound	Upper bound
New product or service	148	138	220
Improved product or service	195	163	533
Reaching new markets	136	131	264
Total	500	452	1083

Refer to Appendix C to gain a detailed understanding on the calculation of the revenue impact numbers.

²⁶ The real value (after adjusting for inflation) of this revenue impact number is ~£700 million.

6 SATISFACTION WITH THE NMS LABORATORIES

Customer satisfaction is monitored by the NMS to understand how their users view the relationship with the NMS labs. This also helps the labs to reflect on their current ways of working and strive to deliver the best value for their users in the future.

To measure satisfaction, customers were asked how likely they were to recommend the NMS to a colleague or other organisation. Based on the results, a **Net Promoter Score (NPS)**²⁷ is calculated to measure customers' loyalty and satisfaction with the products or services provided by the NMS labs. **The overall NPS given to the NMS labs is 47** which is considered 'good' and indicates that there are more happy customers than unhappy ones.

When the score is split into two sections, private sector has a score of 50 and calibration labs have a score of 36. The results from the previous NMS survey conducted in 2018 shows that the private sector had a score of 62 and calibration labs had a score of 59. It should be noted that the scores in the previous survey were calculated based on the sample, not the population. A reasonable drop can be observed in the NPS within the last 4 years, and it is noticeable that the decrease is more significant in the calibration labs.

Table 14 Net Promoter Score

	Sample	Population	NPS	Lower bound	Upper bound
Private sector	461	2270	50%	44%	55%
Calibration laboratories	133	600	36%	21%	52%
Total	594	2870	47%	42%	52%

The NPS has also been configured to represent national challenge areas in the below table. When the challenge areas are in comparison with one another, it can be observed that customers in the *Life Sciences & Health* are better satisfied and *Energy & Environment* are least satisfied. However, it should be noted that these NPS are not statistically different.

Table 15 NPS for challenge areas

National Challenge Areas	NPS	Lower bound	Upper bound
Prosperity	50%	41%	58%
Life Sciences & Health	53%	44%	61%
Energy & Environment	48%	41%	55%
Security & Resilience	51%	43%	59%

²⁷ On a scale of 0-10, the customers were asked how likely they are to recommend the NMS laboratories to a colleague or other organisation. Customers are classified as 'promoters' if they answer 9 or 10, 'passives' if they answer 7 or 8, and 'detractors' if they answer 6 or under. The NPS is calculated by subtracting the percentage of detractors from the percentage of promoters.

Within the UK's public sector, the National Health Service (NHS) has the NPS of 23.9, and public services has the NPS of 18.3²⁸. In comparison, this highlights the moderately strong performance of the NMS labs.

When the scores of other private sector organisations are considered, it can be observed that the NMS laboratories have a lot of scope for improvement. Moreover, over the years, the NPS for organisations such as Amazon and Google have followed an upward trajectory, but the NPS for the NMS labs has declined by 16% for the private sector and by 22% for the calibration labs²⁹.

Table 16 Benchmarks in the private sector³⁰

Organisation	NPS
Tesla	97
Amazon	73
Lloyds	62
Apple	61
Google	58
NMS laboratories	47
Samsung	47
IBM	27
Dell	24
Barclays	13
HSBC	7

The customers were also asked how satisfied they were with the products or services provided by the NMS labs in terms of timeliness of delivery, quality, and price. In this case, we could adapt the technique used to calculate the NPS by considering *Very satisfied* as 'Promoters', *Somewhat satisfied* as 'Passives', and *Somewhat dissatisfied* and *Very dissatisfied* as 'Detractors'. Therefore, the highest NPS can be clearly observed by quality, followed by timeliness of delivery, and price at the lowest.

Table 17 Satisfaction scores

	Detractors	Passives	Promoters	NPS
Timeliness of delivery	5%	29%	66%	61%
Quality	3%	23%	74%	72%
Price	8%	37%	55%	46%

²⁸ These values were taken from the 'Business Benchmarking' study conducted by The Institute of Customer Services for NPL in 2023.

²⁹ These values are calculated based on the NPS (n) from 2017 and 2023 NMS surveys.

³⁰ [Customer Gauge Report 2023](#)

7 CONCLUSION

The NMS labs have a substantial reach in the UK and the businesses that work with the NMS make great contributions to the UK's economy. These businesses employ ~711,490 people in the UK and collectively have an aggregate turnover of £154 billion. 50% of these businesses operate within the manufacturing sector, and this accounts for 13% of the manufacturing sector workforce in the UK. 20% of the private businesses self-identify as commercial calibration laboratories. The NMS labs work with 35% of all the UKAS accredited calibration labs in the UK. The reach of the NMS labs is extended by providing support to these labs. It is estimated that the NMS indirectly supports ~75,500 organisations in the UK through the fanout of calibration services provided by the customers.

It is believed that there are many products or services would be non-existent without support from the NMS labs, and these generate a substantial sales revenue for their customers. Around 88% of the NMS users made a change to their products or processes and 18% of the customers have disrupted the industry through an innovation change. 2870 private businesses in the UK that interacted with the NMS collectively created a total annual revenue impact of £1.56 billion before accounting for attribution. 32% customers mentioned that their products or services would not exist without the support from the NMS labs, and they collectively attribute £500 million in revenue to the NMS.

It is important to understand how their users view the relationship with the NMS labs to deliver greater impact in the future. The overall NPS given to the NMS labs is 47 which is considered 'good' and indicates that there are more happy customers than unhappy ones. However, this also suggests that the NMS labs need to reflect on their current ways of working and strive to deliver the best value for their users. It was also noted that the NMS users are most satisfied with the quality and least satisfied with price.

It should be noted that this report focuses on generating the first findings i.e., essential headline numbers from the survey that would be useful for the NMS laboratories. In the near future, this report could be updated with additional information on the analysis or any further updates to the numbers.

7.1 NEXT STEPS

Two further reports detailing on the measurement and innovation question sets of the survey will be published shortly. The measurement report will focus on highlighting the analyses surrounding the value of turnover spent on measurement, conformance testing, type 1 and type 2 errors, scrap rates, and so forth. The innovation report will focus on highlighting the analyses surrounding spillovers, knowledge transfers, hurdle rate, among others.

APPENDIX A : ADDITIONAL ANALYSIS FOR ATTRIBUTION TO THE NMS SUPPORT IN CHALLENGE / TECHNOLOGICAL AREAS

This section details the additional analysis performed to showcase the attribution to the NMS using a regression approach. The regression line tells how the dependant variable changes as the independent variable changes. In this case, ‘innovation attribution to the NMS’ is the dependant variable and ‘connection to the firm’s line-of-business’ is the independent variable. It can be observed from the below figure that sections of the Environment and Health sectors have registered maximum contribution from the NMS.

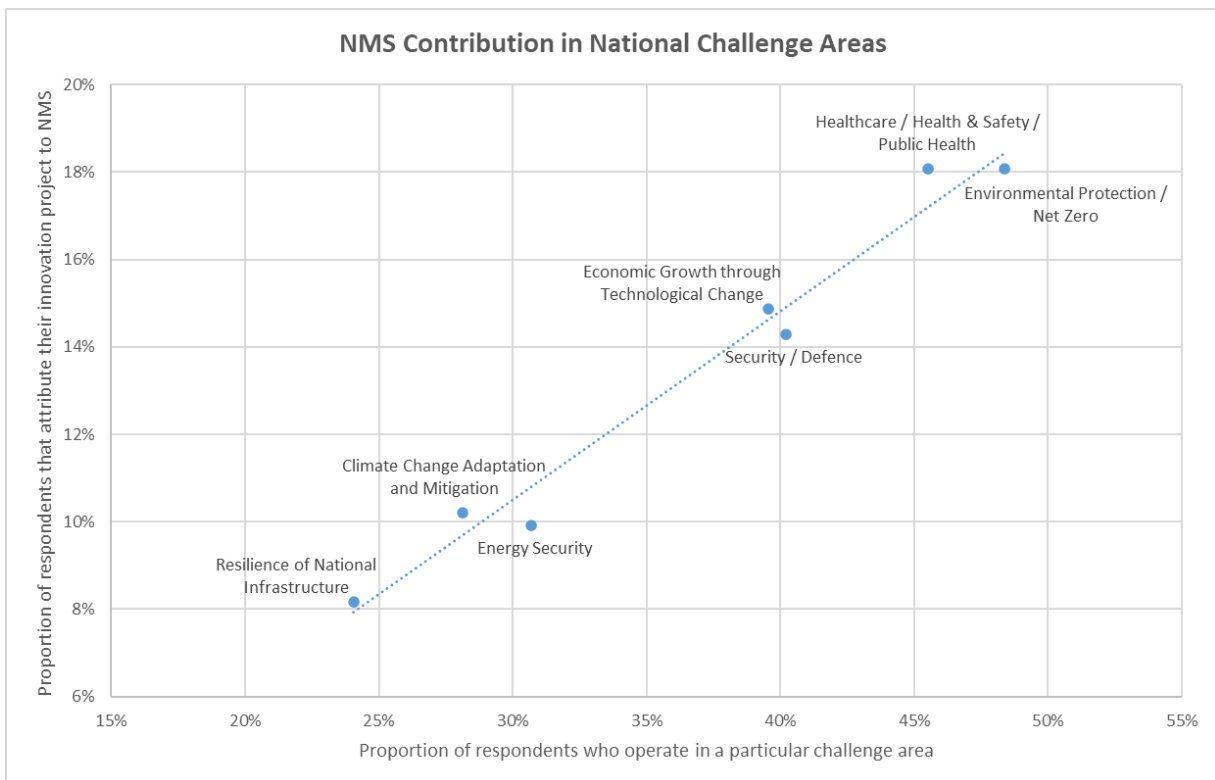


Figure 12 Scatter plot for NMS support provided within national challenge areas

The below table showcases a quotient analysis modelled on regional quotients, using the regression³¹ approach. The quotient shows the significance of the NMS’s contribution to innovations in a challenge area. Out of all the challenge areas, the Health sector stands out at the highest i.e., when the predicted outcome is at 17%, the actual outcome is 18%, which is ~5% more. The same value also resonates with a section of the Environment sector. This shows that the firms that operate in the Environment and Health challenge areas in the UK consider the NMS as an important factor to help develop their innovations.

³¹ A caveat for this regression (as it assumes a linear relationship) is when observations are either too big or too small, the estimates produced might not be quite right.

Table 18 Quotient analysis for national challenge areas

National Challenge Areas	Actual outcome	Predicted outcome	Residuals	Quotient	% change
Economic Growth through Technological Change	0.15	0.15	0.00	1.02	2%
Environmental Protection / Net Zero	0.18	0.18	0.00	0.98	-2%
Healthcare / Health & Safety / Public Health	0.18	0.17	0.01	1.05	5%
Security / Defence	0.14	0.15	-0.01	0.96	-4%
Resilience of National Infrastructure	0.08	0.08	0.00	1.03	3%
Energy Security	0.10	0.11	-0.01	0.92	-8%
Climate Change Adaptation and Mitigation	0.10	0.10	0.01	1.05	5%

Similarly, it can be observed that Quantum technologies is a significant technological area. Despite making up a small fraction of the technological sphere, quantum has registered maximum contribution from the NMS.

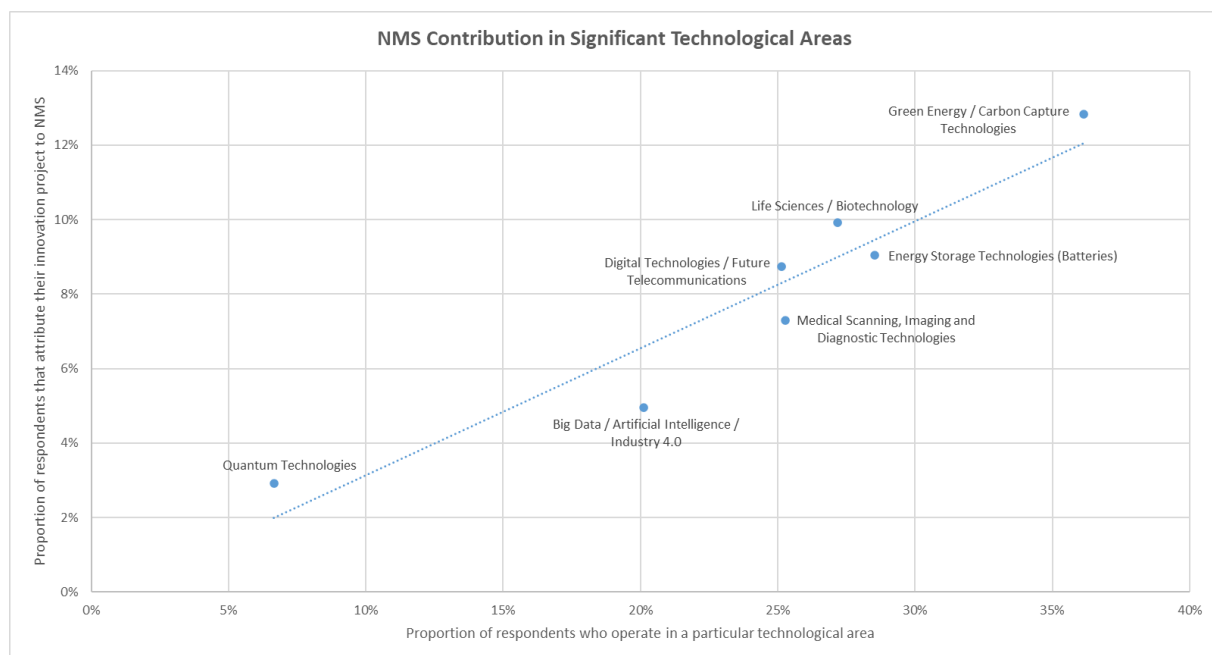


Figure 13 Scatter plot for NMS support provided within significant technological areas

In the quotient analysis, out of all the technological areas, Quantum technologies stands out at the highest i.e., when the predicted outcome is at 2%, the actual outcome is 3%, which is ~50% more. This shows that the nascent quantum sector in the UK consider the NMS as an important factor to help develop their innovations.

Table 19 Quotient analysis for significant technological areas

Significant technological areas	Actual outcome	Predicted outcome	Residuals	Quotient	% change
Green Energy / Carbon Capture Technologies	0.13	0.12	0.01	1.06	6%
Energy Storage Technologies (Batteries)	0.09	0.09	0.00	0.96	-4%
Life Sciences / Biotechnology	0.10	0.09	0.01	1.10	10%
Medical Scanning, Imaging and Diagnostic Technologies	0.07	0.08	-0.01	0.87	-13%
Digital Technologies / Future Telecommunications	0.09	0.08	0.00	1.05	5%
Big Data / Artificial Intelligence / Industry 4.0	0.05	0.07	-0.02	0.75	-25%
Quantum Technologies	0.03	0.02	0.01	1.46	46%

APPENDIX B : CALCULATION OF HEADLINE NUMBERS

The headline numbers in this report have been calculated using the *svyset* command in Stata which allows the application of poststratification adjustments to the sampling weights for set variables. *Svyset* is an extremely useful command that declares the dataset as survey data and helps manage the analysis of that dataset. In this case, the *svyset* command used 'segments' as poststratum identifiers for respective population totals or sizes. The final step includes using the *svy* prefix command which fits statistical models for complex survey data by adjusting the results of a command for survey settings identified by *svyset*.

However, this process has also been mathematically replicated in Excel to ensure the alignment of headline numbers generated by Stata. For example, let us consider how to calculate the fanout number of ~75,500. The steps are as follows :

1. Calculate the below table to understand the how many responses could be actually used from the raw survey data. In this case, all the respondents have provided adequate answers that could be used for analysis. However, if that was not the case, the response weights would be higher and thereby the total weights would differ.

$$\text{Response weight} = \frac{\text{Sample}}{\text{Usable responses}}$$

$$\text{Total weight} = \text{Sample weight} * \text{Response weight}$$

When total weight is multiplied by usable responses, it should give us back the population. This is just to cross-check that we have performed the calculations in the right manner.

Table 20 Assignment of weights based on responses to the question

Segment	Sample	Usable responses	Response weight	Sample weight	Total weight	Total weight * Usable responses
M-E	63	63	1.0	3.8	3.8	241.0
SME-E	130	130	1.0	3.7	3.7	475.0
L-E	52	52	1.0	6.6	6.6	341.0
M-S	52	52	1.0	2.5	2.5	131.0
SME-S	174	174	1.0	2.8	2.8	481.6
L-S	86	86	1.0	5.1	5.1	440.0
SME-R*	97	97	1.0	2.5	2.5	246.4
L-R	82	82	1.0	6.3	6.3	514.4
Total	736	736				2870

2. In the column that represents the number of laboratories that the self-identified commercial calibration laboratories provide calibration services/reference materials to³², assign '0' to the respondents who have answered that they are not a commercial calibration laboratory³³.

³² To understand the fanout of traceability in the economy, how many laboratories do you provide calibration services/reference materials to?

³³ Do you classify yourself as a commercial calibration laboratory?

3. Assign the calculated total weight to all the 736 respondents based on the segment they belong to.
4. Create the below table to calculate the total fanout number.
 - **x** refers to the number of labs that receive calibration services/reference materials from self-identified commercial calibration labs.
 - **f** refers to the number of sites in the population marked against their response to the number of labs.
 - The total product of **x** and **f** gives the final fanout number of 75,522.

Table 21 Calculation of the fanout number

Number of labs (x)	Frequency (f)	Cumulative frequency (cf)	Cumulative distribution function (cdf)	x*f
0	2410.7	2410.7	84%	0.0
1	52.5	2463.2	86%	52.5
2	16.7	2479.8	86%	33.3
3	15.4	2495.2	87%	46.1
4	14.4	2509.7	87%	57.8
5	16.6	2526.3	88%	83.1
6	2.5	2528.8	88%	15.2
9	5.1	2533.9	88%	46.0
10	34.2	2568.1	89%	341.8
12	6.3	2574.4	90%	75.3
13	2.5	2576.9	90%	33.0
15	2.5	2579.4	90%	37.8
20	28.0	2607.5	91%	560.3
25	19.1	2626.6	92%	477.9
30	2.5	2629.1	92%	75.6
48	6.3	2635.4	92%	301.1
50	29.7	2665.0	93%	1483.2
75	14.1	2679.2	93%	1059.2
80	5.1	2684.2	94%	406.5
100	97.3	2781.5	97%	9730.7
136	2.5	2784.1	97%	345.5
150	7.8	2791.9	97%	1174.0
200	18.9	2810.8	98%	3778.0
400	7.9	2818.7	98%	3153.3
500	14.3	2833.0	99%	7174.7
600	2.8	2835.8	99%	1660.5
620	2.5	2838.3	99%	1575.1
800	2.5	2840.9	99%	2032.4
1000	17.8	2858.7	100%	17776.5
1400	2.5	2861.2	100%	3556.8
2000	9.2	2870.4	100%	18378.5
	2870			75522

The total number of labs to estimate the fanout generated by Stata using the svy command for that variable is the same as the number calculated in the above method. The very minor difference in the total between the two methods arises from how Stata rounds off the decimals. Therefore, it can be concluded that the NMS labs indirectly support ~75,500 organisations in the UK through the fanout of calibration services provided by the customers.

```
. svy linearized : total ccl3
(running total on estimation sample)

Survey: Total estimation

Number of strata = 1           Number of obs = 736
Number of PSUs  = 736        Population size = 2,870
N. of poststrata = 8         Design df      = 735
```

	Linearized			
	Total	std. err.	[95% conf. interval]	
ccl3	75497.85	13049.47	49879.17	101116.5

Figure 14 Results of the fanout number from Stata

This same method has been repeated to produce the remaining headline numbers that appear in this report.

APPENDIX C : PARETO DISTRIBUTION

For calculating the revenue impact headline number, the most important step was to figure out how to fill in the substantial number of missing values. To resolve this issue, multiple imputation technique has been used to impute missing values.

Multiple imputation is mostly used in clinical trials i.e. Randomised Controlled Trials (RCT). It is highly encouraged to use multiple imputation to fill in the missing values when compared to historical approaches such as complete case analysis, mean imputation, and single imputation. This is because multiple imputation helps overcome a potential result in bias, incorrect estimates of standard errors, and consequently incorrect tests of statistical significance, which the other techniques might not.

In this case, multiple imputation was the preferred method to handle missingness as it helps in maintaining the validity of the statistical inferences. If this method was not used, it could have led to less power, results restricted to those individuals without missing values, violation of the intent-to-treat principle, possible non-random loss, and ultimately to results that may not apply to the original full sample.

For example, let us consider how to calculate the revenue number of £148 million from the sales of new products or services. The steps are as follows :

1. In Stata, using the *mi* command, 50 imputations have been performed such that every imputation represents the proportion of population that would fall in each revenue band. It was then observed that this data best fits a pareto distribution.

Table 22 Frequency distribution of revenue from new products or services

Revenue bands	Endpoint (x)	f	cdf	ln(x)	ln(1-cdf)
0	100	70.7%	70.7%	4.6	-1.2
Up to £1,000	1000	6.2%	77.0%	6.9	-1.5
More than £1,000 and up to £5,000	5000	4.2%	81.2%	8.5	-1.7
More than £5,000 and up to £50,000	50000	7.3%	88.4%	10.8	-2.2
More than £50,000 and up to £150,000	150000	5.4%	93.8%	11.9	-2.8
More than £150,000 and up to £1,000,000	1000000	4.6%	98.4%	13.8	-4.2
More than £1,000,000 and up to £2,500,000	2500000	0.4%	98.8%	14.7	-4.4
More than £2,500,000 and up to £20,000,000	20000000	0.7%	99.5%	16.8	-5.3
More than £20,000,000 and up to £100,000,000	100000000	0.5%	100.0%	18.4	#NUM!

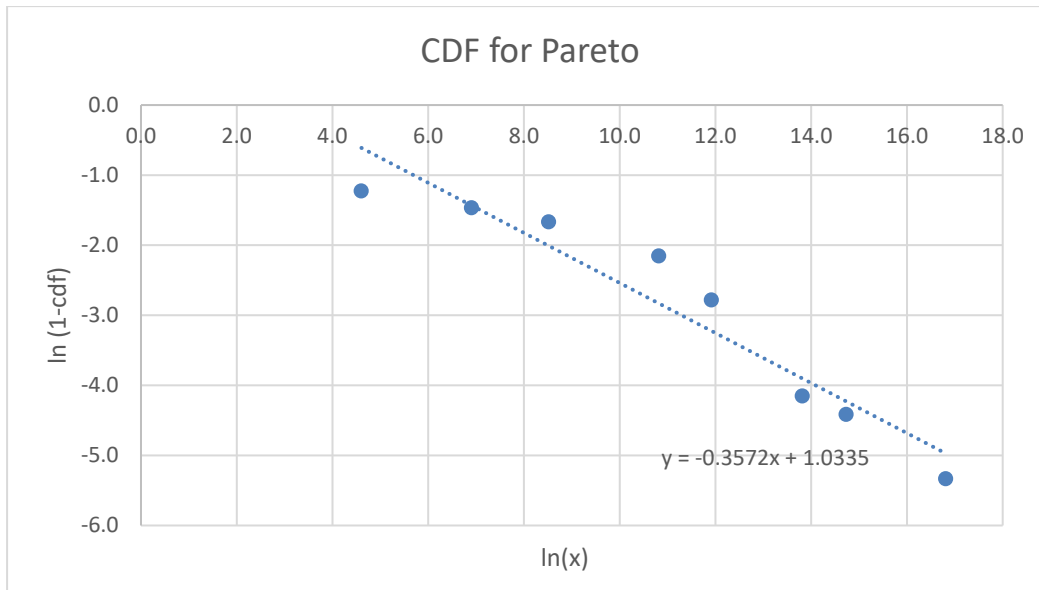


Figure 15 Pareto CDF of revenue from new products or services

2. The CDF for a pareto random variable which have the parameters α and x_m can be defined as :

$$F(x) = 1 - \left(\frac{x_m}{x}\right)^\alpha$$

This equation can be rewritten as :

$$1 - F(x) = \left(\frac{x_m}{x}\right)^\alpha$$

Adding log on either sides :

$$\ln(1 - F(x)) = \alpha * \ln(x_m) - \alpha * \ln(x)$$

Therefore, after rearranging the equation :

$$x_m = e^{\left(\frac{\alpha * \ln(x_m)}{\alpha}\right)}$$

From the above Figure 21, we know that :

$\alpha * \ln(x_m)$ is the intercept of the equation = 1.0335

α is the slope³⁴ of the equation = 0.3572

Substituting the values in the previous equation, we get $x_m = 18.05345$.

³⁴ It should be noted that alpha should be positive in the pareto distribution.

3. Given the values of α and x_m , random samples could be generated using inverse transform sampling. When a random U is drawn from the uniform distribution function between (0,1), the variate T is :

$$T = \frac{x_m}{U^{1/\alpha}}$$

For each respondent, the values are assigned according to their segment. The missing values are replaced with T . For obtaining population estimates, these values were then multiplied with the respective sample weights. This would result in the revenue estimates for each individual site in the population. When these values are summed up at the end, this would provide the total revenue estimate for new products or services.

This process was repeated for 100 times and the values were placed in an ascending order such that the totals are represented as percentiles. The 50th percentile, also known as the median, is used to compute the headline number. The 25th and the 75th percentiles form the lower and upper bounds of the confidence intervals, respectively³⁵.

Similarly, all the above three steps have been repeated for other components 'improved product or service' and 'reaching new markets'.

4. The below table shows the final numbers for revenue impact while accounting for innovation change, real values, and attribution.

Table 23 Total attributed revenue impact estimates

	Median	Filters (to be multiplied with median to get headline number)			Headline number	Lower bound	Upper bound
		Non-zero values	Innovation	Attribution			
New product/service	1872	0.29	0.79	0.34	148	138	220
Improved product/service	3246	0.24	0.81	0.31	195	163	533
Reaching new markets	2505	0.21	0.80	0.32	136	131	264
Total	7622	0.25	0.83	0.32	500	452	1083

³⁵ When the value of α is less than 1, the descriptive statistics such as arithmetic mean cease to exist and this leads to large confidence intervals. Therefore, it could be appropriate to calculate the confidence intervals for pareto distributions in the above suggested manner.

APPENDIX D : QUESTIONS AND RESPONSE OPTIONS

1. Which of the following best describes your job role?
 - Technical (Engineer/Scientist)
 - Operational (Sales/Functions)
 - Production (Manufacturing/Delivery)
 - Other

2. In which of the following regions is your site based?
 - North East
 - North West
 - Yorkshire and the Humber
 - East Midlands
 - West Midlands
 - East of England
 - London
 - South East
 - South West
 - Wales
 - Scotland
 - Northern Ireland

3. Which of the following standard industrial classification section best describes your organisation?
 - A: Agriculture
 - B: Mining and Quarrying
 - C: Manufacturing
 - D: Electricity, Gas, and Steam
 - E: Water Supply and Waste Management Activities
 - F: Construction
 - G: Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
 - H: Transportation and Storage
 - I: Accommodation and Food Service Activities
 - J: Information and Communication
 - K: Financial Activities
 - L: Real Estate Activities
 - M: Professional, Scientific, and Technical Activities
 - N: Administrative and Support Service Activities
 - Z: Other

4. Currently, how many employees are present at the site that you work at?
 - Up to 1
 - 2 – 9
 - 10 – 49
 - 50 – 249
 - 250 – 499
 - 500 – 999
 - 1000 – 1999
 - Greater than or equal to 2000

- Don't know
5. In which of the following scientific areas do you conduct the majority of your measurement activity? (Please select one option only)
- Mass & Dimensional
 - Material Properties
 - Temperature & Humidity
 - Pressure
 - Flow
 - Electromagnetic & Electrochemical
 - Biological
 - Chemical
 - Gas & Particles
 - Optical / Radiometric Metrology
 - Quantum
 - Time & Frequency
 - Nuclear & Radiation
 - Acoustics & Ultrasound
 - Force/Torque
 - Other
6. Do you classify yourself as a commercial calibration laboratory?
- Yes
 - No
7. Are you UKAS accredited for the following?
- Testing and Analysis
 - Calibration and reference materials
 - None of the above
8. To understand the fanout of traceability in the economy, how many laboratories do you provide calibration services/reference materials to?
9. Of the site that you work at, what was your financial turnover/revenue in tax year ending in 2022?
- Up to £200,000
 - More than £200,000 and up to £2,000,000
 - More than £2,000,000 and up to £10,000,000
 - More than £10,000,000 and up to £50,000,000
 - More than £50,000,000 and up to £100,000,000
 - More than £100,000,000 and up to £200,000,000
 - More than £200,000,000 and up to £400,000,000
 - More than £400,000,000
 - Site is operating at pre-revenue stage
 - Don't know
10. Does your firm's line-of-business connect to any of the following National Challenge Areas?
- Economic Growth through Technological Change

- Environmental Protection / Net Zero
 - Healthcare / Health & Safety / Public Health
 - Security / Defence
 - Resilience of National Infrastructure
 - Energy Security
 - Climate Change Adaptation and Mitigation
 - None of the above
11. Does your firm's line-of-business connect to any of the following technologies?
- Green Energy / Carbon Capture Technologies
 - Energy Storage Technologies (Batteries)
 - Life Sciences / Biotechnology
 - Medical Scanning, Imaging and Diagnostic Technologies
 - Digital Technologies / Future Telecommunications
 - Big Data / Artificial Intelligence / Industry 4.0
 - Quantum Technologies
 - None of the above
12. How satisfied were you with the service NMS provided in terms of the following?
- Timeliness of Delivery
 - Quality
 - Price
13. Overall, has working with NMS helped you to achieve any of the following? (Please tick all that apply)
- Expand your organization's capabilities
 - Increase your users' satisfaction
 - Increase measurement confidence
 - Attract more business / customers
 - Form new partnerships and collaboration agreements
 - Improve training, qualifications, or professional development for employees
 - N/A
 - Other
14. On a scale from 1-10, where 1 is 'Not At All Likely', to 10 'Very Likely', how likely is it that you would recommend NMS to a colleague or other organization?
15. On a scale of 0 to 10, what level of innovation change was achieved by the project? (From 0, Incremental (small improvement to your organization), to 10, Disruptive (transformed the market / industry))
16. Would the changes made have been possible without the support of NMS?
- Yes
 - No
 - Don't know
 - Prefer not to say

17. As a result of the innovation you worked on with NMS, if 'developing new products or services' in financial year 2022, what were the annual sales of your new product or service?
- Up to £1,000
 - More than £1,000 and up to £5,000
 - More than £5,000 and up to £50,000
 - More than £50,000 and up to £150,000
 - More than £150,000 and up to £1,000,000
 - More than £1,000,000 and up to £2,500,000
 - More than £2,500,000 and up to £20,000,000
 - More than £20,000,000 and up to £100,000,000
 - More than £100,000,000
 - Don't know
 - Prefer not to say
 - N/A
18. As a result of the innovation you worked on with NMS, if 'existing products or services were improved' in financial year 2022, what were the annual sales of your improved product or service?
- Up to £1,000
 - More than £1,000 and up to £5,000
 - More than £5,000 and up to £50,000
 - More than £50,000 and up to £150,000
 - More than £150,000 and up to £1,000,000
 - More than £1,000,000 and up to £2,500,000
 - More than £2,500,000 and up to £20,000,000
 - More than £20,000,000 and up to £100,000,000
 - More than £100,000,000
 - Don't know
 - Prefer not to say
 - N/A
19. As a result of the innovation you worked on with NMS, if existing products reached new global markets in financial year 2022, what would you say the annual sales from the new markets were?
- Up to £1,000
 - More than £1,000 and up to £5,000
 - More than £5,000 and up to £50,000
 - More than £50,000 and up to £150,000
 - More than £150,000 and up to £1,000,000
 - More than £1,000,000 and up to £2,500,000
 - More than £2,500,000 and up to £20,000,000
 - More than £20,000,000 and up to £100,000,000
 - More than £100,000,000
 - Don't know
 - Prefer not to say
 - N/A

20. As a result of the innovation you worked on with NMS, did it have an impact on any of the following National Challenge Areas?

- Economic Growth through Technological Change
- Environmental Protection / Net Zero
- Healthcare / Health & Safety / Public Health
- Security / Defence
- Resilience of National Infrastructure
- Energy Security
- Climate Change Adaptation and Mitigation
- None of the above
- Don't know
- N/A

21. As a result of the innovation you worked on with NMS, did it have an impact on any of the following technologies?

- Green Energy / Carbon Capture Technologies
- Energy Storage Technologies (Batteries)
- Life Sciences / Biotechnology
- Medical Scanning, Imaging and Diagnostic Technologies
- Digital Technologies / Future Telecommunications
- Big Data / Artificial Intelligence / Industry 4.0
- Quantum Technologies
- None of the above
- Don't know
- N/A