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# **The Economic Impact of the National Measurement System Programme: A Business Case Model**

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## **National Physical Laboratory (NPL)**

### **The Economic Impact of the National Measurement System Programme: A Business Case Model**

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We are the UK's National Metrology Institute (NMI), a world-leading centre of excellence that provides cutting-edge measurement science, engineering and technology that underpins prosperity and quality of life in the UK.

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# Contents

<b>1</b>	<b>Introduction</b> .....	<b>5</b>
1.1	The NMS Laboratories .....	5
1.2	Key Role of the NMS.....	5
<b>2</b>	<b>Public Funding</b> .....	<b>7</b>
<b>3</b>	<b>Impact Stream: Measurement Infrastructure</b> .....	<b>11</b>
3.1	Average Benefits .....	16
3.2	Marginal Benefits.....	16
<b>4</b>	<b>Impact Stream: Innovation</b> .....	<b>17</b>
4.1	Average Benefits .....	19
4.2	Marginal Benefits.....	19
<b>5</b>	<b>Rates of Return on the NMS</b> .....	<b>19</b>
<b>6</b>	<b>Value for Money (VfM) Analysis for the NMS</b> .....	<b>20</b>
6.1	Measures of VfM .....	23
<b>7</b>	<b>Calculating RoRs for Other Options</b> .....	<b>25</b>
7.1	Option 1 (Preferred Option).....	25
7.2	Option 2 (Do Less: Maintenance of Core Capabilities) .....	25
7.3	Option 3 (Do More: National Scientific Infrastructure).....	26
<b>8</b>	<b>Conclusion</b> .....	<b>27</b>
<b>9</b>	<b>References</b> .....	<b>28</b>
<b>10</b>	<b>Annex 1 – Innovation Stream Benefits When Including All Taxes</b> .....	<b>32</b>
10.1	Average benefits .....	33
10.2	Marginal benefits.....	33
10.3	Rates of Return on the NMS .....	33
<b>11</b>	<b>Annex 2 – VfM Analysis for Other Options</b> .....	<b>34</b>
11.1	VfM Analysis for Option 2 (Do Less: Maintenance of Core Capabilities).....	34

11.2 VfM Analysis for Option 3 (Do More: National Scientific Infrastructure)..... 37

**12 Annex 3 – Calculating Marginal Rate of Return from Average Rate of Return ..... 42**

12.1 Knowledge stock adjustment over time..... 42

12.2 Linking knowledge to economic benefit ..... 43

12.3 Average vs marginal return on public funding..... 44

**13 Annex 4 – Deflators and Discount Rates ..... 46**

13.1 Deflator..... 46

13.2 Discount Rate..... 46

**14 Annex 5 – Near Saturation of the UK Measurement Infrastructure ..... 47**

14.1 Productivity of the Measurement Infrastructure ..... 47

14.2 Medium term ..... 48

14.3 Long Term..... 49

# 1 Introduction

The UK's National Measurement System (NMS) programme funds the NMS laboratories to ensure that the infrastructure supporting reliable and internationally recognised measurements continues to operate effectively. This is done through the establishment of primary measurements, which are disseminated through reference methods and/or materials, with new measurement knowledge needing to be developed to tackle emerging needs or challenges. There is also a need to assure that measurements are consistent across borders, to ease non-tariff barriers and assure quality when buyers and sellers in different countries are conducting trade. Therefore, the NMS has counterpart programmes around the world who work together to agree on the best available means to realise and define each of the units of measurement. This was founded as *The Metre Convention* in 1875, creating the International Bureau of Weights and Measures (Bureau International des Poids et Mesures, BIPM).

## 1.1 The NMS Laboratories

In the UK, the National Physical Laboratory (NPL) is the UK's National Metrology Institute (NMI) and works in partnership with six designated institutes, which are:

- National Measurement Laboratory at LGC (NML @ LGC) – designated for chemical and biological metrology.
- National Engineering Laboratory (NEL) – designated for fluid flow metrology.
- National Gear Metrology Laboratory (NGML) – designated for gears metrology.
- National Institute for Biological Standards and Control (NIBSC) – designated for bioactivity metrology, funded by the Department of Health & Social Care.
- National Institute of Airborne Acoustic Metrology (NIAAM) - designated for airborne acoustics, founded and run by the University of Salford.
- The Government Chemist – works to resolve legal disputes using scientific analysis and provides an advisory role, primarily in the food and feed industries.

## 1.2 Key Role of the NMS

As detailed in the *Measuring up to the Competition* (1989) white paper, the central objectives of the NMS programme are:

1. To enable individuals and organisations in the UK to make measurements competently and accurately and to demonstrate the validity of such measurements.
2. To co-ordinate the UK's measurement system with the measurement systems of other countries.

These key objectives are achieved, by drawing on the NMS's funding, through the provision of **fundamental measurement standards** (primary standards), developed by the NMS laboratories. This will include the infrastructure, services and international agreements which assures users in both the UK and abroad of the accuracy and comparability of their measurements. Beyond the primary standards, the NMS laboratories also do significant work in the **development of technical standards**, working with industry to create product or process requirements. These ensure that best practices are being followed, while encouraging new and innovative approaches to meet requirements. A natural extension of this work sees the NMS supporting **legal metrology and regulation**, assuring that those conducting measurements are meeting the required specification and informing the development of those specifications within regulation and legislation, while also underpinning the UK's quality infrastructure. The measurement infrastructure also includes a network of commercial businesses and public organisations that depend on direct access to the measurement standards based at the NMS laboratories. Moreover, this network of organisations goes on to provide services that feed into the rest of the economy, making it the main way that **measurement standards are disseminated** in the form of measurement services and reference materials. In turn, this sees measurement standards circulated through the economy and assures the accuracy of measurements used in the provision of public services.

This report details the impact of the NMS based on the Business-as-usual (BAU) option submitted for Spending Review 2025 (SR25). The rest of the document is structured as follows: Section 2 summarises the NMS funding allocation across its four main impact themes. Sections 3 and 4 present the monetised and unmonetised impacts from these streams. For monetised benefits, we set out the theoretical framework and quantitative estimates. We compute average and marginal returns to assess impacts, which represent the potential benefits lost if the NMS was either cut in its entirety or cut by a proportion, respectively. Following these calculations, Section 5 reports the overall rates of return and Section 6 presents a value-for-money (VfM) analysis for the BAU option. Section 7 compares two alternative options with the BAU. Section 8 concludes the report.

A supplementary Excel calculator is published alongside this report. The workbook implements all formulae used in the quantitative analysis and provides a transparent, reproducible set of calculations for the rates of return and Value for Money metrics presented here.

## 2 Public Funding

Under the Business-as-Usual (BAU) option, the NMS would remain unchanged. Its structure would stay the same, with NPL as the National Metrology Institute and the other labs (NML and NEL) as designated institutes for their respective fields. The NMS labs would also continue to perform a mixture of R&D and service delivery.

This option would see maximum utilisation of public investment due to minimal adjustment costs which also makes it lowest risk. It also lends itself to government objectives – supporting economic growth, the NHS, and net-zero. Given the NPL's unique position as an NMI, there is little chance of duplicating the work of other government programmes.

Impact from the NMS is funnelled through four channels or streams as outlined in the NMS evaluation framework:

- **Measurement Infrastructure** involves supplying the high-level calibrations<sup>1</sup> and reference materials that underpin the comparability and reproducibility of measurements, as well as providing training and consultancy that help businesses and other organisations to improve their in-house measurement capabilities.
- **Innovation** involves collaborating with businesses and public sector organisations to support their innovation projects. Economic gains generated from these collaborations can be estimated by using the number of supported firms as a measure of productivity gains.
- **Research** comprises the foundational measurement science and R&D undertaken across the NMS laboratories, which advances metrology capability and supports

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<sup>1</sup> Calibration refers to the process of comparing the measurements made by an instrument or system against a known reference standard to verify accuracy and, if necessary, adjust the instrument to align with that standard. In the context of the NMS, calibrations ensure that measurements used across industry and public services are traceable to national and international standards, thereby guaranteeing reliability, comparability, and confidence in measurement results.

emerging technologies. While these impacts are not yet monetised in the business case model, they contribute to the evidence base underpinning the innovation and measurement infrastructure streams.<sup>2</sup>

- **Knowledge Transfer** includes training, good-practice guidance, and the codification of measurement expertise. These activities support diffusion of best practice across industry. Their impacts are not monetised within this model but operate as enabling mechanisms within the two core economic channels.<sup>3</sup>

For the NMS, its benefits are generated via two different streams, both of which have been modelled, published (links provided) and are monetisable:

### Measurement Infrastructure

- This benefit stream focuses on the capital side of the NMS, assuring that the capability needed to realise the UK's National Measurement Standards is fit for purpose, and congruent with the capability described in NPL's Calibration and Measurement Capability<sup>4</sup> (or CMCs).
- This benefit stream depends on regular investments in physical capital, including both hardware and software, as well as complementary investments in associated human capital, which is comprised of the skilled scientists that operate the physical capital. For measurement, the priority is on the human capital, with the experience of long-serving scientists and engineers representing most of the capital housed at the NMS labs.
- Other activity also includes the decommissioning of infrastructure no longer needed by the NMS, international comparisons of CMCs to validate its measurement standards and the maintenance of UKAS accreditation.
- The paper that analyses these benefits uses values from the period 2015 to 2019 to estimate its model.

<sup>2</sup> We track the number of papers published and collaboration done by the NMS labs, but we currently cannot monetise this work. This may be explored in the future through new kinds of impact analysis.

<sup>3</sup> While we track the number of learners for in-person and online trainings by NPL, it is difficult to assign monetary value to the impact.

<sup>4</sup> A CMC, or **Calibration and Measurement Capability**, is the metrological claim of a laboratory to offer a specific calibration and measurement service with a stated level of uncertainty.

[https://www.bipm.org/documents/20126/42177518/CIPM\\_2007\\_11\\_CMC\\_BMC\\_accepted.pdf/c25f8606-4c85-f26c-c606-616a46a32efe](https://www.bipm.org/documents/20126/42177518/CIPM_2007_11_CMC_BMC_accepted.pdf/c25f8606-4c85-f26c-c606-616a46a32efe)

## Innovation

- This benefit stream focuses on the NMS's collaboration work, primarily with the private sector.
- Firms often come to the NMS for solutions to their measurement issues, which may require a bespoke or "off-the-shelf" solution. Following on from projects with the NMS, these firms could see a range of benefits, be it a higher success rate in their innovation projects, meeting regulatory requirements or better demonstrating the benefits to their respective customers.
- This benefit stream also includes the NMS's innovation support schemes which target SMEs who usually are unable to access its capabilities.
- The paper that analyses these benefits considers values from the period 2009 to 2015 to estimate its model.

The vast majority of NPL's projects include benefits from both respective streams. Because of this, they can be viewed as inextricably linked and not additively separable, which is why we assume that both benefit streams come from a single funding pot.

To generate the rates of return for the models detailed above, the Public Sector Cost used in these papers is approximately £80 million, representing the NMS's funding in the period when the models were estimated (which can be referred to as *Old Money*). However, the current funding level of the NMS is £100 million per year, which is used to generate the net benefits in the options analysis (referred to as *New Money*). This calculation can be represented as follows:

$$\text{New Money Benefits} = \left( \frac{\text{Old Money Benefits}}{\text{Old Money Costs}} \right) \times \text{New Money Costs}$$

$$\Rightarrow \text{New Money Benefits} = \text{Old Money Rates of Return} \times \text{New Money Costs}$$

This difference is due to an increase in the NMS's funding in the 2020s – driven primarily by inflation. Using the [September 2025 deflators](#), the price level increased by 8% between 2015 and 2019. Therefore, it was reasonable to maintain a funding level of £80 million when modelling both benefit streams. However, in the period from 2019 to 2024, the price

level increased by 23%. These effects required the NMS budget to be increased to £100 million to allow for the NMS labs to maintain the same output.<sup>5</sup>

Having detailed the streams that can be monetised, the next key thing to note is the difference between if the NMS saw a cut in its entirety or saw a proportion of its funding cut. The NMS has continued to maintain a stock of knowledge through government funded R&D projects. Private and social benefits from the NMS can be valued by estimating the economic damage that would be caused by discontinuing or diminishing the NMS programme. Our analysis shall compute two main types of rates of return:

- **The average rate of return** relates to the effect of scrapping the entire NMS programme. It gives us an estimate of the benefits attributable to the whole of the NMS. We use this estimate to determine the average rate of return on public investment.
- **The marginal rate of return** relates to the effect of cutting a fraction of to the NMS funding for development projects. We assume here that the cut applies to funding for development of the measurement infrastructure but not the maintenance of it, which will remain safeguarded. If maintenance takes a cut, we default to the average cut scenario.

If the NMS were to be scrapped entirely, there would be an instant effect on the economy. Whereas, if funding for the NMS were reduced, it would take some years for the effect to filter through the economy. Consequently, marginal effect of a cut is less than the corresponding average effect of the cut due to social rate of time preference (SRTP)<sup>6</sup>.

Assume that it takes 6 years for the effect to filter through the economy (Frontier Economics, 2024) and use the discount rate of 3.5% (HMT's Green Book). We arrive at the result that **marginal private return is 66% of the corresponding average private return**.<sup>7</sup> This is because marginal returns on public funding are consistently lower than average returns due to each additional £1 facing frictions like depreciation, discounting, and delays that diminish incremental gains in present value terms.

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<sup>5</sup> In addition to higher inflation in the 2020s, the revision of NPL's operating model in 2022 may also have contributed to the increase in NMS funding, as a greater proportion of NPL's costs began to be charged directly to the NMS contract.

<sup>6</sup> The Social Rate of Time Preference is the rate at which society discounts the value of future benefits compared to present ones. Currently HM Treasury lists the SRTP at 3.5%, as detailed in the linked report.

<sup>7</sup> See [Annex 3](#) for full derivation.

**In the context of a government spending review, one should focus on the *marginal rate of return*.**

The next couple of sections will detail the impact from the two monetisable impact streams. Estimates of the benefit from the Measurement Infrastructure are based on a new analysis, although this was built on older papers. Estimates of the benefit from supporting innovation have been established for several years and featured in prior spending reviews. More fundamentally, the innovation model could be used to assess the impact of other science programmes, while the model used for the measurement infrastructure is much more specific to the distinctive capabilities of the NMS.

### 3 Impact Stream: Measurement Infrastructure

The economic analysis of the measurement infrastructure advances the scope of the benefit-cost analysis for the NMS by quantifying, for the first time, the economy-wide value of the “fanout” of high-quality calibrations. Whilst this analysis isn’t as tried and tested as the analysis for the innovation benefits, it integrates insights from three longstanding empirical studies into a version of the Solow model (a well-established model in macroeconomics).

The NMS labs maintain and update the primary standards that underpin a distributed system for the certification of calibrations, and for ensuring their comparability to corresponding standards around the world. Calibrations traceable to these primary standards are delivered to more than 74,000 businesses via a network of calibration labs distributed across the UK. (Since a top-tier calibration lab can supply calibration services to a second-tier calibration lab, this estimate of 74,000 businesses represents just the first tier of fanout across the economy.)

We have a new economic analysis for the benefits of this national measurement infrastructure, which is based on extending the Solow model to allow for malfunctions within production that sometimes produce defective outputs. This analysis is derived from

a recent report for the benefits of the measurement infrastructure.<sup>8</sup> The report takes a theory-based approach to bring together insights from three earlier reports listed below:

- King, M. & Renedo, E. (2020). *Estimating the Price Elasticity of Demand for NPL's Services*. NPL Report. IEA 6.
- Fennelly, C. (2021). *Quantifying Measurement Activity in the UK*. NPL Report. IEA7.
- King, M. & Nayak, S. (2023). *An Economic Model for the Value Attributable to High-Quality Calibrations by Reducing Mistakes in Conformance Testing*. NPL Report. IEA 19.

Insights from these reports can be brought together by considering an economy in which production processes sometimes malfunction but where reliability is maintained through conformance testing (CT).<sup>9</sup> That is, our report establishes a macroeconomic model in which production processes sometimes generate defective outputs, but where such incidents can be detected, and then corrected, through an economy-wide system of quality control. Lastly, the earlier reports provide estimates for some of the key parameters in this new macroeconomic model and so enable our model to generate quantitative results.

By extending the classical Solow model<sup>10</sup>, our new model highlights how the amount spent on conformance testing affects Total Factor Productivity (TFP)<sup>11</sup> and economic performance. The core idea of the model is that production processes may generate defective outputs due to malfunctions. Conformance testing serves as a quality control measure, ensuring only compliant outputs are released into the market. This enhances TFP by reducing waste and optimizing production efficiency, ultimately leading to economic growth. Key components of the model include:

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<sup>8</sup> King, M. & Nayak, S. (2025). *A Macroeconomic Model with Imperfect Production Processes and Conformance Testing*. NPL Report. IEA 27. Doi: <https://doi.org/10.47120/npl.IEA27>

<sup>9</sup> Conformance testing is a quality control process that verifies whether products or processes meet specified standards and requirements, ensuring reliability and reducing the likelihood of defects in production.

<sup>10</sup> The Solow model, developed by economist Robert Solow, is a foundational theory in macroeconomics that explains long-term economic growth through the accumulation of capital, labour, and technological progress.

<sup>11</sup> Total Factor Productivity (TFP) refers to the portion of output growth that cannot be attributed to the growth of capital and labour inputs; it reflects the efficiency and effectiveness with which these inputs are used.

- **Capital Intensity:** The amount of capital (machinery and equipment) available per worker.
- **Production Reliability:** The proportion of the capital stock that operates correctly.

In this model, engineers are employed to regularly inspect machinery, allowing for the identification and correction of faults. This approach helps maintain production reliability and reduce the occurrence of defective outputs. The model operates under the assumption that firms allocate a fraction of their output toward conformance testing. This investment helps ensure that only functioning machines contribute to production, effectively scrapping outputs from malfunctioning machines.

Two important parameters emerge in the conformance testing process:

1. **Detection Rate:** The likelihood that an engineer correctly identifies and fixes a malfunctioning machine.
2. **Regret Rate:** The probability of erroneously scrapping usable outputs due to false positives in the testing process.

The relationship between these parameters affects overall productivity and economic outcomes.

The model is formulated with a system of differential equations that describe the evolution of capital intensity and production reliability over time. This allows the identification of a steady-state equilibrium where:

- **Labour Productivity Increases:** Enhancements in TFP, driven by effective conformance testing, positively influence labour productivity. Higher productivity can lead to increased wages, thereby improving overall welfare and living standards.
- **Economic Growth is Observed:** As the capital intensity grows, it contributes to a rise in gross value added (GVA), indicating increased economic output and prosperity.

The model shows that investments in conformance testing yield substantial economic benefits:

- **Reduced Defective Outputs:** By minimizing the incidence of errors, businesses can maintain higher quality standards and reduce waste, leading to greater efficiency.

- **Increased Savings and Investments:** As productivity rises, so does per capita income. This leads to a larger pool of savings that can be reinvested into further capital formation, creating a cycle of growth.

A key element to the model is the National Measurement System (NMS), which underpins the national quality infrastructure. The NMS provides measurement services and standards essential for ensuring product quality and reliability. Using “precise calibrations”<sup>12</sup> that are traceable to primary standards reduces the Relative Standard Deviation (RSD)<sup>13</sup> of measurements by about 3%. (This is based on a comparison to “Basic calibrations” with a Test Accuracy Ratio of around 1:4.)

Regarding conformance testing, the NMS's role can be summarised in three main functions:

1. **Traceability:** Ensures all measurements conform to established standards.
2. **Quality Assurance:** Provides businesses with the confidence that their products meet specifications, enhancing market trust and reducing transaction costs.
3. **Process Control:** Ensures production processes are optimised so that they operate closer to the technological frontier.

A significant point of the model is the potential economic impact of funding cuts to the NMS:

- **Loss of Quality Control:** Businesses would face reduced access to precise calibrations, leading to increased production errors and more defective outputs.
- **Economic Losses:** It is predicted that cuts lead to declines in economic output, as reliant sectors experience decreased productivity.

In conclusion, this macroeconomic model highlights the role of conformance testing in ensuring production reliability and enhancing economic productivity. By integrating these

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<sup>12</sup> "Precise calibration" means a calibration process that focuses on achieving very consistent and repeatable measurements, ensuring the readings are very close together even if they might not be perfectly accurate to the true value, while a "basic calibration" is a simpler check that verifies if an instrument is within a broader acceptable range of accuracy, often using fewer data points and less rigorous procedures.

<sup>13</sup> Relative Standard Deviation (RSD) is a statistical measure that indicates how precise a measurement is relative to its average value. A smaller RSD indicates that data points are clustered closer to the mean, signifying higher precision, while a larger RSD suggests data points are more spread out from the mean, indicating lower precision.

elements into the Solow model, the importance of quality control systems in real-world economic applications becomes much clearer. The findings of the study suggest that sustained investment in national quality infrastructure helps to maintain high productivity and foster long-term economic growth.

If funding for the NMS labs were withdrawn and the laboratories were no longer able to operate, then users from within the UK would be signposted to foreign National Measurement Institutes (NMIs), such as VSL (Van Swinden Laboratory) in the Netherlands. This scenario would lead to a decrease in the UK's use of "precise calibrations" traceable to high-quality national standards. Our study shows that the cost of having to send instruments overseas for calibrations means that around one-third of the businesses who currently benefit from "precise calibrations" would revert to using "basic calibrations". The subsequent decline in precision suffered by those businesses would lead to a higher uncertainty in measurements made during conformance testing. The Relative Standard Deviation (RSD) of such measurements will increase by 1%.

This increased uncertainty makes it more likely that some test results will fall outside the acceptable limits purely due to variation in the measured values rather than because of an actual defect in the product being tested, thereby raising the likelihood of false positives from 0.30% to 0.35%. An increased number perfectly viable products will be incorrectly rejected which can lead to wasted resources and effectiveness in the inspection process.

Since inspections are themselves costly (due to the cost of testing) and will begin yielding less reliable results, the frequency of inspections will be reduced upon a reassessment of what's the optimal amount of testing to undertake. UK manufacturers will decrease the optimal inspection frequency<sup>14</sup> by 1.1%, which means a corresponding decrease in the amount spent on conformance testing. UK spends around £28.8 billion on conformance testing each year, so this decrease will amount to a drop in spending of £317 million.

To recap, less reliable measurements mean that conformance testing is less able to discriminate between defective and non-defective outputs. Furthermore, less effective tests lead to a drop in the frequency of inspections, which means that production itself

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<sup>14</sup> Optimal inspection frequency refers to how often quality checks should be performed to balance cost and accuracy in conformance testing. If inspections are too frequent, they may become costly and time-consuming. If they are too infrequent, defects might go unnoticed, leading to quality issues.

becomes less efficient. Moreover, due to the overall decline in the efficiency of production, each additional capital item (an extra piece of machinery or equipment) adds less value to the production process. As a result, the Marginal Product of Capital ( $MP_K$ ), i.e., the value from investing in an additional unit of capital, will decrease. Naturally, production will begin to depend a little more on labour than on capital and the economy will move towards a less capital-intensive equilibrium, i.e., the economy's capital intensity<sup>15</sup> will decrease by 0.09%. The UK's real economy holds a GVA of £1.2 trillion, so this drop in capital intensity will cause the economy's output to contract by £1.1 billion.

### 3.1 Average Benefits

Based on the aforementioned figures, we can deduce the average private net-benefit (total benefit minus private costs) from users going to the NMS labs for "precise calibrations" instead of foreign NMIs as  $£1.1 \text{ billion} - £317 \text{ million} = £783 \text{ million}$ . Therefore, the average private return on public investment (private net-benefit per unit of public funding) amounts to  $£783 \text{ million}/£80 \text{ million} = 9.79$ , i.e., £1 spent on the NMS by the government yields a private net-benefit of £9.79.

Social costs for this scenario can be computed by including essential NMS funding with the private costs. Therefore, the social net-benefit amounts to  $£1.1 \text{ billion} - £397 \text{ million} = £703 \text{ million}$ . Correspondingly, the average social return on public investment is  $£703 \text{ million}/£80 \text{ million} = 8.79$ , i.e., £1 spent on the NMS by the government yields a social net-benefit of £8.79.

### 3.2 Marginal Benefits

We know that marginal private return equals 66% of the corresponding average private return. As such, the average private return on public investment of 9.79 becomes a marginal private return of 6.46, i.e., an additional £1 spent on the NMS by the government yields a private net-benefit of £6.46. We deduce a marginal social return of 5.46 on public investment by subtracting 1 to account for deduction of public costs from total benefits<sup>16</sup>

<sup>15</sup> The capital intensity of an economy is the amount of capital in relation to other factors of production, especially labour.

<sup>16</sup> 
$$\frac{\text{Social net-benefit}}{\text{public costs}} = \frac{\text{Total benefits} - \text{social costs}}{\text{public costs}} =$$

$$\frac{\text{Total benefits} - \text{private costs} - \text{public costs}}{\text{public costs}} = \frac{\text{Total benefits} - \text{private costs}}{\text{public costs}} - 1 = \text{Private return on public funding} - 1$$

i.e., an additional £1 spent on the NMS by the government yields a social net-benefit of £5.46.

## 4 Impact Stream: Innovation

This model aims to quantify economic benefits channelled through UK’s private sector. The direct economic benefits are measured through “Regularly Supported Firms (RSFs)”, also referred to as “Treated” firms. We define support as either collaboration with NPL on R&D or accessing NPL’s paid services, and “RSFs” are firms who were supported for at least five years within a six-year period. Further details can be found [here](#).

A synthesis of Belmana’s Econometric Study suggests that such firms grow by an average of 6.3 additional employees each year due to the support received<sup>17</sup>. These employees experience a wage increase of £4,080 per year. According to the NMS Customer Survey, the benefits going to these firms endure for 6 years which comes down to 5.12 years post discounting<sup>18</sup> (at the rate of 3.5%, as specified in the Green Book (2022)).

$$\begin{array}{cccccc}
 \text{Extra Wages} & = & \text{RSF} & \times & 6.3 & \times & \text{£4,080} & \times & 5.12 \\
 \text{Wage Benefits (extra} & & \text{No. of} & & \text{Growth in} & & \text{Wage premium} & & \text{Discounted} \\
 \text{labour productivity)} & & \text{Treated} & & \text{employment} & & \text{going to the} & & \text{lifetime of} \\
 & & \text{firms} & & \text{at a Treated} & & \text{job switchers} & & \text{an innovation} \\
 & & & & \text{firm} & & & & 
 \end{array}$$

Dearden et al (2005) suggests that the increase in a firm’s profits is roughly equal to the increase in wages. Compared to the benchmark for the split between capital and labour of 1:3, the study suggests that when it comes to splitting the proceeds of innovation, capital gets relatively higher share because of high risks associated with innovation activities.

Wages and profits account for only two of the three components of Gross Value-Added (GVA); the remaining component being taxes collected by the government to fund public spending. Therefore, we can dial up the GVA at factor cost to the Gross Domestic Product (GDP) at market prices by adding tax revenue to our calculation of the direct benefits. However, the appropriate dial up should only include indirect taxes on production, i.e., those

<sup>17</sup> Nayak, S.; Olakojo, O.; King, M. (2023) NMS Support for Innovation and Business Outcomes: A Synthesis of Evidence from Belmana’s Econometric Study. NPL Report. IEA 17. <https://eprintspublications.npl.co.uk/9682/>

<sup>18</sup> According to the NMS Customer Survey, the average lifetime of a firm’s innovation benefits is around six years. The lifetime used in the calculation is reduced from 6 years to 5.12 years because future benefits are discounted relative to current benefits.

components of total tax revenue that aren't economic transfers from employees and firms to the government.<sup>19</sup> At present, we haven't worked out a reliable method to estimate the appropriate dial up factor. Therefore, for simplicity and to avoid overstatement, we exclude all tax revenue from our analysis and focus solely on wages and profits (i.e., we restrict our estimate to GVA at factor cost).<sup>20</sup> Using this approach, a conservative estimate of direct benefits can be obtained by scaling up the "Extra Wages" as follows:

$$\text{Direct Benefit} = \frac{\text{Extra Wages}}{\underbrace{0.50}_{\text{Wages to Profits}^{21} \text{ Ratio}}} = \text{Extra Wages} \times 2$$

Frontier Economics (2023) draws on a comprehensive meta-analysis of studies which have estimated the returns to R&D published since 1980. The returns to R&D include the private returns (benefits that accrue to the businesses making R&D investments), and social returns (benefits accruing to other businesses, or to wider society, for example through knowledge spillovers). The evidence is consistent with the view that social returns exceed private returns. A conservative assessment, based on the highest quality studies, is that social returns are around twice as high as private returns on average.

$$\text{Total Benefit} = \frac{\text{Direct Benefit}}{1 - \underbrace{0.5}_{\text{Spillovers}^{22} \text{ Ratio}}} = \text{Direct Benefit} \times 2$$

In 2023, NPL reported 429 regularly supported firms. Using the above equations, we may deduce a flow of direct economic benefits amounting to £113.8 million and a lower bound

<sup>19</sup> Tax revenue comprises multiple components. Components such as taxes on wages and corporation tax on profits are economic transfers from employees and firms to the government. Since our analysis uses *gross* wages and profits, including these taxes would lead to double counting in our calculation of benefits. In contrast, taxes that are not economic transfers – such as Value Added Tax (VAT), duties on things used in production (e.g., fuel duties, import duties), etc. – are not embedded in *gross* wages or profits, and can, in principle, be included in the calculations of direct benefits.

<sup>20</sup> Refer to [Annex 1](#) for an alternative analysis, where we dial up the GVA at factor cost by including all taxes in the calculation of direct benefits.

<sup>21</sup> The benefits from productivity growth are typically split 50:50 between labour (workers) and capital (shareholders).

<sup>22</sup> In the long run, value of the "indirect benefits" - through the diffusion of technological knowledge - accounts for half of the "total benefit" coming from innovation.

for the present value of total benefits worth £227.6 million, which we round down to £225 million for simplifying calculations.

#### 4.1 Average Benefits

We can conclude that UK will experience a loss of £225 million GVA if the NMS programme is fully discontinued. However, the private sector would save around £55 million from not working with the NMS and re-investing those funds<sup>23</sup>, leading to a net private loss of £170 million. In this scenario, the government also saves £80 million which gives us a net social loss of £90 million.

Therefore, the average private return on public investment amounts to 2.13, i.e., £1 spent on the NMS by the government yields a private net-benefit of £2.13 via Innovation. Similarly, the average social return on public investment is 1.13, i.e., £1 spent on the NMS by the government yields a social net-benefit of £1.13 via Innovation.

#### 4.2 Marginal Benefits

Corresponding to the results on average returns, we estimate a marginal private return of 1.40, i.e., an additional £1 spent on the NMS by the government yields a private net-benefit of £1.40 via Innovation. Marginal social return on public investment can be computed by subtracting 1 i.e., an additional £1 spent on the NMS by the government yields a social net-benefit of £0.40 via Innovation.

### 5 Rates of Return on the NMS

The total quantified benefits from the NMS programme would be the sum of distinct benefits arising from Measurement Infrastructure and Innovation impact streams. To calculate the overall social rate of return on public funding, the private rates of return on public funding for both streams are added together 1 is subtracted from that sum to account for the public spend. This is because:

#### Social return on public funding

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<sup>23</sup> For further details, refer to: King, M; Olakojo, S (2023) *NMS business case model: an explanatory note*. NPL Report. IEA 15. <https://eprintspublications.npl.co.uk/9681/>

$$= \frac{\text{Social net benefit}}{\text{Public costs}}$$

$$= \frac{\text{Total benefits} - \text{Private costs} - \text{Public costs}}{\text{Public costs}} = \frac{\text{Private net benefit}}{\text{Public costs}} - 1$$

$$= \frac{\text{Private net benefit from Measurement Infrastructure} + \text{Private net benefit from Innovation}}{\text{Public costs}}$$

$$= \text{Private return on public funding from Measurement Infrastructure} \\ + \text{Private return on public funding from Innovation} - 1$$

$$\text{Average social rate of return on NMS funding} = 9.79 + 2.13 - 1 = 10.91$$

$$\text{Marginal social rate of return on NMS funding} = 6.46 + 1.40 - 1 = 6.86$$

That being said, the public funding figure used to calculate the rates of return is also responsible for the unquantified benefits from Research and Knowledge Transfer impact streams – such as the environmental, health and resilience-based impact. This means that the rates of return computed above represent a lower bound of returns on NMS activities.

## 6 Value for Money (VfM) Analysis for the NMS

In this section, we present a Value for Money (VfM) analysis for the BAU option.<sup>24</sup> The NMS funding requested during the five-year SR period under this option is shown below:

<b>Year →</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	
	<b>2025/26</b>	<b>2026/27</b>	<b>2027/28</b>	<b>2028/29</b>	<b>2029/30</b>	<b>Total</b>
<b>Nominal Funding</b>	100.07	102.57	104.62	106.71	108.84	522.81
<b>Real Funding</b>	102.08	102.57	102.57	102.57	102.57	512.34

<sup>24</sup> All calculations presented in this and the following sections are also implemented in a supplementary Excel workbook published alongside this report. The calculator contains the parameter sheets for both monetisable impact streams, the inflation and discounting assumptions, and the step-by-step calculations used to derive the NPSV and Value for Money results for each option.

<b>PV of Real Funding<sup>25</sup></b>	105.65	102.57	99.10	95.75	92.51	495.57
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Table 1: Public Costs - NMS funding requested (in £million) during the five-year SR period

As mentioned earlier, £80 million in NMS funding leverages about £317 million in private sector costs (investments) through the measurement infrastructure stream and £55 million in private sector costs (investments) through the innovation stream annually. In other words, every £1 in NMS funding leverages about £4.63 (£3.96 through measurement infrastructure stream plus £0.67 through innovation stream) in private sector costs (investments) annually. For simplicity, we assume that this leverage ratio stays constant across different options throughout the SR25 period (i.e., 2025/26 – 2029/30). We use this leverage ratio to calculate the present value (PV) of total *real* private costs during the five-year SR period as approximately £2,294.79 million (= £495.57 million × 4.63). PV of the total *real* social cost, which is the sum of PV of *real* public and private costs, is approximately £2,790.35 million.

In the previous section, we obtained the following results:

**Average social rate of return on NMS funding = 9.79 + 2.13 – 1 = 10.91**

**Marginal social rate of return on NMS funding = 6.46 + 1.40 – 1 = 6.86**

Multiplying the social rate of return on NMS funding by real funding provides the real net social benefit / value.<sup>26</sup> That is:

**Real Average Net Social Value<sub>t</sub> = Real Funding<sub>t</sub> × Average Social RoR on NMS funding**

$$\begin{aligned} \text{Average NPSV}_t &:= \text{PV of Real Average Net Social Value}_t \\ &= \text{Real Average Net Social Value}_t \times d_t \end{aligned}$$

<sup>25</sup> Real funding is calculated after applying an appropriate deflator to the nominal funding. Present Value (PV) of real funding is then calculated after applying an appropriate discount factor to the real funding. As per the guidance received from HMT during SR25 submission, the base year is set as 2026-27, i.e., the first year of the Phase 2 Spending Review period. Refer to [Annex 4](#) for further details.

<sup>26</sup> Note that the Average and Marginal RoRs calculated in this paper are *net* values.

where  $d_t$  is the discounting factor from Annex 4 for year  $t$ , with 2026-27 (Year 1) as the base year. Summing across all years in the appraisal period, we can write

$$\text{Average NPSV} = \sum_t \text{Average NPSV}_t$$

Likewise,

**Real Marginal Net Social Value<sub>t</sub>** = Real Funding<sub>t</sub> × Marginal Social RoR on NMS funding

$$\begin{aligned} \text{Marginal NPSV}_t &:= \text{PV of Real Marginal Net Social Value}_t \\ &= \text{Real Marginal Net Social Value}_t \times d_t \end{aligned}$$

$$\text{Marginal NPSV} = \sum_t \text{Marginal NPSV}_t$$

Using these equations, we calculate the average and marginal NPSV, as shown below:

<i>Year</i> →	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
	FY	FY	FY	FY	FY	Total
	2025/26	2026/27	2027/28	2028/29	2029/30	
<b>Based on Average RoR</b>						
Real (Deflated) Average Net Social Value	1113.90	1119.25	1119.25	1119.24	1119.25	
PV of Average Net Social Value (Average NPSV)	1152.89	1119.25	1081.40	1044.83	1009.50	5407.86
<b>Based on Marginal RoR</b>						
Real (Deflated) Marginal Net Social Value	700.47	703.83	703.83	703.83	703.83	
PV of Marginal Net Social Value (Marginal NPSV)	724.98	703.83	680.03	657.03	634.82	3400.70

Table 2: Average and Marginal NPSV for the BAU Option

Next, we calculate the total social benefits based on the average and marginal returns as follows:

**PV of Total Social Benefits (based on average return)**

$$\begin{aligned}
 &= \text{PV of Social Net Benefits (based on average return)} + \text{PV of Total Social Costs} \\
 &= \text{Average NPSV} + \text{PV of Total Social Costs} \\
 &= \text{£5,407.86 million} + \text{£2,790.35 million} = \text{£8,198.22 million}
 \end{aligned}$$

### **PV of Total Social Benefits (based on marginal return)**

$$\begin{aligned}
 &= \text{PV of Social Net Benefits (based on marginal return)} + \text{PV of Total Social Costs} \\
 &= \text{Marginal NPSV} + \text{PV of Total Social Costs} \\
 &= \text{£3,400.70 million} + \text{£2,790.35 million} = \text{£6,191.05 million}
 \end{aligned}$$

## **6.1 Measures of VfM**

For transparency and robustness, we present three different measures of VfM.

1. **Benefit-Cost Ratio (BCR):** The ratio of the PV of total social benefits to the PV of total social costs. BCR is calculated as:

$$\begin{aligned}
 &\textbf{Benefit – Cost Ratio (based on average return)} \\
 &= \frac{\text{PV of Total Social Benefits (based on average return)}}{\text{PV of Total Social Costs}} \\
 &= \frac{\text{£8,198.22 million}}{\text{£2,790.35 million}} \\
 &= 2.94
 \end{aligned}$$

And,

$$\begin{aligned}
 &\textbf{Benefit – Cost Ratio (based on marginal return)} \\
 &= \frac{\text{PV of Total Social Benefits (based on marginal return)}}{\text{PV of Total Social Costs}} \\
 &= \frac{\text{£6,191.05 million}}{\text{£2,790.35 million}} \\
 &= 2.22
 \end{aligned}$$

2. **Return on Public Sector Cost:** The amount of social value created by each £1 of public sector spending in the NMS programme. It is calculated as:

$$\begin{aligned}
 &\textbf{Average Return on Public Sector Cost} \\
 &= \frac{\text{Average NPSV}}{\text{Nominal Public Sector Cost}} \\
 &= \frac{\text{£5,407.86 million}}{\text{£522.81 million}} = 10.34
 \end{aligned}$$

And,

### Marginal Return on Public Sector Cost

$$= \frac{\text{Marginal NPSV}}{\text{Nominal Public Sector Cost}}$$

$$= \frac{\text{£3,400.70 million}}{\text{£522.81 million}} = 6.50$$

Compared to the Benefit–Cost Ratio (BCR), the return on public sector cost is significantly higher. This is because the NMS programme crowds in substantial private investment, as reflected in the leveraged private costs. The BCR denominator includes both public and private costs, so the ratio is diluted by the large volume of private spending. In contrast, the return on public sector cost uses only public expenditure as the denominator, which is relatively small. From a government perspective, this measure provides a more meaningful indicator of value for money, as leveraging additional private investment is a positive outcome rather than a drawback.

3. **NPSV-DEL Ratio:** Each year, NPL pays the Department for Science, Innovation and Technology (DSIT) a rent of approximately £20 million for operating on the Teddington site. We treat this rent as the opportunity cost of occupying the Teddington site, on the basis that alternative uses could be found for the land and buildings. This cost is therefore included in the public cost of the programme. The Departmental Expenditure Limit (DEL) reflects the budget allocated to and spent by DSIT on the NMS programme. Since NPL pays the rent back to DSIT, it is netted off from the public cost to calculate DEL, as shown below:

$$\text{DEL} = \text{Nominal Public Sector Cost} - \text{Rent paid by NPL to DSIT}$$

During the five-year SR period, NPL will pay DSIT approximately £100 million in rent. Therefore, DEL is equal to £422.81 million (= £522.81 million – £100 million). This approach assumes that the rent does not contribute to any activity generating benefits through the NMS programme and that the site has an alternative productive use. If these assumptions do not hold, the opportunity cost may be overstated. Under these assumptions, the NPSV-DEL ratio represents the amount of social value created by each £1 of DSIT’s spending on the programme. It is calculated as:

### NPSV – DEL Ratio (based on average return)

$$= \frac{\text{Average NPSV}}{\text{DEL}}$$

$$= \frac{\text{£5,407.86 million}}{\text{£422.81 million}} = 12.79$$

And,

**NPSV – DEL Ratio (based on marginal return)**

$$= \frac{\text{Marginal NPSV}}{\text{DEL}}$$

$$= \frac{\text{£3,400.70 million}}{\text{£422.81 million}} = 8.04$$

## 7 Calculating RoRs for Other Options

In this section, we present the Rates of Return (RoRs) calculations for the other options. Once we have estimated the rate of returns in the business-as-usual case, we use simple assumptions to calculate RoRs for the other options.

### 7.1 Option 1 (Preferred Option)

The preferred option that was submitted as part of SR25 is same as business-as-usual. Hence, the RoRs remain the same as above.

### 7.2 Option 2 (Do Less: Maintenance of Core Capabilities)

In this option, we assume that much of the NMS would be reduced to a minimum funding pot (real funding of about £80 million a year). This would likely see the core functions, as detailed in the subsection “Key Role of the NMS”, operating and offered at a subsidised cost but nothing else could be done. This would lead to Research, Innovation and KT functions being no longer viable. That is, only the measurement infrastructure impact stream would continue to exist, and we would lose the innovation impact stream.

Using the RoRs for the measurement infrastructure stream that we calculated above, we can compute the social RoRs for Option 2 as follows:

$$\text{Average social rate of return on NMS funding} = 9.79 - 1 = 8.79$$

$$\text{Marginal social rate of return on NMS funding} = 6.46 - 1 = 5.46$$

### 7.3 Option 3 (Do More: National Scientific Infrastructure)

In this option, the total funding goes up by roughly 29% compared to the BAU option (while there are year-on-year differences, the average across five years is 29%).

- In the short-term, we assume that this 29% additional funding will generate benefits through the innovation impact stream only. That is, the new funding will not contribute to new measurement infrastructure.<sup>27</sup> Rather, it will help NPL utilise and build on the existing measurement infrastructure to run more emerging programmes and support a broader base of UK companies to generate more innovation benefits.
- We also assume that innovation benefits scale linearly with funding, so a 29% increase in funding leads to a 29% increase in innovation benefits. The average private RoR for the innovation impact stream therefore remains unchanged.
- However, since the increased public funding doesn't generate new infrastructure benefits, the average private RoR for this stream falls by 22.5% (as the numerator stays fixed while the denominator is 29% higher). That is, the average private RoR for the measurement infrastructure stream becomes 7.59 (= 9.79/1.29), and the marginal private RoR becomes 5.01 (= 6.46/1.29).

We can compute the social RoRs for Option 3 as follows:

$$\text{Average social rate of return} = 7.59 + 2.13 - 1 = 8.71$$

$$\text{Marginal social rate of return} = 5.01 + 1.40 - 1 = 5.41$$

To summarise the overall rates of return for the three options are given as:

Option	Name	Average Social RoR	Marginal Social RoR	Notes
Option 1 / BAU	Metrology, Standards and Support to the UK economy	10.91	6.86	Maintenance, Estates & Development

<sup>27</sup> The rationale for this assumption is set out in [Annex 5](#).

<b>Option 2</b>	Do Less: Maintenance of Core Capabilities	8.79	5.46	This option would see Research, Innovation and KT functions no longer viable. It would only see benefits coming from the measurement infrastructure stream.
<b>Option 3</b>	Do More: National Scientific Infrastructure	8.71	5.41	This option will see more benefits coming from the innovation stream but no increase in the benefits coming from the measurement infrastructure stream.

Table 3: Summary of RoRs for the Three Options

The Value for Money (VfM) analysis for Options 2 and 3 is presented in Annex 2.

## 8 Conclusion

This report presents a rigorous economic appraisal of the UK’s National Measurement System (NMS), quantifying its impact through two monetisable streams: Measurement Infrastructure and Innovation. By integrating empirical evidence with macroeconomic modelling, we estimate that the NMS programme delivers substantial returns on public investment. The average social rate of return is 10.91, and the marginal social rate of return is 6.86. Both of these represent lower bounds, given that they exclude unquantified benefits from research and knowledge transfer. In terms of fiscal efficiency, the NMS programme generates £10.34 of net present social value (NPSV) for every £1 of public spending on average, and £6.50 per £1 at the margin. These results underscore the NMS’s role as a foundational component of the UK’s scientific infrastructure, supporting productivity, innovation, and quality assurance across the economy.

The analysis also shows that every £1 of public funding leverages approximately £4.63 in private sector investment annually. The bulk of the quantified benefits arise from the measurement infrastructure stream, which underpins productivity and quality assurance across a wide range of sectors. Using conservative assumptions, we estimate that the innovation stream contributes an additional £225 million in total benefits, including

spillovers. When combined, the present value of total social benefits over the SR25 period amounts to almost £6.19 billion based on marginal returns. These findings provide strong evidence that continued and stable investment in the NMS is not only economically justified but essential for sustaining the UK's competitiveness, resilience, and long-term growth.

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## 10 Annex 1 – Innovation Stream Benefits When Including All Taxes

This annex presents an alternative analysis for the innovation stream benefits, where we dial up GVA at factor cost to GDP at market prices by adding tax revenue to our calculation of the direct benefits. Wages and profits account for only two of the three components of GVA – the remaining component being taxes collected by the government to fund public spending. The UK has a tax-to-GDP ratio of around 33%. That is, two-thirds of the total benefits goes to labour and capital, while the remaining one-third is taxes. Using this approach, an estimate of direct benefits can be obtained by scaling up the “Extra Wages” as follows:

$$\text{Direct Benefit} = \frac{\text{Extra Wages}}{\underbrace{0.50}_{\substack{\text{Wages to Profits}^{28} \\ \text{Ratio}}} \times \left( 1 - \underbrace{0.333}_{\substack{\text{Tax Ratio}^{29}}} \right)} = \text{Extra Wages} \times 3$$

Using findings from Frontier Economics (2023), we can scale direct benefits to obtain a conservative estimate of the total benefits as follows:

$$\text{Total Benefit} = \frac{\text{Direct Benefit}}{1 - \underbrace{0.5}_{\substack{\text{Spillovers}^{30} \\ \text{Ratio}}}} = \text{Direct Benefit} \times 2$$

In 2023, NPL reported 429 regularly supported firms. Using the above equations, we may deduce a flow of direct economic benefits amounting to £170 million and a lower bound for the present value of total benefits worth £340 million. As expected, this is about 50% higher than the value we obtained when we excluded the tax revenue.

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28 The benefits from productivity growth are typically split 50:50 between labour (workers) and capital (shareholders).

29 Based on a typical tax-to-GDP ratio, around one-third of the value from economic growth ultimately goes to HMRC in the form of “extra tax revenue”

30 In the long run, value of the “indirect benefits” - through the diffusion of technological knowledge - accounts for half of the “total benefit” coming from innovation.

## 10.1 Average benefits

We can conclude that UK will experience a loss of £340 million GVA if the NMS programme is fully discontinued. However, the private sector would save £55 million from not working with the NMS and re-investing those funds, leading to a net private loss of £285 million. In this scenario, the government also saves £80 million which gives us a net social loss of £205 million.

Therefore, the average private return on public investment amounts to 3.56, i.e., £1 spent on the NMS by the government yields a private net-benefit of £3.56 via Innovation. Similarly, the average social return on public investment is 2.56, i.e., £1 spent on the NMS by the government yields a social net-benefit of £2.56 via Innovation.

## 10.2 Marginal benefits

Corresponding to the results on average returns, we estimate a marginal private return of 2.35 i.e., an additional £1 spent on the NMS by the government yields a private net-benefit of £2.35 via Innovation. Marginal social return on public investment can be computed by subtracting 1 i.e., an additional £1 spent on the NMS by the government yields a social net-benefit of £1.35 via Innovation.

## 10.3 Rates of Return on the NMS

The total quantified benefits from the NMS programme would be the sum of distinct benefits arising from Measurement Infrastructure and Innovation impact streams. Using the same approach as earlier, to calculate the overall social rate of return on public funding, the private rates of return on public funding for both streams are added together 1 is subtracted from that sum to account for the public spend. And we would get:

$$\text{Average social rate of return} = 9.79 + 3.56 - 1 = 12.35$$

$$\text{Marginal social rate of return} = 6.46 + 2.35 - 1 = 7.81$$

As expected, these are higher than the Average and Marginal Social RoRs of 10.91 and 6.86, respectively, that we obtained when we did not include tax revenue in the calculation of benefits.

## 11 Annex 2 – VfM Analysis for Other Options

This annex presents a Value for Money (VfM) analysis for Options 2 and 3.

### 11.1 VfM Analysis for Option 2 (Do Less: Maintenance of Core Capabilities)

The table below shows the NMS funding requested under this option:

<b>Year →</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	
	<b>2025/26</b>	<b>2026/27</b>	<b>2027/28</b>	<b>2028/29</b>	<b>2029/30</b>	<b>Total</b>
<b>Nominal Funding</b>	80.00	81.60	83.23	84.90	86.59	416.32
<b>Real Funding</b>	81.60	81.60	81.60	81.60	81.60	408.00
<b>PV of Real Funding<sup>31</sup></b>	84.46	81.60	78.84	76.17	73.60	394.67

Table 4: Public Costs - NMS funding requested (in £million) during the five-year SR period under Option 2

As discussed earlier, under this option, only the measurement infrastructure impact stream would continue to exist, and we would lose the innovation impact stream.<sup>32</sup> Thus, every £1 in NMS funding will leverage about £3.96 in private sector costs (investments) through measurement infrastructure stream.<sup>33</sup> For simplicity, we assume that this leverage ratio stays constant across different options throughout the SR25 period (i.e., 2025/26 –

<sup>31</sup> Real funding is calculated after applying an appropriate deflator to the nominal funding. Present Value (PV) of real funding is then calculated after applying an appropriate discount factor to the real funding. As per the guidance received from HMT during SR25 submission, the base year is set as 2026-27, i.e., the first year of the Phase 2 Spending Review period. Refer to [Annex 4](#) for further details.

<sup>32</sup> Since we assume that we lose the innovation impact stream under this option, the leveraged private costs through the Innovation stream would also be zero.

<sup>33</sup> We assume that measurement infrastructure is close to saturation in the short-term at the level corresponding to NMS funding under the BAU option. Any additional funding above this level is therefore assumed not to generate further measurement infrastructure benefits. Conversely, under Option 2, where public funding is lower than the BAU level, we assume that both measurement infrastructure benefits and leveraged private costs scale linearly with funding. In other words, a reduction in funding from the BAU level results in a proportionate reduction in these benefits and costs.

2029/30). We use this leverage ratio to calculate the PV of total *real* private costs during the five-year SR period as approximately £1,563.88 million (= £394.67 million × 3.96). PV of total *real* social cost, which is the sum of PV of *real* public and private costs, is approximately £1,958.55 million.

Additionally, we obtained:

**Average social rate of return on NMS funding = 9.79 – 1 = 8.79**

**Marginal social rate of return on NMS funding = 6.46 – 1 = 5.46**

Multiplying the social rate of return on NMS funding by real funding provides the real net social benefit / value.<sup>34</sup> As before, we can calculate the average and marginal NPSV:

<i>Year</i> →	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	
	<b>2025/26</b>	<b>2026/27</b>	<b>2027/28</b>	<b>2028/29</b>	<b>2029/30</b>	<b>Total</b>
<b>Based on Average RoR</b>						
Real (Deflated) Average Net Social Value	717.06	717.06	717.06	717.06	717.06	
PV of Average Net Social Value (Average NPSV)	742.16	717.06	692.81	669.38	646.75	3468.16
<b>Based on Marginal RoR</b>						
Real (Deflated) Marginal Net Social Value	445.52	445.52	445.52	445.52	445.52	
PV of Marginal Net Social Value (Marginal NPSV)	461.11	445.52	430.45	415.89	401.83	2154.80

**Table 5: Average and Marginal NPSV for Option 2**

Next, we calculate the total social benefits based on the average and marginal returns as:

**PV of Total Social Benefits (based on average return)**

= Average NPSV + PV of Total Social Costs

<sup>34</sup> Note that the Average and Marginal RoRs calculated in this paper are *net* values.

$$= \text{£}3,468.16 \text{ million} + \text{£}1,958.55 \text{ million} = \text{£}5,426.71 \text{ million}$$

**PV of Total Social Benefits (based on marginal return)**

$$= \text{Marginal NPSV} + \text{PV of Total Social Costs}$$

$$= \text{£}2,154.80 \text{ million} + \text{£}1,958.55 \text{ million} = \text{£}4,113.35 \text{ million}$$

### 11.1.1 Measures of VfM

1. **Benefit-Cost Ratio (BCR):** The ratio of the PV of total social benefits to the PV of total social costs:

**Benefits – Cost Ratio (based on average return)**

$$= \frac{\text{PV of Total Social Benefits (based on average return)}}{\text{PV of Total Social Costs}}$$

$$= \frac{\text{£}5,426.71 \text{ million}}{\text{£}1,958.55 \text{ million}}$$

$$= 2.77$$

**Benefits – Cost Ratio (based on marginal return)**

$$= \frac{\text{PV of Total Social Benefits (based on marginal return)}}{\text{PV of Total Social Costs}}$$

$$= \frac{\text{£}4,113.35 \text{ million}}{\text{£}1,958.55 \text{ million}}$$

$$= 2.10$$

2. **Return on Public Sector Cost:** The amount of social value created by each £1 of public sector spending in the NMS programme:

**Average Return on Public Sector Cost**

$$= \frac{\text{Average NPSV}}{\text{Nominal Public Sector Cost}}$$

$$= \frac{\text{£}3,468.16 \text{ million}}{\text{£}416.32 \text{ million}} = 8.33$$

And,

**Marginal Return on Public Sector Cost**

$$= \frac{\text{Marginal NPSV}}{\text{Nominal Public Sector Cost}}$$

$$= \frac{\text{£}2,154.80 \text{ million}}{\text{£}416.32 \text{ million}} = 5.18$$

3. **NPSV-DEL Ratio:** During the five-year SR period, NPL will pay DSIT approximately £100 million in rent. Therefore, DEL in Option 2 is equal to £316.32 million (= £416.32 million – £100 million). And NPSV-DEL ratio is calculated as:

**NPSV – DEL Ratio (based on average return)**

$$= \frac{\text{Average NPSV}}{\text{DEL}}$$

$$= \frac{\text{£3,468.16 million}}{\text{£316.32 million}} = 10.96$$

And,

**NPSV – DEL Ratio (based on marginal return)**

$$= \frac{\text{Marginal NPSV}}{\text{DEL}}$$

$$= \frac{\text{£2,154.80 million}}{\text{£316.32 million}} = 6.81$$

## 11.2 VfM Analysis for Option 3 (Do More: National Scientific Infrastructure)

The table below shows the NMS funding requested under this option:

<b>Year →</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>Total</b>
	<b>2025/26</b>	<b>2026/27</b>	<b>2027/28</b>	<b>2028/29</b>	<b>2029/30</b>	
<b>Nominal Funding</b>	126.62	131.59	135.79	138.93	141.69	674.63
<b>Real Funding</b>	129.16	131.59	133.12	133.54	133.52	660.93
<b>PV of Real Funding<sup>35</sup></b>	133.68	131.59	128.62	124.66	120.43	638.98

<sup>35</sup> Real funding is calculated after applying an appropriate deflator to the nominal funding. Present Value (PV) of real funding is then calculated after applying an appropriate discount factor to the real funding. As per the guidance received from HMT during SR25 submission, the base year is set as 2026-27, i.e., the first year of the Phase 2 Spending Review period. Refer to [Annex 4](#) for further details.

Table 6: Public Costs - NMS funding requested (in £million) during the five-year SR period under Option 3

Under this option, the total funding goes up by roughly 29% compared to the BAU option (while there are year-on-year differences, the average across five years is 29%). As discussed earlier:

- In the short-term, we assume that this 29% additional funding will generate benefits through the innovation impact stream only. That is, the new funding will not contribute to new measurement infrastructure.
- We also assume that innovation benefits scale linearly with funding. Thus, the average private RoR on public funding will stay the same for the innovation impact stream.
- However, since the increased public funding doesn't generate new infrastructure benefits, the average private RoR on this stream of benefits falls by 22.5% (as the numerator stays the same while the denominator goes up by 29%). That is, the average private RoR for the measurement infrastructure stream becomes 7.59 (= 9.79/1.29), and the marginal private RoR becomes 5.01 (= 6.46/1.29).

We obtain the social RoRs for Option 3 as follows:

$$\text{Average social rate of return} = 7.59 + 2.13 - 1 = 8.71$$

$$\text{Marginal social rate of return} = 5.01 + 1.40 - 1 = 5.41$$

Moreover, we saw earlier that £80 million in NMS funding leverages about £317 million in private sector costs (investments) through the measurement infrastructure stream and £55 million in private sector costs (investments) through the innovation stream annually. In other words, every £1 in NMS funding leverages about £3.96 through measurement infrastructure stream plus £0.67 through innovation stream in private sector costs (investments) annually. For simplicity, we assume that these leverage ratios stay constant across different options throughout the SR25 period (i.e., 2025/26 – 2029/30). We use them to calculate the PV of total *real* private costs in the following way:

- **For Innovation Stream:** We assume that private costs scale proportionately with funding, in the same way as benefits. In other words, a 29% increase in funding would lead to a corresponding 29% increase in leveraged private costs. This reflects the underlying assumption that additional innovation funding enables NMS laboratories to

work with more companies, thereby increasing the private investment associated with the innovation stream. Thus,  $\text{Private Cost}_{\text{innovation}} = \text{Leverage Rate}_{\text{innovation}} * \text{Public Cost}$ , which is equal to £426.93 million ( $= 0.67 \times \text{£}638.98 \text{ million}$ ).

- **For Measurement Infrastructure Stream:** We assumed that measurement infrastructure is close to saturation over the SR25 period (short term) at the level supported by BAU funding. Within this time horizon, additional funding is not assumed to generate further measurement infrastructure benefits, as bringing new capabilities on stream typically requires multi-year investments in facilities, specialist staff, and underpinning R&D.<sup>36</sup> Consequently, it is reasonable to conclude that leveraged private costs through this stream also reach a cap in the short term, meaning new funding would not lead to additional private costs beyond those observed under the BAU option. This can be expressed as:  $\text{Private Costs}_{mi} = \text{Leverage Rate}_{mi} * \min \{ \text{Public Costs under this Option}, \text{Public Costs under the Preferred Option} \}$ , which is equal to £1,963.68 million ( $= 3.96 \times \min \{ \text{£}638.98 \text{ million}, \text{£}495.57 \text{ million} \} = 3.96 \times \text{£}495.57 \text{ million}$ ).

Thus, the PV of total *real* private costs during the five-year SR period is approximately £2,390.61 million ( $= \text{£}426.93 \text{ million} + \text{£}1,963.68 \text{ million}$ ). PV of total *real* social cost, which is the sum of PV of *real* public and private costs, is approximately £3,029.59 million.

Multiplying the social rate of return on NMS funding by real funding provides the real net social benefit / value.<sup>37</sup> As before, we can calculate the average and marginal NPSV:

<b>Year →</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	
	<b>2025/26</b>	<b>2026/27</b>	<b>2027/28</b>	<b>2028/29</b>	<b>2029/30</b>	<b>Total</b>
<b>Based on Average RoR</b>						
Real (Deflated) Average Net Social Value	1125.23	1146.47	1159.80	1163.41	1163.24	

<sup>36</sup> Some of these capabilities could materialise over the medium- to long-term. Additionally, some R&D undertaken through the Innovation stream may support new or enhanced measurement capabilities, but these effects lie outside the scope of the current quantitative model.

<sup>37</sup> Note that the Average and Marginal RoRs calculated in this paper are *net* values.

PV of Average Net Social Value (Average NPSV)	1164.62	1146.47	1120.58	1086.05	1049.18	5566.90
<b>Based on Marginal RoR</b>						
Real (Deflated) Marginal Net Social Value	698.74	711.93	720.21	722.45	722.34	
PV of Marginal Net Social Value (Marginal NPSV)	723.20	711.93	695.85	674.41	651.51	3456.90

Table 7: Average and Marginal NPSV for Option 3

Next, we calculate the total social benefits based on the average and marginal returns as follows:

**PV of Total Social Benefits (based on average return)**

$$\begin{aligned}
 &= \text{Average NPSV} + \text{PV of Total Social Costs} \\
 &= \text{£5,566.90 million} + \text{£3,029.59 million} = \text{£8,596.49 million}
 \end{aligned}$$

**PV of Total Social Benefits (based on marginal return)**

$$\begin{aligned}
 &= \text{Marginal NPSV} + \text{PV of Total Social Costs} \\
 &= \text{£3,456.90 million} + \text{£3,029.59 million} = \text{£6,486.49 million}
 \end{aligned}$$

### 11.2.1 Measures of VfM

1. **Benefit-Cost Ratio (BCR):** The ratio of the PV of total social benefits to the PV of total social costs:

**Benefits – Cost Ratio (based on average return)**

$$\begin{aligned}
 &= \frac{\text{PV of Total Social Benefits (based on average return)}}{\text{PV of Total Social Costs}} \\
 &= \frac{\text{£8,596.49 million}}{\text{£3,029.59 million}} \\
 &= 2.84
 \end{aligned}$$

**Benefits – Cost Ratio (based on marginal return)**

$$\begin{aligned}
 &= \frac{\text{PV of Total Social Benefits (based on marginal return)}}{\text{PV of Total Social Costs}} \\
 &= \frac{\text{£6,486.49 million}}{\text{£3,029.59 million}} \\
 &= 2.14
 \end{aligned}$$

2. **Return on Public Sector Cost:** The amount of social value created by each £1 of public sector spending in the NMS programme:

**Average Return on Public Sector Cost**

$$= \frac{\text{Average NPSV}}{\text{Nominal Public Sector Cost}}$$

$$= \frac{\text{£5,566.90 million}}{\text{£674.63 million}} = 8.25$$

And,

**Marginal Return on Public Sector Cost**

$$= \frac{\text{Marginal NPSV}}{\text{Nominal Public Sector Cost}}$$

$$= \frac{\text{£3,456.90 million}}{\text{£674.63 million}} = 5.12$$

3. **NPSV-DEL Ratio:** During the five-year SR period, NPL will pay DSIT approximately £100 million in rent. Therefore, DEL in Option 2 is equal to £574.63 million (= £674.63 million – £100 million). And NPSV-DEL ratio is calculated as:

**NPSV – DEL Ratio (based on average return)**

$$= \frac{\text{Average NPSV}}{\text{DEL}}$$

$$= \frac{\text{£5,566.90 million}}{\text{£574.63 million}} = 9.69$$

And,

**NPSV – DEL Ratio (based on marginal return)**

$$= \frac{\text{Marginal NPSV}}{\text{DEL}}$$

$$= \frac{\text{£3,456.90 million}}{\text{£574.63 million}} = 6.02$$

## 12 Annex 3 – Calculating Marginal Rate of Return from Average Rate of Return<sup>38</sup>

In this model, the knowledge from NMS labs acts like a productive asset that wears out over time. Hence, more funding increases that knowledge, which in turn increases benefits, but not instantly, and not forever. That is, because of depreciation, discounting, and delays, the **extra** benefit from each new £1 of funding is smaller than the **average** benefit from all past funding. In this model, that “shrinkage” factor is about **two-thirds**.

### 12.1 Knowledge stock adjustment over time

Figure 1 shows how NMS labs’ “knowledge stock” adjusts when funding changes.

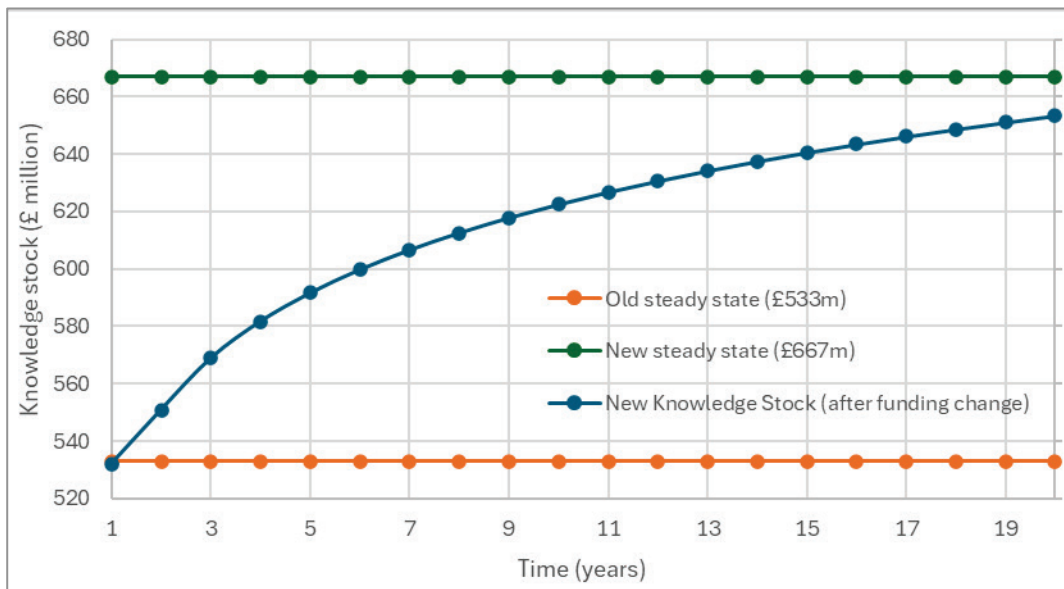


Figure 1 Knowledge stock adjustment over time

If funding has been constant for a long time, then the stock of knowledge has settled into balance. And the amount lost each year due to depreciation ( $\delta = 15\%$ )<sup>39</sup> is replaced exactly by the £80m of new funding. That steady-state stock of knowledge turns out to be:

<sup>38</sup> This annex is based on Section 32.4 of King, M; Nayak, S (2025) *A macroeconomic model with imperfect production processes and conformance testing*. NPL Report. IEA 27. DOI: <https://doi.org/10.47120/npl.IEA27>. Refer to the paper for a full mathematical derivation.

<sup>39</sup> We assume a depreciation rate ( $\delta$ ) of 15%.

$$\mathcal{K}_0 = \frac{\text{£80 million}}{15\%} = \text{£533 million}$$

This is the "knowledge capital" the NMS labs have in the current steady state.

When funding increases<sup>40</sup>, the NMS labs don't instantly become more capable, knowledge builds gradually. Likewise, if funding falls, capabilities erode over time rather than collapsing immediately. That is, labs' knowledge builds gradually toward a new level after a funding change (Figure 1).

### 12.2 Linking knowledge to economic benefit

The purpose is to make clear that private net benefits are proportional to the stock of knowledge.

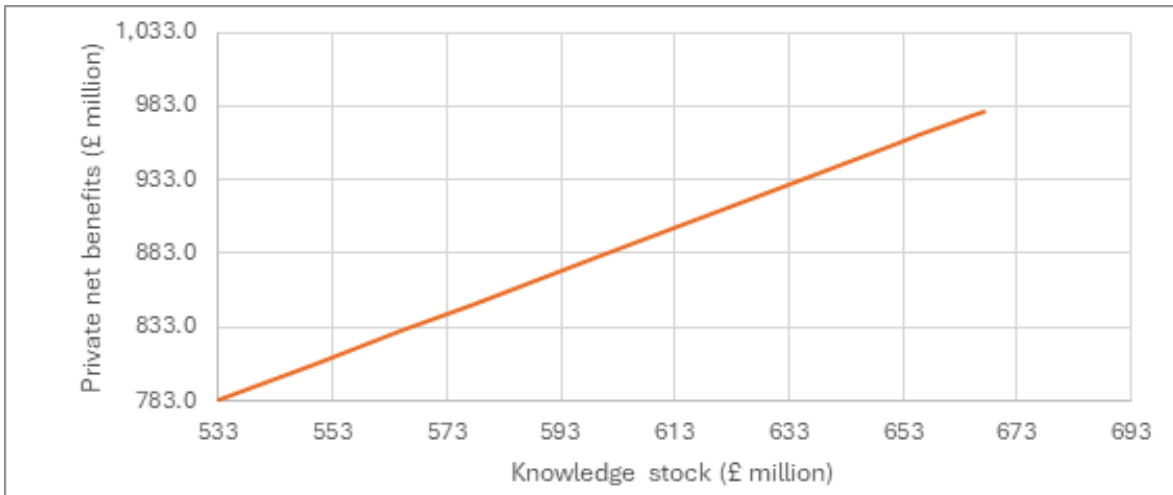


Figure 2 Linking knowledge to economic benefit

The figure above demonstrates this intuitive relationship: more knowledge enables more spillovers to industry. That is, as the stock of knowledge grows, economic benefits (profits, cost savings, innovation advantages) that industry gets from the NMS grow *proportionately* to this knowledge stock. Thus, if knowledge grows by 10%, benefits grow by 10%. This is based on the expression that:

$$\Pi_t \propto \mathcal{K}_t$$

<sup>40</sup>  $\mathcal{K}_1 = \frac{\text{£100 million}}{15\%} = \text{£667 million}$

where  $\Pi_t$  represents the private net benefits and  $\mathcal{K}_t$  represents the stock of knowledge at time  $t$ . Hence,

$$\frac{\Pi_t}{\Pi_0} \propto \frac{\mathcal{K}_t}{\mathcal{K}_0}$$

In our model, we set  $\Pi_0 \approx \text{£}783$  million when NMS funding is  $\text{£}80$  million. Using this with values for  $\frac{\mathcal{K}_t}{\mathcal{K}_0}$ , and  $\mathcal{K}_t$  helps to generate  $\Pi_t$  as  $\mathcal{K}_t$  rises (Figure 2).

### 12.3 Average vs marginal return on public funding

This is to demonstrate that marginal returns are smaller than average returns because of depreciation and discounting. That is, it illustrates how depreciation, discounting, and delay reduce the marginal return relative to the average.

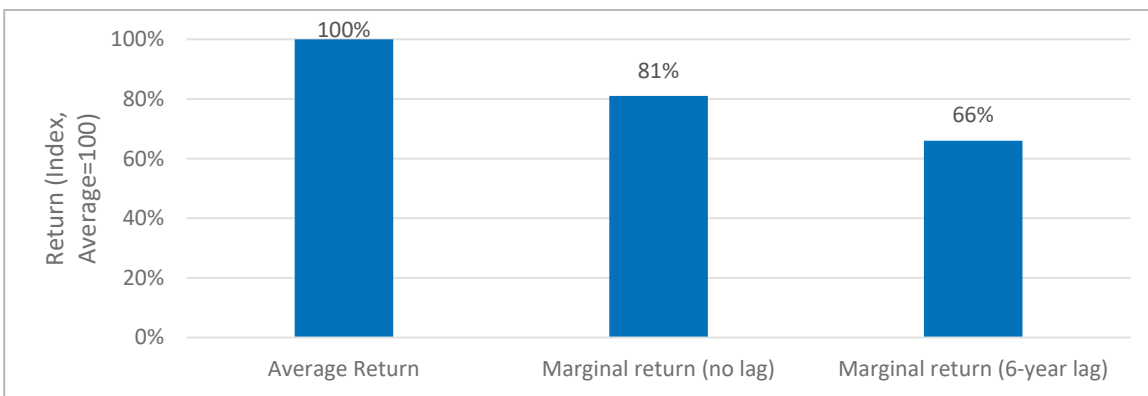


Figure 3 Average vs marginal return on public funding

The figure shows that each step represents a real-world friction (time preference, obsolescence, and lag) that reduces how much extra benefit is generated if annual flow of funding goes up by  $\text{£}1$ . The first step represents the reduction that happens because of the following adjustment factor:

$$\begin{aligned} \text{Marginal Private Return on Funding} &= \frac{\text{PV of Change in Private Net Benefits}}{\text{PV of Change in Funding}} \\ &= \frac{\int_0^\infty \exp(-\rho t) - \exp(-(\rho + \delta)t) dt}{\int_0^\infty \exp(-\rho t) dt} \\ &= \frac{1/\rho - 1/(\rho + \delta)}{1/\rho} = \frac{\delta}{\rho + \delta} \\ &\approx 0.81 \end{aligned}$$

where  $\rho$  represents the Social Time Preference rate (discount rate) of 3.5% and  $\delta$  represents the depreciation rate of 15%.<sup>41</sup>

In reality, it takes time before new R&D produces visible benefits – evidence suggests this time lag is about **6 years**. Therefore, we discount those benefits again by 6 years of waiting:

$$\text{Discount factor} = \exp(-3.5\% \times 6) \approx 0.81$$

Multiplying this with the earlier 0.81 gives:

$$0.81 * 0.81 \approx 0.66 = 66\%$$

So, with the delay, the marginal return is about **66% of the average return**.

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<sup>41</sup> For full derivation, refer to Section 32.4 of King, M; Nayak, S (2025) *A macroeconomic model with imperfect production processes and conformance testing*. NPL Report. IEA 27. DOI: <https://doi.org/10.47120/npl.IEA27>.

## 13 Annex 4 – Deflators and Discount Rates

This report uses the following:

### 13.1 Deflator

Based on Office for Budget Responsibility's (OBR's) October 2024 Economics and Fiscal Outlook,<sup>42</sup> we have used an annual inflation rate of 2% for this SR period.

### 13.2 Discount Rate

Based on Green Book (2022)<sup>43</sup> guidance, we use a Social Time Preference rate (Discount rate) of 3.5%.

Setting inflation as 2% and discount rate as 3.5%, we get:

<b>Year →</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>	<b>FY</b>
	<b>2025/26</b>	<b>2026/27</b>	<b>2027/28</b>	<b>2028/29</b>	<b>2029/30</b>
<b>Deflators (with 2026/27 as baseline)</b>	1.020	1.000	0.980	0.961	0.942
<b>Discount factor (with 2026/27 as baseline)</b>	1.035	1.000	0.966	0.934	0.902

Table 8: Deflators and Discount Factors by Years (base: 2026/27)

<sup>42</sup> Available at: [https://obr.uk/docs/dlm\\_uploads/OBR\\_Economic\\_and\\_fiscal\\_outlook\\_Oct\\_2024.pdf](https://obr.uk/docs/dlm_uploads/OBR_Economic_and_fiscal_outlook_Oct_2024.pdf)

<sup>43</sup> Available at: [https://assets.publishing.service.gov.uk/media/6645c709bd01f5ed32793cbc/Green\\_Book\\_2022\\_\\_updated\\_links\\_.pdf](https://assets.publishing.service.gov.uk/media/6645c709bd01f5ed32793cbc/Green_Book_2022__updated_links_.pdf)

## 14 Annex 5 – Near Saturation of the UK Measurement Infrastructure

### 14.1 Productivity of the Measurement Infrastructure

To outline why the Measurement Infrastructure is close to saturation in the short-term, some context is needed. Measurement Infrastructure sees the diffusion of measurement information through the economy, with the source of this information being the NMS labs, through the realisation and dissemination of the primary standards via measurement services.

This information is used to facilitate and support both process optimisation and conformance testing, but not all information is the same. If unreliable information is used in the testing, this would lead to poorer decision-making and more mistakes, ending up with an increased scrap rate and suboptimal production processes. Poorer control of production processes would lead to a reduction in the economy's Total Factor Productivity (TFP) - reducing overall economic output. Access to more reliable measurement information (traceable to standards of the NMS labs) reduces the gap between the technically feasible TFP of the economy and the actual TFP of the economy. It should be noted that the traceability of measurement information to national standards is a form of public good, which enhances real-world productivity but doesn't push up the frontier TFP. (So, this is not the same as technological change, which would see the frontier TFP increase.)

The stock of the measurement capabilities has been built up over many decades, with the NMS's capabilities aligned to the needs of UK's main industries. Currently, the [NMS covers 75% of the Calibration and Measurement Capabilities \(CMCs\) areas as listed by BIPM](#), which is in-line with the other top five NMIs. For the top five NMIs, they cover most CMCs, with slight differences in coverage reflecting varying national relevance. Given that only [14% of the NMS's users](#) use a foreign NMI for their traceability needs, it suggests that the NMS is very close to saturation with regards to coverage. But given that there is a proportion of the userbase that uses foreign NMIs for their traceability needs, it suggests that there is some room for expansion into niche areas needed by a minority of the userbase. Moreover, in the long-term, technological and structural changes to the UK

economy will necessitate new and improved metrology capabilities, but this sits outside of the purview of the current model. For the purpose of this report, the SR25 period is treated as the short term; medium- and long-term developments are therefore discussed qualitatively but are not quantified.

Having provided the context, we now discuss the two ways through which the benefits being generated by the UK Measurement Infrastructure could be increased, although it's important to recognise that both these ways only take effect in the medium- or long-term.

## 14.2 Medium term

In the medium term, additional investment could focus on reducing the NMS's existing capacity constraints and improving the utilisation of current measurement capabilities. Scientific activity at the NMS's current sites is constrained by available space, facilities, and specialist staffing, which has contributed to the NMS becoming "one-deep" in a lot of its capabilities. This creates risk around continuity of services when key staff retire or leave, which can be mitigated through ongoing investments targeted at maintaining skills and ensuring effective knowledge transfer. While these improvements primarily enhance the performance of existing capabilities, medium-term investment can also begin laying the groundwork for future expansion to meet evolving technological needs, even though the major impacts from such developments would only be realised in the long term.

Furthermore, due to the one-deep nature of many capabilities, some services also see significant congestion, leading to long turn-around times. This can be seen in the most recent version of the [customer survey](#), which found that the NMS's "highest NPS can be clearly observed by quality, followed by timeliness of delivery, and price at the lowest". The price reflects the scarcity of the very specialised, scarce human capital (measurement scientists), while the turn-around time issues reflect the congestion. The purpose of the broader measurement infrastructure is to provide multiple access points, with differing levels of accuracy, to reduce the effect of this bottleneck on uptake.

Due to the downtime, users often go without their instruments for a significant period of time, reducing output for our direct users. This, in-turn, affects those down the calibration chain, reducing economic output across the whole economy. To prevent this, an expansion of the NMS labs could create capacity for greater depth in our offerings. This would reduce turn-around times, which would increase output for the economy as a whole.

Beyond addressing the turn-around issues, an increase in capacity to deliver services would also future-proof them as well.

### **14.3 Long Term**

In the long-term, as detailed above, there could be a move to increase the NMS's coverage of the Calibration and Measurement Capabilities (CMCs) to keep pace with new technologies, emerging industries, and evolving national needs. This would see a significant amount of funding needed to build new facilities, train new scientists and develop new Measurement Infrastructure. Not only would the NMS need to expand, but the rest of the UK's quality infrastructure would expand to deliver the new capabilities, which would require the development of new standards, new UKAS accreditation and new capabilities in the private sector.



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