THE OPERATIONAL RESEARCH SOCIETY

Blackett Memorial Lecture

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Superforecasters and Moon Shots:

The Idea of Operational Research in the 21st Century

Rt Hon Chris Skidmore MP

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Thank you for the invitation to address the society.

I am honoured to have been asked to give this prestigious lecture, named after one of our most distinguished scientists, the Nobel Prize winner Patrick Blackett.

Particularly since, as a historian and politician, I feel a sense of trepidation, or rather impostor syndrome, addressing a field of equally distinguished members of a society that has promoted and pursued the endeavour of operational research for decades.

There is little wisdom, if any, that I can impart to you about operational research that you don't already know.

What I would like to do, however, is use this opportunity to help shape a narrative, to not only restate the importance of operational research for the future, but to point to a direction of how its importance can be truly realised.

THE FUTURE OF R&D: AN OVERVIEW

I had the privilege of being the UK's Science, Research and Innovation Minister not once, but twice, between 2018 and 2020. It was, and still is, a time of uncertainty and unpredictability, not only nationally, but internationally too. We all know how the fortunes of research and scientific investment can be buffeted by the political headwinds, and it has been some storm.

Since 2015, I have fought three general elections in a period where I expected

just one. As the UK has now left the European Union, to become an independent sovereign state, we still await the final shape its future relationships with the EU and the USA. At the same time, the global crisis of the pandemic caused by COVID-19 has and will continue to throw global economies into turmoil.

Amid this sense of uncertainty, the Prime Minister has been crystal clear that he views the future of the UK's place in the world as one of 'global Britain'; a key part of this future international identity is of the UK as a 'global science superpower'.

Words are fine things— but what is the strategy to achieve this? How should the UK position itself to be world-leading for the future, and what investment needs to be made not only in our research infrastructure, but in the skills needed to conduct research in the future?

Back in 2015, the government committed to spending 2.4% of GDP- both public and private of course— to research and development. This was not to achieve 'superpower' status, merely to match the OECD average spend.

Since then, many nations have gone far further, and indeed far faster. China now spends 3% of its GDP on R&D, so too does the USA, Germany is committed to 3% by 2030, while South Korea has already reached 4.5%. In the context of these rises, 2.4% is a modest ambition that sees the UK treading water, not powering ahead.

Still, the UK has a long way to travel. Our current spend on R&D, hovers between 1.7 to 1.8% of GDP— approximately 0.6% of this is public R&D, for which the government holds the purse strings, the rest private investment. We need therefore to uplift research spending by 0.1% of GDP each year, every year, to reach the 2.4% target by 2027.

Lest I remind you, 2027 is 2,229 days away. In this time, we need not only see public spend on R&D double, we need to see private investment in UK R&D double too: from £35billion today to over £70billion per annum by 2027.

At this rate, we need an additional £15.7 million being spend on R&D by the private sector, every single day from now until 2027, to see the 2.4% target being realised. One must seriously consider the realistic ability to achieve this, especially since the global pandemic has caused severe economic disruption, the consequences of which are yet to be realised.

Still, I believe that we have no other option, no other choice. The lessons of the twentieth century show that to disinvest in R&D is to disinvest in one's own future. In pulling the plug on its investment in so many technologies from space to nuclear power, the UK was a case study in how damaging your science and research base leads to not only a loss to the future economy, it causes a brain drain and loss of skills that takes decades to recover.

The events of this year demonstrate also that research isn't just something that we need as human society for the future, we need it now, for the continuation and very existence of our way of life. In the development of a vaccine for COVID-19, our livelihoods, if not our lives, are in the hands of those who have dedicated their own lives to research, for which we are deeply indebted. But that debt must be a financial one if it is to mean that we continue to progress.

The Prime Minister realises this, which is why he remains committed to the 2.4% target. To achieve this, he has already held up the public R&D side of the bargain. Last year's General Election manifesto commitment to double public investment in science and research was the largest single commitment to R&D since Harold Wilson's 'White Heat' speech. This has now been followed by the spring financial statement by the Chancellor, setting out the figures that R&D will increase from around £12 billion currently to £22 billion by 2025.

The first fruits of this investment are already appearing. £1billion has been committed for the new Ayrton Fund, investing in climate change research across developing nations. Last week's defence spending announcement saw an extra £1.5billion to be spent on military R&D, taking this figure to now £5.8billion.

We will soon know whether the UK will associate or not to Horizon Europe, but it is expected that the budget for this is approximately £3billion, the financial envelope for which the government has already stated in the event of non-association, they will invest in a replacement international scheme.

If the spending commitments on R&D are beginning to rack up, then so too is the formulation of a wider R&D strategy, in the form of the Road Map published early this year. This Road Map is currently being consulted upon, but I believe that it marks an important moment for the government to decide which forms of research that it wishes to prioritise, and to fashion its future around.

The vital questions, as always, are what research should be funded within the financial envelope, no matter how large, that has been provided? And which research will have the greatest impact and change our futures?

The role of government in deciding this question has always been hotly contested, but I strongly believe, perhaps contrary to my Conservative background, that an active state is needed in research, not least if we are to take society and tax payers on a journey that proves the true value of investment in research.

To this, we add the inevitable question— in which direction?

In recent years, through its Industrial Strategy, the government has sought to invest in challenge led funding, through direction led funds such as the Industrial Strategy Challenge Fund or the Strategic Priorities Fund, as well as seeking to invest in specific technologies through the Quantum Technologies Hubs, and through its wider catapult network that has allowed the growth in application led technologies such as the Offshore Wind Catapult, the Advanced Manufacturing Catapult or the Satellite Applications Catapult.

This direction of travel, away from more blue-skies, discovery led, research has been a decade in the making. I sought, however, a return to more flexible forms of research funding, making the first real-terms increase in QR since 2010 when I was a minister, while the government has also committed in its manifesto to £800 million being invested into a UK ARPA.

Both challenge led and blue skies research have their place in the UK's ecosystem, but a decision does need to be taken on the appropriate funding mix for the future, and how this can be engineered to achieve the 2.4% target.

I return to the challenge of harnessing private R&D investment. Leverage is the single most important feature of that challenge. Without it, the target will fail. Yet leverage is not simply a financial problem: yes, we can seek to create funding mechanisms similar to the Fraunhofer model, yet the leverage from the private sector will not happen unless the research itself is exciting and cutting edge enough to be seen as truly valuable to invest it. So we need both discovery led research and applied technologies.

Yet the tension between what research to fund, and how to fund it, will only grow with the expectation of increased budgets. The government will need to

decide how to prioritise resource, and then to communicate to the research community and beyond why it has taken these decisions.

This is where I believe that operational research is needed more than ever, in playing a central role in planning for the government's future R&D vision— indeed for operational research to be placed at the heart of government and Whitehall policy thinking on R&D.

SUPERFORECASTERS: OPERATIONAL RESEARCH AND WHITEHALL REFORM

Last week, the Government Chief Scientist, Sir Patrick Vallance, called for more science for policy, not policy for science. Embedding scientific and analytical tools, and the more effective use of data science and computer modelling, in Whitehall, was a keen interest of the Prime Minister's Chief Adviser, Dominic Cummings, who made every Special Adviser read a copy of Philip Tetlock's Superforecasters.

Tetlock's 2015 work famously sought to demonstrate that the science of forecasting by data analysis alone was as effective as a monkey throwing a dartboard at a computer, yet through the effective application of experienced human judgement, and importantly that judgement recognising when mistakes were being made, it was possible to make more accurate forecasts. If this is not essentially operational research— placing the application of human judgement and decision making above computer and data analysis, I don't know what is.

With Cummings' departure, government needs to ensure that this message of human analytical capability and future strategic planning through operational research is not lost, particularly when it comes to investing in future R&D spend. You all are fully aware of the vital use that business makes of operational research in its own investment decisions through use of business intelligence technologies, structured around predicative analysis, monitoring and reporting.

Government R&D policy needs to start thinking in a similar manner, not least because the investment decisions needed today will determine whether we meet the 2.4% target or not. It will not be enough to deliver the public uplift in R&D, unless that research can yield the private R&D uplift.

To achieve this, we need a dynamic R&D budget that is delivered across a multi-annual financial framework. For the private sector does not wait for government. When decisions are needed to be taken on where to invest future R&D capability, major international companies are not going to sit around for the next financial year for UKRI to release an additional tranche of funding. Indeed, all too often, they walk away from what could have been a fantastic collaborative opportunity. Too many times, private R&D investment has been sacrificed to an inflexible approach to public R&D funding.

The Industrial Strategy has provided welcome stability and long term strategic thinking on where UK investment should take place, but it has done so by applying the existing funding levers, through traditional channels, which has left the entire research funding system over burdened with a plethora of funding pots, bearing little relation to one another, causing increased bureaucracy and application fatigue. The government now recognises the need to cut bureaucracy, and is conducting a 'Bureaucracy Review', however I fear that without reform of the funding system itself, cutting down the number of pages of an application form will not go far enough to addressing the key challenge of how can we take a systems wide approach to funding and how it is delivered, that will prevent universities and researchers, institutes, companies and start-ups burning valuable energy up on repeated applications, in a world where time is not only money, it is an invention, a breakthrough, a cure. It seems that, with the next REF and its framework up for re-evaluation, now is the moment to make this systemic change.

The establishment of UKRI was a major milestone in creating a unified organisational approach for research, but in many senses it has merely papered over the cracks in a diffuse network of structures and sub-structures, each with competing budgets. If we are serious about delivering on 2.4%, then we should be serious also about how public funding for R&D is not wasted, and can deliver the maximum impact and investment. I am sure the R&D Roadmap will address these concerns, yet it will be in the design of a funding mechanism for public R&D that is both rapid and dynamic, responsive and agile to opportunities that will be key.

This need for agility has been recognised in the work by Sir Adrian Smith and Graeme Reid on international research collaboration and future funding, yet it applies domestically too. The £22 billion cannot wait until 2025: we need a front loading of this investment, to deliver a signal that the UK is open for R&D business, and that we welcome the opportunity for future partnership, and

are willing now to invest in opportunities presented. We need to recognise that where we have had a 'push' R&D strategy in place, with UK investment being heavily indebted to those challenge funds and the historic priorities of research councils, we need to re-evaluate what a 'pull' strategy might look like, beyond making R&D tax credits more competitive, if we are to attract major international R&D private investment in order to reach 2.4%.

Assessing these opportunities, and their impact, at the same time as designing how a portfolio approach to R&D investment might look for the future, is the kind of exercise that operational research was created to deliver. Involving the operational research community in the R&D roadmap, and in the design of a future funding mechanism should be a given— but government relies also on the enthusiasm and commitment of what might be termed 'the research society' to guide and at times cajole.

The need for 'research' on research has long been advocated by key organisations such as NCUB, CASE and indeed, the aptly named, Research on Research Institute. Yet for some reason, operational research and its practitioners have sat outside the orbit of the 2.4% public policy debate.
So my clarion call this evening is to you, as a society and as practitioners, get involved, make the case, persuade and win the argument: that operational research can help drive and be part of the answer to the question that the 2.4% agenda has long presented, and with dwindling time to spare, 'How?'.

THE ROLE OF OPERATIONAL RESEARCH IN GOVERNMENT

It isn't just in the government's R&D strategy that I believe operational research can play a greater role— but in the wider decision making of government too. Of course, Whitehall already makes use of operational research through its Government Operational Research Service, or GORS. This employs currently a thousand researchers- though remains, I believe, largely in the shadows of government.

The Minister for the Cabinet Office, Michael Gove, is currently engaged in what the future of the civil service should look like and operate. Now is an opportune moment to re-assess how operational research can be embedded in the decision making processes of government. For too long, Whitehall has been a response-mode operation, rather than a proactive, future-facing outfit. Historic departmental boundaries have driven the creation of siloed budgets and in turn siloed thinking. Currently these are circumnavigated by the use of

cabinet sub-committees and inter-ministerial taskforces.

Yet that challenge-led approach that I spoke of as part of the Industrial Strategy is one that Whitehall needs to embrace too. Last year signed the UK commitment to achieve net-zero carbon emissions by 2050 into law, becoming the first G7 country to do so. Next year, the UK will host the UN climate conference, COP26, at which major decisions on future emissions strategies will be taken.

It is clear that Net Zero is, and will be for decades, a driving policy commitment of successive governments. It requires planning and policies across departments, which would best be enabled through taking a horizontal approach to establishing its own quasi-department, with a permanent secretary for Net Zero, and a Net Zero ministry.

The same could be said for 2.4% perhaps. There are other government commitments which are greater than the sum of the departments needed to deliver, for instance space policy, which is why I established the National Space Council.

We can and should be much more imaginative about how government can meet the challenges for the future by reforming itself around those challenges.

And in doing so, operational research can be crucial— mapping future direction, evaluation policy proposals and their impact, assessing their delivery, and vitally— something which Whitehall has a poor track record on— helping to take decisions to end funding if policies are not working.
Operational research should take place, not as it currently does as a adjunct of government, where work can be commissioned, where enthused civil servants can go to for advice. Instead, we need operational research practitioners not hidden out of sight, but in full view as directors within policy teams, teams which shouldn't be limited in future to departments.

Tomorrow the Chancellor will deliver his one year spending review. This is not the multi-annual spending review framework we had hoped it might be, but this nevertheless gives us a window to be more dynamic with how government spending, and indeed research spending might operate for the future.

And if the Chancellor is looking for how saving investments might be made

for the future, he might perhaps look at the opportunities that operational research can bring to increasing both government productivity and efficiency. Already operational research has demonstrated its savings potential in a number of fields, including energy transmission and communications, where spectrum management in the US has delivered over $10 billion worth of savings. Major companies such as BT recognise the value of operational research for techniques in areas such as automated network design, field force management, asset management and process optimisation. With the application of high performance computing to help drive further and faster processing and algorithmic decision making, it is clear that the potential for operational research to embed itself in future strategy must be taken.

The perceived returns for government need not be seen in merely financial terms. In healthcare, for instance, there are a myriad of examples where individual trusts or localities have applied operational research to yield impressive returns to the survival and quality of human life.

Algorithms developed by University of Glasgow researchers led to over 200 more kidney transplants taking place between 2008 and 2017 that is estimated to have been the case had a previous algorithm continued to be used. This potentially saved the NHS around £52m over a 10-year period.

Redesign and optimisation of mental health caseloads resulting in improved health outcomes for severely mentally ill adults across South Wales per patient by an average of 51%, reduced time off work due to severe mental health episodes by 65% and a reduction in the number of crisis admissions by 66% and avoiding ineffective and unnecessary acute hospital admissions by 79%.

Imagine if we had invested in operational research for pandemic modelling—if Operation Cygnus had placed research, by which I mean operational research, at the heart of its strategy, to help design pathways and decisions for delivering with community transmission, NHS capability and capacity, the economic impact of lockdowns along with a host of equally problematic decisions to be taken on school and university closures.

The lessons of COVID-19 are that we cannot wait for our future, whatever it holds, we must as a responsible government seek now to recognise that operational research matters, and must, as a first point of principle, be embedded in the future from the very start in key national strategies and civil

contingency planning.

Operational research should be a required part of the process of policy making, without which no policy should be signed off. The Treasury might act as an important lever here, and with its Green Book and rules around infrastructure spend being reviewed, it would make sense for new rules to reflect and embrace what the private sector already knows: that investment in operational research pays dividends, prevents wrong turnings, and helps deliver commitments and results at a more rapid pace.

MOONSHOTS AND THEIR OPERATION

And what of those commitments? I have already mentioned Net Zero 2050 as an era-defining challenge, one which will outlast governments. It is likely that Net Zero will be the first of other, future facing ambitions that require a whole of government approach. The pandemic has woken society to the recurring need for healthcare innovation, while the Prime Minister's 10-point plan for a Green recovery highlighted the need for the government to step up to energy creation through new sources such as advanced modular nuclear reactors, fusion and an expansion in wind power.

The Prime Minister has equally made clear his enthusiasm for 'moon shots'—for which the establishment of mass testing for COVID seems to have been taken as an early pilot. It is worth noting that the Council for Science and Technology were approached earlier this year by the Prime Minister to help articulate what a successful moonshot might look like. They replied that

A 'moon-shot' can be defined as a highly ambitious national or international goal, which, through several scientific, engineering, or technological breakthroughs, delivers a disruptive innovation or solution. It is, by its nature, a multi-disciplinary and multi-stakeholder enterprise, bringing together a range of partners from academia and industry to work towards the overall, single goal.

From this definition, we have identified seven key principles that should guide the process of formulating a moon-shot. A moon-shot should:

i) *Excite and inspire the public, academia, and industry, galvanising academic and industrial research and development. A successful moon-shot will engender a sense of motivation, collective achievement, and national pride.*

ii) Relate to and help solve an important societal issue which the public can identify with.
iii) Be truly disruptive and ground-breaking, not merely a 'ramping up' of effort in an existing activity or objective.
iv) Focus on areas where the underpinning science is at a stage to make a major breakthrough feasible.
v) Be specific and well-defined in what it sets out to achieve, with a clear timeframe for completion, and an explicit, single measure of overall success. It will be obvious to everyone, including the public, when the moonshot has achieved its goal.
vi) Take advantage of areas where the UK is, or is poised to be, a world leader; a moon-shot should demonstrate national capability on the international stage.
vii) Finally, a moon-shot should offer the prospect of generating significant additional benefits from scientific and technological advances which have the potential to be applied in other areas, providing benefits in their own right.

I wanted to highlight this important response, for it seems to me that the criteria for which future moonshots should be defined and framed will need operational research in their creation, and in their choosing and evaluation, if they are to meet and succeed in meeting the Committee's recommendations. If moonshots are to be created in the future, then perhaps now is the time for government and the operational research community to work together in the design and delivery of what could be exciting national programmes.

IT'S PEOPLE, STUPID

And if we can embed operational research and prove its worth in government, I hope that it's value will be recognised more widely as a form of research which needs its own form of investment.

If the effective functioning of government depends on harnessing the talents of the civil service, ensuring that they are embracing the opportunities that operational research can bring to policy and strategy making, this highlights a wider point that I wish to make about delivering on the UK's R&D strategy—that without the people doing the research in place, increased investment matters little, for the research simply won't happen.

I'm sure operational research analysts can far better model a scenario better

than I can, but I believe it is estimated that to realise the output of 2.4% in research activity, we will need approximately 200,000 extra people performing research or being employed in R&D intensive industries. Building a pipeline of talent that identifies how we will increase- and retain- the number of people conducting research.

It was the 'People' element of a wider vision on 2.4% that I sought to address in the first of four speeches given in the summer of 2019— and in my final speech as Minister, I announced a People Strategy for Research.

Already we have increased the number of PhD places and masters degrees, either through funded studentships in areas of focus such as AI or through establishing a postgraduate student loans system, which has made finance more available for those wishing to pursue research degrees. Nearly a thousand Doctoral Training Partnerships have been established with university and industry, helping to train the next generation of engineers, computer scientists and physicists among many other disciplines.

There are a number of institutions which offer operational research PhDs and masters degrees, but more can be done to embed operational research as its own separate discipline into the government's planned investments in postgraduate programmes. Yes operational research forms part of many AI and computer science research degrees, but that should not mean that operational research should be taken as a means to an end, or as simply the little brother of AI and data analytics. We need operational researchers, trained as operational researchers, for operational research.

If operational research, as I have argued, needs to play a central role in helping to devise the UK R&D framework, helping as it were to devise the ingredients of the cake, it should have its own slice and eat it too. One means of embedding operational research as a discipline for the future would be for operational research to have its own research institute- either a physical location, or perhaps a virtual network across key organisations and universities, reinforcing the need for operational research and demonstrating its value.

But it isn't just at postgraduate and post-doctoral level where attention should be focused.

Operational research also suffers from not having a clearly identified

undergraduate route in the UK. Contrast this with the United States, where there are more than 100 institutions offering operational research batchelor's degrees. With the value of operational research to business well known, it would make perfect sense at a time when graduate employability has become a focus of attention for operational research to take off as a vocational career path, with its own separate degree course.

Perhaps with the future creation of a flexible post-18 education system, modular courses in operational research might also benefit those wishing to access Higher Technical Education. Either way, now is the moment for institutions to be thinking about future course provision, and how they might benefit from establishing operational research courses, rather than this discipline be taught through engineering, computing, physics and maths.

And if we recognise the paucity of provision at undergraduate level, why not go further, and investigate what more could be done to create that 'pipeline of talent' back into the school system. I am wary of venturing on the well-trodden territory of politicians believing that the answer to every problem is to add something to the national curriculum. Yet the challenge facing operational research is, perhaps unsurprisingly, the same challenge that engineering faces. While it is not a separate discipline at school, how can its value, or perhaps more importantly, its exciting and alluring potential, be communicated to a pupil who may be deciding their future A-levels or degree? Just as engineering has sought through the Young Engineers of the Future and the Year of Engineering programme to encapsulate the problem solving aspect of the discipline, so too could operational research reach out to sell itself as not only a sustainable career, but an enriching and rewarding life choice.

Operational Research must not simply be subsumed into the study of computing and AI, as a process: its application as a discipline in and of itself matters, because it demonstrates I believe the future of learning alongside machine learning. Human decision taking and human evaluation of data, as Philip Tetlock has shown, is essential. It's why I believe that we must not, in a focus on becoming a 'global science superpower', forget that science isn't just about the sciences.

This isn't a problem in other countries, where 'scientia' translates more effectively into research across all forms of knowledge. But in the UK, we are in danger of turning CP Snow's Two Cultures into another culture war—

pitting STEM against the arts, social sciences, humanities and languages.

I have long argued that we need not just the creative arts, vital that they are for our economy, but the humanities placed at the heart of our decision making on science and technology, for innovation cannot happen without scale, and scale cannot take place without understanding human need and human behaviour.

The same is the case for tackling climate change and meeting Net Zero, or indeed achieving any successful moonshot in the future, or indeed achieving any successful government policy. For they are achieved through being lived through— and only by understanding this, by applying the lessons we can learn from the humanities and social sciences, will we achieve.

Yet these lessons, and the essential need for human involvement, lies too at the heart of operational research. Indeed, operational research forms a bridge between Snow's Two Cultures, and can help demonstrate why all research and inquiry is valued. In making sense of processes and mapping their future trajectory and success, operational research can not only be a vital tool in government policy, it demonstrates why blended forms of interdisciplinary work are essential for the moonshots of the future.

I guess what I have been trying to say all along, is something that all of you already know: that operational research matters, and as a discipline could prove extremely important to government and society as the UK seeks to invest in R&D, to realign its economy across new scientific and green priorities, and face the challenges of the future.

It is time for operational research to come out of the shadows, to end its Cinderella like status by entering the mainstream thought of government, of research and indeed of universities and our education system. The future success of our society depends upon it.

Thank you.

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