Selling less of the family silver

An independent, post election manifesto for a better UK innovation and industrial policy

David Connell and Bobby Reddy

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David Connell

After a period with the UK's National Economic Development Office David joined Deloitte Haskins and Sells where he led its High Technology Group. Between 1989 and 2006 he was a member of the recently founded Technology Partnership's management team. As TTP Group plc this became one of Cambridge's most successful STEM based companies with several spin-out product businesses. David led TTP's strategy consulting arm, advising international corporations on R&D strategy, corporate venturing and innovation. He was also Chief Executive of TTP Ventures, an early stage VC fund backed by Siemens, Boeing and financial institutions.

At CBR, as a Senior Research Associate, his research has focused on the start-up strategies and funding models of successful STEM based companies, the challenges of commercialising academic research and innovation policies in other countries, in particular, US procurement based policies and intermediate research organisations in the US, Europe and Asia.

In 2004 he organised a campaign with Anne Campbell, MP for Cambridge, and support from leading entrepreneurs, VC investors and research scientists to get a UK procurement based funding programme similar to the US SBIR established in the UK. This was backed by Chancellor Gordon Brown in his 2005 Budget. He carried out a review of the programme for Prime Minister Theresa May in 2017.

David has degrees in physics, operational research and economics from Bristol, Lancaster and London (Birkbeck College) Universities respectively.

Bobby Reddy

Bobby is the Professor of Corporate Law and Governance at the University of Cambridge. Prior to joining academia, Bobby was a partner at the global law firm, Latham & Watkins LLP, practising in both its London and Washington D.C. offices. As a dual-qualified UK/US lawyer, Bobby specialised in mergers and acquisitions, private equity, venture capital, funds formation, and financial regulation.

After his period as a corporate lawyer, Bobby joined the charitable corporate governance think-tank, Tomorrow's Company, initially as a senior consultant, then as a director trustee. At Tomorrow's Company, Bobby was involved right across the spectrum of corporate governance issues, including growth, stewardship, long-termism, and board dynamics.

In academia, Bobby conducts research on the efficiency, operation and innovation of capital markets, private equity, and the real-world impact of regulatory approaches and policies. He has published extensively on dual-class shares, special purpose acquisition companies, corporate governance, the health of the London Stock Exchange, and on stock exchange dynamics generally. He is the author of "Founders Without Limits" published by Cambridge University Press. Bobby is also a J M Keynes Senior Fellow in Financial Economics and a Global Distinguished Visiting Professor of Law at the University of Notre Dame. He has been cited or quoted in numerous mainstream publications, including Bloomberg, The Guardian, the Financial Times, City A.M. and Reuters.

About the Centre for Business Research

The CBR, established in 1994, conducts interdisciplinary, evidence-based research on the determinants of sustainable economic development, innovation and growth. CBR research has pioneered new methods of data collection and analysis of enterprise and innovation, novel approaches to macroeconomic modelling, and original datasets tracking legal and regulatory changes and their economic impact over time. Current projects are examining inequality in cities, the effects of IMF structural adjustment policies, macroeconomic projections for the UK economy, social rights and poverty alleviation, law and finance in the BRICS, the role of universities in knowledge exchange, business development in the Cambridge region, and the relationship between contract forms and innovation in construction and infrastructure projects.

The Centre's areas of specialisation include the construction and analysis of large and complex datasets on SMEs and innovation, longitudinal analysis of regulatory change affecting business firms, and fieldwork-based studies of corporate governance and organisational practice. The Centre has made a significant contribution to the development of research methods and theory in the analysis of law and finance. The Centre's research is disseminated to and used by managers, policymakers and regulators in numerous countries. Its research draws on expertise in University of Cambridge departments ranging from the Faculties of Economics, Law, and Human, Social & Political Science, the Departments of Geography, Land Economy, Politics & International Studies and Engineering, to Cambridge Judge Business School.

Foreword

This report examines what we believe to be one of the most important issues for UK innovation and industrial policy: the early sale of many of our most promising new science and technology companies to overseas-based corporations, and the truncation of further growth in the UK.

This is a complex and difficult policy problem to solve.

Our analysis draws upon our experience in the private sector and public markets, with start-ups, major corporations and investors, and from a strategy, finance and legal perspective, as well as on our research at the University of Cambridge.

The election of a new government presents a vital opportunity to make radical reforms to promote economic growth. We believe that this report provides a timely input into the detailed process of budgeting and policy development that the new government must now begin.

The total cost of government programmes to support and encourage business research and development in start-ups and larger companies is now some £14 billion, and it is overwhelmingly dominated by tax breaks and related blanket subsidies. This report is a rare attempt at a holistic analysis of this spending, in terms of expenditure by programme, the relevance of those programmes to businesses of different kinds, and the economic impact of the current system.

Many promising and successful British companies will always be acquired by foreign corporations. It is a feature of the vibrant global economy in which we live and from which we benefit. However, if we want the UK's economy, the savings and pensions of individuals, and society generally to fully benefit from the UK's science, technology and entrepreneurial talent, we must also adopt policies that enable visionary individuals with the desire and ability to grow a significant UK-based business over the long-term to achieve that goal. The UK has an envied pipeline of talent and innovative early-stage businesses, and it is imperative that we support them to grow those businesses into thriving British companies.

Our analysis suggests that the current innovation policy mix is poorly aligned to this objective. We offer a series of new and revised policy ideas to address this, together with proposals for a change in the overall balance of spending across the policy portfolio so it is more cost effective. We also recommend policies and new mechanisms to foster the listing and growth of British companies on the London Stock Exchange.

Our final recommendation is for a new way of monitoring and managing the overall policy portfolio so that the type of analysis we have undertaken here is a regular part of the process by which future governments of all colours can ensure innovation policy spending is evidence-based, relevant, appropriately funded and cost-effective.

Achieving the incoming Government's policy goals will be critically dependent on whether it can put in place effective policies to accelerate the growth of the business economy and capitalise on its science and technology assets. More of the same is not an option. This report offers a new approach.

David Connell and Bobby Reddy

Executive Summary

It has become increasingly clear that the key challenge for UK industrial and innovation policy is the early acquisitions of our most promising new R&D based companies by overseas-based corporations and private equity, and the truncation of subsequent growth in the UK.

This is largely the result of the UK's position as a medium-sized economy in the global market place, the dynamic economies of scale available to competitors based in the largest economies and the attractiveness of UK companies to acquirors. In recent years the problem has been compounded by declining interest in growth companies amongst investors on the London Stock Exchange making IPOs increasingly unattractive for both company founders and their investors.

In many cases a trade sale is the desired and most logical outcome for the founders and management teams of successful STEM-based[1] start-ups, but it is essential that ambitious entrepreneurs with the desire and ability to grow a major UK corporation are given as much help as possible to do so, whether this be as a public or private company.

Solving this problem will be difficult. The aim of this discussion paper is to examine the factors that create or exacerbate that problem and offer some possible policy solutions.

Section 1 explores the policy problem and summarises developments in UK innovation policy over the last 25 years. These are characterised by gradual evolution from a policy based on an aversion to being seen to be "picking winners" with minimal financial support for business R&D, to today's position where Government is much more active across a range of policies, with spending dominated by tax breaks and other blanket subsidies costing £12 billion a year.

Section 2 examines ten issues, opportunities and role models where a better understanding might provide some inspiration for new and improved policies and managing the overall balance of funding between them:

- The role and limitations of venture capital funding;
- The difference between investment led and revenue led start-up models and funding strategies, and what policy objectives would need to be set to maximise the long term contribution of both to the UK economy;
- The viability of the London Stock Exchange as a forum for growth companies, and how new or improved policies might enhance it;
- Lessons from the UK STEM-based start-ups that **have** become major UK-based companies, many of which have avoided, minimised or delayed venture capital;

- The key role of lead customers, and policies to stimulate the public and private sector markets for innovation;
- Making Government support for new STEM-based companies relevant to **all** entrepreneurs, including those lacking the support of a university employer;
- Encouraging UK corporations to create new ventures despite a domestic investor base motivated more by regular income than growth;
- The scope for growing a modern UK version of the German Mittelstand through enhanced support for founder controlled businesses and employee ownership trusts;
- Policies to harness the potential contribution of breakthrough technologies to the UK business economy , including how the UK Catapult model could be changed to that of the Fraunhofer Institutes it was originally supposed to emulate;
- The cost of the many different policies for funding R&D in companies and absence of a proper mechanism for managing the overall balance across Government agencies and programmes.

Section 3 discusses opportunities for new, expanded or improved policies and makes proposals under the following headings:

- Creation of a US-style innovation procurement contracts programme through an enhanced, expanded and renamed SBRI similar to that proposed in the 2017 review of SBRI for 10 Downing Street;
- Significantly increased funding for Innovate UK R&D grants including small 100% start-up grants under the “de minimis rule” and an expanded programme for 70% funded larger grants awarded in phases;
- Possible mechanisms for funding private sector lead customer innovation contracts with UK SMEs;
- Increased early stage government equity funding for breakthrough technology start-ups;
- A new model for UK intermediate research laboratories;
- British Business Bank funding to accelerate the growth of STEM-based companies that have been sold to employee ownership trusts;
- Measures to incentivise UK institutional investment in UK-listed growth companies, including better investment research on existing listed growth companies and those intending to list;
- The use of dual-class shares to give shareholders a UK IPO exit route at the same time as returning control over ownership and other key strategic decisions to the management team, and the development of government-sponsored special purpose acquisition companies (SPACs) to create a mechanism to encourage growth companies on to the London Stock Exchange.

Section 4 examines the balance of spending across the key policies for supporting the creation and growth of STEM-based UK companies.

Subsidies and grants for business R&D currently total around £14 billion, of which R&D Tax and Expenditure Credits (RDEC) and the Patent Box, both blanket subsidies open to any company with a valid claim, account for over 80%. No other OECD country comes close to putting this level of emphasis on tax breaks and blanket subsidies in its support for business R&D.

British Business Bank investments, direct and via venture capital funds amount to around £300m a year. Increasing Government equity investments through

experienced professional VC fund managers might be more cost effective than subsidies given that they would be expected to deliver a return over the portfolio as a whole.

The report proposes a more cost effective policy portfolio, with RDEC more closely focused on where it can make a difference to reduce "deadweight", and the axing of the Patent Box. Savings would enable the creation and expansion of policies aimed at STEM-based start-ups following the kind of revenue-based funding models adopted by many of the UK's most successful start-ups, for which RDEC is of little relevance. These include measures to increase lead customer funding from both the public and private sector and an expansion of minimally dilutive R&D grants.

Section 5 discusses the organisational problems that have hindered the development of innovation policy across government as a whole and the balance of funding between different policy instruments. The power of the Treasury as the arbiter of innovation policy spending and its lack of resources to do the job has led to a process based on bargaining rather than evidence.

As a result, the design and balance of funding between different policies and programmes has failed to take account of the economic evidence, and has been overly influenced by the best funded and most vocal lobby groups, together with the political requirement for announcements and new initiatives.

The paper proposes a new Independent Office for Innovation and Industrial Policy, to improve policy planning and monitoring.

Section 6 summarises the findings of the report and highlights the implications of the recent, largely unpublicised, major revision to official statistics of UK R&D expenditure.

In July 2023 the Office of National Statistics increased its estimates of R&D spending by UK businesses from a figure of around 1.7 to 1.9% of gross domestic product (GDP) where it had been for nearly two decades to 2.9% in 2021.[2] This is well ahead of the government target of 2.4%, but still below most of our leading competitors.

That the UK has apparently exceeded Government's long term R&D target whilst failing to grow and retain many financially successful new R&D-based businesses illustrates the complexity of the problem. It also underlines the importance of refocusing policy objectives on "outcomes" in terms of the growth, longevity and profitability of UK firms as opposed to intermediate "outputs" in terms of R&D spending.

This will require a much more holistic and joined-up approach to policy planning and management than has been the case hitherto.

Section 1
The problem

Government announcements placing innovation at the centre of its industrial and economic policy have had a long history in the UK, from Harold Wilson's "White Heat of Technology" speech in 1963 to Boris Johnson's June 2021 announcement of the Government's intention to "Restore Britain's Place as a Science Super Power".

The failure of some of the Wilson Government's high profile interventions was followed by a quarter of a century or more in which any proposal that could be tagged as "backing winners" would be career limiting for the politician making it. Spending departments cut back their own investment in research and development (R&D), and subsidies for business R&D were very limited in value. These were largely restricted to "collaborative R&D grants" involving universities and companies working together. Interest in the collaborative R&D model was largely based on a misreading of Japan's 1970s MITI programmes and their impact on its semiconductor and computer industries, coupled with restrictions implicit in EU competition policy.[3] It also reflected a "technology push" model of innovation which continues to bias policy thinking.

The UK's stance began to change a few years into the Blair administration, with R&D Tax Credits being the first key step.

R&D Tax Credits were first introduced for small- and medium-sized enterprises (SMEs) in 2001, but were rapidly extended to large corporations and later to non-tax paying companies and hence start-ups.

For politicians they had the great advantage that any company doing R&D could make a claim. So, ministers and officials could not be accused of trying to pick winners.

Over the last 25 years, spending on innovation policy has been steadily increased and extended, including:

- funding to universities to support exploitation of academic inventions, spin-outs and science parks;
- tax subsidies for private investors in early-stage companies through the Enterprise Investment Scheme (EIS), Seed Enterprise Investment Scheme (SEIS) and Venture Capital Trust (VCT) schemes;
- increased spending on R&D grants, for many years still focused on collaborative R&D, and the creation of The Technology Strategy Board, later renamed Innovate UK, an arm's length agency to manage these and many other programmes, including recent embryonic programmes like "Investor Partnerships" and "Innovation Loans";
- increasingly generous R&D "tax and expenditure credits" which now dominate innovation policy spending;

- the “Patent Box” tax subsidy, aimed at encouraging the commercialisation of British inventions in the UK;
- public sector innovation procurement contracts through the struggling “Small Business Research Initiative” (SBRI) scheme, inspired by the $4 billion a year US Small Business Innovation Research (SBIR) programme;
- Government co-investment programmes to help early-stage UK venture capital (VC) funds get established;
- the British Investment Bank, and its subsidiary British Patient Capital, whose programmes include investment in larger venture capital funds and direct co-investments in R&D intensive start-ups;
- a network of “Catapult Centres”, intermediate R&D laboratories inspired by the German Fraunhofer Institutes;
- the Advanced Innovation and Research Agency (ARIA), designed to perform a similar role to that of ARPA, later DARPA, in the US.

The cost of total Government funding to businesses through these policies is now around £14 billion a year and some good progress has been made in stimulating the growth of the UK innovation economy, most notably an increase in the number and funding levels of university spin-outs and other new science and technology companies being created each year.

R&D Tax Credits and the related R&D Expenditure Credit represent the lion’s share of total innovation policy spending and now cost the Treasury around £10 billion a year,[4] while tax breaks from the Patent Box cost £1.4 billion.[5]

But there is a problem

Whilst many more science and technology-based companies are being started each year than 25 years ago, and with much more funding available now, this is not translating into the creation of large, profitable, UK-controlled companies that continue to grow and innovate within the country. Instead, the nature of the UK’s position within the global economy, and the VC funding model on which most R&D based start-ups are based, has resulted in the most promising start-ups tending to be sold early, before they are profitable, and usually to overseas multinationals, with subsequent UK growth curtailed or worse.

For example, the Cambridge cluster is now less effective at turning start-ups into sizeable UK businesses than it was a quarter of a century ago.[6]

Acquisitions and consolidation are an important feature of the corporate world, especially as markets mature. For many young companies, and their founders, a trade sale is probably the best outcome.

However, for UK start-ups, with neither a credible domestic exchange on which to list nor a pipeline of large UK-listed companies seeking to grow through acquisitions, sales to overseas strategic buyers and private equity have become a routine outcome, while not necessarily the best outcome for those companies or the wider UK economy.

A recent league table of UK-listed “Technology Companies” includes only 9 valued at over £1 billion as of 2 May 2024, with one of those companies, Darktrace, subject to, as of the date of this paper, a recommended takeover offer.[7] Most are business software consultancies, vendors, consultants and IT integrators. The largest, by a factor of three, is Sage Group, created in 1981 as essentially a spin-out from a small printing business.[8]

Sage also had the highest revenues at £2.2 billion, although this was exceeded by two of the three most successful unlisted STEM-based, UK start-ups in recent years: Dyson at £6.5 billion, and BET365 at £3.4 billion. Both are still privately held by their founders and families, and like the third, Arm, were built without venture capital.

In short, the UK is quite simply failing to create sufficient major new STEM-based companies to replace sectors in decline. Solving this problem will be difficult. Nothing in recent policy announcements has sufficiently addressed it.

The UK company rankings in industry league tables of global market capitalisation, shown in Box 1 illustrate the problem, as well as its corollary – that potential acquirers of growing UK companies are increasingly based overseas.

Government must therefore do much more to support entrepreneurs with the desire and ability to build a major UK business over the long term.

The problem is made more difficult to solve because of the fragmented nature of the existing political and administrative apparatus for creating and monitoring the different innovation policy instruments and branches of Government involved. As a result, the design and balance of funding between different policies and programmes has failed to take account of the economic evidence, and has been overly influenced by the best funded and most vocal lobby groups, together with the political requirement for announcements and new initiatives.

Whatever the colour of the next UK Government it will be faced with very difficult funding decisions across the whole field of public spending. Much more relevant and cost-effective innovation and industrial policies will be needed to deliver the economic growth required to fund our health, social, security and environmental policy aspirations.

The purpose of this document is:

- to improve understanding of the policy problem and outline new policy instruments that could address it
- to show how total innovation policy funding across Government could be rebalanced to address the key policy challenges and improve overall value for money without additional Government expenditure
- to propose a new mechanism to enable Government to manage innovation policy and, in particular, the design and balance of funding of different policy instruments across the various sponsoring departments involved so that it delivers the best outcomes based on evidence and value for money.

BOX 1

UK firms in global league tables of companies in key STEM-based sectors

- Pharmaceuticals is the industry in which UK-based companies figure most strongly in global league tables. Astra Zeneca (Anglo-Swedish) 8th largest and GSK the 19th largest by market capitalisation are the only UK-based listed companies included in the 50 largest pharmaceuticals and biotech companies globally. (Source: companiesmarketcap.com 19 Feb 2024)
- A list focusing instead on the 25 largest "true biotech" firms, excluding pharmaceutical companies, with a heritage of small-molecule, non-biologic drug development, but including biotech research tools like Illumina, includes no UK-listed companies. (Source: Genetic Engineering and Biotechnology News, 5 May 2023)
- There is one British firm in the world's 50 largest medical device companies by revenue, Smith and Nephew at 25. (Source: Medical Design and Outsourcing; 2023 data.)
- There is one UK business in the world's 24 largest listed scientific and technical instrument companies, Spectris, at number 10. This was created through a wholesale reconstruction of an existing UK company through a series of acquisitions in the sector, including the four instrumentation and controls businesses of Spectris AG of Germany in 2000. (Source: companiesmarketcap.com 19 Feb 2024)

The high reputation of UK academic research in these fields, and the fact that the NHS, UK Research Councils and UK medical research charities could, in principle, be lead customers for new technologies, might be expected to have led to a much stronger UK industrial position globally. The evidence suggests that the public sector has been largely unable to play this "pre-commercial procurement" role, a key issue discussed later in this report.

- There is one UK company in the world's 100 largest semiconductor companies, Arm at number 40, and only one company, RS Group, a distributor of third-party components, in the 100 largest electronics companies. (Source: companiesmarketcap.com 29 Feb 2024)
- Sage is the only UK firm amongst the world's 100 largest listed software companies. (Source: companiesmarketcap.com 19 Feb 2024)
- The UK has three firms amongst the world's largest chemical companies ranked by annual sales in 2021, Ineos at number 6, Shell at 24, and Johnson Matthey at 42. Ineos is a privately-owned company, largely built by acquisition. Two further UK-headquartered companies are included in the top-100 companies by market cap, Linde at number 7 and Synthomer, previously known as Yule Catto, at 73. Originally founded in Germany, Linde has grown by a series of large mergers in the industrial gas and related markets, including the acquisition of UK-based BOC in 2006. The company is incorporated in Ireland, and headquartered in the UK. (Source: Largest Chemical Producers by Sales, Wikipedia and companiesmarketcap.com 29 Feb 2024)

Section 2
Where to look for inspiration

To develop a more effective innovation policy, we must:

(i) Understand better the role of venture capital in building new companies and the drivers and limitations which affect its impact on the UK economy;

(ii) Take into account the strategies and funding pathways new companies adopt as they develop and grow, and the impact that different approaches have on entrepreneurial control and ultimately UK footprint and jobs;

(iii) Understand and address the reasons for differences between the appetites of investors for growth-based STEM companies listed on US and UK stock markets, and the impact this has on venture capital and private equity investor preferences for trade sales as opposed to IPO's as a means of realising their investments;

(iv) Learn from the history of UK companies founded by successful entrepreneurs who have managed to retain control and build sizeable UK businesses;

(v) Understand the important role of lead customer funding in the innovation process and early stages of new STEM based companies, and devise policies to encourage both the public and private sectors to play this role. "Technology push" remains dominant in policy thinking;

(vi) Adopt policies that make it as easy for talented entrepreneurs with a business background to start innovative new companies as it is for university academics;

(vii) Encourage large corporations to create new ventures where they have an inside track, but are reluctant to commit because their embryonic markets are seen by top management as too small to justify financial and managerial commitment, or shareholder pressures restrict their strategic options;

(viii) Recognise the contribution that specialised STEM-based companies selling innovative components, systems and solutions into supply chains, by combining new, but proven, technologies, can make to the UK economy. Policies that help entrepreneurs create and grow these sorts of companies, which have constituted the bulk of the important German "Mittelstand" economy, could be at least as productive in the UK as attempts to capitalise on high profile, breakthrough research projects where start-ups are destined to compete with those with powerful backers in larger economies and, if technically successful, are likely to be acquired for their strategic value;

(ix) Re-examine the potential contribution that breakthrough technology businesses can make to the UK economy and the policies that can best harness it;

(x) Find a better way of managing the balance of innovation policy funding across Government agencies and programmes.

Each of these considerations are discussed next.

2.1
The role of venture capital in a global economy

While companies pioneering new technologies in the UK may, in principle, face a more or less level playing field compared with those in other markets during the start-up phase, once sales begin to take off, the economies of scale available to their US competitors rapidly kick-in, simply because of the size of the home market which tends to power early sales.

Any new UK company developing and selling products into a new but fast growing international market will almost certainly find that a US competitor, starting at the same time, will grow faster. This in turn means that US start-ups are able to attract larger amounts of venture capital and spend more on marketing and R&D than UK competitors as markets take off. The internet and globalisation have not eliminated this basic fact of economics.

Venture capital is high risk capital and investors in VC funds (large "funds-of-funds", the private offices of wealthy individuals, sovereign wealth funds, trusts and other institutions, and to a limited extent in the UK currently, pension funds) expect high returns to offset the riskiness of this asset class. VC fund managers are remunerated through a mixture of management fees over the course of the lifetime of the fund, and "carried interest", a share in the capital gain made after the fund has sold or listed its investments.

VC funds typically have finite lifetimes, usually of 10-13 years, and in practice this means that their management teams need to raise new funds every three years to continue making new investments and earning management fees. To do so they need to demonstrate that their existing funds have been creating benchmark-beating returns for existing investors by making exits as quickly as possible. The best way to achieve this is by selling portfolio companies that have not yet reached profitability to strategic buyers, that is to say large corporations for whom an acquisition could deliver a significant impact on their existing businesses. This could be, for example, by furthering sales of new or improved products and services through their existing distribution channels, or by introducing innovative new technologies to improve overall competitiveness, strengthen brand position or appeal to shareholders by signalling strategic intent.

This kind of early trade sale, before a company has incurred the costs and risk of scaleup, is particularly attractive to its VC investors. They often appoint management with prior experience of this kind of exit and incentivise them to seek it.

Alternatively, if an investee company has robust cash-flows, private equity may step-in as an intermediate acquirer, using debt leverage, to enable the venture capital investors to exit, before selling on the business to a strategic corporate buyer, or less commonly float the company, ideally within a few years.[9]

Most acquirers of UK companies are large foreign corporations, with US firms playing a dominant role in many STEM-based industries. For these acquisitive companies, UK start-ups are particularly attractive. Their management and employees speak English, the international language of science and business, and the UK has well-regarded legal, regulatory, employment and financial systems. In recent years the weak pound has also made UK companies "cheap" for US companies with US dollar operations.

So, the UK is particularly vulnerable to the long-term effects of this feature of the global economy.

The UK must therefore (i) develop policies that harness venture capital more effectively for the benefit of the economy, and (ii) support start-up and funding models that are less reliant on VC funding.

2.2
The effect of start-up models and funding strategies on entrepreneurial control

Investment led start-ups

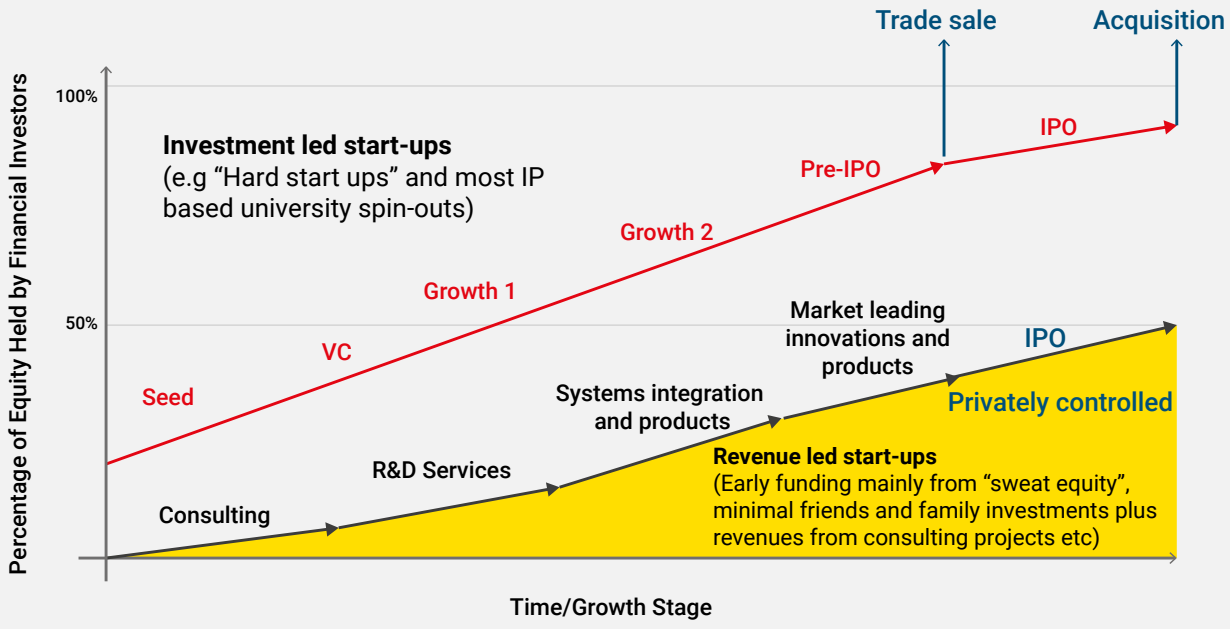
Whenever policies to help more UK start-ups become successful are discussed, by politicians, policy-makers, lobbyists or the media, it nearly always revolves around private investment. The implicit assumption is that for start-ups to be successful they must go through a series of funding rounds, starting with seed finance from angels or specialist VC funds and moving through a series of progressively larger rounds and possibly an IPO before profitability is achieved.

This is sometimes known as the "hard" start-up model as the company's future products or services, or the breakthrough research IP on which they are to be based, are usually pretty well defined in the initial business plan.

Indeed, most university spin-outs follow this path, with initial VC investments of a few million pounds typically taking 20 to 30% of the voting shares and further dilution with each subsequent funding. This results in financial investors rapidly gaining de facto control. [10]

A trade sale or intermediate private equity buyout, driven by investor needs, is a regular result, and VC's will usually ensure that senior management is recruited and incentivised to achieve this.

Exhibit 1
STEM-based start up financing and ownership pathways



An IPO may provide an alternative exit option, but investors are usually prevented from exiting fully on IPO, and, in recent years at least, a perception exists that valuations are significantly lower for IPOs (particularly of tech companies) on the London Stock Exchange than on US markets. As a result, Nasdaq and the New York Stock Exchange have become increasingly preferred for large IPOs by UK companies. Lower liquidity on the London Stock Exchange further exacerbates the problem.

The most successful UK start-up companies to have followed the UK IPO route seem to be those in financial services and other markets that can be transformed by the adoption of digital technology to manage transactions and provide greatly increased information to buyers and sellers, rather than the application of new science. Their start-up risks are, therefore, predominantly about the viability of the business model and execution efficiency, compared with the technological and competitive risks associated with propositions based on scientific research. Time to market is also relatively quick, and though still susceptible to hostile acquisitions by larger companies, it is the success of their business model that makes them attractive, rather than the future value of their technology to the acquirer.

In contrast, companies based on breakthrough science, even though they tend to consume large amounts of cash during the R&D stage, can become very attractive to corporate acquirers for their strategic value whilst they are still rather immature as businesses and have very low revenues. Although the UK may reasonably be described as a science research super power, leveraging this to become a *science-based* ***business*** super power is far more challenging.

Two or three decades ago, apart from short "technology booms", there was a severe lack of venture capital for UK start-ups and investor returns were very low compared with other asset classes. Over the last decade or so, though, UK venture capital has become more profitable as an asset class and more readily available.[11] In recent years the perceived lack of later stage "patient capital" has received greater emphasis. However, the size of early-stage VC investment rounds in UK companies has often arguably been at an insufficiently large level to allow them to progress quickly enough to the stage where they can attract significant patient capital later on.

Although investment led start-ups have received much attention in the media and from policy makers, it is important to recognise that this is not the only funding strategy adopted by start-ups.

Revenue led start-ups

Many of the UK's most successful STEM-based companies were started with sweat equity (working for low pay or nothing), modest personal or family investments, minimal angel investment, and/or early revenues from consulting services or one-off contracts from customers. This approach is sometimes termed "bootstrapping". As a result, ambitious founders have been able to avoid, minimise or delay venture capital funding and (i) retain control to this day (e.g. Dyson, Bet365, Renishaw), or (ii) grow a sizeable, profitable, UK-listed and headquartered company (Sage, Oxford Instruments), or (iii) build a significant, profitable business in the UK, before succumbing to pressures for a trade sale or private equity acquisition (e.g. Arm, Abcam, Autonomy, a spin-out from revenue funded Neurodynamics, and Cambridge Antibody Technologies).[12]

The founders of some of these companies were unable to raise venture capital. Examples include, Cambridge Antibody Technology, Abcam and Neurodynamics. Others simply avoided it. Several were "soft start-ups", whose product strategy only evolved after founders had undertaken a series of R&D contracts for larger organisations, based on their expertise.

Policy implications

To help companies pursuing these two different approaches to make a significant contribution to the UK economy over the long-term, the Government must adopt policies which:

(i) support revenue-led companies and soft start-ups with policies appropriate to this business model;

(ii) reduce the dependency of investment led and hard start-ups on institutional equity, i.e. by shifting the ownership curve in Exhibit 1 downwards, so more founders with a long-term vision for their companies have a better chance of avoiding a hostile acquisition;

(iii) create a public investment environment where growing companies are better valued and UK IPOs are more attractive to both investors and company founders.

2.3 The viability of the London Stock Exchange as a forum for growth companies

Public and private equity markets are intrinsically linked. Public markets can provide a source of equity finance for companies to continue their growth after exhausting private sources of capital, as well as an exit option for founders and early investors seeking to crystallise their investments.

Cultivating this exit route is especially pertinent in the UK context where (unlike the US) there is a lack of large, domestic public companies with acquisitive strategies, leading to UK private companies being more likely to be acquired by overseas companies than US private companies.

Although many large UK unicorns have the option of listing on an overseas exchange, such as the NYSE or Nasdaq, other private UK companies do not have the scale or overseas footprint needed to make a foreign listing viable. In cases where UK companies do list abroad, this can lead to a gradual shift of operations, leadership and jobs to the overseas jurisdiction.

Ensuring that the UK has a thriving domestic stock exchange is therefore crucial to support the domestic growth of UK businesses, especially those in innovative sectors.[13] Two issues significantly impact the viability of the London Stock Exchange as a forum for growth companies – low valuations, and the propensity for sales to be the exit option of choice for VC and private equity investors rather than IPOs.

(i) Valuations of growth companies

The London Stock Exchange is not currently an attractive option for founders of high-growth, companies, especially science and technology businesses yet to achieve profitability, since a perception exists (although the evidence is mixed[14]) that valuations for high-growth companies on the London Stock Exchange are lower than can be achieved elsewhere, whether through a sale to an acquirer or a listing on another global exchange. That perception is underpinned by a general recognition that investors in companies listed on the London Stock Exchange, particularly UK-based asset managers, are much less interested in high-growth companies than those investing in the US market, preferring instead "value" companies which generate reliable dividends. Low valuations deter not only founders of growth companies from listing their companies on the London Stock Exchange, but also other early-stage investors, including private equity and VC investors, who will naturally seek the highest value in their exit options.

Generating greater interest in UK-listed high-growth companies amongst institutional investors could potentially enhance valuations and ongoing trading volumes on the London Stock Exchange. This is vital to make the exchange a viable market on which growing UK companies will choose to float. Much has been made in the past about a cultural malaise in the UK where investors in UK stock exchanges are just not interested in betting on growth, leading to a market dominated by old economy companies rather than the kinds of growing "new economy" companies that have driven returns on the US exchanges over the last couple of decades. Incentivising investment in growth companies, drawing UK-based pension funds and insurance companies back to the London Stock Exchange, and improving the quality and quantity of investment research on growth companies will be crucial steps in transforming that culture. Accordingly, these aspects are discussed in Sections 3.8 and 3.9.

(ii) Exit preferences for VC and private equity investors

Private equity and VC firms are prolific investors in UK private companies.[15] Both, types of asset class are structured as funds with finite life-times. Upon the exit of an investment, investors in those funds expect the proceeds (less any fees accrued to the sponsor of the fund) to be immediately distributed. In relation to an individual investment, private equity and VC funds therefore prefer a single, full exit rather than a series of partial exits.

A consequence, not unique to the UK, is that, all things being equal (particularly in relation to price), private equity and VC firms tend to prefer sales rather than IPOs. A listing usually precludes a full exit at the time of IPO, since underwriters generally insist that VC and private equity investors enter into lock-up arrangements preventing them from selling more than a certain percentage of their shares before a specified date.

Even subsequent to the expiry of the lock-up date, the sale of a large block of shares can depress share price, and it is therefore common for such investors to sell-out over time post-IPO. Such an approach delays the generation of returns for distribution to underlying investors, motivating an exit through sale rather than listing.

With, as discussed above, a dearth of potential domestic acquirers in the UK, the preference of private equity and VC investors for trade sales exacerbates the haemorrhage of UK companies to foreign climes. Improving valuations, as discussed above, can enhance the attractiveness of an IPO on the London Stock Exchange, although, even then, the urge to exit fully will always weigh heavily on private equity and VC investor exit decisions. Nevertheless, the London Stock Exchange could be made a more hospitable environment for exits.

First, to the extent that private equity or VC investors consider a listing as a partial exit option, it can be beneficial for such investors, particularly in growing, innovative companies, to maintain control post-IPO. Even where those investors are disposing of a majority of the equity, if they are required to continue to maintain an equity stake in the company upon IPO, the ceding of control to public shareholders[16] with little understanding of the company's business will be concerning to such investors who may have, along with the founder, nurtured the business for several years.

As discussed in Section 3.10, a more welcoming environment to dual-class shares, which enables investors to maintain control while holding only a minority of the equity, could facilitate listings of private equity- and VC-backed companies, as well as making listings more attractive to the founders of innovative, high-growth firms.

Second, the special purpose acquisition company (SPAC) is a vehicle that could enable the listing of private equity- and VC-backed companies while additionally fostering more fuller exits for those investors. A SPAC is a cash-shell company listed on an exchange with the sole purpose of acquiring an operating company. Post-acquisition, the operating company effectively becomes a listed company. In 2020 and 2021, in the US, SPACs became a prolific exit option for private equity and VC portfolio investments, and since 2021, US-style SPACs have become permitted on the London Stock Exchange. However, SPACs are not without controversy, and the US experience has not been wholly positive, with SPACs regularly over-paying for operating companies and bringing companies to the market that are ill-suited and which generate poor returns (if any) for investors. In Section 3.11, though, a more benign form of SPAC is discussed which could jump-start private equity and VC exits on the London Stock Exchange.

2.4 Lessons from UK start-ups that became major UK-based companies

We have already discussed the importance of the soft start-up model. Founders of soft start-ups seek early revenues from consulting and bespoke technical development or systems integration contracts based on their personal expertise. This often leads to opportunities to develop and sell standard products based on their accumulated experience, understanding of unmet needs or IP developed on the back of solving problems for individual "lead customers".[17] So either the company gradually changes its business model to focus on products or it creates a spin-off to exploit the opportunity.

The early development of the Cambridge cluster was largely dependent on the soft start-up model across a range of different industries.[18] Lead customer contracts were key drivers in the creation of three of the four most successful[19] STEM-based Cambridge businesses created in the 1980's and 1990's – Domino Printing Sciences and Cambridge Silicon Radio, both spun out of Cambridge Consultants, and Autonomy, spun out of Neurodynamics.[20]

Each raised new or, in one case replacement, capital from VC's, at the time they were spun-out, and by building on customer funded technology were rapidly able to achieve profitability and a listing on the Main Market of the London Stock Exchange. Each eventually had at least 1,000 employees.

In the case of the fourth and most successful, Arm, the lead customer was its parent, Acorn Computers. Acorn needed a faster semiconductor solution than those commercially available for its next model, and decided to develop its own design using a novel RISC (Reduced Instruction Set Computer) approach. Apple, the second lead customer, invested in the spin-out that resulted. Arm became more successful than Acorn itself and

listed on the London Stock Exchange in 1998.[21] Additionally, lead customer funding has played a key role in the creation of other businesses in the Cambridge Cluster, including Cambridge Antibody Technology, the UK's most successful biotech start-up and now part of Astra-Zeneca.[22] Aveva, a leading global supplier of industrial software, was originally based on technology developed under contract for Akzo and Isopipe in 1973 by the Government-funded CAD Centre, created in 1967 as an early UK intermediate research organisation on the Fraunhoffer model.[23]

The role of lead customers can also be seen elsewhere in the UK.

The origins of Renishaw, based in Gloucestershire, are similar. David McMurtry, a Rolls Royce engineer, and a colleague created the company in 1973 as a part-time business, with the blessing of their employer, to commercialise more widely a machine tool probe they had developed for the manufacture of Concorde engines. Today it employs over 5,000 people and remains under the effective control of McMurtry and his cofounder.[24]

Oxford Instruments (1959) and Sophos (1985) are the University of Oxford's most commercially successful spin outs. Both followed revenue led strategies with minimal venture capital investment. Oxford Instruments, with 2,000 employees remains listed on the London Stock Exchange. Sophos with 4,000 employees listed in 2015, but was acquired by a US private equity firm in 2020.

All these start-ups were able to avoid, delay or minimise venture capital and launch their products on the market rapidly as a result of previous customer funding. Some were able to list on the London Stock Exchange with the founders continuing to hold significant equity giving them a strong influence over the business's future direction and ownership, or, in the case of Cambridge Antibody Technology, sell out to a larger British company.

Though these businesses were started decades ago, and the financing strategies adopted in some cases probably reflected the limited availability of venture capital, they illustrate the potential economic impact of policies to encourage lead customer innovation contracts, particularly in the early stages of a new company, when equity is expensive and time-consuming to raise.

As companies pursuing this kind of funding model have a very low profile in the financial press, compared with VC-backed and listed companies, there are probably some whose success is yet to be widely recognised.

2.5 Harnessing the market for innovation and role of lead customers

One of the best forms of funding a start-up can have is not equity investment, loans or Government grants, but a contract from an informed industrial or commercial customer to fund the development and trialling of a technology or product it can use or sell itself.

Informed lead customers in industry usually have a much better understanding than any venture capital investor or Government employee of what a new technology might be able to do for their business, as well as awareness of competing technologies that already exist or are under development. They will also be familiar with the challenges involved in completing development and incorporating a new technology into the company's wider operations and business and/or taking it to market.

Experienced lead customers break down contracts into stages with clear deliverables and functional targets, moving from feasibility through to market readiness. The results of each stage inform go/no go decisions by the customer on subsequent stages.

The continued interest of the customer's team, and the expenditure they manage on behalf of their employer, ensures that the supplier's team are strongly focused on hitting key deliverables targets prior to end-of-phase meetings leading to go/no go decisions on the next phase.

All this serves to concentrate the minds of the scientists and engineers involved. Accordingly, development contracts with phased deadlines can often be a much better driver of innovation than pure financial investment. Companies sometimes like to call these contracts "collaborations" to imply some level of equality, but it is usually clear who the paymaster is. They should not be confused with the "collaborative R&D" projects that are grant funded by Innovate UK, and in which there is usually no financial relationship between participants. The partners in collaborative R&D grants often have limited ability to influence the pace, effectiveness and, often precise deliverables, of the other collaborators.[25]

Public sector customers can also be powerful drivers of innovation and the development of new STEM-based businesses.

In the US, Federal Government Agency R&D procurement contracts have long been its most important mechanism for funding innovative new companies, utilising Department of Defence, NASA and other agency R&D budgets.

Projects are 100% funded, typically phased with go/no go decisions at the end of each phase determining whether a project should receive the increased funding needed to move through to higher "technology readiness levels (TRLs)" taking the product or technology closer to the point at which it is safe and reliable enough to use in a real operational situation.[26]

The Small Business Innovation Research programme (SBIR) is the supermarket end of this process, aimed predominantly at start-ups.[27] Along with the closely related Small Business Technology Transfer Programme, its annual budget, currently worth over $4 billion a year, is defined by law and provides 100% funding in $300k (Phase 1) and $2million (Phase 2) chunks for R&D projects. Further, Phase 3 and ad hoc contracts may be available from agencies' mainstream (i.e. non-SBIR) budgets.

The US National Institutes of Health fund R&D projects in fields which in the UK would fall under the NHS's National Institute of Health and Care Research and the Medical Research Council (MRC), and has an SBIR programme worth $1.3 billion a year. Though its awards are usually described as "grants", they are 100% funded and no different in practice from other SBIR contracts.

The research programmes of the UK's NHS and MRC are strongly focused on academic research, with minimal funding for companies.

The SBIR programme is often described as "America's Seed Fund". Entrepreneurs can start a business with no other source of finance.

DARPA (the US Defense Advanced Research Projects Agency) provides much larger R&D contracts aimed at game changing, breakthrough technologies and projects. Although focused on national security, many of the projects funded have dual use applications. DARPA's annual budget is roughly the same size as the SBIR programme at around $4 billion.[28] A new US organisation ARPA-H was established in 2022 to fund

transformative biomedical and health breakthroughs using a similar model. It had a $1.5 billion budget for 2023.[29]

The Department of Defence and NASA also spend heavily on outsourced R&D outside either of the flagship SBIR and DARPA/ARPA programmes.

There have been numerous attempts by successive UK Prime Ministers and Chancellors over the last 25 years to get spending departments to play a similar role through the, misnamed, Small Business Research Initiative (SBRI).[30] However, it has struggled to attract the attention of senior officials in spending departments or meaningful budgets.[31]

The main source of Government funding for R&D projects in small businesses is Innovate UK's R&D grant programme. However, grants do not cover more than 70% of project costs, ruling out many start-ups unless they have already secured investment.[32] Furthermore as "grants", rather than "contracts", they lack the all-important interest and focus that a prospective customer provides.

2.6 Making government support for new STEM-based companies relevant to all entrepreneurs

Interest in the contribution university research spin-offs could make to the economy really took off in the UK when Lord Sainsbury became Minister for Science and Innovation in 1998.

Since then, the spin-out process has become more and more institutionalised, with university licensing and venture teams helping academics capture and manage intellectual property, write business plans, raise money and recruit business cofounders. Founding academics usually remain on full salary throughout this process. Some universities have their own seed funds. There are many venture funds with a strong university spin-out focus, nationally and regionally.

Academics seeking to start spin-outs can do so openly. They can use university time to create technology demonstrators, write business plans, talk to advisers and possible customers and partners, build start-up teams and meet possible investors. The IP they have created through years of research is part of what they offer investors, though their university will often want a significant share of the start-up equity in exchange for its own de facto historical investment. Founders may not have any experience of marketing, finance, managing a commercial organisation or negotiating, but their investors and advisors can help them find people who do.

Engineers, scientists and managers working for an existing company have none of these advantages. Any IP they have created, or ideas they have had (and discussed or written about) are the property of their employer. They cannot use work time to write a business plan or contact possible investors.

Their employment contracts may include a non-compete clause and/or a non-solicitation clause, preventing them from taking customers, employees or distributors from their former employer for a specified duration.

The experienced mid-career scientists, engineers and managers in a company who are probably best equipped to create their own business will quite probably have a young family and a mortgage. Working for long without an income will probably not be practical.

They may be able to raise some money from friends or relatives, but for many this may not be a viable option.

Sometimes redundancy forces the issue. Cambridge Antibody Technology was created with the redundancy pay of founder, David Chiswell, and colleagues from Amersham International, together with Greg Winter, of the MRC Laboratory of Molecular Biology in Cambridge.[33]

The solution is often to start a consulting or contract development business – selling expertise – as a first step towards systems integration, IP and products, but this is rarely an attractive business model to VCs.

Sweat equity – working for nothing – and R&D funded by customers does not attract R&D Tax and Expenditure credits, which now constitute around 85% of Government funding for business R&D.[34] Additionally, the company contribution required for projects that are grant funded – at least 30% - makes Innovate UK support also of limited relevance to these kinds of start-ups.[35]

Government needs to put much more funding into policies covering 100% of R&D costs if it is to help talented scientists and engineers from a commercial background, and without venture capital, get started and, in due course, develop their own products. Founders with this kind of background can do much to build the UK's innovation economy, especially as they are more likely than academic scientists and engineers to want to grow and manage a successful business over the long term.

2.7 Encouraging corporations to create new ventures

The histories of Arm, based on technology developed for its parent, Acorn Computers, Renishaw, based on technology developed for Rolls Royce, and Vodafone, spun out of Racal (itself a soft start-up company built on wireless technology contracts for the Ministry of Defence (MOD)),[36] illustrate the value of spin-offs from established companies.

However, to deliver value for their shareholders, the boards of large listed corporations must have a strong focus on the financial performance of their main business units in the short to medium term. In mature companies this usually means demanding annual financial targets for their component divisions and subsidiaries. Using profits to fund timely acquisitions is often a more important way of innovating than in-house R&D projects and new ventures.[37] For most London Stock Exchange-listed companies, the primary focus is ensuring that profits are used to pay reliable and consistent dividends to shareholders.

Even for many non-British acquirors, unless a new line of business can offer an additional 10-15% of revenues and profits in the short-to-medium term it is unlikely to be attractive.

Against this background, it should not be surprising that, once the integration of acquired STEM businesses has been completed, their CEOs are often then given business development roles in the acquirer's head office, but soon discover that the promising new opportunities they identify are simply too small in the medium term to justify the corporations' investment of management time and money.

Despite this, large corporations do from time-to-time set-up corporate venturing teams to look for spin-off opportunities. Rolls Royce, piqued by the success of Renishaw, in which it had no equity, set up Rolls Royce Ventures 15 years later. Like most other such initiatives, trying to **force** the venturing process, it failed and was closed a few years later.

Encouraging new ventures and spin-offs based on technologies developed within an established company should be a legitimate target for Government innovation policy, provided that a suitable policy instrument can be devised. Policies to attract more investors interested in growth rather than dividends would also help here.

2.8 Growing a modern UK version of the Mittelstand: supporting founder controlled businesses and employee ownership trusts

UK economists and policymakers have regularly cited the importance of the German Mittelstand in the post war rejuvenation of Germany's industrial base and its continuing success as a supplier of high value added, innovative products into global markets. Although the reasons for its success, not least the role of loan finance in the creation and growth of its companies, have generally been poorly articulated, there have been several calls for Government to support a UK equivalent.[38]

In theory, the term Mittelstand refers to mid-sized companies with annual revenues of between roughly £50m and £1 billion, a segment responsible for around 36% of German exports, though in practice it relates more to a set of values and management practices found in many German companies of all sizes. Mittelstand companies have particular strengths in supplying specialised goods into supply chains, and premium consumer products.[39] Its firms are predominantly family-owned and focused on stability, longevity and conservative financing; in practice it is continuing control by founders and a management team committed to the long-term success of their businesses that makes the difference.

Very few are public companies.

Many Mittelstand companies grew by dominating niche markets worldwide. Products are developed in close cooperation with customers, often to a client's own specifications. Their average R&D spending is 7.2% of revenues compared with 3.5% for all German industrial companies. This is typically twice as much as their international competitors. Their strength comes not from pioneering and applying breakthrough science, but from an innovation-led culture that continuously seeks to identify, introduce, apply and combine new technologies within excellent design and systems integration processes.[40]

This is a very different style of operation to the shorter term, more transaction orientated model of most companies listed on UK and US stock markets.

Indeed, the strategic value of these companies to potential multinational acquirers is probably at much less of a premium to the financial value of their continuing operations compared with breakthrough science-based companies, making them less likely to be takeover targets.

It is arguable that encouraging the creation and growth of innovative companies with a Mittelstand model could be a much more cost effective way of growing the UK economy than the existing policy focus on university research spin-offs. Although in today's world, rather than being family members, founding teams are far more likely to have come together as a result of working together in a university or established company, or to have found one another through networking within their industry, new policies to facilitate long term founder or employee control need to be developed to create the modern equivalent of a Mittelstand in the UK.

2.9 Harnessing the potential contribution of breakthrough technologies to the UK business economy

Governments regularly announce new programmes to help the UK capture the benefits of new technologies, like quantum computing, graphene, plastic electronics, the internet of things and artificial intelligence. These are usually run by Innovate UK and take the form of grant calls, with winners, often collaborations between business and academic teams, awarded on a competitive basis.

In fact, the opportunities to use new technologies to grow the UK economy and make it more competitive take two different forms, each suggesting a different kind of policy response: (i) the adoption and application of new commercially available technologies, and (ii) the commercialisation of breakthrough scientific research.

(i) New commercial technology adoption and application

This kind of opportunity mainly derives from the launch of successive generations of semiconductors and photonic devices by the industry's global hardware leaders. Each successive generation of hardware makes possible major new software, data storage, analysis and communications technologies and thereby, new and improved "digital" business models for user companies based on them.

These technologies usually have applications in a wide range of industries including finance, retail, media, manufacturing, transport and many more. In this case, the key opportunity for British industry is mainly for established companies to introduce these capabilities into their existing businesses, and for small specialist technology consultancies to facilitate this process, possibly as a stepping stone to creating and commercialising their own IP.

The internet of things and artificial intelligence (AI) are two recent examples, both relevant to more or less every area of business.

A much earlier example comes from the creation of the microprocessor by Intel in 1971.[41] Realising the potential impact of microprocessors on the whole of British Industry, the, then Labour Government, launched the Microprocessor Application Programme (MAP).[42] This provided grants to British companies to pay for specialist consultants to advise and assist them with identifying applications of the new technology. Some then went on to help implement them. Besides encouraging companies in traditional sectors, many seen as rather conservative in outlook, to adopt the new technology, MAP seeded the creation of specialist small consultancies, some of which went on to become successful technology businesses in their own right.[43]

The timely use of this intervention model could still be relevant. Accelerating the rapid, informed and widespread application of artificial intelligence across British businesses is just one recent example.

(ii) Applying and commercialising breakthrough scientific research

The second kind of breakthrough technologies are those emanating from laboratory research in universities and other academic institutions, like graphene, plastic electronics, CRISPR (the genome editing technology), and many other areas of materials and medical science. In these cases, moving from a published result based on laboratory research to a saleable commercial product is typically a process of many years or decades. The funding required is huge and failure rates high.

Nevertheless, venture capital firms have become increasingly willing to fund these kinds of opportunities if the ultimate potential value is high enough. If technical and commercial progress is made, the value of a business increases with each successively larger round of funding, and the impact that Government subsidies or co-investment can make diminishes, not least in terms of encouraging the retention of the business in the UK.

There is therefore a strong argument for Government investment just to focus on the very early stages of these kinds of business, where the cost of equity is relatively low, rather than participating in later "growth funding" where pre-investment valuations are higher and Government funding can bring little additionality or influence. Doing so could offer the opportunity to build equity positions with which to support founders who wish to grow a substantial business in the UK.

A programme of this kind would need careful design. The risks associated with individual investments of this kind are high, but a portfolio of investments, identified and managed by experienced financial intermediaries could also be expected to deliver a financial return.

Another way of maximising the benefits to UK companies from the national investment in breakthrough scientific research would be through more effective support during the early stages of the transition from a university research environment to commercial applications. There is often still much to be done before a technology is ready for commercialisation through a VC-backed start-up and there are many reasons why it is difficult to achieve this within a university environment (see Box 2). The alternative approach to commercialisation, relying on collaboration with a large corporation to bridge the gap is often rather unattractive from an economic policy point of view, because in many areas of technology the natural industry collaborators are foreign companies. If the UK is to develop major new businesses based on its research as a "science super power", it must have better policies in place to address these major commercialisation challenges. We describe the role that "intermediate research organisations" could play next.

The role of intermediate research organisations and proposed changes to the UK Catapult model

Many countries have created Intermediate Research Institutes as an environment in which to bridge the gap between university research and the commercialisation of research.

The German Fraunhofer Gesellschaft is generally regarded as the role model. Founded in 1949, today it employs 31,000 people in 76 institutes around the country, each with a specific technology focus. Its annual R&D budget is around €3 billion.[44]

The UK Catapult Network was established in 2011 to create UK equivalents to the German Fraunhofers after a report by Hermann Hauser, cofounder of Arm. The report placed particular emphasis on their potential role in *"closing the gap between universities and industry through a 'translational infrastructure' to provide a business-focused capacity and capability that bridges research and technology commercialisation"*.[45]

Today the Catapult Network has 9 Catapults, the largest, High Value Manufacturing, operating through 7 centres and 18 locations, some predating its formation.

Like the Fraunhofer Institutes, Catapults are supposed to operate a "third, a third, a third" funding model, i.e. one third "core funding" from Government through Innovate UK, one third publicly funded projects through Government contracts or collaborative grants ("CR&D"), and one third commercial R&D contracts.

BOX 2
Accelerating the commercialisation of academic research

A four-year research project on the practical problems of commercialising academic research funded by the Engineering and Physical Sciences Research Council and Technology Strategy Board (now Innovate UK) identified seven important factors that can inhibit attempts to accelerate commercialisation in a conventional (or near conventional) university research setting.

- Most externally funded research projects in universities are undertaken by teams staffed by PhD students and post-docs who tend to move on quickly. As a result, it is very hard to retain competence in depth or build the core technology team required to create a spin out business. This is exacerbated by the dominance of short-term grants and employment contracts
- The time that must be devoted to writing publications, teaching, supervisions and giving papers at academic conferences means that R&D during a pre-venture stage can only be advanced in fits and starts
- IP is often not managed throughout a project, but is typically only thought about at the point of considering a spin-out or negotiating with large users who may wish to commercialise the technology. Past leakages of various kinds and competitor positions may only then become apparent. The problem is particularly acute for the long lead time technologies which typify much academic research as there may be an accumulation of IP over successive projects involving many different individuals attached to a given research group. Failure to protect early inventions (or where appropriate to publish to ensure "freedom to operate") can compromise commercialisation opportunities that may arise several years later.
- Pressure to collaborate with industry, coupled with changes in personnel, means that exploitation rights are not always properly thought through or managed over the long-term in the way that a company or Intermediate Research Organisation such as a Fraunhofer Institute (as discussed below) would. This can cause conflicts to emerge later that can restrict the potential for spin-off or effective licensing and contract research developments with potential commercial funders.
- It is very difficult to accelerate the pace of R&D prior to the stage when a technology becomes ripe for exploitation, for example by increasing the size and commercial orientation of the R&D team during the pre-venture stage. As a result, any competitive advantage can be eroded at this critical stage.
- Universities are not normally equipped with the expertise or resources to take technologies to the demonstrator stage required to attract investment or customer interest.
- University academics lack the time and experience to manage a portfolio of projects using stage gate approaches to manage risk and progressively focus funding on the projects which are most promising from a commercial perspective

In order to explore how Intermediate Research Organisations (IROs) in different countries tackle the commercialisation problem and the effectiveness of this approach, members of the CBR team visited examples of national IROs in Germany, the US, Taiwan and Korea as well as IMEC, the international semiconductor R&D centre in Belgium.*

** The Role of TICs in Rejuvenating British Industry*; Submission to House of Commons Select Committee on Science and Technology Enquiry on Technology Innovation Centres with recommendations based on extensive international research programme on best practice models led by David Connell, February 2011

David Connell, Professor Alan Hughes and Dr Andrea Mina, Centre for Business Research, University of Cambridge.

However, most Catapult's have fallen far short of their commercial R&D contract revenue targets, with the shortfall filled by grants. In 2022/23, Innovate UK awarded £37m in core funding to Catapults and £93m in R&D grants. Other government departments and agencies provided a further £31m.[46]

The November 2023 Spending Review committed the Government to core funding of £234m per annum over the next five years for the Catapult Network, implying a similar additional level of R&D grant funding through the third:third:third model.

Unlike the UK Catapults, the Fraunhofer-Gesellschaft publishes a detailed annual report, making its business model more transparent. A key focus of its activities is the creation of intellectual property. This generates income through licensing and can also seed R&D contracts with commercial companies. The creation of spin-off companies is also an integral part of Fraunhofer's strategy and Fraunhofer Venture has equity in over 80 spin-off companies. In 2022 it recorded 375 patent applications, €160m in license fee revenue and 18 spin-out companies.

These activities appear to be almost totally lacking amongst the UK Catapults, and the contrast between the objectives and mission statements of the two organisations, as outlined in Box 3, suggests why.

Indeed, the evidence suggests that the creation and exploitation of IP on the Catapults' own behalf is actively discouraged for fear of being seen to be competing with commercial customers and partners. Instead they seem to have become largely concerned with services, such as providing start-ups and other customers with access to expensive, specialised equipment, sometimes in competition with non-subsidised UK companies.

The 2021 Government Review of Catapults and its 2023 response does not discuss these fundamental issues.

2.10 Managing the balance of innovation policy funding for companies across government agencies and programmes

Many parts of Government are responsible for designing, funding and managing programmes within the UK's innovation policy, with the Treasury, by default, having overarching control over the balance of funding between different policy instruments and many of their key features.

There has been little or no attempt to link these programmes to the needs of companies pursuing different business and funding models or manage the overall balance of funding.

This is most clearly illustrated in funding support for business R&D. This is provided:

(i) As a blanket subsidy covering a proportion of R&D costs incurred by companies with UK operations in the form of R&D Tax and Expenditure Credits (RDEC). These are administered by HMRC with the precise rules and subsidy rates typically defined as part of the Treasury's annual budgeting process. In 2022/3, the total cost was £10.2 billion, with £6.5 billion under the SME scheme (with SMEs defined as companies with less than 500 employees) and £3.7 billion under the RDEC scheme, predominantly to larger companies.[47] The cost of these schemes roughly doubled over the previous five years, and very high levels of fraud and error have recently been exposed, particularly in SME claims.

BOX 3

Differences between Fraunhofer and Catapult missions

Objectives of the Fraunhofer Institutes:

The key objective of the Fraunhofer-Gesellschaft is to transform scientific expertise into applications of practical utility.

"Concentrating on future-relevant key technologies and transferring our ideas and research findings to industry, business and society, we are helping shape German and European innovation.

- *We see ourselves as a trailblazer and trendsetter for both innovative developments and research excellence.*
- *Our inspiring ideas and sustainable scientific and technological solutions support and empower our customers and partners – for the benefit of society.*
- *Our interdisciplinary research teams, working alongside partners from business, universities and the public sector, turn original ideas into innovations.*
- *We coordinate and implement key policy research projects that are of systemic relevance, and we strengthen the German and European economy with ethical value creation."*

Fraunhofer website:
www.fraunhofer.de/en/about-fraunhofer.html

"Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. A trailblazer and trendsetter in innovative developments and research excellence, the Fraunhofer Gesellschaft supports science and industry with inspiring ideas and sustainable scientific and technological solutions and is helping shape our society and our future."

Fraunhofer-Gesellschaft Annual Report 2022

Objectives of UK Catapults:

- *To work with industry, and regional, national and international partners, to commercialise innovation in a way that drives long-term benefit to the UK economy*
- *To provide businesses with access to the appropriate mixture of expertise, facilities and equipment needed for them to invest in innovation where these are not readily available due to market failure or commercial risk.*
- *To work collaboratively together and with the wider R&D ecosystem to enable the development of innovative solutions to overcome key challenges; and*
- *To take an active role in removing industry-wide barriers to innovation and commercialisation where they exist.*

Source: Working with Catapults; Guidance for government departments on how to contract and engage with Catapults; Department for Science, Technology and Innovation, September 2023

(ii) In the form of Innovate UK R&D grants, awarded selectively to companies competing against thematic calls and covering between 50 and 70% of eligible R&D costs. R&D grants are administered by Innovate UK, funded mainly from its own budget, but also on behalf of other Government agencies and spending departments.

In 2022/3, it awarded £1.1 billion in R&D grants to 4,084 companies, 70% of this to 3,481 SMEs. Roughly 48% of R&D grants to businesses were as part of collaborative projects (CR&D), with the rest being single company awards. Total funding for collaborative projects was £766m, with 1,969 businesses receiving £548m and 763 other organisations (Catapults, universities, and research and technology organisations) receiving the remainder.[48] Innovate UK also manages grants on behalf of other Government departments. The total in 2022/3 was £503m, with £450m going to companies.

According to a study for the Royal Academy of Engineering, university spin-outs received 274 grants in 2022, averaging £345k, a total of £95m.[49]

(iii) To a very limited extent in the form of small 100% funded Innovate UK grants under "de minimis" subsidy rules originally defined by the EU.

(iv) As 100% funded "pre-commercial procurement contracts" for the development and trialling of technologies and products to meet the needs of Government departments and agencies or to address their policy objectives. The Small Business Research Initiative* was designed to be a UK version of the $4 billion plus a year US Small Business Innovation Research Program.

For at least 25 years, UK Governments of all colours have tried to strengthen the potential contribution to innovation and industrial policy of lead customer procurement contracts. SBRI was first announced by Lord Sainsbury as Science Minister in 2000, but virtually no contracts were awarded until 2010.

Some SBRI competitions are administered and managed by Innovate UK on behalf of budget holders in spending departments and agencies. Others, notably for the MOD and Security Services are directly managed by the budget holder. Total funding in 2022/3 was £112m spread over 283 contracts.[50] Despite the efforts of Innovate UK's dedicated team, the average value of individual Phase 1 and Phase 2 contracts has been consistently below SBRI guidelines and most are too small to have much impact.

The balance of funding between these different programmes is completely unplanned and at variance with most of our major international competitors. No other major country has put so much emphasis on blanket subsidies through R&D tax credits,[51] and in the US, 100% funded innovation procurement contracts are the dominant Federal Government policy instrument.

The UK's reliance on blanket subsidies through the tax system is largely the result of the fear that politicians have had over many years of being accused of "picking winners" and, as the cost of the subsidy has grown, from the increasingly strong lobbying pressure from interest groups like the CBI, venture capital investors and the 84,000 companies that currently benefit.

Many senior Government officials believe the scheme carries a lot of "deadweight" i.e. it has little or no impact on the R&D spending of many recipients.

*The Small Business Research Initiative was rebranded as *Contracts for Innovation* in May 2024

Other important components of UK innovation policy include:

(i) The Patent Box, another tax break aimed at encouraging investment in R&D and the commercialisation of UK intellectual property. This benefits only 1,500 companies and costs the Government £1.4 billion a year. It is of dubious value and open to gaming through international tax planning, including royalty payments and transfer charges between group companies.[52]

(ii) The EIS and SEIS tax breaks for investors in early stage companies (including STEM and non-STEM based companies) costing £330m and £95m a year respectively.[53]

(iii) A tax break for private investors in Venture Capital Trusts (VCT's) costing £330m across investments in STEM and non-STEM based companies per annum.

(iv) Modest British Business Bank programmes of direct investments in STEM-based companies and STEM-focused venture capital funds (see Box 4).

Each of these programmes has been created independently, in many cases in response to lobbying pressure. Nowhere is annual spending brought together or linked to the circumstances of founders from different backgrounds and different start-up funding models

If the UK is to develop a more effective innovation and industrial strategy, it must change the balance of its policy portfolio significantly and put in place an evidence-based policy management process that optimises overall policy spending.

BOX 4

Business Bank and British Patient Capital

British Patient Capital, a subsidiary of the British Business Bank, was set up in 2018. It took over some existing British Business Bank programmes and its existing portfolio of investments in venture capital funds. Its role now is *"to support UK businesses with high growth potential to access the long-term financing that will enable them to grow into world-class businesses"*.

During the 2022/3 financial year, it invested a total of £287 million, split roughly 70/30 between investments in VC funds and direct investments in companies. Average commitments to VC funds were around £27m.

The Future Fund: Breakthrough is a £375m UK-wide programme focused on UK-based, R&D intensive companies with significant UK operations. It can take up to 30% of an investment round of up to £30m in total led by an established venture capital investor.

Average direct investments in companies are around £7m per round. As with private sector investments, British Patient Capital expects to invest in at least one follow-on round in companies it has backed.

The British Business Bank also has responsibility for setting up the Long-term Investment for Technology and Science (LIFTS) programme to encourage the establishment of new funds or investment structures to crowd in UK institutional investment, particularly Defined Contribution (DC) pension funds, "to support the growth and ambitions of the UK's most innovative science and technology companies".

It expects an initial Government-funded commitment of up to £250m to be available to support successful proposals in mobilising institutional investment into the UK's science and technology companies. This is essentially a pilot programme and the structures and incentives involved will depend upon private sector proposals.*

* British Business Bank seeks proposals to deliver Long-term Investment for Technology and Science (LIFTS) initiative. British Business Bank press release, 23rd May 2023.

Section 3

Opportunities for new, expanded or improved policy instruments

In this section we outline a series of policy measures that could help address the issues discussed in Section 2.

3.1 US style innovation procurement contracts

The easiest way to introduce non-dilutive, customer-driven funding into the UK policy mix would be by adopting a properly funded equivalent to the US Small Business Innovation Research (SBIR) programme.

Senior UK politicians have attempted to do so for over two decades, they include, Gordon Brown, David Cameron, George Osborne and Theresa May. In each case their attempts have been thwarted by the unwillingness of either spending departments or the Treasury to commit dedicated funds. As a result, the current, "Small Business Research Initiative/ Contracts for Innovation programme" falls far short of what is required or intended.

Recommendations to solve the problem, drawn-up following a wide-ranging review commissioned by Prime Minister Theresa May in October 2016 (the Connell Review), were lost in the confusion and frequent ministerial changes of the 6 years that followed.[54]

Other efforts to improve the UK's poorly functioning Government procurement processes have repeatedly failed to address this problem.

The Procurement Act 2023 states that *"Our ambition is that, over time, these developments will make public procurement into one of the most powerful levers to drive innovation nationally"*. It describes projects funded under the SBRI as **exemplifying good practice, but underused because of public sector culture, incentives and attitudes**.[55] However, other than saying that such programmes are now "permitted" as part of a procurement process (which they always have been) it offers nothing to address the absence of departmental budgets for this kind of activity, the principal barrier to procurement based innovation. It also completely fails to recognise the role of procurement in funding UK businesses to develop potential solutions to public sector challenges **some years before** the public sector is in a position to incorporate them into a mainstream procurement project.

The Connell Review's recommendations to Downing Street in 2017 remain equally valid today. An updated version, with a £500m a year budget for 100% funded contracts awarded over three phases with increasing value is included in Appendix 1 of this document.

3.2
Minimally dilutive R&D grants

Many new product and service ideas do not fit naturally with the needs and interests of Government departments and agencies, so innovation contracts cannot be made available. For these, R&D grants remain important sources of minimally dilutive early-stage funding.

From 2024, the EU has increased the de minimis limit on EU State Aid, to which the UK effectively conforms, from €200k to €300k over a 3-year period. Grants to companies within this limit can cover 100% of costs. Apart from some emergency programmes during Covid, Innovate UK has made virtually no use of this mechanism.

The de minimis mechanism could be used to provide funding to STEM-based start-ups in their first year, using the normal competitive grants process, and possibly as the first phase of a process leading to larger follow-on grants. By doing so the UK could greatly reduce the barriers that prevent entrepreneurial scientists and engineers from a corporate environment from starting their own companies, helping to level the field compared with academic founders.

Under UK and EU State Aid rules other Innovate UK R&D grants can only cover a maximum of 70% of costs. There has been a significant increase in Innovate UK grant funding in recent years, with £1,135m awarded in 2023 and a further £450m awarded on behalf of other departments. Grant calls are typically many times oversubscribed.

There is merit in further increasing the annual budget for this programme and structuring awards in phases, with awards of increasing value for the most promising projects and companies.

It would also make sense to move the model for grant funding to SMEs closer to the EU's SME Accelerator programme (the "EIC Accelerator"). This was originally established in 2013 as the "SME Instrument" in an attempt to emulate elements of the US SBIR programme within a non-procurement jurisdiction.[56] It is a competitive grant programme offering SMEs 70% funded grants of up to €2.5 million with the option of parallel equity investment for the remaining 30% by the EU and private sector venture capital funds. Its budget for 2024 is €1.1 billion, 63% in grants and 37% in EU-funded equity.

Innovate UK has recently introduced a similar scheme through introductions to private sector VC firms, though only a very small proportion of grants (£35m in 2023) have so far attracted VC investments.[57]

Public sector funded equity investment would make this scheme quicker and more effective.

3.3
Harnessing the potential of lead customer R&D contracts from the private sector

Many of the case histories referenced in this report illustrate the pivotal role often played in the creation of new STEM companies by contracts for R&D, feasibility studies, technology demonstrators, and prototypes placed by private sector corporations.

However, there are also many large corporations for which placing such contracts is countercultural. Typically, these are companies with a strong focus on short term profitability, tight cost management, growth by acquisition, and minimal interest in using innovation to drive the performance of their business.

Encouraging more UK corporations, and the UK operations of foreign ones, to play this lead customer role could be of benefit to both the SMEs involved and their customers.

There are three main ways in which this could be achieved:

(i) Through R&D Tax and Expenditure Credits. The treatment of subcontractors in the RDEC rules is already complex. One way of encouraging large companies to play the lead customer role more effectively would be to pay companies credits above an annual ceiling in the form of vouchers to be used to fund innovative projects with SME contractors with whom they had not previously worked.

(ii) Through New Technology Feasibility Programmes. Using a similar approach to the successful MAP programme described in Section 2.9 on a theme-by-theme basis would both encourage the take-up of new technologies by established UK firms, improving their productivity and competitiveness AND stimulate the creation and development of specialist UK technology consultancies and suppliers.

(iii) Through themed grant calls to potential customers for innovative new technologies to part-fund the development and evaluation of demonstrators and prototypes by innovative UK suppliers.

3.4 Encouraging new ventures within established companies

The problem with devising an incentive to encourage established corporations to grow new ventures is how to distinguish the venture from the natural evolution of the existing business.

However, it might be possible to achieve this by requiring prequalification based on a clear plan and management responsibilities, together with a separate board and company accounts. This would also help ensure there is genuine championship.

The payment of RDECs on new venture R&D at the highest SME level for a limited period of, say three years, would encourage established corporations to take advantage of opportunities to create innovative new businesses.

3.5 Government equity funding for breakthrough technology start-ups

We discussed in Section 2.9 how early Government investments in breakthrough technology companies, while valuations are low, could enhance the chances of successful founders being able to continue to grow their business in the UK, if they have the desire and opportunity to do so, rather than being forced to sell-out early for the strategic value of the business to an overseas-based corporation.

Given the overall size of UK Government innovation policy spending with companies (currently around £13.3 billion a year, including the R&D Tax and Expenditure Credits and Patent Box) and the questionable impact of the two tax breaks which together account for over 87% of this spending, there are strong arguments for diverting a modest amount of this total to increased direct investment in start-ups. For example, investing, say £10m, in each of the 25 most promising breakthrough technology start-ups each year, and with another £400m reserved for participation in follow-on rounds alongside private sector investors would represent roughly a sevenfold increase in the level of direct investment by British Patient Capital in 2022/3.

The risks of investing in these sorts of companies, are of course very high, but so also are the potential returns on equity investments if the portfolio is large enough, to spread the risk and investments are well chosen and managed. The programme could be operated through experienced VC investment firms to select and manage investments, and with strong financial incentives, to make the programme a success. As most successful portfolio companies would probably be sold or listed, this would be expected to at least cover the costs of the Government's investment as well as giving the investment firms the returns they need, whilst making it easier for ambitious entrepreneurs to grow and retain control of sizeable UK businesses

3.6 A new model for UK intermediate research laboratories

The weaknesses in the business model currently adopted by the UK Catapult network was discussed in Section 2.9.

Moving the Catapult business model closer to the Fraunhofer model envisaged by Hermann Hauser and others by locating small Intermediate Research Organisations (IROs) alongside selected individual academic research groups could play a key role in the early stages of new business creation. It would accelerate pre-venture R&D and reduce technical and commercial risks so that ventures were more valuable to venture capital investors, and their shareholdings smaller. This in turn would increase the probability that successful start-ups based on breakthrough academic research would be retained in the UK.[58]

Limiting guaranteed Government funding to each IRO to a fixed seven or ten-year term, with one possible seven-year extension, rather like the Medical Research Council's Centre of Research Excellence funding programme, could ensure continuing renewal and refocusing of the model.

Government reviews of the UK Catapults, have so far been focused on adherence to their currently rather unhelpful targets and objectives. Though some improvements in performance metrics are being implemented, they reinforce the focus on **providing**

services to SMEs and helping them raise money, rather than the **development and application of IP** which forms a key part of the Fraunhofer model.[59] A more fundamental review of their business model and the kind of role they might be able to play within the UK economy is long overdue.

3.7 Encouraging founder, family and employee control to build a modern UK "Mittelstand"

It is highly unlikely that the factors that led to the Mittelstand becoming such an important part of the German economy could be replicated in the UK.

However, the creation of a type of UK version has lots of attractions.

Throughout this report, we have argued for various funding and investment related policies that would make it easier for ambitious founders to grow and retain a degree of control of globally competitive, UK-based STEM businesses.

There is also one specific business model that could, with a new funding instrument, help to build a UK equivalent of the German Mittelstand: the Employee Ownership Trust (EOT).

EOTs provide a mechanism to transfer all, or part of the shareholdings of founders and other investors to Trusts held on behalf of employees. A zero capital gains tax incentive for sellers, combined with the ability of the Trust to pay for the shares acquired over a period of years, provides a mechanism for founders to exit at, or close to, market value without either a trade sale or an IPO. Adoption of the model has been growing rapidly since new legislation was introduced in 2014.[60]

There is strong evidence to show that, by giving all employees a share in the future profits of the business, transition to an EOT increases employee engagement and productivity.[61]

The EOT model is very flexible and allows institutional investors to own up to 49% of a company alongside the Trust. But EOT's with high levels of non-founder/employee shareholdings are rare, and for VC's and private equity investors the low likelihood of being able to exit via a trade sale makes either retaining, or investing in, shares in EOT controlled companies unattractive.

To unlock the full potential of the EOT model further Government action is required.

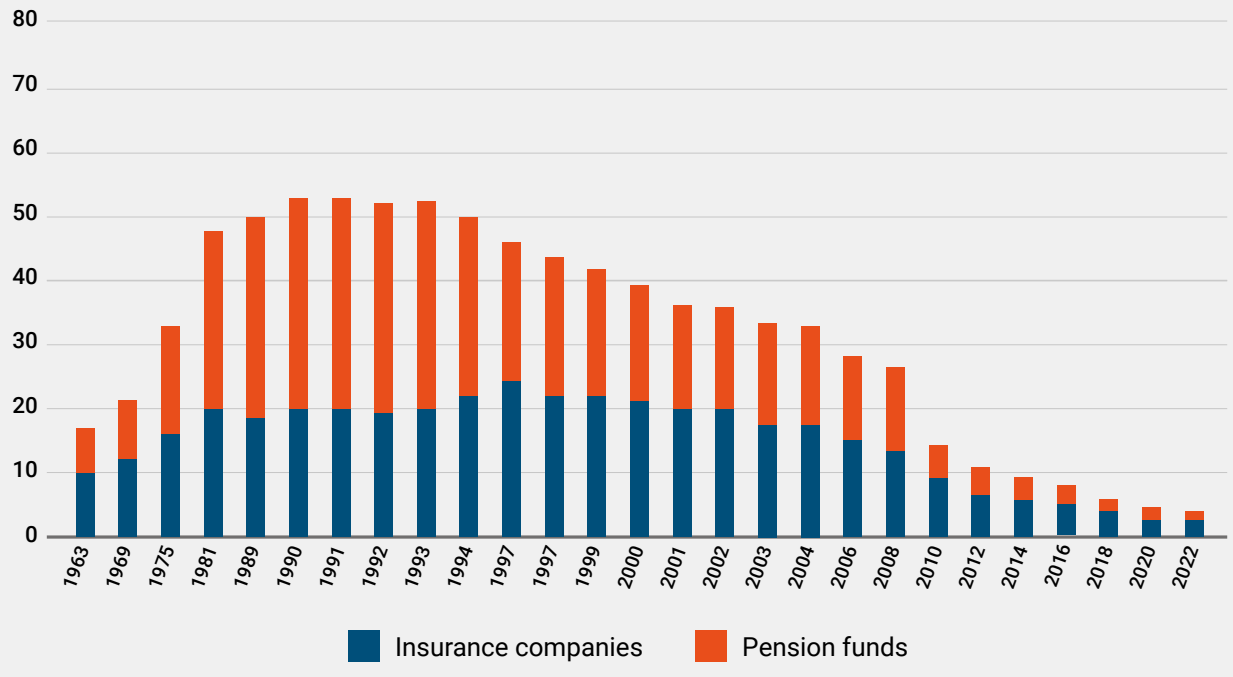
By developing more relevant sources of equity and loan funding for EOT or part-EOT owned businesses through the British Business Bank, Government could encourage increased R&D led growth and diversification. This could be especially important during the first five to eight years of an EOT's existence while it is using profits to pay for the shares acquired and the business has only modest surpluses to invest in R&D. It would also make transitioning to an EOT in the first place more attractive to STEM-based product businesses.

3.8
Incentivising institutional investment in listed high-growth companies

Generating greater interest in high-growth companies amongst institutional investors on the London Stock Exchange is vital if valuations and ongoing trading volumes are to make it a viable market on which growing UK companies will choose to list.

The low participation of UK pension funds is an important part of the picture. As of the end of 2022, UK pension plans only owned 1.6% of domestic listed equities (as compared to over 30% in the early 1990s), a figure that pales into insignificance when compared to domestic pension plan investment in local stock exchanges in countries such as the US and Australia. As a result of regulatory rules that have incentivised UK insurance companies to de-risk their investments, the participation of UK insurance companies in the London Stock Exchange has also declined significantly, down from 22% in the early 1990s to 2.6% as of the end of 2022.

Exhibit 2
Percentage ownership of UK quoted shares



Source: Office of National Statistics

Many of the rules governing (particularly defined benefit) pension plan investments were developed for laudable reasons to shore-up the health of such funds. However, an unintended consequence has been that such pension plans have less diverse investments with liability-matching and other regulatory reforms driving such funds to prioritise bonds and gilts as investment assets. Pension funds are poorer as a result and the lack of diversity will have exacerbated the liability-driven investment ("LDI") pensions crisis of 2022. Similarly, solvency capital requirements that were implemented to buttress insurance companies have many positive facets, but have also deterred insurance companies from investing in volatile assets such as listed equities.

The entire regulatory environment for these investor classes needs to be reassessed, including aspects of the liability-matching regime applicable to pension funds and the manner in which equities are valued by long-term investors. Devising measures to solve these questions is beyond the scope of this report, and would require careful crafting to ensure there are not unintended consequences. However, the prize could be a big one.

Outside of pension funds and insurance companies, the culture of the UK public equities investment market needs to be changed into one that better supports growth companies. Altering the current bias on the London Stock Exchange in favour of "value companies" could possibly be achieved by providing tax incentives for institutional investors and their beneficiaries when investing in "high-growth" companies.
In defining "high-growth", the level of investment (including R&D) by that company as a fraction of profits could be a relevant metric. Investors would only receive the tax break if they had invested in the relevant company for a sufficiently long period of time. Again, the detail of the relevant tax rules is beyond the scope of this report, but culture and behaviour will only be modified through the careful shaping of incentives.

3.9 Investment research

Another obstacle to the viability of the London Stock Exchange as a forum for growth companies is the deficit in analyst coverage of high-growth, particularly STEM-based, companies in the UK. A lack of investment research into such firms not only detrimentally affects liquidity (since fewer investors are attracted), but also has a substantial impact on the efficiency of the market; if information disclosed by companies is not properly evaluated, valuations may not be accurate leading to depressed share prices. A deficit in analyst coverage can also result in share prices becoming particularly sensitive to rumour and speculation.

Rachel Kent's 2023 UK Investment Research Review[62] commissioned by the Chancellor of the Exchequer, noted that the UK is no longer as pre-eminent a location for investment research as it was ten to fifteen years ago, particularly for companies with market capitalisations of less than £1 billion, and for companies in sectors that are under-represented on the London Stock Exchange (such as technology companies).

Part of the reason for the deficit in analyst coverage in the UK relates to unintended consequences from previously adopted Financial Conduct Authority (FCA) and EU regulatory rules that require the unbundling of investment research fees from trading costs. Although those regulatory rules could be simply reversed[63] another factor at play is a "chicken-and-egg" commercial problem pertinent to the tech industry. Market participants do not expend significant resources on investment research on UK-listed tech companies because there are few such companies listed on the London Stock Exchange. Conversely, there are few tech companies listed on the London Stock Exchange partly because there is a dearth of investment research on those companies.

The 2023 UK Investment Research Review recommended:

- stablishing a "Research Platform" to provide a central facility for the promotion, sourcing and dissemination of research – in particular, in relation to smaller companies;
- amending UK restrictions on how investment research is paid for to allow clients and their managers greater choice and ensure the UK is no longer at a competitive disadvantage compared with other jurisdictions;
- reviewing the current complex and difficult to navigate regulatory regime to ensure the same research is available to retail investors as institutional investors; and
- harnessing the knowledge and experience within our universities to assist in the provision of research on innovative companies and sectors.

We endorse these proposals and it is imperative that these measures target not just companies that have already listed, but also private companies seeking to list on the exchange. Low valuations at the time of IPO can deter flotations.

It will be important to address the chicken-and-egg scenario described above in the context of investment research on technology companies as revising the regulatory rules to create greater flexibility in how investment research is paid for will not necessarily result in investors paying for investment research in technology companies while there are so few listed on the London Stock Exchange.

Accordingly, establishing a Research Platform, as recommended by the Kent Report, which subsidises the provision of analyst coverage of UK technology companies will be vital to encourage such companies to list on the exchange. The manner in which the Research Platform is funded should be carefully considered. It may be appropriate for Government funding to establish and maintain the Platform in at least the short-term.

3.10 The role of dual-class shares

In principle, issuing dual-class shares at IPO can provide a way to make listing a company on a public exchange more attractive to founders and company management, as well as private equity and VC investors.

Dual-class shares typically operate by issuing a class of shares with enhanced voting rights to pre-IPO investors to which are attached multiple voting rights (for example, ten votes per share). New public investors are issued "one share, one vote" shares. The pre-IPO investors can therefore engineer the retention of majority voting control while disposing of a majority of their equity. It has been commonly used within the US tech industry in recent times, with, for example, the founders of tech behemoths Google (now Alphabet), Facebook (now Meta), Workday, Square, Zoom and Snap all utilising dual-class shares at the time of IPO to retain significant voting rights in those companies while divesting of substantial equity.

Dual-class shares can be especially beneficial where a visionary founder seeks to protect his or her long-term strategy for the business in the face of a public shareholder profile without the domain experience or vision of the founder. Those public shareholders may not be able to accurately discern the benefits of the long-term investment required for the future success of such companies, or fully understand the company's

business plan or future products. In such cases, low profits while the company is growing and investing can result in a decline in share price. With a typical "one share, one vote" structure (when a dual-class shares structure has not been implemented), a declining share price can open-up the company either to an opportunistic takeover or to public shareholders using their control to remove the founder from his or her position leading the company.

The threat of losing control of a company the founder has nurtured over many years can, therefore, quite reasonably, deter him or her from listing on the exchange, reducing potential access to further growth capital. Dual-class shares, however, would enable that founder to veto takeovers, and protect his or her position leading the company by giving the founder control over board appointments and removals (with the board, in turn, having power over hiring and firing those in managerial leadership roles such as the CEO).

Dual-class shares are not appropriate for all types of companies, but evidence from the US suggests that public investors are able to discern where they are justifiable on a case-by-case basis.

Although dual-class shares were common on the London Stock Exchange in the 1950s and 1960s, they were gradually phased-out, with subsequent regulatory changes further hindering their adoption on the exchange through an effective prohibition from the premium tier of the London Stock Exchange. Dual-class shares continued to be available on the standard tier of the London Stock Exchange, and clearly there is an appetite for dual-class shares amongst tech companies with the standard tier dual-class shares listings of THG, Deliveroo, Oxford Nanopore and Wise in 2020 and 2021. However, companies on the standard tier face a variety of compromises, including a shallower pool of capital and exclusion from the FTSE indices which precludes passive index-tracker investors from investing in those companies. A late-2021 regulatory reform that facilitated the adoption of a limited-form of dual-class shares on the premium tier of the London Stock Exchange was largely unsuccessful likely owing to the associated restrictions mandated by the relevant regulations which hindered the listing of companies with the types of "dual-class stock" seen on US exchanges. The reform effectively only permitted a five-year takeover blocker, without giving founders the ability to also control board composition, as would have been the case with fully-fledged dual-class shares.

A recent 2023 consultation by the Financial Conduct Authority ("FCA") has recommended liberalising the use of dual-class shares further as part of the proposed unification of the premium and standard tiers. We support the proposed dual-class shares reform, since, if implemented, it would represent a progressive step in developing the London Stock Exchange as a more attractive venue for high-growth, innovative companies, by providing their founders with an avenue to list on the market, crystallise wealth and issue further equity for growth, while retaining control in the same way as they can in the US.

Dual-class shares could also be beneficial to non-founder pre-IPO shareholders such as private equity and VC investors. As discussed earlier in Section 2.3, upon an IPO, private equity and VC investors are rarely able to exit fully. If they were, however, able to retain enhanced voting shares through a dual-class shares structure at IPO, they could at least retain control of the firm post-IPO even when disposing of a majority of the equity. VC and, even more pertinently, private equity firms have business models predicated on exerting varying degrees of control over portfolio companies. Dual-class shares could assuage the concern of private equity and VC investors of not only being locked-in to the investment for a period post-IPO, but also of losing control over the company. Accordingly, while perhaps not making IPOs more attractive to such investors than sales, dual-class shares could narrow the gap.

The FCA's 2023 proposals on dual-class shares also include mandatory "transfer-driven" sunset provisions. If such an approach is implemented, subject to exceptions, a seller of enhanced voting shares within a dual-class shares structure would see their enhanced voting rights eliminated upon completion of the sale. We support such a requirement, since where a company is listed with VC investors, for example, holding enhanced voting shares alongside a founder, as those VC investors exit more fully post-IPO (and their enhanced voting shares are converted into lesser voting "one share, one vote" shares upon a sale), the founder's proportion of the total voting rights in the company will progressively increase. Potentially, the founder could reacquire voting control over time post-IPO. Several VC-backed tech companies have listed in the US with such a mechanism baked-in.

To be in any way game changing, reforms to make dual-class shares more accessible need to be accompanied by measures, as discussed elsewhere in this paper, that shift the UK investment bias from value to growth companies. Without such measures, companies adopting dual-class shares may draw suspicion from the buy-side community in a manner that is not as extreme in other jurisdictions such as the US. For example, the listings of THG, Deliveroo, Wise and Oxford Nanopore with dual-class shares on the standard tier attracted extraordinary opprobrium from UK institutional investors. The performance of all four of those companies was commensurately impacted, leading to the founders of some bemoaning the decision to list in the UK. Although US dual-class shares IPOs without sufficient justification for dual-class shares have also attracted objections, the protestations were more ideological in nature in the UK, even though those same UK investors readily invest in companies with dual-class shares in other jurisdictions. The FCA's proposed reforms are welcome, but reform without a change in culture and attitude toward high-growth companies on the exchange will not move the needle when it comes to encouraging our innovative tech companies to remain growing in the UK.

3.11 Government sponsored special purpose acquisition companies

In 2020 and 2021, the US exchanges saw a surge in the listing of "special purpose acquisition companies" (SPACs). SPACs are cash-shells listed with the sole intention of acquiring or merging with another, usually private, company, thereby bringing that private company on to the public markets. SPACs became a valuable exit option for private equity and VC-backed portfolio companies during that period.

Until recently, "US-style" SPACs were not permitted on the London Stock Exchange. The erstwhile UK rule provided that upon a SPAC-merger being announced or leaked, all trading in the SPAC would be suspended. With investors cautious about investing in a SPAC and being tied-in no matter their evaluation of the proposed merger, UK SPACs were generally very small, often micro-cap companies of less than a £1 million. In August 2021, the FCA reformed the rules around SPACs, relaxing the suspension of trading requirements if the SPAC adhered to certain terms.[64] Those terms broadly replicated the terms seen in US SPACs which are described next, along with the reasons why such SPACs have been controversial.

The US SPAC model and its weaknesses

The US SPAC model typically works as follows:

- The SPAC is created by an experienced investment team (the "sponsor") to search for acquisition candidates in fields and geographies in which they have specialist knowledge. The SPAC goes through an IPO, with "units" offered to new investors, comprising one share and a warrant, typically for a third or half of a share. The warrant can only be exercised after the SPAC merges with an operating company.

- The IPO proceeds are placed in a trust account and the SPAC has a defined time, typically 24 months (the "acquisition period") in which to identify, negotiate and merge with a target company, otherwise IPO funds must be returned to the public shareholders. If extra funds are needed for the merger, the SPAC may raise them by issuing debt or more shares through a "PIPE" ("private investment in public equity") transaction.
- Completion of the merger is usually subject to approval of the SPAC shareholders. Public shareholders are also given the option to redeem their shares and receive a return of their IPO investment (and often a little more) prior to the completion of the merger. Typically, the sponsor will receive a bonus allocation in shares in the SPAC (known as the "promote") if a merger is completed, customarily amounting to 20% of the merged company's equity.

As discussed earlier in this paper, SPACs are controversial vehicles. Although SPAC listings were prolific in the US in 2020 and 2021, very few of the companies subsequently acquired by SPACs could be considered successful from the perspective of continuing investors in the SPAC post-acquisition. Many SPAC mergers were overpriced with poor business prospects.

Two important aspects of the typical US-style SPAC model have led to this result.

First, the sponsor receives no returns if the SPAC does not complete an acquisition within the acquisition period, but receives a huge windfall if an acquisition is completed. Sponsors can make significant returns even if the acquisition is loss-making for pre-acquisition public investors in the SPAC who remain as shareholders post-merger. This all-or-nothing incentive structure has frequently led to sponsors overpaying for target companies and seeking to complete mergers within the acquisition period window come what may.

Second, though US SPACs generally require acquisitions to be approved by the SPAC shareholders, this does not always lead to them vetoing transactions where the SPAC is overpaying for a target. This is because the redemption mechanics allow SPAC shareholders to redeem their shares prior to a merger even if they vote in favour of the merger. This has attracted hedge funds and other investors adopting perverse approve-and-redeem strategies with shareholder approval being almost a formality in most cases. Such shareholders can redeem their shares and receive their investment back, while at the same time approving the transaction to ensure that the warrants that they hold retain value. On the other hand, post-IPO investors who are less aware of these features may remain as shareholders in the SPAC post-merger even if the SPAC is paying over the odds for the target company and they will be heavily diluted by the sponsor's promote, thereby often incurring substantial losses.

How a redesigned SPAC could benefit the UK economy

A UK SPAC with an existing shareholder base (from investors investing in the SPAC at IPO before the SPAC has completed a merger) before it seeks out a merger could, if the inherent regulatory weaknesses and perverse incentives of the US model were moderated, offer important benefits for both growth company founders and managers, and for investors. A merger between a private company and a SPAC facilitates that private company becoming listed (and thereby having access to public investment) without having to proceed through a traditional IPO itself. The benefits of this model are as follows:

(i) compared with a conventional IPO, a SPAC acquisition can lead to a more appropriate valuation negotiated between the SPAC sponsor and the company, based on: private style due diligence on what is effectively an acquisition by the IPO shell company; the sponsor's specialist expertise; and confidential discussions between the sponsor and target company on the future prospects of the company;

(ii) unlike a traditional IPO where existing private equity and VC investors are, as discussed earlier in this paper, usually required to retain a substantial proportion of their shares for a period post-IPO, a SPAC acquisition of a company backed by private equity or VC investors could potentially allow those investors to more substantially exit upon the completion of the acquisition; and

(iii) a SPAC merger allows companies that may be closed-off from the traditional IPO process to procure access to the public markets. A traditional IPO may not be appropriate for such companies due to challenges (A) in public shareholders understanding innovative products or visionary founders and business models, or (B) in the company disclosing commercially sensitive information to potential public shareholders prior to an IPO to generate interest without such disclosure harming the company's competitive position.

One possibility would be to launch an annual programme of Government-sponsored and part-funded SPACs aimed at growth companies in specific target sectors, and managed by professionals with experience in the relevant sectors.

To ensure the success of Government-sponsored SPACs, it would be imperative to mitigate the ingrained incentives in US-style SPACs that have led to the controversies and poor returns of SPACs in the US. Potential investors would require comfort that the sponsor would only target acquisitions that can generate positive returns for SPAC shareholders continuing to hold shares in the SPAC post-acquisition, and that any shareholder approval is a genuine representation of shareholder views on the merits of the transaction. Accordingly, a Government-sponsored SPAC should implement more benign incentive terms, including a performance-based promote for the Government sponsor, a large level of skin-in-the-game invested in the SPAC by the Government sponsor, and a shareholder acquisition approval mechanism that only allows dissenting shareholders to redeem shares prior to an acquisition (the implementation of

the last of these terms would require further regulatory amendment, since the current FCA rules require such SPACs to allow all shareholders, whether they dissent or not to the proposed transaction, to redeem their shares).

The Government should be entitled to recover its skin-in-the-game investment if the SPAC does not complete an investment within the acquisition period in the same way that public shareholders would receive back their investments. If all performance-based thresholds are achieved after the SPAC acquires a private company, the Government, as sponsor, will receive its entire promote, which, if implemented as per the model US SPAC, could amount to an extra 20% of the equity – a sizeable upside on the Government's investment.

The Government's professional partner in the SPAC could be remunerated by being granted a proportion of the Government's promote linked to the level of skin-in-the-game the partner is prepared to put into the SPAC at IPO. The Government could further incentivise the partner by capping its own returns under the performance-related promote, with the remainder being allocated to the partner in the event that the SPAC acquisition is highly successful.

Another ancillary benefit of a Government-sponsored SPAC is that the Government could consider on a case-by-case basis whether, upon the completion of a merger, a dual-class shares structure should be implemented to support the founder of the acquired company. Normalizing the use of dual-class shares within the tech industry, for example, could influence the market's culture and attitude toward growth companies on the London Stock Exchange.

This model would be expected to generate a positive return for the Government investment over a portfolio of perhaps five Government-sponsored SPAC IPOs a year with a Government skin-in-the-game investment of up to, say, £50 million in each. Not every such SPAC will complete an acquisition within its acquisition period, but since the Government would be entitled to a return of its £50 million investment, the risks only encompass the opportunity costs of the capital being tied-up for up to 24 months. It would not, however, take many successful SPACs for the Government to make significant returns, and such SPACs would potentially bring promising high-growth, innovative companies to the public markets.

Section 4

Changing the overall balance of UK government funding for innovation in companies

4.1 Current funding balance

Current levels of annual expenditure on the principal UK Government policies designed to support business innovation and the growth of new STEM based companies are shown in Exhibit 3.

This shows that over 98% of policy funding takes the form of subsidies, with only around 2% in the form of Government investments. Blanket subsidies, through R&D Tax and Expenditure Credits and the Patent Box, are overwhelmingly dominant, with a total annual cost of £11.6 billion.

Exhibit 3

Annual cost of UK government support for STEM-based companies (expenditure, subsidy cost and investments)

Funding instrument	Annual expenditure (£ billion)
Subsidies and Contracts (Cost)	
R&D Tax and Expenditure Credits	10.2
Patent Box	1.4
Innovate UK R&D Grants	1.2
R&D Grants from Other Government Departments and Agencies Managed by Innovate UK	0.4
SBRI (Procurement)	0.1
EIS/SEIS Subsidies (not 100% for STEM companies)	0.4
VCT Subsidies (not 100% for STEM companies)	0.4
Total	**14.1**
Investments and Loans	
British Patient Capital Coinvestment in VC Funds	0.2
British Patient Capital Coinvestment in Companies	0.1
SPACS	0.0
Total	**0.3**
Overall Total	**14.4**

This picture raises three important issues:

(i) Whereas subsidies represent a pure cost to the Treasury, and any benefits flowing back to the economy as a whole, through their impact on company investment in the UK, do so over the long-term, Government co-investments through professional investment firms, directly into companies or through VC funds (or SPACs, if a Government-sponsored scheme were to be implemented), could be expected to deliver a profit across a broad portfolio.

Unless the additionality delivered by the existing subsidies is very high (i.e. much greater than one), a shift in the balance towards investment rather than subsidies could therefore be more cost effective;

(ii) Innovation procurement contracts,similar to the US Federal Government's SBIR and related programmes that have kick-started much of the US innovation economy, remain at a derisory level in the UK, despite the efforts of UK Prime Ministers and Chancellors over nearly 20 years.[65]

(iii) The economic impact of the two blanket subsidies that dominate spending – R&D Tax and Expenditure Credits and the Patent Box - is highly questionable. Using grants to focus subsidies on individual businesses and projects, more in line with other successful economies, and with higher rates of support, could be more cost effective and less susceptible to fraud;

The dominance of blanket subsidies is largely a result of the obsessive fear of trying to "pick winners" that has restricted Government policy thinking in the UK for decades. This fear derives largely from the failure of a few very large-scale Government projects 50 years ago, and should not apply to a large portfolio of projects and companies judged to have good potential as "competitors", in the same way that many governments support their countries most promissing athletes. Lobbying from the large number of recipients of R&D Tax and Expenditure Credits has led to increases in their generosity and coverage and, with the emergence of specialist advisers, many operating on a performance fee basis, to high levels of fraud, especially amongst SME claims.

The annual cost to the Exchequer of R&D Tax and Expenditure Credits has doubled to £10.2 billion a year since 2017/18, most of the growth coming from SME claims.[66] This is largely due to the increase in the **number** of SMEs claiming (up 112% between 2015/16 and 2021/2). Many of these were for very modest amounts; 17% of claims were for less than £5,000, averaging £2,600 per claim. Roughly half of SME claims were for less than £25,000, arguably too small to have any significant impact.

The most recent report by the National Audit Office notes that the SME scheme cost £15 billion more than forecast between 2015-16 and 2020/21. HMRC's Annual Accounts have been qualified by the National Audit Office for several years because of the level of fraud and error. It estimates that levels of error and fraud across companies of all sizes could be between 13.0% and 23.2%. Its central estimate for the SME scheme is 24.4%.[67]

There are therefore powerful arguments for reviewing the overall balance of Government innovation policy spending. But to make meaningful changes without increasing the overall cost, it will be necessary to cut back on blanket subsidies: R&D Tax and Expenditure Credits and the Patent Box. It is crucial, not just to reduce the level of fraud entailed in these subsidies, but also to re-examine their cost effectiveness and relevance to the UK's key policy challenges. The Treasury focus on reducing costs has led to this more fundamental issue being largely ignored in recent changes.

In Section 4.2 we therefore examine the cost effectiveness of RDEC in some detail, and in particular the differences between the flawed economic assumptions underlying the Treasury models, on which their attractiveness has been based, and the real life factors influencing R&D spending in companies of different types.

Section 4.3 then examines the cost effectiveness of the Patent Box.

In Section 4.4 we propose a more effective spending balance, together with new and improved policy instruments.

And in Section 5 we discuss implications of this report's analysis for policy planning and management across the key Government departments and agencies involved, and propose a new mechanism to make this more effective.

4.2 Weaknesses in UK R&D Tax and Expenditure Credits policy

The aim of R&D Tax and Expenditure Credits is to encourage inward investment into the UK by R&D intensive companies and increase investment in R&D by existing UK business. By 2020, the cost of RDEC already represented a higher proportion of GDP than similar schemes in any other OECD country.[68] It has since increased by almost 50%.

As far as the value of tax breaks as a tool for attracting and retaining mobile R&D activities is concerned, the published evidence is very clear. A major study of multinational companies by the US National Academies lists tax breaks as ninth in importance in a list of factors influencing choice of site for investment in R&D facilities in developed economies outside the home country. Quality of R&D staff and IP protection were first and second in importance. Access to academic expertise and ease of collaboration with universities were third and fourth. Costs were eleventh in importance.[69]

The relocation of Astra Zeneca's R&D operations from Loughborough and Cheshire to Cambridge at a cost of £1 billion illustrates this.[70]

A study for the European Commission concurs with this view of tax breaks, stating that: *"there is a consensus in the literature that special incentives to foreign-owned firms are not an appropriate instrument to attract R&D of foreign owned firms".*[71]

Changing the overall balance of UK government funding for innovation in companies

As far as existing firms are concerned, the theory behind R&D tax credits is that if the cost of doing R&D is reduced, companies will switch more of their operating expenditure into it.

Treasury evaluations of the policy's effectiveness are limited to the use of two complex econometric models across multiyear financial data for all subsidy recipients in the "large" and "SME" categories. These start by applying a central assumption of neoclassical economics, i.e. that if the "price" (i.e. cost) of a unit of R&D is reduced through subsidy, companies will do more of it. They then attempt to estimate the additional amount of R&D companies "buy" for each £1 of subsidy. Similar evaluation approaches have been used by econometricians in other countries. This is difficult to do because all UK companies have access to the same level of subsidy each year so the results are driven by changes in levels of subsidy from year-to-year, when many other factors are changing. For example, there is no allowance for a global trend in the R&D intensiveness of national economies, a feature observable in recent OECD data. There is no "counterfactual" analysis.

The most recent HMRC analysis of tax credits for large companies, undertaken by Treasury econometricians, concluded that each £1 of tax credit generated between £2.4 and £2.7 of additional R&D.[72] A different team of academics was commissioned to look at SMEs and concluded that each £1 of subsidy increased R&D spending by just £1.[73] These results contrast with an OECD analysis of studies across a wide range of economies which concluded that the ratios were 1.6 for small companies, 1.4 for medium-sized companies and 0.4 for large companies; in other words differences in impact by company size opposite to the HMRC analyses.[74]

These variations in conclusions typify the literature and show how problematic this kind of econometric approach can be. Nevertheless, an additionality figure of 2.4 has been quoted by Minsters and officials, sometimes as a figure for all companies.

The HMRC models are highly complex and produce a very poor explanatory fit to the data. The final results were selected from several different approaches each with very different values. Neither team reported carrying out any exploratory analysis of individual company results to refine the model structure.

A more useful approach is to consider the likely impact on companies in different situations.

RDEC almost certainly provides a meaningful subsidy for loss-making R&D intensive start-ups with funding from investors, and in doing so increase investor returns. Average internal rates of return (IRRs) on UK venture capital investments, particularly early-stage investments, have been consistently lower than returns on later-stage and private equity investments for most of the last two or three decades, and returns on technology investments less than non-technology, but the gap has closed significantly in recent years. R&D Tax and Expenditure Credits have almost certainly played a role in this, as well as stimulating an increase in annual VC investments in the asset class.[75]
On the other hand, since RDEC is designed to encourage firms to spend more of their own cash on R&D, they have little or nothing to offer sweat equity 'funded' start-ups and those undertaking R&D based contracts for paying customers.

Even for a marginally profitable medium-sized company that is not VC-backed, and needs to continue investing in the growth of its existing operations, increasing R&D spending is a real challenge, and R&D Tax and Expenditure Credits offer little help.

For large corporations the impact of RDEC on R&D spending is limited by both organisational issues and competing calls for investment. Tax planning is the responsibility of the group treasury function and budgeting is a top management and group board activity. It has to choose whether to invest surpluses in additional marketing, operations, overseas activities and acquisitions to acquire complementary businesses, market access or new technology. Acquisition is often the best way to acquire technology for these businesses, as it provides access to a much wider range of de-risked innovations than can be generated by in-house R&D. Small R&D subsidies are likely to have minimal impact on levels of internal investment.

Furthermore, for established companies in mature sectors most R&D spending, for example to introduce new information systems and technologies, is a prerequisite to staying in business. Some companies aim simply to maintain spending as a percentage of R&D at an industry norm.

In 2021/22 companies in the financial and insurance sectors received £305m from RDECs and there are specialist firms to help them make claims.[76] Indeed three UK banks, HSBC, Lloyds and NatWest are amongst the nation's top 10 investors in R&D.[77] For many of these companies, continuous R&D to upgrade IT systems and service models as new technology becomes available is a straightforward requirement of doing business. The value of R&D Tax and Expenditure Credits these companies receive may be large in value, but result in little or no extra R&D spending.

Many senior officials responsible for UK innovation policy believe that the R&D Tax and Expenditure Credit programme carries a great deal of "deadweight". However, identifying quite where this sits and convincing the thousands of companies, investors and their lobby groups that benefit from the annual cheque that there is a better way will be challenging.

At the same time, many struggling SMEs have come to rely on R&D Tax and Expenditure Credits payments to keep them afloat, even if this is only on a temporary basis, leading to strong resistance to any change.

What started as a tonic has turned into a narcotic.

The difficulty of separating high risk R&D from the kind of ongoing technical enhancements required to maintain a profitable company's competitiveness, the impossibility of accurately auditing employee time sheets, and the specialised expertise needed by HMRC employees to review claims makes the utility of the R&D Tax and Expenditure Credits policy increasingly problematic.

A series of changes to the RDEC regime have been made since 2021, the most recent introduced from 1st April 2024. These are aimed at simplifying the levels of subsidy, limiting amounts claimed for overseas subcontractor costs, and reducing fraud. The reporting and administration overhead for companies will be very considerably greater.

4.3 Weaknesses of the UK Patent Box

The Patent Box is a tax break designed to encourage companies to invest in UK R&D and commercialise it in the UK. Many countries operate patent box schemes and the UK Patent Box was introduced in 2013 after lobbying from R&D intensive companies in pharmaceuticals and other industries.

By 2021, 19 OECD countries had "patent boxes" of some kind and 18 had R&D tax credits.

The rules of the UK scheme are complex and the economic impact of this kind of incentive has been the subject of much controversy. At the time of its introduction the Institute for Fiscal Studies argued that it was "poorly targeted, expensive and would fail to foster innovation". The Engineering Employers Federation described it as an "expensive, inefficient and ineffective give away".[78]

A detailed analysis is beyond the scope of this report and it is important to distinguish between the arguments presented by advocates for lobbying purposes and subsequent decisions on where assets are located.

The UK scheme operates by reducing corporation tax to 10% on income generated from patents granted in the UK, by the European Patent Office or in certain other European jurisdictions. According to HMRC projections 1,510 companies benefited from Patent Box subsidies in 2021/2, at a total cost of £1.36 billion. Of these, 362 "large" companies received 94% of this total, an average of £3.5 million each.[79]

There are two areas in which the Patent Box is open to gaming. First, although the incentive is open to patents granted in the UK, certain other European jurisdictions or by the European Patent Office, since R&D projects are often undertaken by international teams, particularly in large corporations, a valid patent for UK Patent Box purposes does not necessarily reflect a previous decision to invest in UK R&D. Second, revenues can accrue in the UK through royalties and transfer payments between group subsidiaries in different countries, enabling profits to be concentrated in the UK to reduce the overall group tax burden, even though, in reality, the commercialisation of the patent is taking place overseas.

An analysis of the accounts of Illumina Inc., a US based company built on the acquisition of Solexa, a Cambridge University spin out, illustrates this. In one year, intra group royalty rates were increased from 12% to 25.2%, giving Patent Box receipts of $39.6m, an annual subsidy equivalent to $66k for each of Illumina's UK employees at the time. [80]

Some advice to Japanese clients from one of the UK's leading accounting and advisory firms is particularly revealing:

Extract from EUROPEAN PATENT BOX REGIMES, a document published by Japan External Trade Organisation and written by PriceWaterhouseCoopers, April 2013

The UK patent box provides opportunities for Japanese parented groups to significantly reduce the tax payable on their European operations. It is possible for a UK subsidiary to benefit from the regime even if the IP is owned by the parent company in Japan, and there is no requirement for the R&D or manufacturing to be carried out in the UK. Due to the formulaic calculation method the regime can be very generous and can include a wide scope of income and profit relating to patented products.

The evidence also suggests that the Patent Box and R&D Tax and Expenditure Credits have little or no influence on international relocation decisions by major R&D based multinationals. One of the largest of these was the 2011 decision by Pfizer Inc. to close the majority of its site in Sandwich in Kent, at the time employing 2,400 people.

Pfizer Ltd's UK Managing Director told a House of Commons Select Committee that, "*though Government are sending positive signals to the industry with some of the things that they have announced – a desire to reduce corporation tax, the introduction of the patent box, and the R&D tax credit system are all considerations for companies looking to place R&D here. Given that this discussion is about our decision about Sandwich, it is important to say that, in our particular case, with this particular plant, those weren't considerations*".[81]

Equally, Astra-Zeneca's 2013 decision to close its Cheshire R&D activities and rebase almost its entire UK R&D operations together with its head office in Cambridge was based on access to scientific talent and academic research, despite the enormous expense involved– its new building alone is estimated to have cost over £1 billion. As it was a move within the UK there were no tax benefits.

Academic studies of the effectiveness of patent box schemes are extremely difficult to undertake, especially when patent box claims are made alongside R&D tax credits or other R&D subsidies. A recent theoretical paper argues *"that when countries set their tax policies non-cooperatively, innovation is fostered, at the margin, only by the R&D subsidy. The patent box tax rate is instead targeted at attracting international profit shifting."*[82]

The only Government evaluation of the Patent Box was published in 2020. It used a novel approach to tackle a very difficult impact measurement challenge with a complex econometric model and produced a very poor fit to the data.[83] The author acknowledged the many difficulties involved.

Given the potential for significant gaming through tax planning, IP management and intercompany licensing and transfer payments, it seems likely that if it were subject to the level of scrutiny recently applied to R&D Tax and Expenditure credits, similar problems might be revealed.

In view of the lack of convincing evidence to suggest the Patent Box is cost effective, we believe there are strong arguments for axing it altogether. A proper review of the Patent Box which examines its use and impact by companies of different sizes and in different circumstances, is overdue.

In the meantime, we have assumed that the funding it absorbs would be better deployed in other ways.

4.4
A more cost effective policy portfolio

We believe that a more balanced and cost effective policy portfolio would include the following elements:

(i) A significantly increased innovation procurement contracts programme in line with the US SBIR and follow-on procurement funding streams. This would provide 100% funding progressively focused on the best projects over three phases as recommended in the Connell Review.

(ii) A much expanded programme of Innovate UK R&D grant programmes, providing a similar funding ladder for early stage companies from 100% funded £300k grants, under an equivalent of the "de minimis" EU subsidy limit, to subsequent 70% funded phases of up to £10m, and with later stages sometimes alongside Government, VC or other private-sector investments as in the well-regarded Horizon Europe "EIC Accelerator" model.[84]

(iii) Removing the bias in R&D grant calls towards collaborative projects, which represent almost half of Innovate UK's grants to companies, and allowing companies to choose to carry out projects alone or with subcontractors or other collaborators as they see fit. Collaborative projects tend to be more appropriate to research rather than product or process development where subcontractor relationships are more appropriate.

(iv) A very significant increase in annual co-investments in early-stage companies by British Patient Capital. Besides providing a much more cost effective source of funding than subsidies, the British Patient Capital shareholding could on occasions, where appropriate, be used to support a founder/management team under threat from an unwanted acquisition.

(v) An increase in British Patient Capital's investment in VC funds.

(vi) An investment or lending mechanism designed to make the EOT model attractive to later-stage STEM-based companies and accelerate post-transition growth either directly or through specialist, private sector managed funds.

(vii) A Government-sponsored SPAC programme, under which a small number of SPACs, managed by experienced teams with sector knowledge, would be sponsored each year to identify suitable candidates in a particular target field, and complete the process by which they become listed on the London Stock Exchange. The Government, as sponsor, could consider whether a dual-class shares structure be implemented upon acquisition of the relevant candidate company to support the needs of a founder. A programme of five SPACs a year, each with a Government investment of up to £50m would be an appropriate initial target. To ensure that high-quality targets are acquired and that long-term public investors are attracted, such SPACs should incorporate terms that do not ingrain the types of pernicious incentives that have tarnished the majority of SPACs that have listed in the US in recent years.

(viii) A refocused RDEC programme bringing greater additionality, less deadweight, a lower overall cost per annum, and better value for money.

Such a refocussed RDEC programme could involve some or all of the following elements:

a. Higher levels of support for new ventures within established companies.

b. A ceiling on the amount of R&D expenditure on which a company can claim RDEC each year or a lower percentage rate of subsidy on R&D expenditure above that ceiling.

c. Subsidy rates linked to the percentage of a company's overall operating costs spent on R&D, with higher rates for companies at an R&D intensive stage of development. Changes to the rules in 2024 include a higher rate for companies with R&D expenditure exceeding 30% of total expenditure, reduced from 40% the previous years. However, there are strong arguments for focusing support on companies with much higher percentages of spending on R&D.

d. Support linked to growth in a company's R&D spending per annum.

e. Part payment to larger, profitable firms in the form of vouchers to be spent with new SME R&D suppliers as lead customers for innovation projects, demonstrators and prototypes.

(ix) Abolition of the Patent Box

The financial impact of the changes we propose is shown below in Exhibit 4 and illustrated in Exhibit 5. The most recently published figure for the total annual cost to the Treasury of R&D Tax and Expenditure Credits is £10.2 billion. This is likely to be reduced by the actions HMRC has put in train to tackle fraud and error, as well as by recently introduced rule changes. We anticipate that the reforms we propose for RDEC would deliver further savings, releasing funds for implementation of our other proposals.

Exhibit 4
Current and proposed annual expenditures by policy instrument

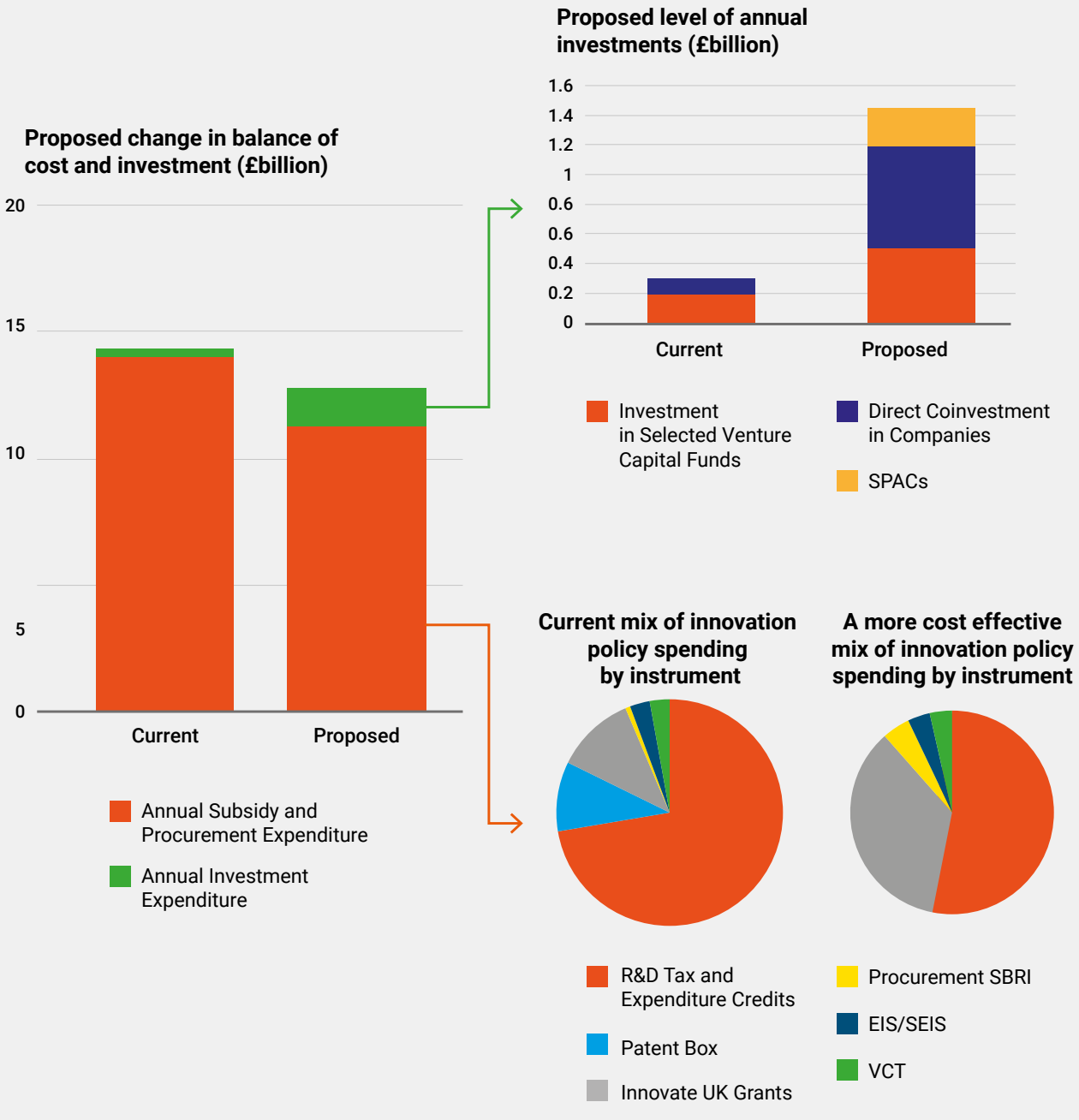
Funding instrument (subsidy cost)	Current Annual Expenditure (£ billion)	Proposed Future Annual Expenditure (£ billion)
Subsidies and Contracts (Cost)		
R&D Tax and Expenditure Credits	10.2	6
Patent Box	1.4	0.0
Innovate UK R&D Grants and R&D Grants from Other Government Departments and Agencies Managed by Innovate UK	1.6	4.0
SBRI/Contracts for Innovation (Procurement)	0.1	0.5
EIS/SEIS Subsidies (not 100% in STEM companies)	0.4	0.4
VCT Subsidies (not 100% in STEM companies)	0.4	0.4
Total	**14.1**	**11.3**
Investments and Loans		
British Patient Capital Investment in VC Funds	0.2	0.5
British Patient Capital Coinvestment in Companies	0.1	0.7
SPACs	0.0	0.25
Total	**0.3**	**1.45**
Overall Total	**14.4**	**12.75**

Notes:

(i) Advanced Innovation and Research Agency (ARIA) expenditure is not included in the table as it has not yet awarded any contracts. It is also unclear what proportion of funding will go to companies as opposed to universities, and over what time period its initial funding of £800m will be spent. ARIA contracts could become an important part of the policy mix.

(ii) The costs incurred in VC investments, direct coinvestments in companies and SPAC sponsorship would be offset by investment returns and probably exceeded over the ongoing portfolio. To the extent a SPAC fails to identify a suitable target company within the relevant investment time limit, the Government would receive a refund of its sponsorship funding.

Exhibit 5
Rebalancing the policy portfolio



Section 5

Transforming innovation policy management across government

Why the current system does not work

Section 2.10 highlighted the wide range of innovation funding programmes across Government and the skewed balance of expenditure that has developed over the last 25 years.

There are a number of reasons for this:

First, the levers of innovation and industrial policy are spread across Government. There is no overarching responsibility for policy and no meaningful co-ordination. Business and Research and Innovation Ministers from both major parties have expressed frustration over this situation for at least 20 years.

Second, the data required to monitor individual policy instruments is grossly inadequate and nowhere is annual spending on different policies, the business and financing challenges they are designed to address or their cost effectiveness in terms of outcomes pulled together.[85] Pressure to justify existing programmes tends to lead to brochure-like reports.

Third, policy reviews tend to be focused on individual policies in isolation. And they are dominated by submissions from funding recipients, with an understandable bias towards increasing and widening them.

Fourth, the role played by the Treasury in policy design and management is incompatible with its capabilities. It has typically had just two or three economists monitoring Innovate UK spending and a similar number for RDEC and the Patent Box. Managing the cost of programmes against the many other pressures on Government finances requires a focus on spending rather than policy design and leads to a bargaining approach when it comes to policy proposals from spending departments.

Three examples illustrate the impact of these pressures.

First, in 2018, when mid-ranking officials from the Department of Business, Energy and Industrial Strategy were attempting to secure funding for an enhanced SBRI programme following a review for 10 Downing Street[86], they were required to submit three options at different cost levels. Alongside the recommended approach, designed to make SBRI work effectively, the team offered the Treasury two less costly approaches, both of which had already been tried and failed, hence the Review. In the end, no changes were made.

Second, during preparation of David Connell's independent review of R&D Tax and Expenditure Credits in 2020[87], the Treasury officials directly responsible for monitoring the scheme explained that lack of resources meant the small team mainly relied on the Confederation of British Industry for analysis.

Third, by 2017 a significant discrepancy had developed between, on the one hand, the measure of total UK Business Enterprise R&D ("BERD") estimated by the

Office for National Statistics from sample survey data, (the official "gold standard") and, on the other hand, the R&D expenditure disclosed by UK businesses when claiming RDEC from HMRC. Claims for RDEC appeared to indicate substantially larger levels of R&D than the estimates provided by the Office for National Statistics. In 2020 Treasury officials were unable to explain the reasons for the difference, even though it raised major questions regarding the cost effectiveness of the whole scheme. The sequence of events that followed is described in BOX 5.

Finally, policy thinking is strongly influenced by the best funded and most powerful lobby groups, in particular VCs and other financial interests, and the academic research lobby.

The enthusiasm of well-respected academics for turning breakthrough research in British universities into world-beating UK businesses has long had a powerful influence on politicians, officials and policy. The perceived potential of many start-ups based on breakthrough science is often amplified by analysts, brokers and the financial press. Achieving "unicorn" status – i.e. a market value of over $1 billion, based on the price at which the last investor bought shares - has come to be seen as the ultimate measure of success. This perception is magnified during the booms that characterise technology investment markets.
The reality is that for decades there have been poster child spin-outs from our top research universities, but very few of them turn into profitable UK companies. Businesses based on breakthrough academic science usually take many years to bring their products to market: there are usually unexpected technical difficulties; they face competition from improvements to established technologies; and founders are usually unaware of competing approaches emerging elsewhere.

Plastic Logic, a University of Cambridge spin-out founded in 2000 to commercialise a technology for plastic electronics and displays was regularly cited as one of the jewels in the UK's innovation crown by officials and politicians for 10 years or more. But despite raising $500m it was unable to match developments with existing silicon-based technologies. It is to be hoped that the current round of unicorns will do better. But the likelihood is that many will disappoint and the most promising will be sold to overseas-based corporations.

Innovation policy must, of course, support new businesses based on breakthrough academic research, but this must be balanced with support for lower risk start-ups, in less exciting or fashionable areas of science and technology, driven by commercially orientated entrepreneurs.

The reality is that policy continues to be based too much on "technology push".

The problem is exacerbated by the pressure on Ministers for regular spending announcements and initiatives, often focused on new technological breakthroughs recently reported in the media. This is usually far later than scientists and engineers working in the field become aware of them, particularly those who are potential users and customers. Venture capitalists are typically in between: quicker to spot the impact of new technologies than officials and politicians, but often slower than experts in the field working for potential users and customers.

Some examples illustrate the point:

- The R&D programme at Acorn Computers that led to Arm's RISC (reduced instruction set computer processor) semiconductor designs followed the high profile failure of MIPS Computer Systems, a spin-out from Stanford University also focused on

RISC chips. Acorn's initiative was regarded as highly risky by many semiconductor experts.

- Cambridge Antibody Technology (human antibody based drugs) and Abcam (antibody supplier for research), probably the two most commercially significant biotech companies to have emerged in Cambridge were unable to raise venture capital in their early years.
- No politician or Government official from the 1980s would have anticipated that one of the UK's most successful new STEM-based business since then – Dyson – would be in domestic appliances.

So, alongside the sectoral and industry themed competitions for grant funding that help Innovate UK to devise and manage competitions, there is also a need for open competitions and lead customer R&D funding.

Proposal for an "Independent Office for Innovation and Industrial Policy"

The pressure on Treasury officials, in practice the ultimate arbiters of spending decisions, during the budget cycle and their lack of innovation policy expertise has led to a bargaining approach to budget allocations focused on cost management, rather than objectives and policy effectiveness.

As a result, policy debate tends to be dominated by the best funded and organised interest groups – large UK and international corporations directly and through the CBI, venture capital and private equity investment groups, and university research interests and their champions.

It is essential that funding is better directed at the key policy challenge: growing and retaining significant UK-based STEM companies to replace industries in decline. A much better approach to cross Government policy planning and management is necessary to ensure this is acheived. It must be informed, enduring and independent.

Though the problem is rarely debated, there have been some previous attempts to bring more coherence to cross Government policies, notably the creation of the short-lived Department of Economic Affairs in 1964 and the rather longer lived National Economic Development Office. The latter's research played an important role in exposing issues and helping sector working parties focus on them, even though they did not achieve the hoped for cooperation between unions, industry and Government.

The effectiveness of solutions involving the creation of a "super ministry" or ad hoc task force would be compromised by the reshuffles and frequent personality changes all Governments engage in. They would be unlikely to endure beyond the next change of administration.

The remits of existing bodies like Go-Science and the Prime Minister's Council for Science and Technology are overwhelmingly focused on "science" rather than the very different issues associated with the process of creating and growing significant, innovative, UK-based companies.

Select Committees have neither the staffing nor longevity in terms of membership to provide a solution on their own, but would greatly benefit from better data and analysis.

The most relevant existing role model that might point to a solution, though in a different policy sphere, appears to be the Office for Budget Responsibility (OBR).

BOX 5

Recent changes to R&D Tax and Expenditure Credit (RDEC) policies: a story of contradiction and confusion

In an attempt to reduce the steadily increasing cost to the Exchequer of R&D Tax and Expenditure Credits and make it more cost effective, in the 2022 Autumn Statement, the Chancellor announced a halving of the SME scheme level of support together with a 53% increase in the level of support for large companies; decisions in line with the different levels of additionality estimated by the Treasury's flawed "black box" econometric models.

Intensive lobbying from the Biotechnology Industry Association and others led rapidly to an increase in the subsidy rate for R&D intensive VC-backed SMEs. Further changes have been announced to RDEC since.

At about the same time as the Autumn Statement the Office of National Statistics (ONS) reported the results of a previously unannounced review of its own R&D spending survey methods.[(i)] This concluded that it had underestimated the growth in R&D carried out by SMEs, and which had presumably now given ONS the same figures as used in claims to HMRC for R&D Tax and Expenditure Credits. The ONS report noted that R&D spending used to claim R&D Tax and Expenditure Credits (predominantly by large companies) had declined by nearly 20% between 2015/16 and 2020/21, whereas the R&D spending used to claim under the SME scheme had more than doubled over the same period; in other words, implying that the relative cost effectiveness of the scheme as between large companies and SMEs was completely opposite to the conclusions of the Treasury econometric models on which the Chancellor's announcement was based.

The new ONS figures implied a 60% increase in its estimates of overall annual business R&D spending. And this in turn implied that the UK was at, or close to, hitting its target of 2.4% of GDP being spent on R&D, compared with 1.7% reported in 2019.[(ii)]

In February 2024 the National Audit Office reported that it estimated that 24% of the cost of SME claims were due to fraud or error, though the figure could be higher.[(iii)]

It was not yet clear if this would lead to a partial reversal of the ONS estimate of business R&D spending.

Since then the picture has been further complicated by an apparent global increase in the rate of growth in R&D spending as a percentage of GDP since around 2015, with the OECD and World Bank now putting the UK at 2.9% based on the ONS statistics.

(i) *Comparison of ONS business enterprise research and development statistics with HMRC research and development tax and expenditure credit statistics,* Office of National Statistics, 7 October 2022.

(ii) *UK business R&D spending has just jumped by 60% - or has it?* Nature Editorial 29th November 2022.

(iii) *Tax measures to encourage economic growth*, National Audit Office, 31 January 2024.

Established in 2010 the OBR is best known for providing independent economic forecasts at the time of Government budgets. However, it also carries out independent analyses of the public finances and publishes occasional reports during the year. With just 30 permanent staff the OBR operates in a relatively low key manner during most of the year and is highly regarded. Though funded by the Treasury it is fiercely independent and has a strong governance structure to reinforce that independence.

The role of a parallel organisation focused on innovation and industrial policy should be:

- To define and evaluate the underlying problems affecting the growth of the UK's innovation economy, rather than just symptoms and simple aggregate metrics such as R&D spending.
- To identify meaningful metrics against which the cost, progress and impact of policies designed to address these problems can be assessed.
- To evaluate and assess policies and budgetary allocations against underlying policy challenges and related Government objectives.
- To specify the data and reporting process required from spending departments and agencies to enable spending on individual policies to be monitored and evaluated.
- To produce an independent annual report on innovation and industrial policies, objectives, spending programmes, outputs and outcomes.
- To publish independent reports on matters germane to its remit from time-to-time, including lessons from role model STEM successes, overseas institutions and policies, and "missed opportunities'.

The Office might be expected to have around 30 staff, roughly the same as the OBR, together with an appropriate governance structure to support its work and ensure independence.

Section 6
Conclusion

We began this paper by highlighting what we believe is the most important challenge facing UK innovation and industrial policy – the loss of our most promising VC-backed, STEM-based companies to foreign acquirers and truncation of further UK growth. This is not a problem completely of our own making, but also a result of the UK's position as a small, open economy in an increasingly global, market place dominated by companies based in its largest nations, particularly the US.

Solving this problem is no easy task.

But we must find better ways of enjoying the benefits of a vibrant, free market global economy at the same time as giving the small percentage of company founders with the ambition and skills to grow a major UK-based business the chance to realise that goal.

The innovation policy challenge has been exacerbated by an ideological approach to the economics of innovation and politicians' fear of being seen to pick winners. This has led to excessive dependence on non-selective subsidies and tax breaks. In this respect, the UK is way out of line compared with our most successful industrial competitors. Although there has begun to be a reversal in this thinking, changing the balance of innovation policy spending has been, and still is, compromised by the absence of an evidence-based approach and a failure to examine the picture across Government.

In 2004, the then Government set a target of 2.5% for UK investment in R&D as a percentage of GDP to be achieved by 2014.[88] In 2017, the Industrial Strategy committed to a 2.4% target to be achieved by 2027. In 2021, the best estimate of the actual value was still 1.7%.

Since then, the Office of National Statistics has announced a series of new, though still caveated, estimates resulting from changes in the methodologies used. It now estimates that UK R&D spending was at 2.3% of GDP in 2014, increasing to 2.9% in 2021. This is well in excess of the Government's 2.4% target, though still below Israel (5.9%), South Korea (4.9%), Taiwan (3.8%), the United States (3.5%), Belgium (3.4%), Switzerland (3.4%), Austria (3.3%), Japan (3.3%), Germany (3.1%) and Finland (3.0%).

The UK's policy focus on inputs (spending on innovation policies) and outputs (R&D spending) has detracted from the importance of outcomes, i.e. the growth of new and existing STEM-based UK firms and their contribution to UK employment and taxes. This is influenced by many other important factors, in particular the degree to which policy measures match different start-up and financing models. together with their impact on company ownership and their UK growth strategies over the long-term.

Conclusion

In particular we have highlighted the need for policies directed at start-ups with two very different growth and funding strategies: investment led companies such as university research based firms requiring successive funding rounds leading to control by investors looking for an exit; and revenue led start-ups able to avoid, minimise or delay institutional funding, leaving founders in control as a company grows.

Surprisingly perhaps, the UKs most successful STEM based start-ups have tended to pursue the latter course, with the founders and management remaining in de facto control well into the later-stage maturity of the company. To help more start-ups pursue this path, and grow to become sizeable businesses, the UK needs to stimulate more lead customer innovation contracts and offer more minimally dilutive grant funding.

The former category – investment led UK firms, if successful, will under current conditions far more often than not be sold to overseas-based corporations. To reap the full economic benefits, we need measures that encourage such companies to list in the UK. In particular, we need to ensure that innovative high-growth companies are not undervalued on UK public markets, by promoting a more supportive culture for growth companies. Additionally, more support is required for founders seeking to retain control of their companies post-IPO.

In this paper we have developed a series of policy ideas to address the needs of both these categories of firms, and we have proposed a rebalancing of overall policy spending.

Any significant change will need to be funded by cutting back on the cost of blanket subsidies, which currently account for 80% of total policy spending. Whilst R&D Tax and Expenditure Credits undoubtedly have a role, it is essential that these are more closely focused on where they can make a difference. The value of the Patent Box is highly questionable.

Though innovation policy has continued to be high up the priority list of successive governments, progress has been hampered by the fragmented, announcement-led nature of policy planning, influence of powerful lobby groups and paucity of independent, evidence-based thinking on the overall policy mix, together with frequent changes in ministers and senior officials.

The role of the Treasury, in practice the ultimate arbiter of innovation policy spending, but with virtually no resources to do the job, has been a key part of the problem.

It is up to Government to decide which, if any, of our policy proposals to adopt. But what is becoming increasingly clear is that new approaches and a change in the overall policy mix is likely to be needed if the UK is to maximise its potential as a science and technology-based economy.

Success is unlikely unless a properly resourced mechanism is put in place to help plan and monitor innovation and industrial policies across government as a whole, one which is authoritative, independent, enduring, and capable of deep, critical and forensic analysis of all the evidence.

Our final proposal is for a way of achieving this.

Appendix 1:
Turbocharging SBRI[89]

Objectives

To use pre-commercial procurement to leverage the innovative abilities of STEM-based UK companies to develop technological solutions to meet anticipated future departmental and agency challenges, help achieve their policy goals and improve the cost-effectiveness of the public sector.

In doing so to provide non-dilutive, contract funding for R&D to kick-start early-stage companies and help established businesses develop new offerings, thereby making it easier for ambitious entrepreneurs to build successful businesses in the UK.

Challenges

- Ownership, funding and continuing commitment by spending departments to an activity with long-term benefits to both them and the economy as a whole, despite short-term pressures and priorities.
- Lack of technology, innovation and pre-commercial procurement expertise in spending departments and agencies.
- Embedding the identification of innovation needs, opportunities and challenges into the medium- and long-term strategic planning of departments and agencies.

Key Features

A dedicated four year central fund, renewed each year, which departments and agencies can draw on to fund new competition programmes with multi-year spending profiles, despite the short-term budgetary pressures which have so far prevented this.

A Programme Management Board to allocate and monitor central funding to participating agencies based on submissions covering the programme of competitions each wishes to run each year and how it will be managed.

Participating departments/agencies would draw up a rolling list of key unmet technology needs annually with support from their Chief Scientist, Innovate UK and knowledgeable companies within supply chains which would be direct customers for innovations developed. This would then be used to specify a portfolio of competitions of relevance to the agency.

Individual topic competitions would run throughout the year as with the current SBRI model. Contracts would be awarded to companies in three phases, reflecting progress towards a commercial offering, decreasing risk and increasing cost. For example, for a simple hardware or software offering, the phases might be as follows:

- **Phase 1:** Feasibility study: typically, 6 months, £50k to £200k, 100% financed from the central fund
- **Phase 2:** Stand-alone demonstrator, typically 12-18 months, £500k to £2m, 100% financed from central fund
- **Phase 3:** Demonstrator integrated with other components of final product, max 50% financed from central fund, remainder by participating agency and/or other public or private sector sources.

The process would be competitive with each department or agency progressively focusing its funding on the most promising propositions as they progress.

Programme Management

Day-to-day programme management would be coordinated by Innovate UK.

The Programme Management Board should include representatives of Innovate UK and the Cabinet Office, together with the Government Chief Scientist and independent members with an industry/VC background.

The board would meet quarterly to hear progress reports from participating agencies on their competition portfolio and future plans, and to agree the future allocations from the central fund to individual departments/ agencies on a rolling annual basis. It would publish an annual report, with detailed spending statistics and output/outcome information drawing on inputs from participating agencies. Innovate UK would provide ongoing support to participating agencies depending on their in-house capabilities, but ensuring that ownership and responsibility for each procurement contract remains with the department/agency.

Fund Name

It is proposed that the fund is called the Tommy Flowers Fund, after the Post Office engineer who designed and built Colossus, the world's first programmable electronic computer, to help code breakers at Bletchley Park decode German messages using the Lorenz cypher.[90] This is a 1940s illustration of the power of Government R&D contracts to address difficult challenges whilst providing the basis for new businesses.[91]

Annual cost of Phase 1,2 and 3 contracts: £500m.

Benefits

- Improve the cost effectiveness and relevance of public sector bodies and help them achieve policy objectives through the application of science and technology-based innovation.
- Address societal challenges rapidly and cost-effectively.
- Use contracts from lead customers to provide the best possible source of early-stage funding for ambitious entrepreneurs wishing to build a substantial UK business.
- Harness the power of pre-commercial innovation procurement as demonstrated during Covid and times of war, but on a regular basis.
- Build reliance into the UK economy by reducing dependence on overseas suppliers.
- Support levelling-up by helping entrepreneurs based outside the "golden triangle" to access early-stage funding.
- Provide funding for companies developing specialised innovations within supply chains and which can provide the basis for building a UK Mittelstand over the long-term, but which are not well served by funding for academic research, grants for high profile "grand challenges" or venture capital (and hence RDEC).

Notes and references

1. STEM is short for science, technology, engineering and mathematics.
2. *Gross domestic expenditure on research and development, UK: 2021;* Office for National Statistics, 17 July 2023.
3. The pre-competitive collaborative R&D model was introduced in 1984 as a way of encouraging downstream pan-European industrial collaboration and mergers to combat the economies of scale from which their US and Japanese competitors benefited. This was a central plank of Viscount Davignon's vision as European Industry Commissioner. Precompetitive collaborative R&D avoided previous barriers to cross border industrial collaboration.
4. *Report by the Comptroller and Auditor General, HM Revenue & Customs 2022-23 Accounts,* 7th July 2023 National Audit Office
5. *Patent Box Statistics 2023,* HM Revenue and Customs.
6. In the early 2000s there were four Cambridge based STEM companies employing 1,000 or more people, Arm Holdings, Cambridge Silicon Radio, Domino Printing Sciences and Autonomy. All except Arm were listed at the time. All were profitable.

   By 2021, none of these remained independent and an analysis, using the Cambridge Cluster Insights data with Dr Giorgio Caselli of the Cambridge University Centre for Business Research showed that there were still only three companies with 1,000 or more employees, despite the huge growth in start-ups and the local high technology economy being several times larger. These were Arm, by this point acquired by Softbank; Abcam, a supplier of antibodies and other research consumables to the biotech industry, built without venture capital, and with around 1,500 employees globally; and Darktrace, a cyber security company also with around 1,500 employees and listed on the London Stock Exchange in 2021 (and currently, as of the date of writing, subject to a takeover offer from an overseas private equity firm). Abcam, after delisting from AIM in favour of a sole listing on Nasdaq, was acquired by Danaher in December 2023.

   A further three Cambridge start-ups employed between 500 and 900 people, all by then acquired by overseas based companies.

   The largest STEM based company in Cambridge is the Marshall Group, a family-owned business started in 1909 and employing 2,000 people in a range of aircraft related engineering services and other businesses.
7. *Disfold Top 151 Largest UK Companies in the Technology sector by Market Cap,* January 2024; https://disfold.com/united-kingdom/sector/technology/companies/

   Although the table shows 13 companies with market capitalisations above £1 billion, one of the companies on the list is listed on Nasdaq rather than in London (Endava plc), three of the companies have been acquired (Ideagen plc, Blue Prism plc and Micro Focus International plc), and one further company is, as of the date of writing, subject to a recommended takeover offer (Darktrace plc).
8. No venture capital was involved in Sage's start-up, which took place after Graham Wylie, a student at Newcastle University, took a summer job with an accountancy firm and, funded by a Government small business grant, wrote software to help their record keeping. Next, hired by David Goldman to write estimating software for his printing company, Campbell Graphics, Graham used the same accounting software to produce the first version of Sage Accounts. David was so impressed that he hired Graham and academic Paul Muller to form Sage, selling their software first to printing companies, and from 1984 to a wider market through a network of resellers. Source; Wikipedia et al.
9. VC investors may also engineer an exit through a flotation without a private equity acquisition intermediate stage.
10. A review of university spinouts in 2023 showed that investments in spinouts had increased significantly from 2013, averaging around 90 new spinouts a year between 2015 and 2022, and an average initial investment of around £1.5m. Founders and their universities typically had roughly 55% and 23%

respectively after the first round, again with quite wide variations. The study shows a significant decline in the number of start-ups and average first round investment in the first half of 2023. Between 2013 and 2023 a total of £13.3 billion of investment had been secured by university spinouts. Equity investment into spinouts, 2023; Beauhurst.

11. British Venture Capital Association Investment Activity and Performance Data.
12. See *Short Histories of Some of the Most Successful STEM Based Companies to Have Been Started in the UK Over the Last 40 Years,* March 2017; www.davidconnell.org
13. By providing a viable alternative exit route to a trade sale a healthy IPO market also makes early-stage private investment in UK companies a more attractive asset class.
14. Opinion Lex, *UK Stocks: The Discount that Disappears on Closer Inspection* Financial Times (25 October 2023), available at https://www.ft.com/content/de4a48c4-c16f-44dd-8cb1-3cbc94165ef9; Stephanie Stacey and Costas Mourselas, "*UK's 'Staggeringly Cheap' Stocks Trade at Record Discount to the US* Financial Times (23 March 2024), available at https://www.ft.com/content/be46c2c3-1f1f-42e3-912b-b75624dedcbd
15. For example, a 2023 report found that £27.5 billion was invested in UK companies in 2022 by private capital firms (BVCA, *Private Capital: Rising to the Challenges of Turbulent Times* (July 2023)).
16. Public shareholders have significant influence on UK-listed companies. Not only can public investors holding a majority of the votes in the company determine the outcome of hostile takeovers, they also have the power to remove directors from the board. The board, in turn, has the power to hire and fire management. Accordingly, in the shadow of these powers, public shareholders can influence corporate policy and strategy.
17. A lead customer is an organisation that either pays for stages in the development and trialling of a new product or process (from feasibility through demonstrator and prototype) or buys the first commercial product. Apart from providing non-dilutive funding, their commitment helps a start-up company build credibility with investors and further customers. However, though the risk remains high, and lead customers can pull out.
18. *Exploding the Myths of UK Innovation Policy; How "Soft" Companies and R&D Contracts for Customers Drive the Growth of the Hi-Tech Economy,* David Connell and Jocelyn Probert, Centre for Business Research, Univerisy of Cambridge, 2010.
19. "Most successful" defined here as largest profitable new companies by number of employees.
20. *Short Histories*, *Supra* note 12.
21. *Short Histories*, ibid.
22. The founders of Cambridge Antibody Technology tried unsuccessfully to raise venture capital for six months. Antibody based drugs have since become one of the most important areas of development for the global pharmaceutical industry,
23. *Short Histories, Supra* note 12.
24. *Short Histories,* ibid.
25. Companies competing for collaborative R&D grants often choose partners to meet the grant specification rather than because they are critical to the project they wish to undertake.
26. The concept of technology readiness levels was originally developed by NASA in the 1970s and is now widely adopted for characterising R&D projects by the UK Government. There are 9 levels. The MOD version goes from Level 1 - basic principles observed and reported to Level 9 – Actual technology qualified through successful mission operation.
27. *Secrets of the World's Largest Seed Capital Fund; How the United States Government Uses its Small Business Innovation Research Programmme and Procurement Budgets to Support Small Technology Firms,* David Connell, Centre for Business Research, University of Cambridge, 2006.
28. *Does Britain Need a DARPA*, David Connell, 2014; http://davidconnell.org/wp-content/uploads/2023/10/DARPA-BRIEFING.pdf
29. The UK's ARIA, launched in January 2023 with £800m of funding for its first four years, is loosely modelled on DARPA. Its objective is to "unlock scientific and technological breakthroughs that benefit everyone" and its eight programme directors are currently developing programmes for R&D in areas ranging from climate engineering to programmable plants.

Notes and references

30. The term "Research Initiative" has detracted from the important objective of using pre-commercial procurement to fund the development of technologies of potential strategic importance to the public sector as potential purchasers. It is not about pure "research" and while focused on innovative start-ups and SMEs, large companies are not necessarily excluded.
31. DASA, the UK's Defence and Security Accelerator operates a broadly similar programme of themed competitions, but contract values are very small and a high proportion are with universities. In 2022/23 it had 882 proposals and awarded contracts worth £49m, 56% to SMEs and covering 249 "innovations".
32. Subsidy rates are governed by the UK's Subsidy Control Rules, which are broadly similar to EU State Aid Regulations.
33. Human antibodies were yet to be accepted as a useful pharmaceutical technology and there were no UK grants available for businesses working in this field at the time.
34. This excludes notional MOD funding for R&D included in mainstream procurement projects. This is not disclosed by the MOD, even to other government agencies with an R&D policy remit.
35. R&D tax credits can be claimed on the proportion of project costs not covered by the grant,so for a £1m grant funded project, companies can obtain a modest tax credit on its own expenditure of £300k.
36. *The Birth of Racal*, Electronics Weekly, 15 November 2022.
37. However, even then, acquisitive companies are rare on the London Stock Exchange.
38. *E.g. CBI Calls for Boost to Mid-Sized Companies,* Financial Times, 24th October 2011.
39. *"Best of German Mittelstand – The world market leaders"*, by Professor. Dr. Bernd Venohr, Professor Dr. Jeffrey Fear, and Dr. Alessa Witt. Deutsche Standards EDITIONEN Gmbh, Cologne, Germany, 2015.
40. *Best of German Mittelstand*, ibid.
41. The development of the world's first microprocessor by Intel was funded by Busicom, a Japanese calculator company. Intel was able to acquire the IP after Busicom's bankruptcy in 1974, and the rest is history, illustrating once again the importance of customer funded R&D in the innovation, and business building, process.
42. In this case it was new hardware (the microprocessor) that created widespread applications. In today's world it is the new processing, storage and communications tools enabled by new generations of hardware that create widespread new business applications.
43. *The Microprocessor Application Project at Midstream,* Lewis Holmes; Electronics and Power, November/ December 1980.
44. *Fraunhofer Annual Report 2022.*
45. *The Current and Future Role of Technology and Innovation Centres in the UK; A Report for Lord Mandelson,* Secretary of State for Business, Innovation & Skills, 2010.
46. Innovate UK freedom of information inquiry.
47. *Report by the Comptroller and Auditor General, HM Revenue and Customs 2023-23 Accounts*, National Audit Office 7 July 2023.
48. Answer to Freedom of Information Requests, Innovate UK.
49. *Spotlight on Spinouts May 2023,* Beauhurst. 50 Innovate UK.
51. *Direct Government funding and tax support for business R&D, 202*0. OECD innovation database, April 2022.
52. See Pages 15 to 19 of *Is the UK's flagship industrial policy a costly failure?,* David Connell May 2021, Centre for Business Research, Cambridge Judge Business School.
53. HMRC estimates for 2022/23.
54. *Leveraging Procurement to Grow the Innovation Economy; an Independent Review of the Small Business Research Initiative,* Commissioned by 10 Downing Street, David Connell, 2017. Downloadable copy available at www.davidconnell.org.
55. *Transforming Public Procurement: our innovation ambition,* Cabinet Office, 13 November 2023.
56. Other EU measures encourage individual member states to establish US-style innovation procurement programmes.
57. Answer to Freedom of Information Request, Innovate UK.
58. *The Role of TICs in Rejuvenating British Industry:* Select Committee Submission; ibid.

59. The Department for Science, Technology and Innovation's 2023 Update to the 2021 Catapult Network Review calls for KPI frameworks tailored to each Catapult focusing on: total private sector funding secured by UK SMEs; total public sector funding secured by UK SMEs, total headcount growth of UK SMEs, total turnover growth of UK SMEs, CR&D industry match funding, and "discrete partners (collaboration)".
60. Since the new legislation was introduced 10 years ago the number of companies that have become EOTs has grown to over 1,400, with total revenues of £22 billion and 181,000 employees. Most of these are services oriented companies. They include large engineering consultancies Mott McDonald and Ove Arup, and technology consultancies like TTP Group and Team Consulting. These have either created successful spin off, R&D intensive product businesses or have the potential to do so. There are also currently a few low or medium technology manufacturing firms whose potential for R&D led growth could be increased by the availability of suitable finance.
61. *The Ownership Dividend; Report of Enquiry Led by Baroness Bowles of Berkhamsted,* Employee Ownership Association 2014.
62. *UK Investment Research Review*, Rachel Kent 10 July 2023.
63. The FCA has already commenced a consultation on increasing the freedom of choice for investors in paying for investment research: P*ayment Optionality for Investment Research Consultation* Paper CP24/7, Financial Conduct Authority April 2024.
64. As of the date of this report, five "US-style" SPACs have listed on the London Stock Exchange adhering to the FCA's 2021 requirements to trigger the suspension of trading exemption. Of those five SPACs, four have, as of the date of this report, de-listed without completing an acquisition within the requisite "acquisition period" for the SPAC.
65. For a history of how the efforts of Chancellors and other ministers to establish an equivalent of the US's SBIR in the UK have been frustrated over 20 years, see pages 38 to 42 of *Leveraging Procurement to Grow the Innovation Economy*, op.cit.,the report of the independent review commissioned by Prime Minister Theresa May and published with the Industrial Strategy in 2017.
66. *Report by the Comptroller and Auditor General HM Revenue & Customs 2022-23 Accounts,* op cit.
67. *Report by the Comptroller and Auditor General HM Revenue & Customs 2022-23 Accounts.*
68. Direct Government funding and tax support for business R&D, 2020. OECD Statistics Database.
69. The survey covered 250 multinational companies across 15 industries. 44% gave the US as their home base, and 49% were based in Western Europe. *Here or There? A Survey of Factors in Multinational R&D Location,* Jerry Thursby and Marie Thursby, 2006, National Academies Press, Washington D.C.
70. *Astra Zeneca Annual Report* 2020.
71. *Internationalisation of Business Investment in R&D and Analysis of Their Economic Impact,* Bernhard Dachs et al, European Commission Directorate General for Research and Innovation, 2012.
72. *Evaluation of the Research and Development Expenditure Credit (RDEC), Georgia Scott and Tim Glinert, HMRC Working Paper 20, October 2020.*
73. *Evaluation of the Research and Development Tax Relief for Small and Medium-sized Enterprises,* Shaan Devnani, Rohit Ladher and Nicholas Robin, HMRC Research Report 598, September 2019, London Economics.
74. *The Impact of R&D Tax Credits: Results from the OECD MicroBERD+ Project*, OECD 2022 .
75. See BVCA Annual Performance Measurement and Investment Surveys. Profitability varies significantly between fund managers and experienced investors focus on the best performing, whose funds are often oversubscribed. Most are headquartered in the US. Small, early-stage VC funds, of which there are many in the UK, are disadvantaged by suffering excessive dilution, due to their inability to invest increasing sums in follow on rounds.
76. Invenics a specialist advisory firm describes its work for a major bank at <https://www.invenics.com/casestudies/uk-bank/>
77. *Research and Development Spending,* Abbas Panjani, House of Commons Library, 11 September 2023.
78. *Patent box holds key to Pfizer-AZ deal's attraction,* Vanessa Houlder, Financial Times, April 29, 2014.
79. *Patent Box Relief Statistics:* September 2023
80. *Is the UK's flagship industrial policy a costly failure?* David Connell, Centre for Business Research, University of Cambridge, 2021.

Notes and references

81. *Minutes of House of Commons Select Committee for Science and Technology examination of witnesses on 28 February 2011*, question 96.
82. *Attracting profit shifting or fostering innovation? On patent boxes and R&D subsidies,* Andreas Haufler and Dirk Schindler, Oxford University Said Business School, February 2021.
83. *Patent Box Evaluation,* November 2021, Max Rowe-Brown and Huw James, HMRC.
84. Besides helping start-ups pursuing a revenue led funding model with minimal investment, these measures would also be of benefit to university spin-outs and other start-ups pursuing an investment led strategy, as it would enable them to build value at the beginning of the funding pathway and negotiate for investments with less time pressure, thereby reducing the dilution of founder, university and any angel investors, and enabling them to retain some influence on long-term strategy.
85. In some cases, even basic data is unavailable. The level of detail in Innovate UK's annual reporting has steadily decreased since it was incorporated within UKRI. It no longer publishes any kind of annual report, instead being incorporated within UKRI's 150 page Annual Report.

    The amount Innovate UK spends with businesses is unspecified and there is no detailed information on the distribution of grant sizes, support levels and the split between SMEs, large companies, universities and other organisations.

    The number and value of SBRI contracts providing 100% funding for R&D from lead customers in the public sector is also not published, partly because spending departments are not required to provide this information to Innovate UK, which has responsibility for the programme.

    The information in this report has been gratefully supplied as a special exercise by Innovate UK's hard working and committed team through a Freedom of Information Inquiry.

    HMRC publishes very detailed aggregate statistics on R&D Tax Credits and the Patent Box, but has refused to provide data on companies with the largest receipts to facilitate detailed case study analysis of outcomes. This data is publicly available in many published accounts, but the reporting regulations enable most of the UK's largest companies to avoid providing it, as the amounts (though probably often large) are not seen as material in relation to their profits.
86. *Leveraging Procurement* op.cit.
87. *Is the UK's Flagship Industrial Policy a Costly Failure,* David Connell; Foreword by Greg Clark MP May 2021.
88. *Science & Innovation Investment Framework 2004-2014,* H.M. Treasury, Department of Trade and Industry (DTI) and the Department for Education and Skills (DfES), July 2004.
89. Prior to publication of this document Innovate UK announced that SBRI was to be rebranded under the name "Contracts for Innovation", though without any other changes or a defined budget.
90. *Colossus; The secrets of Bletchley Park's code-breaking computers*, B. Jack Copeland and others, Oxford University Press, 2010.
91. Unfortunately, in this case, the technology was covered by the Officials Secrets Act for many years after the war, so the opportunity to kick-start the UK computer industry was lost.

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