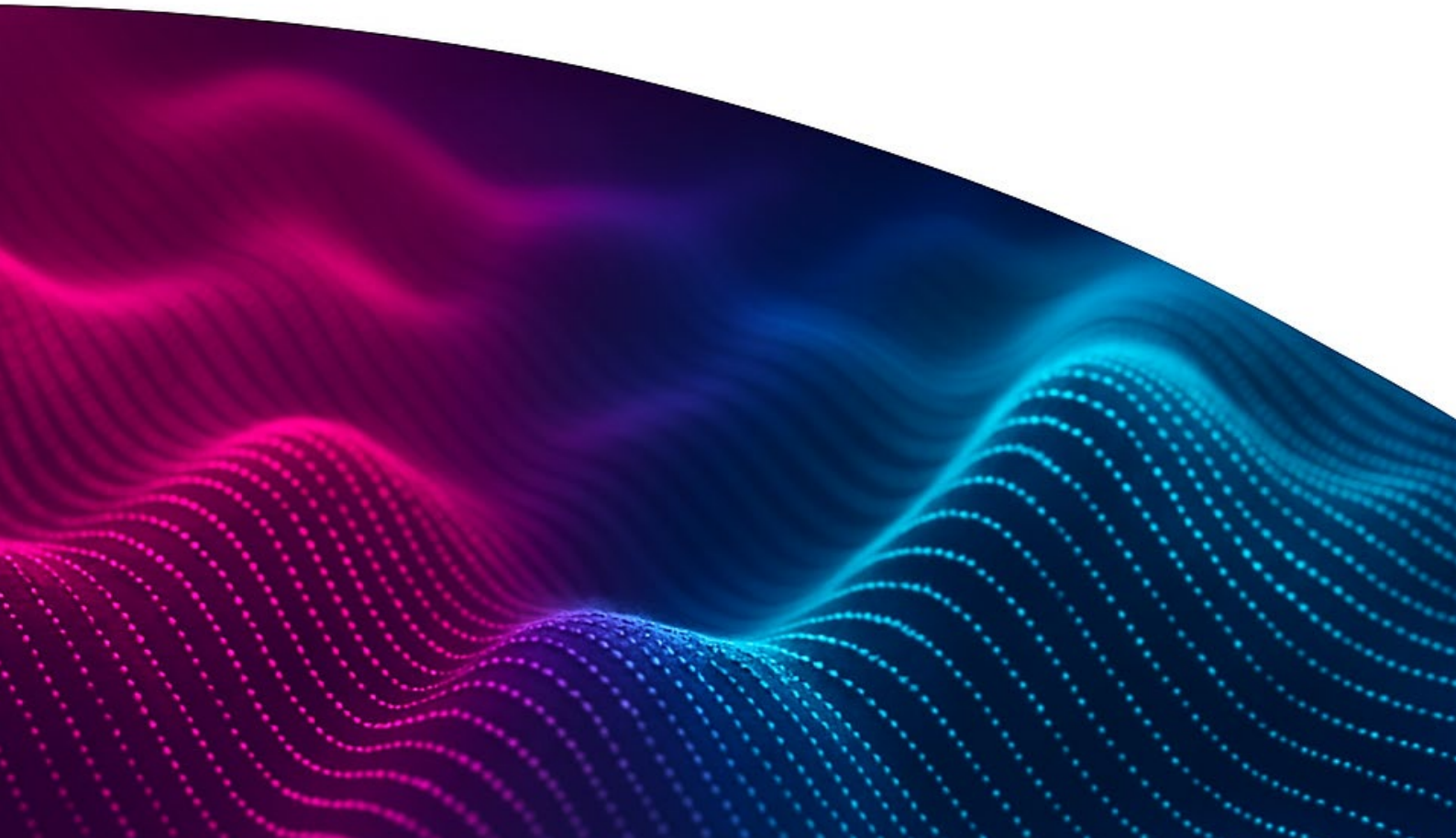
To what extent does public R&D leverage private capital investment?

A report for the Department for Science, Innovation & Technology (DSIT)

May 2025



This report was done in collaboration with the National Centre for Universities and Business (NCUB) and the Science Policy Research Unit (SPRU).

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The modelling and results presented here are based on information provided by third parties, which NCUB has relied upon in good faith in producing this report. Any subsequent revisions or updates to those data will affect the modelling and evaluations shown.

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Context and Rationale for the Study

Public investment in research and development (R&D) is widely recognised as a key driver of innovation, productivity, and long-term economic growth. Governments fund R&D to stimulate knowledge creation, de-risk technological development, and generate wider economic benefits. While the effects of public R&D on private R&D have been well-documented, the broader question of whether public R&D also incentivises private capital investment—investment in physical assets like infrastructure, equipment, and embedded technologies—remains underexplored.

This question matters because capital investment is critical to productivity. Technological innovation can raise aggregate productivity if it is embodied in new capital or business processes. For public R&D to deliver its full economic potential, it must not only produce new knowledge but also catalyse business investment in tangible and intangible assets that bring innovation into real-world application.

In the UK, the gap between research excellence and economic performance has long been a concern. Despite a strong science base, levels of private capital investment have lagged behind international peers. Understanding the extent to which public R&D investment can "crowd in" private capital is crucial for informing strategies aimed at unlocking private sector-led growth.

Our Approach

To examine how public investment in R&D influences business investment in capital—such as machinery, equipment, intellectual property products (R&D, mineral exploration, software, and databases), and infrastructure—we drew on both UK-specific data and a broader international dataset. Our aim was to assess whether public R&D acts as a catalyst for private investment, how this relationship develops over time, and how the UK compares to other advanced economies.

We began with a time series analysis of UK data, looking at how public R&D spending might influence private capital investment in the short and long term. However, the limited number of annual observations restricted the strength of conclusions we could draw from this approach alone.

To overcome this, we conducted a more comprehensive analysis using data from 35 OECD countries over nearly three decades. This cross-country approach enabled us to compare the UK's performance and identify broader trends. We applied a dynamic panel model known as system GMM, which accounts for investment behaviour over time and helps address potential two-way relationships between public R&D investment and private capital investment. Private capital investment is measured as Gross Fixed Capital Formation (GFCF) by the corporate sector, encompassing both financial and non-financial corporations.

We controlled for other key economic factors—including GDP growth, employment, interest rates, and market structure—to help our findings reflect the specific influence of public R&D. To improve reliability, we used internal and external instruments, including patent data linked to public funding, to isolate the effect of public R&D investment.

Although this analysis does not capture all sector-specific or policy-level differences, it aims to provide high-level evidence on how public R&D can contribute to business investment and, by extension, wider economic activity.

What is the Effect of Public R&D Investment on Private Capital Investment?

It is important to note that this is a novel and exploratory analysis, subject to inherent limitations and uncertainty. **As such, the findings should be interpreted as indicative rather than definitive**. We see this as a foundation for further work and are keen to refine the methodology and expand the data sources in future research to improve the robustness and reliability of the estimates.

We attempted to assess the delayed impact of realised technological change driven by public R&D through private capital investment (in **Annex B**); however, data limitations restricted the number of possible lags in public R&D spend to three years. This is unlikely to be sufficient to capture technological changes driven by public investment. Therefore, this report only examines the immediate business investment response to public R&D spend and its subsequent impacts through capital investment persistence.

Table 01 below summarises the core findings from the panel data analysis, highlighting the estimated short- and long-run impacts of a one-off increase in public R&D investment, alongside the persistence of private capital investment.

- **Short-run effect (UK):** A 1% increase in public R&D spending is associated with a 0.15% to 0.20% rise in private capital investment within the same year. This immediate responsiveness suggests that firms view public R&D as a signal of opportunity, adjusting quickly by expanding their investment in capital assets.
- **Long-run effect (UK):** Over a 10 to 16-year period, persistence roughly doubles the short-run effect. A one-off 1% increase in public R&D in the first year leads to a 0.58% to 0.68% cumulative rise in private capital investment. By model design the investment response is front-loaded—most of the effect occurs in the first 5 years, with diminishing influence thereafter.
- **Persistence:** The key mechanism behind the long-run effect is the strong persistence of private capital investment. With 65% to 77% of prior-year investment levels carrying over into the current year, initial responses to public R&D funding continue to shape firm behaviour well beyond the year of the initial intervention. This compounding effect highlights the importance of dynamic modelling in capturing the full economic value of R&D policy.

Table 01: Estimates of the effect of public R&D investment on private capital investment

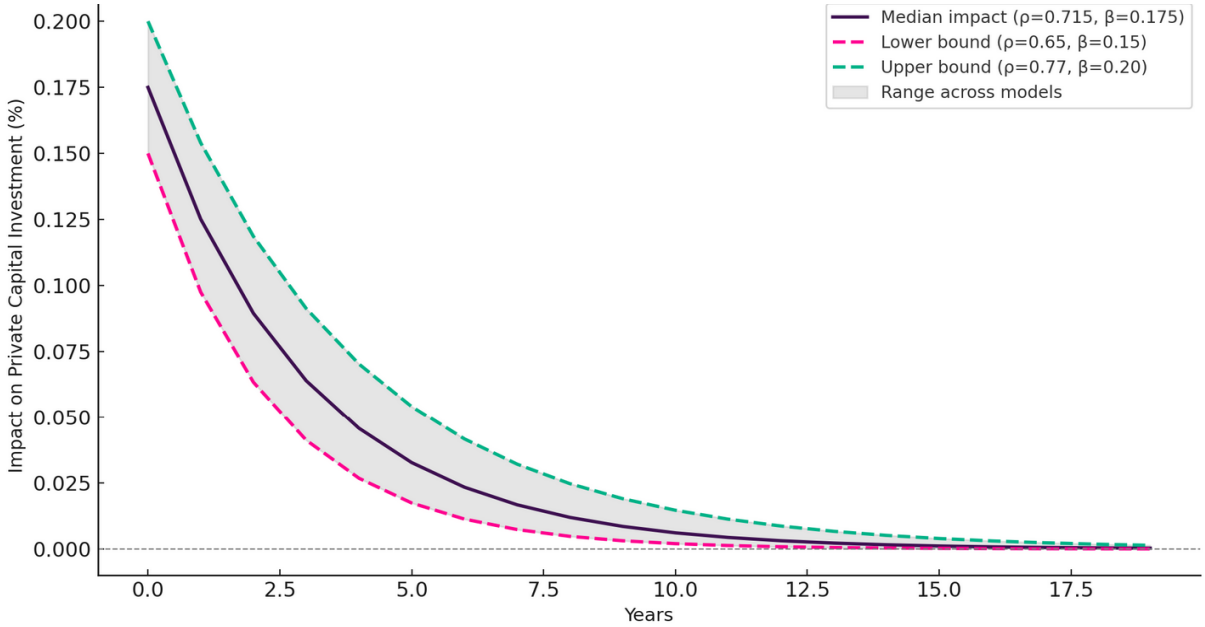
Effect Type	Definition	Impact Range	Interpretation
Short-run effect (UK)	Associated impact within the same year.	0.15 to 0.20	A 1% increase in public R&D spending is associated with a 0.15% to 0.20% rise in private capital investment within the same year.
Long-run effect (UK)	The impact of the short-term effect combined with persistence.	0.58 to 0.68	An aggregate impact from year 1 to year 16, during which a 1% increase in public R&D investment leads to a cumulative rise of 0.58% to 0.68% in private capital investment. The bulk of this effect is concentrated in the first five years.
Persistence (Private Capital Investment)	The extent to which last year's capital investment affects this year's investment.	0.65 to 0.77	A persistence rate of 65% to 77% indicates that most of this year's private capital investment is carried over from last year, with two-thirds to three-quarters of past investment influencing current levels.

These findings suggest that public R&D investment may act as a catalyst for broader business investment in capital formation. It appears that in the short term, it sends a signal which prompts firms to increase capital spending—an effect that is immediate, statistically significant, and consistently observed across all model specifications. Over the longer term, public R&D sets off a chain of investment decisions that accumulate gradually, delivering returns well beyond the year of initial expenditure. The full scale of the effect builds over time, reflecting the persistent nature of investment behaviour. The long-run estimate, derived from the model's dynamic structure, assumes that current patterns of investment persistence continue into the future. It should therefore be interpreted as an indication of the potential scale of cumulative returns, conditional on stable policy frameworks and supportive economic conditions.

How does this relationship evolve over time, and what is the scale of its long-term impact?

Due to investment persistence, the relationship between public R&D investment and private capital investment is dynamic and evolves over time. A one-off 1% increase in public R&D triggers an immediate rise in private capital investment, followed by a gradual decline in impact. The results also show that of the response concentrated in the early years and largely tapering off within 10 to 16 years (see **Figure 01 below**).

Figure 01: Time profile of the impact of public R&D investment on private capital investment



Note: This chart shows the non-cumulative *impact of a one-off 1% increase in public R&D investment on private capital investment over time. Each point reflects the marginal effect in a given year, based on model estimates. The chart illustrates that the response is strongest in the first year and diminishes gradually, with the effect largely dissipating after 10–17 years. The shaded area captures the range of estimated impacts across different model specifications.*

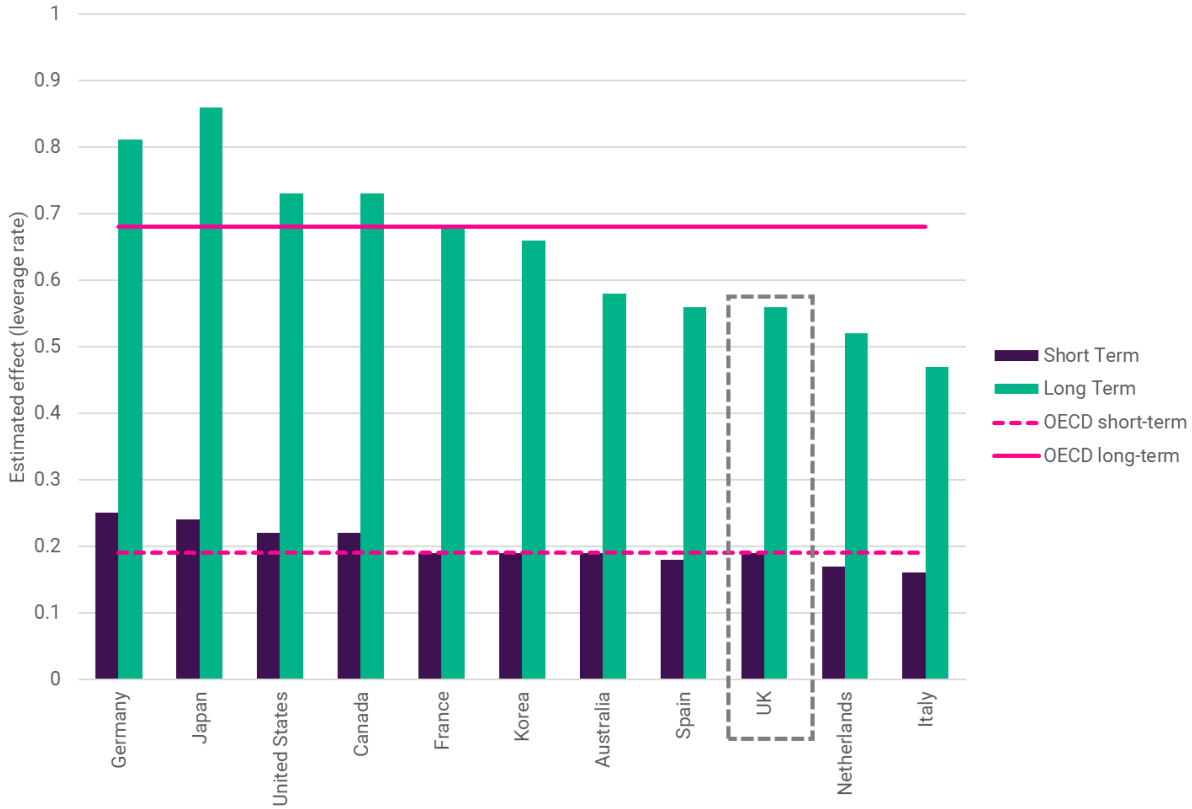
How does the UK compare to other advanced economies in leveraging public R&D to stimulate business investment?

Figure 02 shows how public investment in R&D influences business investment across OECD countries—both in the short term and over the longer run. In the UK, the short-term impact is estimated at 0.19, matching the OECD average and outperforming countries like Italy (0.16), Spain (0.18) and the Netherlands (0.17). This means UK businesses appear to respond at the average rate when government increases R&D funding, boosting their own investment in capital assets such as machinery, infrastructure, and technology.

However, due to differences in investment persistence, the long-term effect in the UK is lower than in many leading economies, with a cumulative impact of 0.56 compared to 0.68 across the OECD, and over 0.80 in countries like Germany, Japan, and the United States. In these countries, public R&D investment appears to spark more sustained private capital investment over time, as business investment is more persistent.

This suggests that while the UK's public R&D spending is effective at generating an immediate business investment response, there is scope to improve the persistence of this investment. The observed persistence reflects the fact that capital investment decisions tend to build on past activity. Public R&D appears to influence this trajectory by prompting firms to initially invest, but sustaining that investment over time likely depends on broader business conditions that influence persistence.

Figure 02: Time profile of the impact of public R&D investment on private capital investment



Role of foreign public R&D and other macroeconomic factors

Interestingly, the estimated effect of public R&D funded by foreign governments and performed abroad on UK private capital investment is statistically significant and comparable in magnitude to that of UK public R&D. This is a surprising result and while international knowledge diffusion may play a role, the results could also reflect broader global investment trends, measurement issues, or modelling limitations. The precise mechanisms behind this relationship remain uncertain. This pattern is not unique to the UK. Foreign public R&D is positively associated with private capital investment across most OECD countries.

We also examined the role of broader macroeconomic conditions. Employment growth consistently emerged as a key driver of higher private capital investment, while interest rates and market concentration showed more variable or limited effects. These findings suggest that the effectiveness of public R&D in stimulating private investment depends not only on the volume of spending but also on the wider economic context in which it occurs

Limitations

While the study makes some contributions, it also faces several limitations:

1. **Data constraints (UK time series):** The UK-specific time series analysis was constrained by the limited number of annual data points, weakening the ability to estimate robust, time-dependent effects. This led to a greater reliance on cross-country panel methods.
2. **Annual frequency:** The use of annual data limits the granularity of analysis. Quarterly data, like that available in the US, would allow for better identification of short-term lags and more precise timing of investment responses.
3. **Macro-level focus:** The analysis is conducted at the aggregate national level. While this provides valuable insights into economy-wide effects, it does not capture sectoral differences or firm-level heterogeneity in investment behaviour.
4. **International comparability:** Exchange rate fluctuations and differences in national accounting practices may introduce noise into cross-country comparisons, despite efforts to harmonise data.
5. **Unobserved structural barriers:** The analysis identifies that the UK underperforms in sustaining long-term investment responses, but does not fully unpack the institutional, financial, or policy barriers responsible for this.

Despite these limitations, the study provides early evidence that public R&D investment may crowd in private capital investment, with effects that continue to accumulate. While exploratory, the findings support the view of R&D policy as a lever for both innovation and long-term growth. Looking ahead, further research could build on these results by refining the methodology and using more granular data—disaggregated by asset type, sector, and region—to better identify where public R&D exerts the greatest influence. Separating technology-related capital formation from other investment types and linking public R&D to firm-level and place-based outcomes, would enable more precise estimates and support the development of more targeted, effective policy interventions. Such work would also help illuminate the channels through which public R&D shapes investment behaviour and the conditions under which its impacts are strongest.

01. Introduction, Background, and Methodology

Introduction

Public investment in research and development (R&D), is widely recognised as a key driver of innovation, productivity and long-term economic growth. Governments invest in R&D to generate new knowledge, support technological breakthroughs, and stimulate wider economic activity. A growing body of evidence confirms that public R&D can leverage private R&D spending — enhancing firms' capacity for innovation and creating spillover benefits that extend across the economy (Soete, 2022; De Lipsis et al., 2023).

However, one crucial aspect of this relationship which remains under-explored is the extent to which public R&D investment also encourages broader private capital investment — that is, investment by businesses in physical assets such as machinery, equipment, infrastructure, and embedded technologies. This form of investment plays an important role in the diffusion and application of innovation, helping translate new ideas and technologies into more productive processes, products, and services.

From a macroeconomic perspective, this matters for two reasons. First, capital investment is a critical determinant of productivity, as it increases the amount of capital available per worker and enables technological change to be embedded in production. Second, for public R&D to deliver maximum economic impact, it must not only generate new knowledge but also stimulate complementary private investment that translates those ideas into tangible outputs.

Despite this, the relationship between public R&D investment and private capital investment has received relatively little empirical attention — particularly at the whole-economy level. Most existing studies focus on firm-level dynamics or isolate R&D-specific investment responses, leaving a gap in our understanding of how public science and innovation funding influences broader patterns of business investment.

This report presents an initial analysis of the relationship between public R&D investment—measured as government-funded gross domestic expenditure on R&D—and private capital investment. It explores three key questions:

- To what extent does public R&D investment in the UK crowd in additional private capital investment?
- How does this relationship evolve over time, and what is the scale of its long-term impact?
- How does the UK compare to other advanced economies in leveraging public R&D to stimulate business investment?

We draw on a combination of UK time series analysis and panel data from 35 OECD countries spanning over three decades. Our approach allows us to capture both immediate and delayed

effects, control for key macroeconomic drivers, and benchmark the UK's performance relative to international peers.

Background

R&D and innovation are widely recognised as core drivers of economic growth, enabling new products, processes, and services while enhancing the productivity of both labour and capital (Griliches, 1992; Aghion & Howitt, 1998). Public investment in R&D plays a key role in supporting these innovation systems — funding upstream knowledge creation, de-risking early-stage technologies, and stimulating follow-on investment by the private sector. The long-standing rationale for public R&D funding is to address market failures in innovation, particularly the underinvestment arising from knowledge spillovers and risk aversion.

While much research has focused on the impact of public investment in R&D on private R&D activity (e.g. David, Hall & Toole, 2000; Guellec & van Pottelsberghe, 2003), a broader and less studied question is whether public R&D also stimulates wider private capital investment — for example, in machinery, equipment, and infrastructure — that embeds technological change into the economy. This is a critical mechanism in the growth process: for technological progress to raise aggregate productivity, it can be embodied in new capital goods (Solow, 1960; Greenwood, Hercowitz & Krusell, 1997). Firms that adopt new technologies through capital upgrades are more likely to realise efficiency gains and increase output per worker, driving growth in total factor productivity (TFP).

This theoretical link has important policy implications. If public R&D improves the expected productivity of capital, it should raise the rate of return on investment and incentivise firms to expand their capital stock. This is particularly relevant in economies like the UK, where private investment levels — especially in non-R&D innovation assets — have historically lagged behind peers (OECD, 2023). A better understanding of whether public R&D can catalyse broader private investment would help clarify its role not just in generating new knowledge, but also in fostering capital deepening and productivity growth across the wider economy.

At the micro level, there is growing evidence of complementarity between innovation and capital investment. In the UK, firms receiving Innovate UK grants have shown measurable increases in turnover and employment, with some spillover effects to firms in proximity to publicly funded research infrastructure such as Catapult centres (Cowling et al., 2024; Vanino and Roper, 2023). Internationally, Liu et al. (2022) find that technological breakthroughs in US firms lead to increases in both investment and hiring, offering support for endogenous growth models in which innovation feeds back into firm expansion. Similarly, Bloom, Bond, and Van Reenen (2007) show that firms with higher R&D intensity are more responsive to investment opportunities, indicating that innovation enhances firms' sensitivity to future growth expectations and reinforces the complementarity between R&D and capital investment.

While these firm-level dynamics are instructive, there remains limited evidence on the macroeconomic link between public R&D and broader capital investment. Most existing studies have concentrated on the effect of public R&D on private R&D, often finding substantial crowd-in effects (Correa et al., 2013; Montmartin 2015, Sussex., et al 2016: Deloitte, 2017; Oxford Economics, 2020; Moretti et al., 2023, Pallante, Russo and Roventini, 2023: and more

recently NCUB, 2024). Other studies have also observed dynamic complementarities between public and private R&D as well as strong effects of public R&D on TFP (Soete, Verspagen, and Ziesemer, 2022; Goodridge, Haskel and Wallis, 2024; Frontier Economics, 2024). However, these estimates focus narrowly on R&D activities and do not capture the potential stimulus to non-R&D capital investment (i.e., all capital expenditures on fixed assets—such as buildings, machinery, equipment, infrastructure, and software—that are not directly used for R&D purposes)— which may be a critical but underappreciated channel of economic impact.

Some recent macro-level studies have started to quantify the wider economic effects of public R&D. For instance, De Lipsis et al. (2023), using a Structural Vector Autoregression (SVAR) model for the United States, find that public R&D has a stronger and more persistent effect on GDP growth than other forms of government spending. However, their analysis does not disaggregate this effect by GDP components such as investment, consumption, or exports. This makes it difficult to isolate how much of the observed growth is driven by increases in business investment — and whether public R&D is directly influencing private capital formation.

In the UK, this gap in evidence is especially significant. The country has strong research capabilities but has long faced challenges in translating scientific excellence into commercial and economic returns (Dowling Review, 2015). Business investment as a share of GDP remains low compared to other advanced economies, and private investment in capital goods has been particularly weak since the 2008 financial crisis and subsequent periods of economic uncertainty (Jones, 2023). If public R&D can be shown to stimulate not only private R&D but also broader capital investment, it would strengthen the case for using innovation policy as a tool to unlock private sector growth and productivity improvements.

Research Methodology

This report adopts a two-stage empirical strategy to examine the relationship between public R&D investment and private capital investment, combining initial UK-specific time series analysis with a more comprehensive panel data approach across OECD countries. While the time series analysis provides initial insights, the limited number of annual observations constrained the robustness of these results. Consequently, the main analytical focus of the report rests on the panel data analysis, which offers broader scope, improved statistical power, and greater generalisability.

Stage 1: UK Time Series Analysis (1995–2022)

We began by exploring the UK-specific dynamics between public R&D and private capital investment using annual national accounts data. This involved:

- OLS and IV regression using patent data linked to public funding as instruments for public R&D.
- First-difference and Error Correction Models (ECMs) to distinguish short-run from long-run relationships.
- Local projection methods to estimate impulse responses and the time path of investment effects.

However, the short length of the time series and structural breaks limited our ability to identify robust leverage effects. While the methods were theoretically appropriate, these limitations meant the time series analysis served mainly as exploratory background. Results of the time series analysis are in **Annex A**.

Stage 2: OECD Panel Data Analysis (1985–2022)

Given the constraints of the UK time series, we pivoted to a panel data approach as the primary method for this study. This strategy uses an unbalanced panel of 35 OECD countries spanning nearly three decades, allowing us to:

- Pool cross-sectional and time variation for more reliable estimation.
- Control for unobserved heterogeneity across countries and time periods.
- Benchmark the UK's leverage rate against international comparators.

The panel models estimate the macroeconomic effect of public R&D on business investment in fixed capital (GFCF), controlling for a wide array of macroeconomic conditions. The details of this modelling strategy are presented in Section 2.

02. Panel data analysis

Our initial strategy for estimating the UK leverage rate relied on time series analysis using Office for National Statistics (ONS) data on Gross Fixed Capital Formation (GFCF) and public R&D expenditure. However, the limited number of annual observations severely constrained model specification and undermined the reliability of the estimates.

To address this limitation, we transitioned to a panel data approach. This method substantially increased the number of observations by incorporating variation across both time and countries, enhancing the robustness of our estimates. Panel data techniques also allowed us to better control for unobserved heterogeneity and mitigate endogeneity through appropriate instrumentation.

Despite the expanded dataset, the number of time periods remained insufficient to explore lagged effects of public R&D beyond three years. As a result, the models are unlikely to capture longer-term impacts associated with technological diffusion, which often materialise over extended horizons. It is therefore plausible that the observed effects reflect a short-term signalling mechanism—where public R&D acts as a commitment signal that prompts immediate investment responses from the private sector—rather than the full realisation of productivity-enhancing capital deepening over time.

Modelling approach

This study employs a dynamic panel data econometric model to assess the causal effect of public R&D spending on private capital investment at the macroeconomic level. The baseline model specification is as follows:

$\ln\_priv\_inv_{it} = \alpha + \rho \ln\_priv\_inv_{it-1} + \beta_{UK}(\ln\_pub\_rnd_{i,t} * UK) + \beta_{other}(\ln\_pub\_rnd_{other,t} * Other) + w'\gamma + \varepsilon_{it}$ [3.3]

In the model above, private capital investment is explained by:

- $\ln\_priv\_inv_{it-1}$ i is the lagged private capital investment at t-1, capturing persistence over time.
- α is a constant term.
- $\ln\_pub\_rnd_{i,t} * UK$: Interaction term capturing the effect of public R&D investment in the UK.
- $\ln\_pub\_rnd_{other,t} * Other$: Interaction term capturing the effect of public R&D investment in other countries.
- β_{UK}: Coefficient measuring the impact of UK public R&D investment on private capital investment in the UK.
- β_{other}: Coefficient measuring the impact of public R&D investment on private capital investment in other countries.
- w: A vector of control variables with corresponding coefficients γ.
- ε_t the error term.

Because capital investment in period t influences investment decisions in future periods (e.g. t+1, t+2), the short-run effect of public R&D can generate a lasting impact on private capital investment over time. This dynamic effect, known as persistence, means that a one-period increase in public R&D investment may not only affect current private capital investment but also shape future investment trajectories.

To assess the distinct effects of public R&D investment in the UK compared to other countries, we estimate separate effects by including country-specific dummy variables and interacting them with public R&D investment. This approach allows us to compare the responsiveness of private capital investment to public R&D investment across different economies, isolating the specific impact within the UK.

We employ a System GMM estimator, as proposed by Arellano and Bover (1995) and Blundell and Bond (1998). This approach helps address potential endogeneity, ensuring consistent and efficient estimates. Additionally, we use external instrumental variables to mitigate the endogeneity of both public R&D investment and private capital investment.

To estimate the long-run impact of public R&D, we account for the persistence of private capital investment by including a lagged dependent variable in our model. Specifically, the long-run effect can be calculated as:

$long\ run\ impact = \beta / 1 - \rho$ [3.2]

This formulation captures the cumulative effect of a one-off increase in public R&D investment over time, accounting for investment persistence. The coefficient ρ captures the persistence of investment behaviour—how much current investment depends on past levels. A high ρ

suggests that the effects of a shock (such as a rise in public R&D) will be gradually transmitted over time, amplifying the total effect. This formulation allows us to distinguish between immediate (short-run) and cumulative (long-run) effects of public R&D on private capital investment.

Model specification and overview of the data

To address the limitations of the time series analysis, we adopted a panel data approach using OECD data, which significantly increased the number of observations and enabled a more reliable and robust estimation of the UK leverage rate. We tested a series of specifications with different combinations of controls including cyclical indicators such as economic growth (using GDP, employment, and GDP per capita) and the cost of capital (proxied by long-term interest rates). We also account for labour market dynamics, competition intensity, trade openness, and exchange rates, as well as proxies for unobservable factors such as institutional quality, where data allow. The full model specification and list of control variables are detailed in **Annex Table B1**.

Summary statistics for the key variables are provided in **Table B2** in the Annex. The panel dataset includes data on private capital investment—measured by business Gross Fixed Capital Formation (GFCF)—and public R&D investment, covering up to 35 OECD countries with an average time span of 29.6 years. For the UK, private capital investment data span 1994 to 2022, while public R&D investment data extends from 1985 to 2022. All monetary variables were deflated using the GDP deflator and Consumer Price Index.

Instrumentation approach

The System GMM method enables the classification of variables as exogenous, pre-determined, or endogenous, helping to address potential endogeneity and ensure more robust estimation of the relationship between public R&D and private capital investment. Proper classification is essential to avoid biased and inconsistent results.

- Exogenous variables are those unaffected by the dependent variable and uncorrelated with the model's error term. In our analysis, long-term interest rates are treated as exogenous, as they are primarily set by central banks based on macroeconomic objectives like inflation and output gaps, rather than in direct response to changes in private capital investment. While it is true that aggregate investment (e.g., GFCF) is influenced by interest rates, the reverse relationship—from investment to interest rates—is less direct and typically operates with long lags via broader economic channels. Given the institutional independence of monetary authorities in most OECD countries, and the fact that GFCF comprises only one component of aggregate demand, interest rates can be reasonably considered exogenous within the scope of our model—particularly over short- to medium-term horizons.
- Pre-determined variables, such as public R&D spending and employment, may be influenced by past investment shocks but remain independent of current ones. For instance, governments may adjust R&D budgets in response to historical private sector

performance, and firms may change employment levels based on prior investment outcomes.
- Endogenous variables, including private capital investment, are determined within the model and correlated with the error term. Their inclusion without correction can result in biased estimates due to simultaneity or omitted variable bias.

To address this, our instrumentation strategy combines two types of instruments:

1. Internal instruments: We use deeper lags of the endogenous variables (e.g., lagged values of private capital investment and public R&D) as instruments within the System GMM framework. These help account for dynamic relationships while reducing endogeneity concerns.
2. External instruments: We incorporate patents linked to public funding as a proxy for public R&D, capturing past innovation outcomes independent of current investment behaviour.

By combining internal and external instruments, we strengthen the credibility and robustness of our estimation strategy. This dual approach allows us to isolate the leverage effect of public R&D investment on private capital investment.

As for external instruments we use the number of patents linked to public funding.[1] We believe this to be a suitable instrument which meets the conditions of relevance (correlated with public R&D spending), exogeneity (uncorrelated with the error term) and the exclusion restriction (no direct impact on GFCF). A panel-wide correlation analysis confirms the relevance condition: the relationship between public R&D investment and patents citing public funding is consistently strong across countries (above 0.80), and particularly high in the UK (above 0.90) (**Figure 2.1**). Regarding exogeneity, we find this to be likely for several reasons:

- Time lags between R&D activity and patent applications reduce the risk of reverse causality.
- Institutional independence of patent-granting bodies ensures the process is not driven by firm-specific behaviour.
- No direct feedback from private capital investment to the patenting process in the short term.

These characteristics make publicly funded patents a strong external instrument for public R&D, as they are shaped by past innovation activity and policy decisions rather than current investment dynamics.

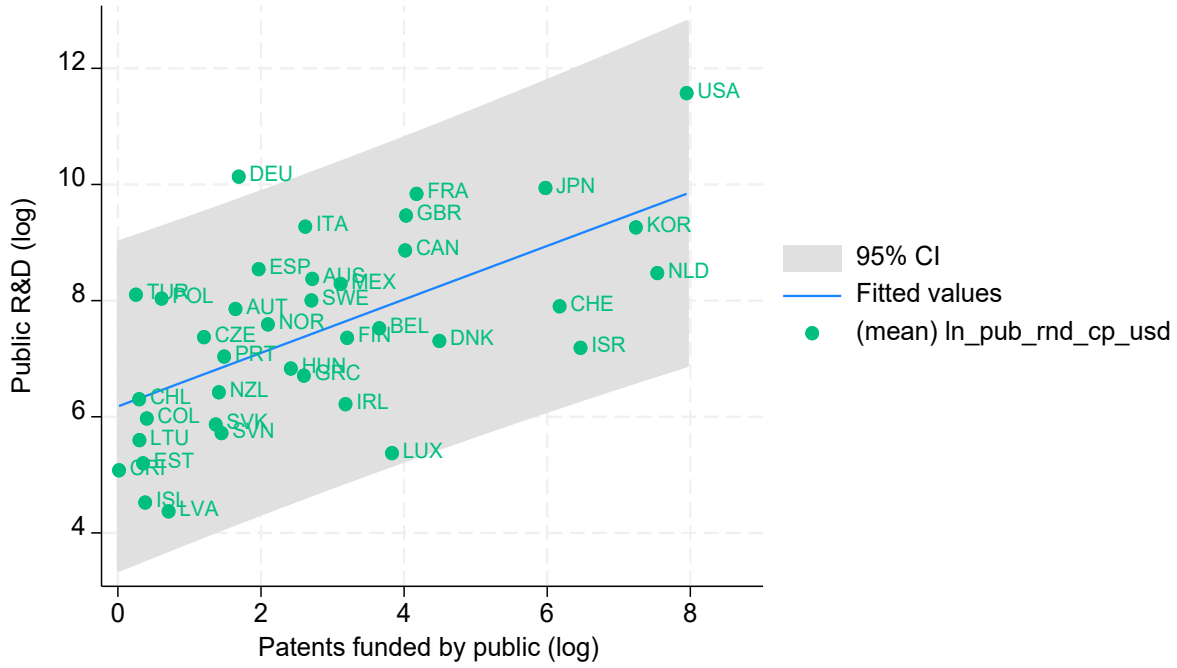
However, like all instruments, this proxy has limitations. First, patenting may lag behind public R&D by several years, introducing potential timing mismatches depending on the specification. Second, not all publicly funded research leads to patents — particularly in disciplines where publishing or open data is more common — which may introduce sectoral bias. Third, some patents may cite public funding for strategic or compliance reasons, not necessarily reflecting the causal effect of public R&D on innovation output. While these

[1] We also tested other external instruments, including business expenditure on R&D and the stock of high-tech patents.

limitations do not invalidate the instrument, they suggest that results should be interpreted with appropriate caution and in conjunction with robustness checks.

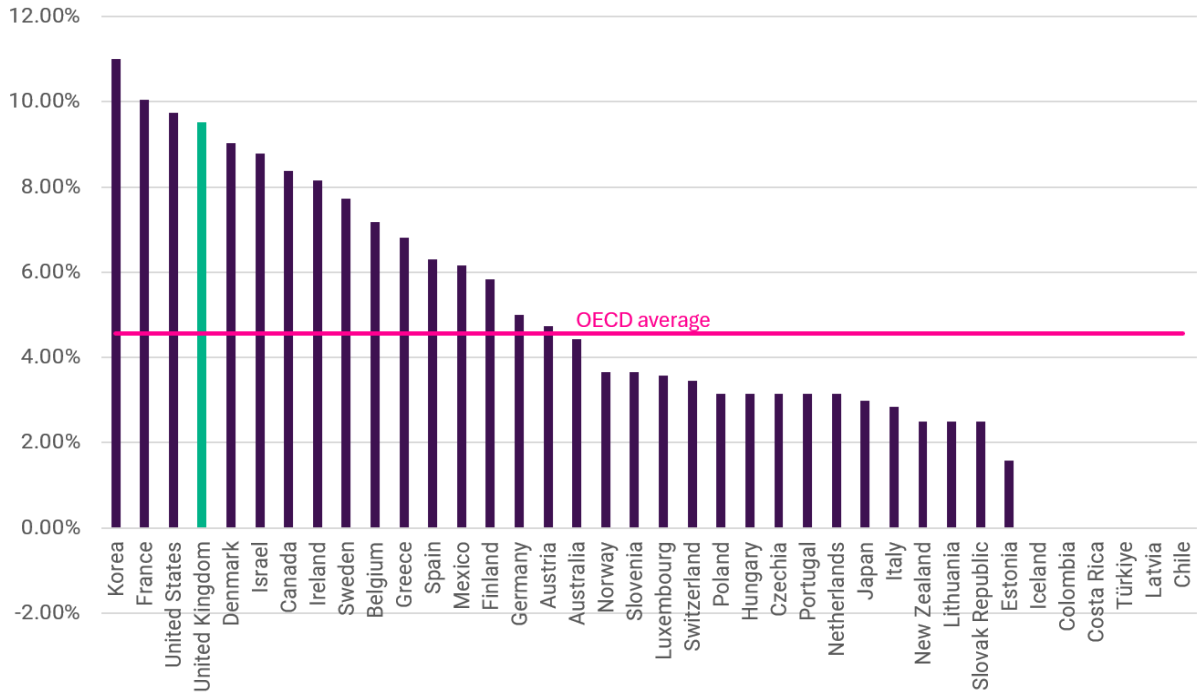
Figure 2.2 presents the average annual growth rate of patents linked to public funding across OECD countries between 1995 and 2022. The data show notable variation in performance, with South Korea and Israel leading the group, both recording growth rates above 10% per year. The United States and the United Kingdom also stand out with strong growth, around 9%, suggesting effective translation of public investment into patenting activity. Countries such as Denmark, Canada, and Ireland also perform well above the OECD average, while more modest growth is observed in France, Germany, and Japan.

Figure 2.1. Public R&D funding vs patents linked to public funding. OECD average



Note: Own elaboration based on OECD MSTI, and Patents that cite public funding. We use APIs from Lens.org to establish links between patents and public funding sources. For operationalisation of this variable look at ***Annex A***.

Figure 2.2. Average growth rate of patents linked to public funding across OECD (between 1995-2022)



Source: Own elaboration

To ensure the robustness of our findings, we implemented the following checks:

- Instrument Validity in System GMM: Non-stationary series in System GMM can weaken instrument validity, leading to inconsistent leverage estimates. Instrument effectiveness depends on stationarity, which holds in our case if the coefficient on the lagged term is less than one. Our regressions confirm this condition, as the estimated coefficient on lagged private R&D is consistently below one.
- Trend Considerations: Including a time trend variable helps account for underlying trends in investment or innovation that are not captured by other variables in the model. Failing to control for these trends can introduce bias, as it may lead to attributing long-term structural changes to the effect of public R&D. We include a trend variable (year effect) in all regressions to control for potential biases.

03. **Results**

The models presented in this section aim to provide the most robust estimate of the public R&D leverage rate in the UK from the specifications tested. To inform the choice of econometric approach, we follow a series of methodological choices. See **Annex B2** for further details on model selection. We selected the model that we believe was best specified and passed key diagnostic tests.

We estimate six preferred models to assess the relationship between public R&D and private capital investment, varying in complexity and currency specification. Models include different controls and instruments to address potential endogeneity, with interest rates treated as exogenous and key economic variables treated as endogenous. Time trends are included to control for underlying growth patterns. While USD-based estimates tend to be slightly lower due to exchange rate effects, they fall within the plausible range defined by GBP-based models. Model selection is based on statistical diagnostics, theoretical consistency, robustness, and alignment across specifications.

UK Leverage Rate Estimates

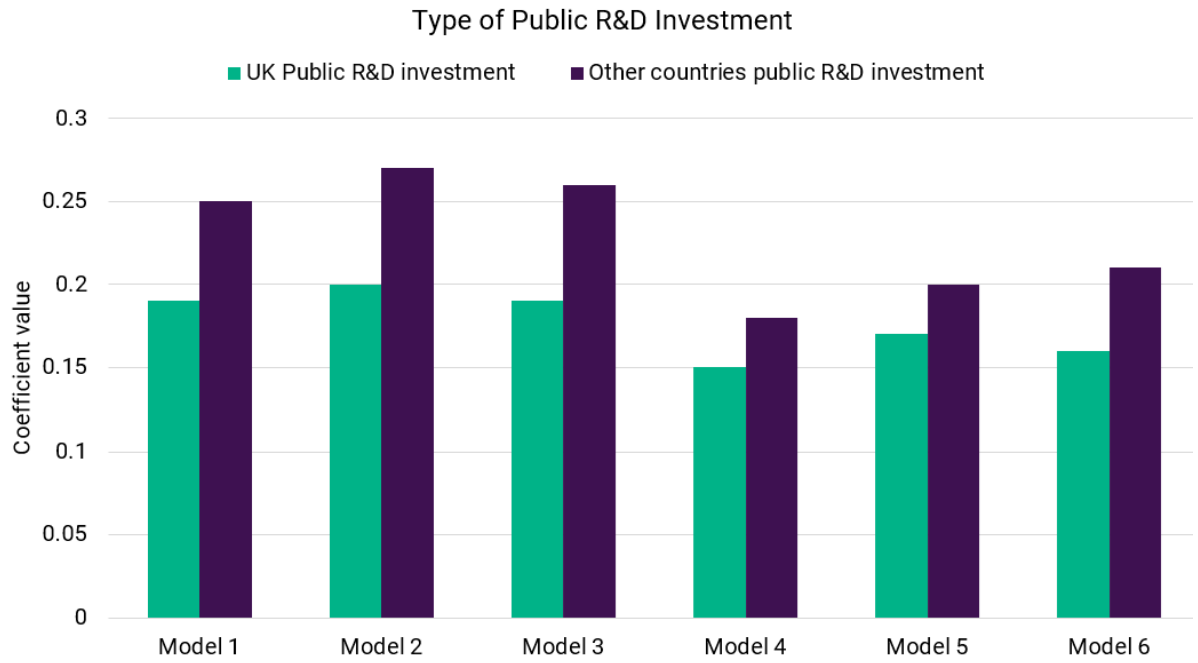
Table B6 in the Annex presents the full regression results, while **Figure 3.1** illustrates the estimated coefficients for both UK public R&D investment and other countries public R&D investment—capturing their respective impacts on UK private capital investment. It is worth noting that the coefficient on other countries public R&D may partly reflect aggregation effects. The "other countries public R&D" variable captures the combined public R&D effort of all other countries in the sample, effectively pooling a much larger volume of investment than that observed domestically. As a result, the estimated coefficient may reflect the broader scale and pervasiveness of international R&D activity, rather than a stronger per-unit impact. This does not necessarily imply that foreign R&D is more effective than UK public R&D, but rather that UK firms are exposed to and benefit from a large pool of global knowledge creation. There is also a chance that these international results are impacted by broader international economic trends that have not been controlled for. To understand the channels through which the international R&D drives UK private capital investment would require further investigation and without this a causal relationship is difficult to establish.

The results indicate that the short-run UK leverage rate, reflected in the coefficient on UK public R&D, ranges from 0.15 to 0.20 and is statistically significant at the 5% level across all model specifications. This means that a 1% increase in UK public R&D investment is associated with a 0.15% to 0.20% rise in private capital investment within the same year. These estimates are broadly consistent with findings across the wider OECD, where short-run leverage rates typically range from 0.18 to 0.27.

Beyond the short-run effects, the coefficient on lagged private capital investment captures the persistence of investment behaviour, providing insight into the long-run impact of public R&D. Our results suggest an increase in capital investment drives further investment in subsequent years. Quantitively our results suggest a one-off 1% increase in private capital investment is associated with between a 0.65% and 0.77% increase in private capital investment in the next year, holding other factors constant. Therefore, when a 1% rise in public R&D drives an initial

0.15% to 0.20% rise in private capital investment it also drives a further 0.11% to 0.16% increase the following year. These effects compound over time, gradually diminishing as the initial stimulus works through the economy.

Figure 3.1: Public R&D investment impact on private capital investment



Notes: Dependent variable: Private capital investment GFCF (log). *Monetary variables specified in GBP (Model 1, 2 and 3) and USD (Model 4, 5, and 6) and deflated using GDP deflator. Models based on regression results in* ***Table B6****, in the Annex.*

Our analysis also indicates that the long-run cumulative impact of public R&D on private capital investment is approximately twice the short-run impact. Specifically, a 1% increase in public R&D spending leads to a cumulative 0.58% to 0.68% rise in private capital investment over 10 to 16 years. By model design, most of this response happens early on as persistence wanes after the initial impact occurs.

While this dynamic modelling provides a valuable estimate of long-run impact, this figure carries greater uncertainty than the short-run estimate. The short-run effect, observed within the same year and consistently statistically significant across all models, is the most reliable figure. By contrast, the long-run estimate is based on the assumption that current patterns of investment persistence continue over time. It should be seen as an indication of the potential scale of returns, contingent on stable policy and stable macroeconomic conditions.

Time profile of the impacts: How does this relationship evolve over time, and what is the scale of its long-term impact?

The dynamic specification allows us to trace how the impact of public R&D on private capital investment evolves over time. In our models (presented in **Table B6** in the Annex), persistence in investment behaviour is already embedded through the inclusion of a lagged dependent variable. This captures the idea that current levels of private capital investment are partly shaped by past investment decisions.

This enables us to estimate the cumulative effect of a one-time increase in public R&D over multiple years. The time profile of the impact is derived using a recursive formula that combines:

- the direct short-run effect of public R&D (i.e., the estimated coefficient), and
- the indirect effect that plays out over time due to the persistence of private capital investment.

This allows us to estimate a time profile of the impact, represented as a curve in which each line corresponds to a different model specification. These specifications vary in terms of both the estimated direct impact of public R&D and the degree of persistence (ρ) in private capital investment.

The long-run impact of public R&D on private capital investment is derived using the following formula:

$$\sum_{j=0}^{t} \beta \rho^{j}$$

This equation reflects how the effect of public R&D propagates over time, capturing the cumulative influence across multiple periods. To assess the time required for the impact to fully materialise, we use the 99% threshold of the total estimated effect as a benchmark. This threshold provides an evidence-based measure of how quickly public R&D stimulates private capital investment, offering insights into both the lag structure and the duration of its impact.

Table 3.1 presents the impacts and periods to realise 99% of the impact. The results indicate that the effect accumulates gradually, with variations in both the speed and magnitude of the impact depending on the model parameters.

- Models with lower persistence (ρ) indicate that private capital investment adjusts more quickly to changes in public R&D investment, with the full impact typically stabilising within around 10 years.
- Models with higher persistence show a more prolonged effect, with investment levels continuing to adjust beyond 15 years before reaching equilibrium.[2]

[2] It is important to highlight that the "Time to 99% Impact" does not imply a delayed effect starting in 10+ years. Rather, it reflects how the initial public R&D shock continues to influence investment over time, with most of the response occurring early and gradually tapering off.

- The 99% threshold, represented by the dashed line, marks the point at which nearly all of the impact has materialised. In most cases, this occurs within 10-15 years, though some models indicate a longer adjustment period.
- It is worth noting that the elasticities estimated in USD typically fall near the lower bound of the confidence intervals of the GBP-based estimates. Although both models rely on the same real values (deflated using GDP deflators), expressing variables in USD introduces exchange rate fluctuations that capture broader macroeconomic dynamics. These currency fluctuations can slightly influence the estimated size and timing of the effects, because the models used are sensitive to how investment patterns change over time and how well the data captures those relationships. Accordingly, we interpret the GBP and USD estimates as jointly defining a plausible range of elasticities.

By explicitly accounting for investment persistence and dynamic propagation, this approach provides a more comprehensive assessment of how the immediate impacts of public R&D on private capital investment reverberate over time, helping policymakers better understand the time horizons needed for R&D policies to yield their full economic benefits.

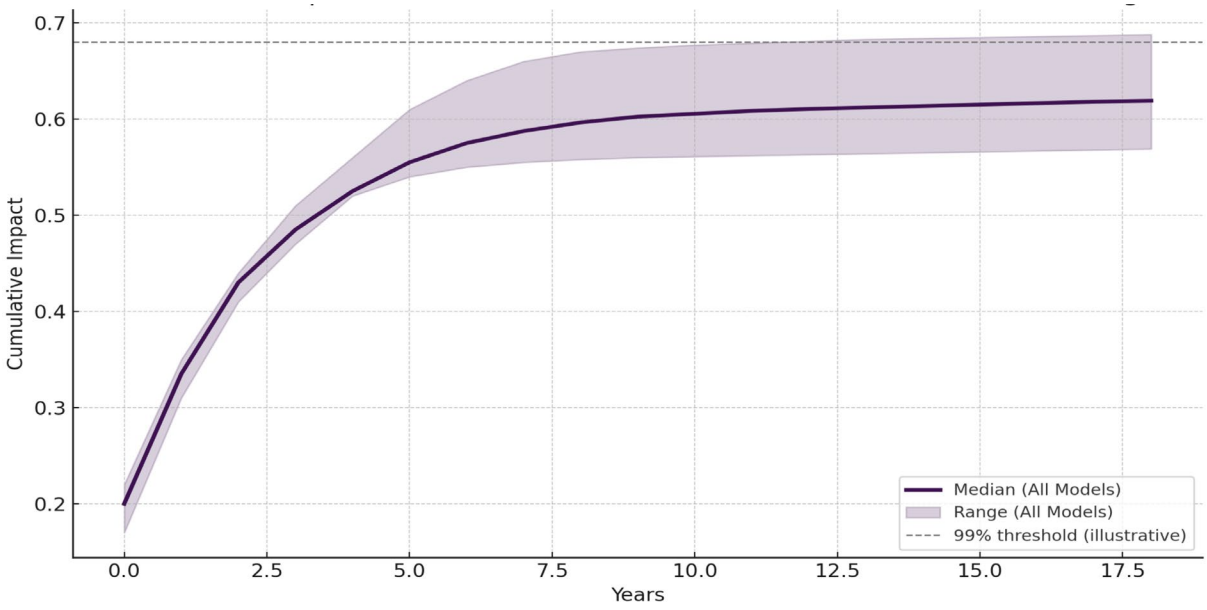
Table 3.1. Level of persistence, long run impact and time to full impact realisation

Model	Persistence (ρ)	Elasticity (β)	Long-run Impact	Time to 99% Impact (TTT)
Model 1	0.67	0.19	0.58	11 periods
Model 2	0.65	0.20	0.57	10 periods
Model 3	0.66	0.19	0.56	11 periods
Model 4	0.77	0.15	0.65	17 periods
Model 5	0.75	0.17	0.68	16 periods
Model 6	0.74	0.16	0.68	16 periods

*Note: Models are based on results in **Table B6** of the Annex.*

Figure 3.2 illustrates the cumulative impact of public R&D on private capital investment across different model specifications.

Figure 3.2. Time profile of the impacts of public R&D on private capital investment



Notes: *This chart shows how public investment in research and development (R&D) influences business investment over time. The purple line shows the typical (or median) response based on different economic models. The shaded area around it shows the range of possible outcomes depending on assumptions in each model. Rates accumulated over time by employing the models found in* ***Table B6*** *of the Annex.*

Robustness checks

We conducted a set of robustness checks to assess the reliability of our findings. These included alternative static and pooled panel specifications, tests for Nickel bias using dynamic panel methods, and re-estimations with restricted samples and alternative weighting schemes. We also assessed the influence of individual countries and tested the sensitivity of our results to different instrumental variables. Across all these tests, our core findings remained consistent. Full details of each robustness check are provided in **Annex B3**.

04. How does the impact differ across countries?

The panel data approach allows us to estimate leverage rates for individual countries and to test whether these rates differ meaningfully. In Section 3, we introduced an interaction term

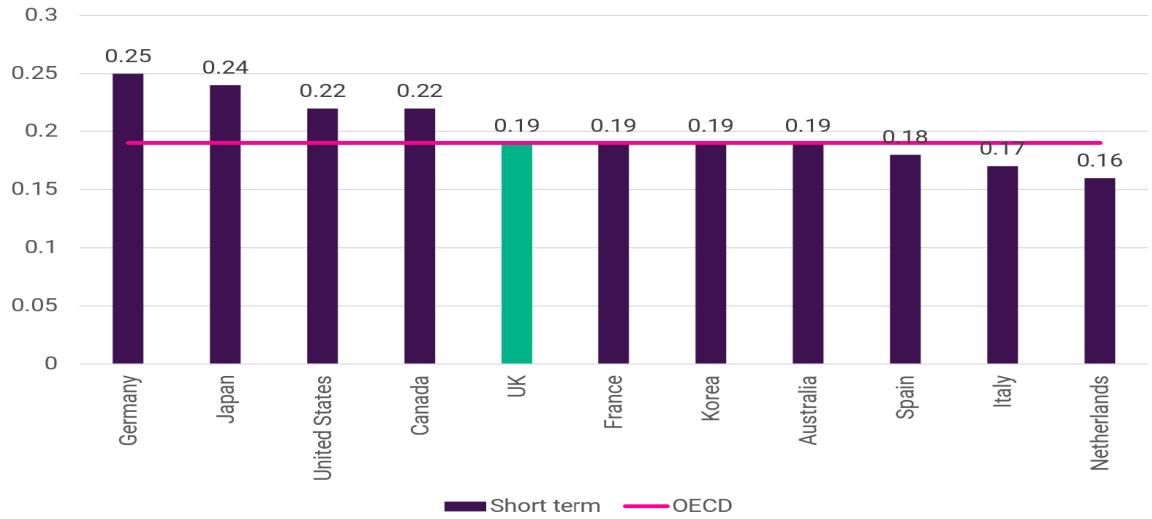
for the UK to separately estimate the effect of public R&D on private capital investment in the UK, compared to other OECD countries. We now build on this by including interaction terms for each country as separate explanatory variables. This enables us to estimate a distinct leverage rate for every country in the sample and assess whether these rates differ from the average effect. To ensure fair comparisons, all countries share the same set of control variables. Only public R&D investment is interacted with country-specific terms, allowing us to isolate and examine differences in how public investment influences private investment across countries

Table B7 in the Annex presents results for selected OECD countries, showing that lagged private capital investment has a strong, positive, and statistically significant effect across all countries (coefficients between 0.64 and 0.72). Both domestic and foreign public R&D are positively associated with UK private capital investment, with the effect of foreign public R&D consistently significant. While this may reflect the influence of international research activity on UK firms' investment decisions, possibly through exposure to global technologies, participation in international supply chains or collaboration with multinational partners, it could also be influenced by broader global economic trends and modelling limitations. The international association is contemporaneous but may also capture responses to the cumulative effect of past foreign R&D efforts, or expectations about the future direction of innovation shaped by international trends. Employment growth generally supports investment, though significance varies, while interest rates and market concentration show no consistent or significant effects. Diagnostic tests (AR2 and Hansen) support the validity of most models, with a few exceptions requiring caution. Overall, the results underscore the persistence of private capital investment, and the importance of both domestic and international public R&D.

The time profile analysis of the cumulative impact of public R&D on private capital investment reveals significant variation across countries in both the magnitude and speed at which the effect materialises. Countries with higher persistence coefficients (ρ), such as Japan (ρ=0.72), the United States (ρ=0.70), and Canada (ρ=0.70), experience a more prolonged accumulation of impact, taking 12 to 14 periods to reach 99% of their long-run impact. In contrast, countries with lower persistence (ρ), such as Italy (ρ=0.64) and the UK (ρ=0.66), see a quicker realisation of the total impact, reaching 99% within 10-11 periods.

The UK's short-term impact of public R&D on private capital investment (0.19) is moderate, matching countries such as France (0.19) and Korea (0.19), and in line with the OECD average (0.19). However, it trails behind top performers like Germany (0.25), Japan (0.24), and the United States (0.22), as shown in **Figure 4.1**. At the same time, the UK outperforms several peers, including Spain (0.18), Australia (0.18), Italy (0.17), and the Netherlands (0.16). This suggests that in the immediate term, public R&D investment in the UK stimulates private sector responses at a reasonable level, though not as effectively as in leading innovation economies. The relatively stronger short-term effects in Germany and Japan may indicate more efficient mechanisms for translating public R&D funding into business investment, possibly through targeted policies, financial incentives, or stronger institutional linkages.

Figure 4.1. Short term impacts of public R&D on private capital investment across different countries



*Notes: Short-term impacts based on results in **Table B6** of the Annex. Coefficients for Italia and Australia are statistically insignificant.*

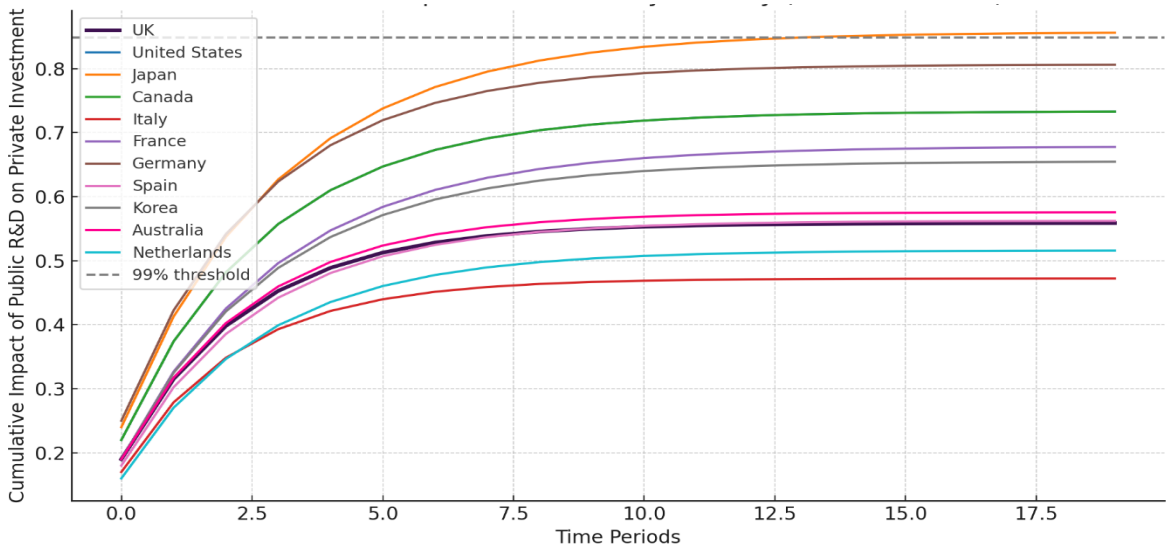
In the long term, however, the UK's performance is notably lower, with an accumulated impact of 0.56 — well below the OECD average and significantly behind countries such as Japan (0.86), Germany (0.81), and the United States (0.73), as shown in **Figure 4.2**. This suggests that while public R&D investment in the UK does initially stimulate private sector responses, its effects appear to weaken over time relative to other advanced economies. This pattern appears to be driven by generally lower persistence in UK business investment, rather than a lack of responsiveness to public R&D per se. By contrast, countries such as Canada (0.73) and France (0.68) also show a more sustained long-term relationship between public and private investment.

Figure 4.2. Long term impacts of public R&D on private capital investment across different countries

*Notes: Long-term impacts based on results in **Table B6** of the Annex. Coefficients for Italia and Australia are statistically insignificant.*

Figure 4.3 summarises the corresponding time profiles for all countries in the sample.

Figure 4.3 Cumulative impact over time by country (first 20 years)



*Notes: Time profile based on results in **Table B6** of the Annex. The 99% threshold represents the point at which 99% of the long-run cumulative impact of public R&D on private investment is estimated to have been realised for each country. Note that the line for the US overlaps with Canada.*

While the reasons for this pattern are not directly tested in this study, one possible explanation is that the UK faces structural barriers to sustaining long-term momentum in business investment. These may include policy uncertainty, limited absorptive capacity in industry, or weaknesses in complementary areas such as access to finance and workforce skills. Although the UK performs better than countries such as Italy (0.47) and the Netherlands (0.52) on both short- and long-term measures, its relative underperformance compared to higher-ranked economies suggests a need for additional support to enhance the long-term impact of public R&D investment. Further analysis is needed to disentangle the drivers of heterogenous investment persistence before drawing causal conclusions.

05. **Conclusions**

This report provides an exploratory, data-driven assessment of the relationship between public R&D investment and private capital investment, both in the UK and across OECD countries. The main research question of this report is: *does public investment in research stimulate business investment in private capital, that are critical for embedding innovation into the wider economy?*

This relationship has received limited attention in previous research, largely due to the lack of suitable macroeconomic data and methodological challenges in isolating causality. Capturing the connection between public R&D funding and business capital investment decisions over time is inherently difficult. As such, this report represents an initial step toward building the evidence base in this area. Due to data limitations, we were unable to assess delayed investment responses driven by longer-run technological change. As such, this report focuses on the immediate impacts of increased public R&D spending, likely driven by signalling effects.

The findings suggest there is a statistically significant association between public R&D investment and private capital investment. In the UK, a 1% increase in public R&D is associated with a 0.15% to 0.20% increase in private capital investment in the same year. These short-run effects point to the potential signalling role of public R&D, encouraging firms to invest in complementary assets. Over the long term—10 to 16 years —the cumulative impact rises to between 0.58% and 0.68%, driven by investment persistence. It is important to note that this reflects the accumulation of short-term positive effects, rather than an acceleration of the impact in later years.

However, while these results indicate a positive relationship, there is some uncertainty about the precise magnitude of the effect. Confidence intervals vary, and the nature of the available data—particularly the reliance on annual observations and country-level aggregates—limits our ability to fully capture the timing and scale of investment responses. These estimates should therefore be viewed as indicative rather than definitive. Improving the precision and robustness of these findings, as well as expanding to examine the impact of technological change, will require further work.

Cross-country comparisons show that UK public R&D performs moderately well in leveraging private capital investment in the short term, outperforming countries such as Spain and Italy, but falling behind long-run leaders like Germany, Japan, and the United States. The UK's cumulative leverage rate flattens earlier than in these countries, which may indicate less sustained private investment responses to public R&D. However, this pattern could reflect broader differences in capital investment persistence rather than shortcomings in the UK's R&D environment alone. Factors such as macroeconomic conditions, policy stability, institutional settings, or access to complementary assets like skilled labour and finance may also play a role. Further analysis is needed to disentangle these effects and better understand the sources of heterogeneity in persistence rates before drawing specific policy conclusions.

The study also finds that international public R&D spending has a strong and consistently positive association with UK private capital investment—comparable in scale to the effect of domestic public R&D. While this may reflect the UK's exposure to global technological developments, it could also be influenced by broader global economic trends, modelling limitations, or aggregation effects from the way the foreign R&D variable is constructed. Although international knowledge diffusion may contribute to this relationship, the precise channels through which foreign public R&D affects UK investment remain outside the scope of this study and represent a valuable direction for future research.

We also explored the role of other macroeconomic factors. Employment growth was consistently associated with higher levels of private investment, while interest rates and market concentration had mixed or negligible effects. This variation across countries reinforces the idea that the effectiveness of public R&D depends not only on funding levels, but also on broader economic conditions and the structure of national innovation systems.

This analysis has several limitations. While the use of annual data restricts our ability to observe short-term investment dynamics or within-year fluctuations, a more fundamental challenge is the lack of clarity around what types of capital are being invested in. GFCF captures total business investment in fixed assets, but does not disaggregate by sector or investment type — making it difficult to trace how public R&D translates into specific capital responses (e.g., in machinery, infrastructure, or new technology). Unlike the US, which benefits from quarterly R&D data, most countries — including the UK — lack high-frequency or sector-linked statistics on public R&D and business investment. Future improvements in data availability, including more granular and timely R&D metrics, would help refine these estimates. In addition, linking firm-level investment records with public funding flows, or analysing sector-specific capital trends alongside public research activities, would provide richer insight into how different parts of the economy respond to public R&D spending.

We see this report as a starting point. Further work is needed to strengthen the methodology and build confidence in the findings. Future analysis would benefit from more detailed, disaggregated data—particularly by asset type, region, and sector—to better identify where public R&D has the strongest impact. In particular, separating GFCF into technology-related and other forms of investment would help refine the methodology and better capture the specific channels through which public R&D influences private capital formation. Patterns of capital investment likely vary between industries, such as high-tech manufacturing and

services, and across regions with differing research strengths. Linking public R&D to business- and place-level outcomes, and improving measures of innovation intensity, would help refine estimates and support more targeted, effective policy.

In summary, the study presents early evidence that public R&D investment may help to crowd in private capital investment, and that this effect accumulates over time. While the findings are exploratory, they support the case for viewing R&D policy not only as a tool for innovation, but also as an important lever for long-term economic growth.

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