

Annex A – Times Series analysis

Time series analysis

Our initial approach to assessing the relationship between private capital investment, and public R&D investment relied on time series analysis of ONS data. Given the availability of time series data, we applied econometric methods to capture and measure how changes in public R&D investment, and other factors influence private capital investment over time.

Private capital investment is not expected to fully respond instantaneously to public R&D investment, as technological change and the adoption of new innovations typically take time to influence firm behaviour. Investment decisions often require planning, budgeting, and alignment with broader market conditions. However, due to limitations in the time series dataset, we are unable to analyse the full lag structure typically associated with these dynamics. As a result, our analysis focuses on the immediate response – which, rather than reflecting the long-run effects of technological change, may instead capture short-term signals from government commitment to R&D spending.

Overview of the data

Variable definitions

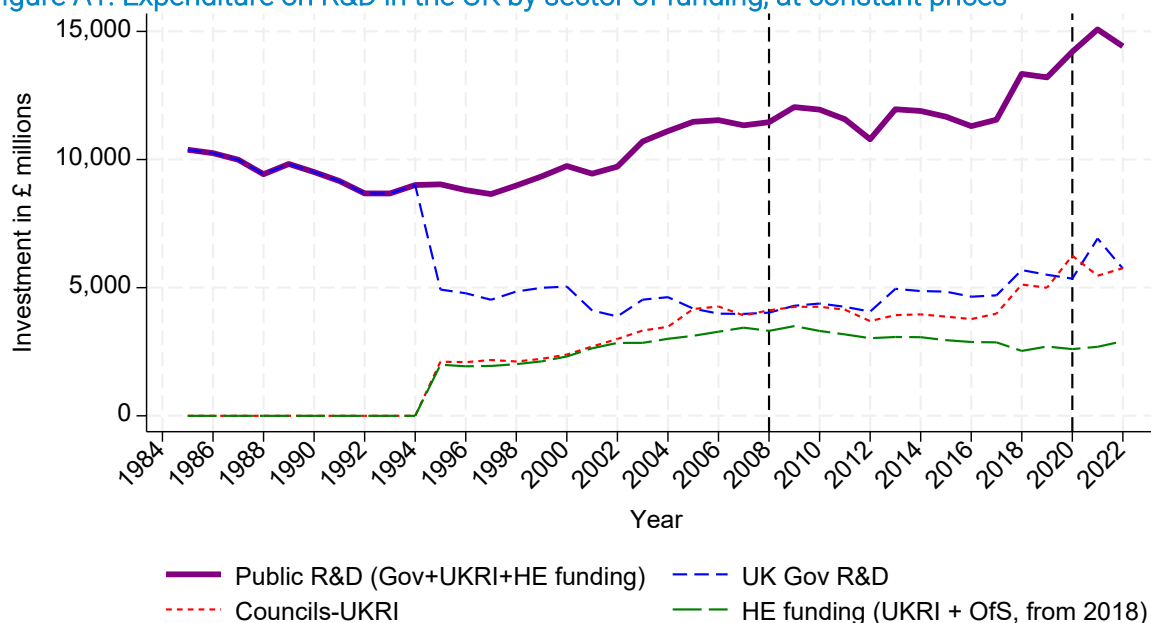
Public R&D: In the UK this refers to research and development (GERD) funded by the government. This can be funded through UK Research and Innovation (formerly the individual research councils), the Higher Education Funding Councils (HEFC) or central government itself. GERD data funded by the government has been collected since 1981, while data from UKRI/research councils and HEFC began in 1995. This dataset will cover the period from 1995 to 2022.¹

Figure A1 presents a line chart showing trends in UK public R&D investment by funding source from 1984 to 2022. The data highlight a steady upward trajectory, particularly from the mid-2000s onward.

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<https://www.ons.gov.uk/economy/grossdomesticproductgdp/compendium/unitedkingdomnationalaccounts/bluebook/2023/supplementarytables>

Figure A1. Expenditure on R&D in the UK by sector of funding, at constant prices



Source: Own analysis of ONS data. Data at constant prices of 2024 using ONS GDP deflators. Dashed lines mark the 2008 Financial Crisis and 2020 Covid Pandemic.

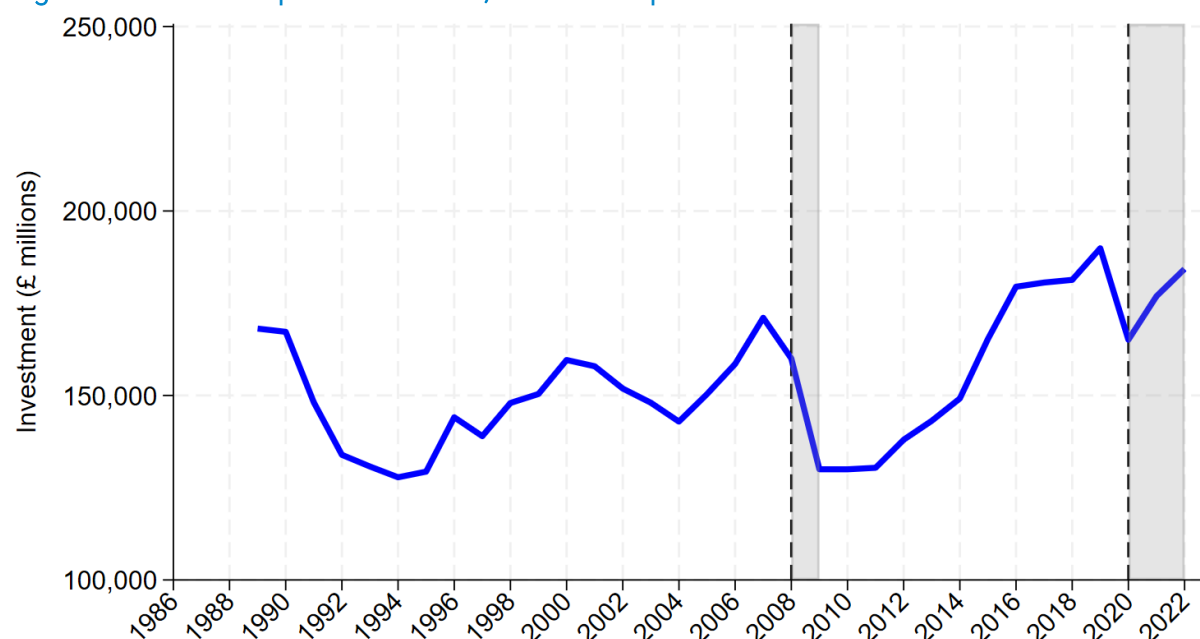
Private capital investment: Annual private capital investment data from the ONS, specifically gross fixed capital formation (GFCF) by the corporate sector. This includes financial and non-financial corporations. ² Existing data cover the period 1989 to 2022.

Figure A2 illustrates the trend in corporate capital investment in the UK from 1986 to 2022, measured in £ millions. The blue line shows a general upward trajectory over time, with periods of fluctuation. Investment grew steadily in the 1990s, experienced a dip around the 2008–2010 financial crisis, and then resumed growth through the 2010s. After a decline in 2020, likely reflecting the impact of the COVID-19 pandemic, corporate investment rebounded strongly, reaching its highest level in 2019. Vertical dashed lines highlight key economic turning points. Data is sourced from the ONS Blue Book in constant prices.

²

<https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/grossfixedcapitalformationbysectorandasset>

Figure A2. Private Capital Investment, at constant prices



Source: Own analysis of ONS data. Dashed lines mark the 2008 Financial Crisis and 2020 Covid-19 Pandemic.

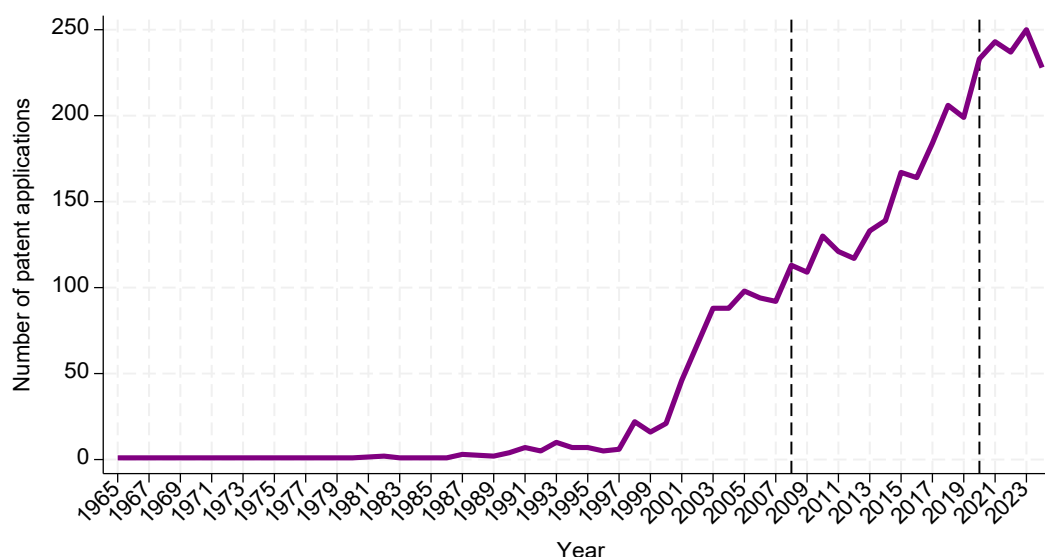
Technologically embedded R&D output: We proxy this relationship using patents that cite government grants. Specifically, we used detailed patent-level data that links patents to public R&D funding, incorporating both the number of patents and their citation counts into our estimations. This involved systematically cross-referencing government funding programmes with the text and metadata of patent documents.

To achieve this, we use application programming interfaces (APIs) from Lens.org to establish links between patents and public funding sources. Lens.org is a comprehensive repository of bibliometric and patent data, integrating non-patent literature (NPL) citations to track science-to-technology knowledge spillovers. The platform hosts data on approximately 130 million patents and identifies scholarly references within patent documents. Lens.org sources bibliometric data primarily from Microsoft Academic and patent data from nearly 100 jurisdictions, including the EPO, USPTO, WIPO, and IP Australia, making it particularly well suited for assessing the impact of publicly funded research on technological innovation. To match patents to funders we use a dictionary of all R&D institutions (see Annex C).

Figure A3 shows the number of UK patent applications linked to public funding from 1965 to 2023. The purple line highlights a relatively flat trend until the late 1990s, followed by a sharp and sustained increase from around 2000 onwards. This suggests a combination of the growing role of public R&D funding in stimulating patentable innovation, along with broader shifts in IP culture—including institutional reforms, simplified application processes, and

heightened awareness—has contributed to the observed trends (Geuna & Rossi, 2011³; OECD, 2009⁴). The peak in patent activity occurs in the early 2020s, with a slight dip in the most recent years. Overall, the trend indicates a steady increase in patent-based innovation outputs arising from publicly funded research over the past two decades.

Figure A3. Patents applications linked to public funding



Source: Own analysis of patents data. Dashed lines mark the 2008 Financial Crisis and 2020 Covid Pandemic.

Table A1 below presents the summary statistics of the variables used in the modelling. Variable operationalisation is presented in Table A2.

Table A1. Summary statistics: UK time series regressions

Variable	Mean	Min	Max
Private capital investment (£, mn)	153,846.50	127,824.60	189,895.00
Public R&D (£, mn)	7,473.04	5,859.95	10,310.61
TFP (Index)	93.51	82.85	100.00
Patents linked to public funding (number)	99.59	2.00	250.00
GDP per hour worked (£)	54.75	44.19	60.48

³ Geuna, A., & Rossi, F. (2011). Changes to university IPR regulations in Europe and the impact on academic patenting. *Research Policy*, 40(8), 1068–1076. <https://doi.org/10.1016/j.respol.2011.05.004>

⁴ OECD. (2009). *University technology transfer and the role of public research institutions*. In *OECD Science, Technology and Industry Scoreboard 2009* (pp. 70–71). OECD Publishing. https://doi.org/10.1787/sti_scoreboard-2009-en

Table A2. Description of variable definitions and data sources

Variable	Description	Source
Private capital investment	Business gross fixed capital formation (GFCF), measuring private sector investment in physical capital (machinery, building and infrastructure) as well as investment in intangible assets, specifically intellectual property products such as Research and Development, mineral exploration, software, and databases.	OECD MSTI, ONS Blue Book
Public R&D investment	Government-financed gross domestic expenditure on R&D (GERD), excluding higher education institution funding.	OECD MSTI, ONS
Employment growth	Annual percentage growth in employment, indicating labour market expansion.	OECD Employment Database
Interest rates	Long-term interest rates, representing the cost of capital for firms.	OECD Main Economic Indicators
GDP	Total gross domestic product in constant prices, used to capture economic scale.	OECD National Accounts
GDP growth	Annual percentage change in GDP, indicating macroeconomic growth conditions.	OECD National Accounts
Exchange rate (USD)	Exchange rate of national currency against the US dollar.	OECD Exchange Rate Statistics
Market concentration (HHI)	Herfindahl-Hirschman Index (HHI), measuring market concentration and competition levels.	OECD STAN Indicators
Patents linked to public funding	Number of patents citing government funding sources, used as an instrument for public R&D investment.	Lens.org via API; compiled by authors

Model

Our model considers the dynamic effects of public R&D on private capital investment, estimating the following:

$$\ln_{\text{priv_inv}}_t = \beta \ln_{\text{pub_rnd}}_t + w'\gamma + \varepsilon_t \quad [1]$$

Where $\ln_{\text{priv_inv}}_t$ is the dependent variable, private capital investment at time t , $\ln_{\text{pub_rnd}}_t$ is the key explanatory variable, referring to public R&D, β is the key coefficient of interest. Variables in w are controls with coefficients γ , and ε_t is an error term. All variables are measured over time t . All models examined in this section of the analysis are basic regression models, which do not incorporate control variables unless explicitly mentioned.

Equation [1] allows us to quantify how changes in public R&D relate to private investment decisions over time. However, estimating a causal effect of public R&D is complicated by potential endogeneity of $\ln_{\text{pub_rnd}}_t$. For example, public R&D may respond to trends in private investment, or both may be influenced by unobserved factors. In such cases, the coefficient β cannot be given a causal interpretation if estimated by OLS.

The coefficient β maps the response of $\ln_priv_inv_t$ to changes in $\ln_pub_rnd_t$. However, since $\ln_pub_rnd_t$ is endogenous, a direct causal interpretation of β is not possible. If an instrument z_t is available, $\ln_pub_rnd_t$ can be instrumented with z_t , enabling the use of Instrumental Variables (IV) to derive causal interpretations.

To address this, we rely on an Instrumental Variables (IV) strategy. If a valid instrument z_t exists—i.e., a variable that is correlated with $\ln_pub_rnd_t$ but uncorrelated with ε_t —we can instrument $\ln_pub_rnd_t$ using z_t and recover a consistent estimate of β , thus allowing for causal inference on the impact of public R&D on private capital investment.

In this analysis, we use patents that cite public funding as an external instrument. To be an appropriate instrument, it must satisfy two key criteria. Firstly, relevance — the instrument must be correlated with the independent variable of interest, which in this case is public R&D investment. This condition is clearly met, as patents linked to public funding are a measurable and direct output of prior public R&D activity. Empirical evidence shows a strong and consistent correlation between these patents and public R&D spending.

Secondly, the exclusion restriction requires that the instrument—patents linked to public funding—affects private capital investment (GFCF) only through its association with public R&D expenditure, and not through any other channel. We argue that this condition is plausibly satisfied in our setting for several reasons. First, the patenting process is inherently lagged relative to both R&D funding and investment activity, reducing the likelihood of reverse causality—i.e., current private capital investment influencing patent outcomes. Second, patents are granted by independent institutions, largely insulated from short-term business investment decisions or macroeconomic fluctuations. Third, patents that cite public funding capture the knowledge-generating effects of R&D, rather than direct financial transfers, and are not themselves a component of capital formation. This makes them a theoretically coherent and empirically grounded proxy for public R&D activity, satisfying the requirement that they influence GFCF only through their effect on public R&D. Taken together, these characteristics support the validity of the exclusion restriction in our instrumental variable approach.

The leverage rate

The coefficient β represents the elasticity of private capital investment with respect to public R&D, as both variables enter the model in logarithmic form. This elasticity can also be interpreted as a *leverage rate*—that is, the percentage change in private investment associated with a 1% change in public R&D. A positive and statistically significant β suggests that increases in public R&D are associated with increases in private capital investment, indicating a potential crowding-in effect. Conversely, a negative value could point to crowding-out. Understanding the magnitude of β is therefore critical for assessing the impact of public R&D policy in stimulating complementary private investment.

Model selection

This section estimates the impact of public R&D on private capital investment in the UK (1995-2022). All variables are in constant prices using the GDP deflator.

To derive the most accurate estimate of the UK's private capital leverage rate, we began by identifying the most suitable model specification based on the characteristics and limitations of the available data. Table A3 presents correlation coefficients between the main variables of interest. Notably, public R&D investment (*ln_pub_rnd*) and total factor productivity (*TFP*) exhibit a high positive correlation. Due to the risk of multicollinearity, these variables cannot be included simultaneously in the regression model, as doing so would undermine the reliability of coefficient estimates and obscure the distinct contribution of public R&D.

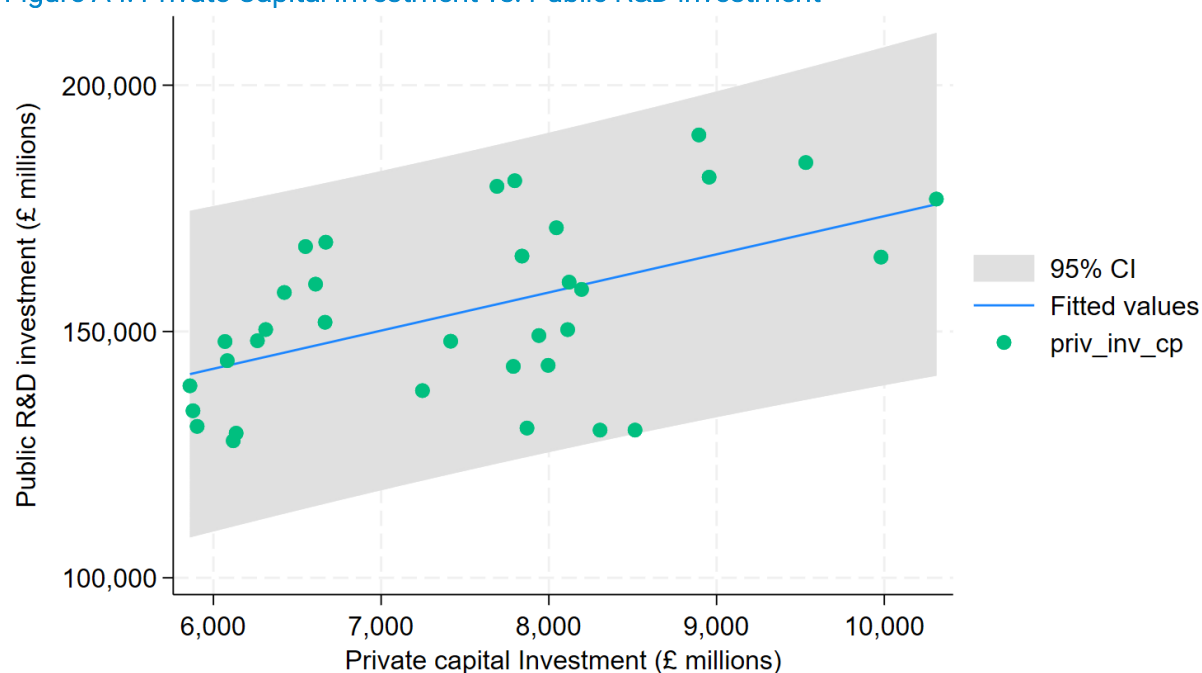
Table A3. Pairwise correlation table

	(1)	(2)	(3)	(4)	(5)
(1) Private capital investment	1				
(2) Public R&D	0.52***	1			
(3) Patents	0.58***	0.93***	1		
(4) GDP per hour worked	0.54***	0.88***	0.92***	1	
(5) TFP (index)	0.53***	0.86***	0.89***	0.97***	1

* $p < .1$, ** $p < .05$, *** $p < .01$

Figure A4's scatter plot shows the link between private investment (x-axis) and public R&D investment (y-axis). Each green dot is the annual figure for the two variables, while the blue line represents the fitted linear regression trend. The grey shaded area around the line indicates the 95% confidence interval. The positive slope suggests that higher private investment is correlated with higher public R&D investment.

Figure A4. Private Capital Investment vs. Public R&D investment



Source: Own elaboration based on ONS data and Blue Book. Data on public R&D investment in constant prices using GDP deflator

Results

Table A4 presents the results of time series Ordinary Least Squares (OLS) and Instrumental Variable (IV) regression models using various lags. These models estimate the relationship between private capital investment and public R&D investment.

The first column reports a simple OLS regression, which suggests a positive relationship between public R&D and private capital investment. However, the potential for two-way causality between these variables can lead to biased and inconsistent OLS estimates. To address this, we use instrumental (or proxy) variables to isolate exogenous variation in public R&D. Specifically, we incorporate two types of instruments: (i) past values of public R&D, which help account for dynamic relationships, and (ii) patents that cite public funding, which serve as an external instrument. These patents are a measurable output of prior public R&D activity and are plausibly exogenous to current private investment behaviour, helping to mitigate simultaneity bias and strengthen the identification of causal effects.

Columns 2 and 3 present the instrumental variable estimations, where private capital investment (in logs) is regressed on public R&D investment. The results indicate a positive and statistically significant relationship. First stage regressions are presented in **Table A5**.

Despite these findings, time series approaches have inherent limitations. While the models in columns 1 to 3 suggest a statistically significant relationship between private capital investment and public R&D investment, there is a risk of spurious regression—where statistical relationships emerge simply because the variables follow similar trends over time rather than due to a true causal link. This issue arises when variables exhibit unit roots, which can lead to invalid regression estimates.

To ensure the robustness of our results, we tested the time series data for stationarity—assessing whether the variables exhibit a long-run equilibrium trend. The Augmented Dickey-Fuller and Phillips-Perron tests indicate that public R&D and private capital investment suffer from unit roots. To address the risk of spurious regression, we re-specified our model using first differences of the logarithms (i.e., growth rates instead of levels).

Columns 4 to 7 in **Table A4** present IV models with the re-specified data, while Columns 8 to 11 report regression estimates using Error Correction Models (ECM) to capture potential long-term cointegration between private capital investment and public R&D investment.⁵ These models did not find a statistically significant relationship.

⁵ Error Correction Models (ECMs) are a type of time series model that capture both the short-term dynamics and long-term equilibrium relationship between variables, allowing for adjustment when variables deviate from their long-run path

Despite applying a range of time series techniques to UK data in growth rates, we were unable to obtain satisfactory, robust models.

Table A4. Results of time series OLS and Instrumental Variable (IV) regressions methods and ECM, using various lags

Dependent variable: Private GFCF levels (1-3) and first difference of logs (4-11). Monetary variables specified in GBP and deflated using CPI

	Private capital investment (Log)			Private capital investment (Log) (First difference)				Private capital investment (Log) (First difference)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	OLS1	IV1	IV2	IV3	IV4	IV5	IV6	ECM	ECM	ECM	ECM
Public R&D (Log)	0.37*** (0.09)	0.39*** (0.11)	0.38*** (0.12)								
Public R&D (Log Diff)				3.01 (7.37)				3.50 (8.43)			
Public R&D (Log Diff) (t-1)					0.66 (2.27)				1.26 (2.81)		
Public R&D (Log Diff) (t-2)						0.64 (2.77)				1.50 (4.58)	
Public R&D (Log Diff) (t-3)							-1.97 (3.63)				-0.04 (0.10)
Constant	8.64*** (0.81)	8.42*** (1.00)	8.52*** (1.07)	-0.03 (0.09)	-0.00 (0.04)	0.00 (0.04)	0.03 (0.04)	-0.04 (0.11)	-0.01 (0.04)	-0.01 (0.07)	0.04 (0.08)
N	34.00	33.00	32.00	32.00	31.00	30.00	29.00	32.00	31.00	30.00	23.00
k_endog				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wald		1.00	1.00	0.21	0.35	0.25	0.42	0.19	0.30	0.15	0.18
Wu_Hausman		258.29***	103.11***	1.30	0.04	0.05	0.93	1.41	0.20	0.19	0.16
p_durbin		0.04	0.17	0.24	0.83	0.81	0.32	0.22	0.64	0.64	0.67

Standard errors in parentheses Note: First stage regression models are presented in the Annex A2 and A3

** p<.1, ** p<.05, *** p<.0*

Table A5. Results of first stage time series Instrumental Variable (IV) simple regressions methods using various lags

Dependent variable: Public R&D investment

	Public R&D investment in levels		Public R&D investment first difference			
	(1) IV1	(2) IV2	(3) IV3	(4) IV4	(5) IV5	(6) IV6
Public R&D (Log)	0.98*** (0.06)					
Public R&D (Log Diff)		0.98*** (0.10)				
Public R&D (Log Diff) (t-1)			0.09 (0.19)			
Public R&D (Log Diff) (t-2)				0.09 (0.19)		
Public R&D (Log Diff) (t-3)					0.09 (0.19)	
Public R&D (Log Diff) (t-4)						0.09 (0.19)
Constant	0.20 (0.54)	0.19 (0.86)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
N	33.00	32.00	32.00	32.00	32.00	32.00
r2_a	0.89	0.77	-0.03	-0.03	-0.03	-0.03

We also employed the local-projection method to analyse the dynamic effects of TFP and public R&D on private R&D, using a sequence of projections:

$$\ln_priv_inv_{t+h} = \beta_H x_t + w' \gamma + \varepsilon_{t+h}$$

Where $\ln_priv_inv_{t+h}$ is the response variable at horizon h , x_t is the impulse variable, which corresponds to public R&D and is endogenous, β_H is the impulse response coefficient. Variables in w are controls with coefficients γ , and ε_{t+h} is an error term. All variables are measured over time t .

The sequence of coefficients $(\beta_0, \beta_1, \dots, \beta_H)$ maps the response of $\ln_priv_inv_t$ to an impulse in x_t . However, since x_t is endogenous, a direct causal interpretation of β_H is not possible. If an instrument z_t is available, x_t can be instrumented with z_t , enabling the use of IV local projections to derive causal impulse response functions (IRFs). We follow the approach of Jordà and Taylor in applying local projections.⁶ Our instrumental variable corresponds to patents linked to public funding.

Impulse responses are presented in **Table A6**. Graphs of the IRFs are presented in **Figure A5**. The results indicate that, when estimated in levels (log-transformed variables), private investment responds positively and significantly to shocks in both total factor productivity (TFP) and public R&D. The effect of TFP becomes statistically significant in years 3 and 4,

⁶ Jordà, Ò., & Taylor, A. M. (2025). Local projections. *Journal of Economic Literature*, 63(1), 59-110.

suggesting a delayed response, whereas the impact of public R&D is immediate and increases in magnitude over time. In contrast, models using first-differenced variables fail to detect statistically significant effects. This likely reflects the fact that differencing removes long-term trends and shared movements between variables, which can obscure meaningful relationships that develop gradually over time. These findings highlight the importance of using level-based models that retain the underlying structure of the data, allowing for the identification of persistent and cumulative effects.

Table A6. Results of time series Instrumental Variable local projection impulse response method

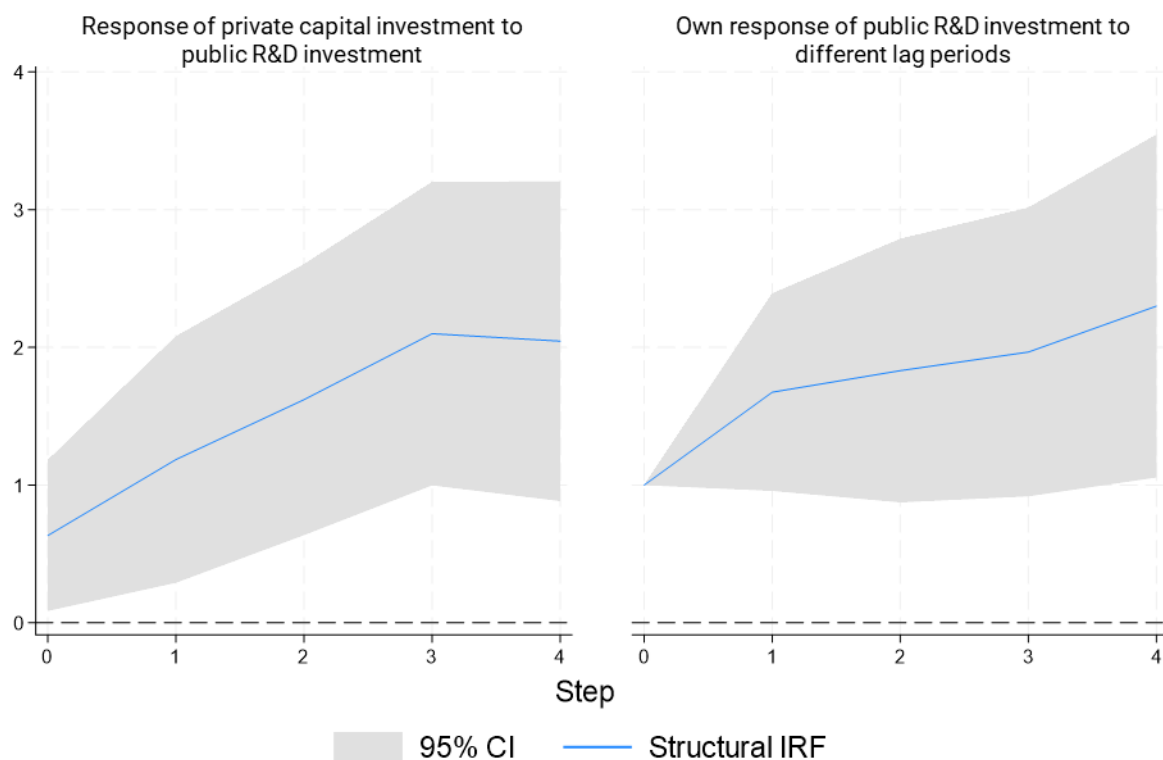
Dependent variable: Private GFCF in log and first difference of logs. Monetary variables specified in GBP and deflated using CPI

	(1) IV1	(2) IV2	(3) IV3	(4) IV4
TFP (Instantaneous)	0.33 (1.31)		0.63** (0.28)	
1 year	1.31 (1.36)		1.19*** (0.46)	
2 years	2.58 (2.08)		1.62*** (0.50)	
3 years	4.54** (2.29)		2.10*** (0.56)	
4 years	3.88** (1.72)		2.05*** (0.59)	
TFP Instantaneous (Diff)		-1.70 (1.28)		-0.42 (2.90)
1 year		1.12 (1.64)		0.13 (2.15)
2 years		1.47 (2.01)		-0.24 (2.28)
3 years		-0.62 (1.29)		0.70 (2.66)
4 years		-1.45 (1.22)		1.32 (3.76)
Public R&D (log)			1.00	
1 year			1.67*** (0.37)	
2 years			1.83*** (0.49)	
3 years			1.97*** (0.53)	
4 years			2.30*** (0.63)	
Public R&D (log difference)				1.00
1 year				-1.14 (2.35)
2 years				-0.47 (2.33)
3 years				-0.93 (2.33)
4 years				-1.55 (3.34)
N	21.00	20.00	28.00	27.00

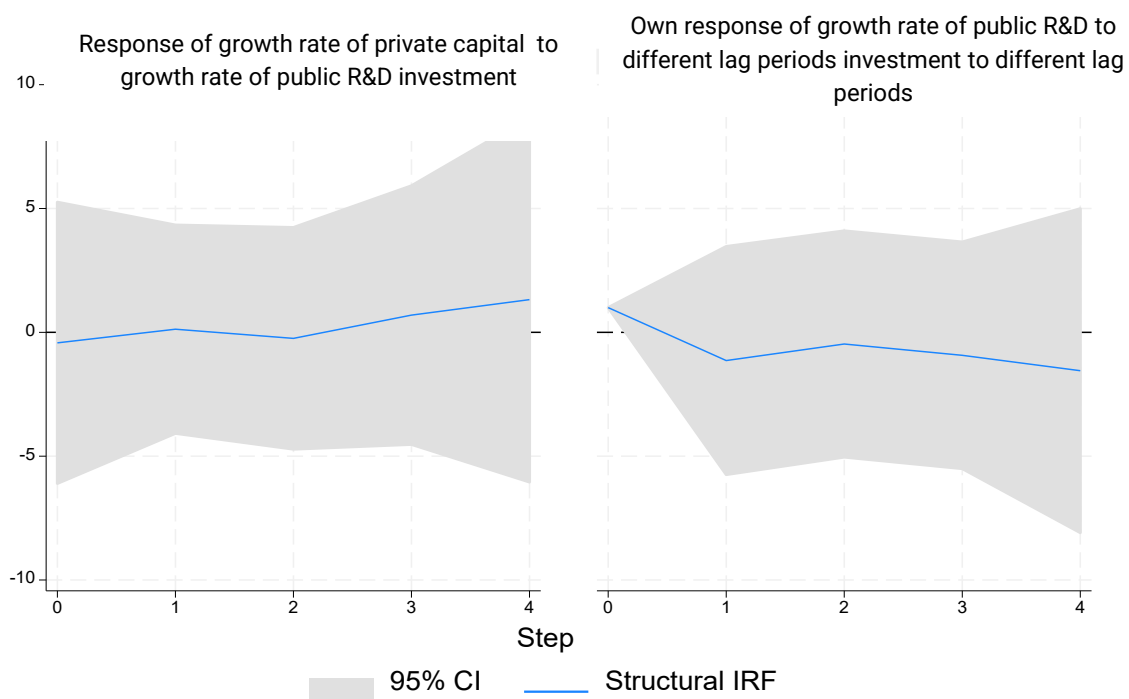
Standard errors in parentheses. IV1 and IV2 refer to instrumental variable regressions of private capital investment on TFP in logs and in first difference of the logs. IV3 and IV4 refer to instrumental variable regressions of private capital investment on public R&D investment. All IV specifications use patents

linked to public funding and deeper lags of the explanatory variables as instruments. * $p < .1$, ** $p < .05$, *** $p < .01$

Figure A5. Structural impulse response functions



Graphs by irfname, impulse variable, and response variable



Graphs by irfname, impulse variable, and response variable

Conclusion from time series analysis

The indicative positive relationship between private capital investment and public R&D investment is an interesting finding. However, its robustness is limited by some inherent challenges in time series analysis—most notably, issues related to degrees of freedom and unit roots. Degrees of freedom refer to the number of independent data points available to estimate relationships in a model. In time series analysis, especially when focusing on a single country over an extended period, the number of usable observations can be quite small once lags and trend terms are included. This limits the model's ability to detect true effects with confidence. Additionally, unit roots—which indicate that a series follows a persistent trend rather than fluctuating around a stable average—can pose a serious risk of spurious regression, where a statistically significant relationship is detected simply because both variables are trending over time, not because one causes the other. These limitations mean that while the observed relationship is suggestive, caution is warranted in interpreting it as robust or causal.

To address these challenges, we believe that panel regressions, which exploit cross-country variations, could provide more robust insights into the relationship between public R&D investment, TFP, and private capital investment. By incorporating data across multiple countries, panel models can:

- Increase the number of observations, improving the reliability and precision of the estimates.
- Account for country-specific heterogeneity, allowing for a more nuanced understanding of how different national policies, institutional environments, and industrial structures influence the effectiveness of public R&D investment.
- Reduce concerns about spurious correlations, as cross-sectional variations help to disentangle common trends from true economic relationships.
- Facilitate more sophisticated econometric techniques, such as fixed-effects or dynamic panel models, to better capture the lagged effects of public R&D investment on private capital formation.

Annex B – Panel data analysis

Annex B1: Model specification

Failing to include the right factors in the model could result in misleading conclusions as changes in private capital investment could be attributed to public R&D investment when they actually result from other factors. This is referred to as “Omitted Variable Bias”.

The broader economic context plays a central role in shaping investment decisions over both the short and long term. We tested the inclusion of economic growth rates to account for cyclical fluctuations, alongside absolute GDP and employment levels to reflect the influence of market size and economies of scale. GDP per capita is included as a proxy for purchasing power. Higher income levels typically reflect stronger demand, better infrastructure, and greater human capital—conditions that support higher returns to capital investment. This helps distinguish overall economic size from the quality of economic opportunity at the individual level, providing a more nuanced control.

The cost of capital is another key determinant, captured through long-term interest rates as a proxy for financing costs. Labour market dynamics also matter, with absolute employment levels and employment growth rates included to reflect both supply-side conditions and demand pressures. We account for the degree of competition, which can either incentivise innovation and investment or constrain returns and reduce investment incentives. Measures of competition are included to capture this duality. International trade and investment dynamics are considered through the export share of GDP, capturing trade openness, and exchange rates relative to the US dollar, which affect the cost of imported capital goods and global competitiveness. Where data availability permitted, we also applied modelling techniques that help account for unobservable or difficult-to-measure factors, such as institutional quality and market structures. Recognising the risk of omitted variable bias, we tested a range of model specifications aligned with the literature. The inclusion of these control variables strengthens the robustness of our estimates and helps clarify the specific relationship between public R&D and private capital investment.

All control variables were sourced from different databases, including the ONS, OECD, and IMF. A detailed description of variable definitions and data sources can be found in **Table B1**.

Table B1. Description of the control variables

Category	Control Variable(s)	Purpose
Broader economic context	Economic growth rate	Captures cyclical fluctuations in investment
	Absolute GDP	Reflects market size and investment opportunities
	Total employment	Indicates labour market size and demand
	GDP per capita	Proxy for purchasing power and potential returns to investment
Cost of capital	Long-term interest rates	Proxy for financing costs
Employment dynamics	Employment growth rate	Captures labour market trends and firm expectations
	Total employment (repeated here for clarity)	Captures labour availability
Degree of competition	Measures of market competition	Reflects incentives or disincentives for investment
International trade & investment	Export share of GDP	Measures trade openness and global exposure
	Exchange rate (relative to USD)	Captures cost of imported capital goods and competitiveness
Structural/unobservable factors	Institutional quality, market structures (modelled where possible)	Controls for unmeasured but influential investment conditions

Correlation analysis can help identify potential issues with control variables. **Table B2** presents correlation coefficients for key variables. We found that GDP is highly correlated with private capital investment and public R&D, making it unlikely that a model including GDP would produce statistically significant coefficients. In contrast, GDP growth, employment growth, interest rates, and exchange rates show no significant correlation with public R&D. Additionally, these variables have a correlation coefficient below 0.40, suggesting that their inclusion in the same model is worth testing.

Table B2. Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Private capital investment	1.000								
(2) Public R&D constant	0.933	1.000							
(3) Employment	0.937	0.953	1.000						
(4) Employment growth	0.282	0.257	0.315	1.000					
(5) GDP	0.955	0.990	0.964	0.294	1.000				
(6) GDP growth	-0.053	-0.053	-0.057	0.234	-0.047	1.000			
(7) Interest rate	-0.190	-0.112	-0.086	0.030	-0.114	-0.006	1.000		
(8) USD exchange rate	0.051	-0.020	0.019	0.017	-0.041	0.087	0.085	1.000	
(9) Herfindahl-Hirschman Index	-0.074	-0.087	-0.016	0.046	-0.068	0.025	0.145	-0.005	1.000

Summary statistics

The summary statistics (**Table B3**) indicate substantial variability across key economic indicators, both between countries and over time. Private capital investment averages \$151 billion per year but exhibits significant dispersion, demonstrating large disparities in investment levels. Public R&D follows a similar pattern, with an average of \$9.27 billion per year and notable fluctuations. Overall, the data reflects substantial heterogeneity, with significant variations both between countries and over time.

Table B3. Summary statistics of key variables

Variable		Mean	Std. dev.	Min	Max	Observations
Private capital investment (US \$, mn, constant)	overall	151155.1	291317.2	1459.65	2535085	N = 1036
	between		231646.8	4491.914	1201215	n = 35
	within		146503.3	-712834	1485025	T = 29.6
Public R&D (US \$, mn, constant)	overall	9271.295	21335.7	36.1891	145179.3	N = 1123
	between		18011.96	83.03782	108565.3	n = 38
	within		4981.04	-31191.4	45885.28	T = 29.5526
Employment (mn people)	overall	15107.95	25651.37	115.669	163198.3	N = 1455
	between		24954.34	156.1613	135439.6	n = 37
	within		3618.419	-17711.7	42866.62	T = 39.3243
Employment growth (%)	overall	0.01064	0.023486	-0.15484	0.24551	N = 1418
	between			0.008328	-0.00493	n = 37
	within			0.022088	-0.14216	T = 38.3243
Interest rates	overall	6.023797	4.504873	-0.52383	34.38167	N = 1326
	between		2.494597	2.680132	13.67487	n = 38
	within		3.963096	-3.37707	26.7306	T = 34.8947
GDP (US \$, mn)	overall	1016962	2497687	7182.728	2.27E+07	N = 1605
	between		2364048	13297.44	1.42E+07	n = 38
	within		777029.7	-6068995	9492424	T = 42.2368
GDP growth (%)	overall	0.024838	0.037306	-0.38741	0.220064	N = 1567
	between		0.010655	0.009376	0.056742	n = 38
	within		0.035769	-0.37671	0.196308	T = 41.2368
Herfindahl-Hirschman Index	overall	0.125533	0.127131	0.030003	0.707534	N = 1193
	between		0.112701	0.048852	0.59385	n = 38
	within		0.055788	-0.30162	0.688779	T = 31.3947
USD exchange rate	overall	109.5707	390.3144	0.000111	4325.05	N = 1584
	between		329.7081	0.646427	1742.91	n = 38
	within		208.3888	-1578.83	2691.711	T = 41.6842

Note: Overall: Refers to the statistics calculated across all observations in the dataset. The overall mean and standard deviation are based on the full panel (all countries and all time periods combined). Between: Refers to variation between countries – i.e. the mean and standard deviation of country-level averages.

Within: Refers to variation within countries over time – i.e. how much each country's values fluctuate around their own mean over time.

Annex B2: Model selection

To inform the choice of econometric approach, we first conducted the Wooldridge test, which indicated that a dynamic panel specification was appropriate. **Table B4** summarises the results of several model specifications using different combinations of control variables. While not exhaustive, the models discussed below illustrate the rationale behind the selection of controls used in the final specification. Regression results are presented in **Table B5**.

In assessing model quality, we considered both statistical diagnostics, including the Arellano-Bond test for second-order autocorrelation (AR(2)) and the Hansen test for overidentifying restrictions, as well as the plausibility of the estimated coefficients. The AR(2) test helps ensure that there is no serial correlation in the second-differenced residuals, a key requirement for valid inference in dynamic panel models. The Hansen test assesses the validity of the instruments by testing whether they are uncorrelated with the error term. In all preferred specifications, these diagnostics fall within acceptable thresholds, supporting the robustness of the estimation strategy. We also considered whether estimated coefficients aligned with theoretical expectations and fell within a plausible range of magnitude – recognising that lack of statistical significance does not, on its own, imply model misspecification if the underlying structure is robust. Time trends were included in all specifications to account for potential bias arising from underlying trends in public R&D and private capital investment – such as those introduced by unit roots or omitted variables.

Table B4. Summary of results of panel regressions using different control variables.

Model	Controls Tested	Key Findings	Notes
1	Interest rates	Coefficients had expected signs; interest rate not statistically significant.	Autocorrelation issues; failed instrument exogeneity test. Interest rates retained for completeness.
2	Absolute GDP levels	GDP significant, but introduced multicollinearity with public R&D.	Public R&D coefficient became insignificant or negative.
3	Absolute employment levels	Employment significant but caused similar multicollinearity issues.	Public R&D coefficient affected as in Model 2.
4	GDP growth	Statistically significant; public R&D retained expected sign and significance.	Preferred over absolute GDP.
5	Employment growth	Statistically significant; public R&D retained expected sign and significance.	Preferred over absolute employment.
6	Herfindahl-Hirschman Index (market concentration)	HHI significant at 5% level; suggests market concentration influences investment.	Best overall specification based on diagnostics and coefficient behaviour.
7	Exports as % of GDP	Coefficient statistically insignificant.	No meaningful influence on private investment.

Model	Controls Tested	Key Findings	Notes
8	Exchange rate	Coefficient statistically insignificant.	No meaningful influence on private investment.

Through this iterative specification testing process, Model 6 emerged as the most robust specification, balancing economic intuition, statistical significance, and model validity. The inclusion of employment growth, interest rates, and market concentration (HHI) provided a well-specified framework for estimating the leverage rate while controlling for key economic influences.

Table B5. Panel results using different control variables

Dependent variable: Private capital investment GFCF (log). Monetary variables specified in US Dollars and deflated using CPI.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Private capital investment (t-1) (ρ)	0.79*** (0.10)	0.77*** (0.16)	0.52*** (0.17)	0.81*** (0.08)	0.70*** (0.07)	0.70*** (0.08)	0.73*** (0.08)	0.71*** (0.06)
Public R&D (log, constant USD) (β)	0.15** (0.07)	-0.16 (0.13)	-0.72*** (0.22)	0.15** (0.07)	0.25*** (0.07)	0.25** (0.08)	0.24*** (0.07)	0.23*** (0.06)
Interest rates	-0.01 (0.01)	-0.02* (0.01)	-0.01 (0.01)	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
GDP (Log)		0.32** (0.13)						
Employment (log)			1.59*** (0.40)					
GDP growth				1.90*** (0.24)				
Employment growth					3.48*** (0.51)	3.41*** (0.57)	3.46*** (0.53)	3.40*** (0.47)
Herfindahl-Hirschman Index						2.04** (1.03)		
Exports share of GDP							0.00 (0.00)	
Exchange Rate against USD								0.00 (0.00)
Constant	-6.92 (6.25)	-4.42 (9.54)	-46.81*** (14.70)	-13.31*** (4.96)	-17.67*** (4.99)	-21.52*** (5.71)	-17.04*** (5.74)	-17.10*** (4.78)
Observations	763.00	763.00	748.00	763.00	748.00	693.00	748.00	748.00
Number of countries	35.00	35.00	34.00	35.00	34.00	33.00	34.00	34.00
Instruments	14.00	16.00	18.00	16.00	16.00	16.00	16.00	16.00
AR2 p-value	0.02	0.03	0.10	0.17	0.13	0.10	0.13	0.11
Hansen P-value	0.01	0.00	0.56	0.07	0.15	0.13	0.21	0.24

*Notes: Robust standard errors in parentheses. Private capital investment (t-1), public R&D, Interest rates, GDP, employment, GDP growth and employment growth are treated as endogenous and instrumented. Patents linked to public funding are an external instrumental variable. HHI, Exports as share of GDP and Exchange rates are exogenous. Year trends are included in all models. Dynamic panel-data estimation, two-step system GMM. * $p < .1$, ** $p < .05$, *** $p < .01$*

Table B6: Panel results using different control variables

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.

	(1)	(2)	(3)	(4)	(5)	(6)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Private capital investment (t-1)	0.67*** (0.11)	0.65*** (0.07)	0.66*** (0.08)	0.77*** (0.08)	0.75*** (0.07)	0.74*** (0.08)
UK Public R&D	0.19** (0.08)	0.20** (0.08)	0.19** (0.07)	0.15** (0.06)	0.17** (0.07)	0.16** (0.07)
Other Public R&D	0.25*** (0.09)	0.27*** (0.06)	0.26*** (0.06)	0.18*** (0.06)	0.20*** (0.06)	0.21*** (0.06)
Employment growth		2.32** (1.15)	2.29** (1.10)		3.32*** (0.57)	3.53*** (0.65)
Interest rates		-0.01 (0.03)	-0.01 (0.03)		-0.00 (0.01)	0.01 (0.01)
Herfindahl-Hirschman Index		0.69 (1.62)	0.70 (1.70)		1.30** (0.55)	1.74** (0.55)
Constant	-19.33*** (6.54)	-16.67 (11.82)	-16.85 (11.69)	-11.89*** (4.43)	-15.64*** (5.41)	-23.30*** (5.41)
Observations	804.00	701.00	701.00	804.00	701.00	701.00
Number of countries	35.00	34.00	34.00	35.00	34.00	34.00
Instruments	22.00	19.00	19.00	22.00	22.00	19.00
AR2 p-value	0.07	0.11	0.11	0.01	0.12	0.11
Hansen P-value	0.13	0.28	0.25	0.16	0.71	0.80
Number of lags used						
Lag of private investment (t-1)	2–8	2–5	2–6	2–8	2–8	2–6
Other public R&D	1–2	1–2	1–2	1–2	1–2	1–2
UK public R&D	1–5	1–5	1–4	1–5	1–5	1–4
Employment growth	1–1	1–1	1–1	1–1	1–1	1–1

Notes: Robust standard errors in parentheses. Dynamic Panel data estimator, two-step system GMM. Private capital investment (t-1), public R&D, Interest rates, Employment growth are treated as endogenous and instrumented. Patents linked to public funding are an external instrumental variable. HHI is exogenous. Year trends are included in all models. Models 2 and 3 share the same specification but differ in the number of lags and instruments used for endogenous variables. The same distinction applies between Models 5 and 6. See table B6b for a summary of the number of lags and instruments used for endogenous variables. Dynamic panel-data estimation, two-step system GMM. * p<.1, ** p<.05, *** p<.01.

Table B7: Panel results for different countries

Dependent variable: Private capital investment GFCF (log). Monetary variables specified in GBP and deflated using GDP deflator.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	UK	United States	Japan	Canada	Italy	France	Germany	Spain	Korea	Australia	Netherlands
Private capital investment (t-1)	0.66*** (0.08)	0.70*** (0.08)	0.72*** (0.08)	0.70*** (0.08)	0.64*** (0.09)	0.72*** (0.07)	0.69*** (0.08)	0.68*** (0.06)	0.71*** (0.06)	0.67*** (0.08)	0.69*** (0.06)
Country specific Public R&D	0.19** (0.07)	0.22*** (0.06)	0.24*** (0.06)	0.22** (0.09)	0.17 (0.11)	0.19** (0.09)	0.25*** (0.07)	0.18** (0.09)	0.19*** (0.07)	0.19 (0.22)	0.16* (0.08)
Other Public R&D	0.26*** (0.06)	0.25*** (0.07)	0.21*** (0.06)	0.24*** (0.07)	0.27*** (0.06)	0.24*** (0.07)	0.25*** (0.07)	0.23*** (0.06)	0.26*** (0.06)	0.25*** (0.07)	0.28*** (0.09)
Employment growth	2.29** (1.10)	2.21 (1.46)	2.30* (1.19)	2.49*** (0.96)	2.03* (1.18)	2.30** (1.16)	2.36** (1.19)	2.09* (1.25)	1.96* (1.15)	2.01* (1.10)	2.22* (1.14)
Interest rates	-0.01 (0.03)	-0.01 (0.04)	-0.01 (0.03)	-0.01 (0.03)	-0.02 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.02 (0.03)	-0.03 (0.03)	-0.02 (0.03)	-0.01 (0.03)
Herfindahl-Hirschman Index	0.70 (1.70)	0.90 (1.88)	-0.06 (2.09)	-0.37 (1.82)	0.26 (1.77)	0.15 (1.74)	-0.01 (1.91)	0.96 (1.81)	0.47 (1.48)	1.68 (1.81)	0.33 (1.33)
Constant	-16.85 (11.69)	-10.54 (13.93)	-11.14 (12.64)	-8.18 (16.63)	-14.22 (15.05)	-6.76 (13.75)	-12.73 (13.12)	-13.64 (13.08)	-0.50 (13.66)	-12.40 (11.36)	-11.24 (12.77)
Observations	701.00	701.00	701.00	701.00	701.00	701.00	701.00	701.00	701.00	701.00	701.00
Number of countries	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00
Instruments	19.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	19.00	21.00
AR2 p-value	0.11	0.12	0.13	0.14	0.13	0.12	0.13	0.10	0.10	0.08	0.12
Hansen P-value	0.25	0.27	0.07	0.12	0.20	0.18	0.09	0.30	0.36	0.13	0.31

Notes: Robust standard errors in parentheses. Dynamic Panel data estimator, two-step system GMM. Private capital investment (t-1), public R&D, Interest rates, Employment growth are treated as endogenous and instrumented. Patents linked to public funding are an external instrumental variable. HHI is exogenous. Year trends are included in all models. Dynamic panel-data estimation, two-step system GMM. * p<.1, ** p<.05, *** p<.01

Time structure of the impacts

Capital investment decisions typically unfold over time. In this case, it likely takes time for publicly funded research to generate actionable knowledge, for firms to absorb that knowledge, and for internal planning and resource mobilisation to occur. However, because public R&D budgets and programmes are often announced ahead of implementation, firms may interpret these as signals of future research activity and begin to prepare in advance – for example, by scouting opportunities, allocating staff, or exploring complementary technologies. This potential for anticipatory behaviour underscores the importance of accounting for both timing and firm heterogeneity when assessing the observed investment response.

Table B8 shows the results of a dynamic regression analysis examining the effect of public R&D investment on private capital investment. The table includes various model specifications, each using different lag structures for public R&D to evaluate how its effects emerge over time. The first two columns provide estimates without lags (these correspond to models 2 and 3 in **Table B6**), capturing the immediate (same-year) effect of public R&D on private capital investment. The following columns present one-year, two-year, and three-year lags, respectively, allowing an analysis of how the impact develops over multiple years. The key variable of interest is the coefficient on UK public R&D, representing the elasticity of private capital investment in relation to public R&D spending.

The results suggest that public R&D has a positive effect on private capital investment, though its impact diminishes over time. In models without lags, the coefficient on public R&D is 0.20, indicating that a 1% increase in public R&D spending is associated with a 0.20% rise in private capital investment within the same year. However, when introducing lags, the effect weakens. The coefficient for the first lag (one-year delay) is 0.11, while for the second and third lags (two- and three-year delays), it is 0.16. Notably, only the third lag is marginally statistically significant.

This pattern suggests that while public R&D can initially stimulate private investment—perhaps by signalling government commitment—the effect tends to fade over time, for the first 3 periods. There are several possible explanations for this attenuation. First, firms may reallocate investment based on more immediate competitive pressures or internal constraints, particularly if public R&D does not align with their strategic priorities (Bloom et al., 2013). Second, if public R&D leads to more basic research rather than applied or commercial-ready innovations, the translation into private capital formation may take longer or fail to materialise (Hall et al., 2010).

That said, there is some indication of renewed impact emerging after a lag of around three years, potentially reflecting the time it takes for knowledge generation or technological change to diffuse into investment decisions. However, this hypothesis would require further lags to be formally tested, which is challenging in the current framework. The annual frequency and relatively short time span of the panel constrain the number of lags that can be reliably included, limiting our ability to capture and assess longer-term dynamics using this method.

As a result, while short-term crowd-in effects are observable, the longer-term influence remains less certain in this context.

Table B8. Panel results using different year lags and specifications

Dependent variable: Private capital investment GFCF (log). *Monetary variables specified in GBP and deflated using GDP deflator.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	0 year lag	0 year lags	1 year lag	1 year lag	2 year lags	2 year lags	3 year lags	3 year lags
Private capital investment (t-1)	0.65*** (0.07)	0.65*** (0.08)	0.91*** (0.13)	0.91*** (0.12)	0.88*** (0.13)	0.86*** (0.14)	0.84*** (0.06)	0.81*** (0.06)
UK Public R&D	0.20** (0.08)	0.21** (0.08)	0.11 (0.09)	0.11 (0.09)	0.16* (0.09)	0.15 (0.12)	0.15** (0.07)	0.16* (0.09)
Other Public R&D	0.27*** (0.06)	0.28*** (0.07)	0.05 (0.11)	0.05 (0.11)	0.06 (0.11)	0.08 (0.12)	0.11* (0.06)	0.13** (0.06)
Employment growth	2.32** (1.15)	2.62*** (0.99)	2.13*** (0.72)	2.18*** (0.64)	1.60*** (0.51)	1.47** (0.60)	2.22*** (0.64)	2.26*** (0.67)
Interest rates	-0.01 (0.03)	-0.00 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.03 (0.02)	0.00 (0.01)	0.00 (0.01)
Herfindahl-Hirschman Index	0.69 (1.62)	0.22 (1.71)	4.60** (2.18)	4.49** (2.14)	3.07** (1.39)	3.12* (1.89)	3.46*** (1.30)	3.39** (1.66)
Constant	-16.67 (11.82)	-18.39 (11.83)	-18.94*** (6.78)	-19.61*** (6.61)	-15.38* (8.55)	-8.76 (7.92)	-25.91*** (6.85)	-24.66*** (7.05)
Observations	701.00	701.00	715.00	715.00	708.00	708.00	705.00	705.00
Number of countries	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00
Instruments	19.00	17.00	19.00	17.00	19.00	17.00	19.00	17.00
AR2 p-value	0.11	0.10	0.02	0.02	0.03	0.02	0.09	0.09
Hansen P-value	0.28	0.11	0.57	0.39	0.90	0.55	0.75	0.47

*Notes: Robust standard errors in parentheses. Dynamic Panel data estimator, two-step system GMM. Private capital investment (t-1), public R&D, Interest rates, Employment growth are treated as endogenous and instrumented. Patents linked to public funding are an external instrumental variable. HHI is exogenous. Year trends are included in all models. The left and right columns share the same model specification but differ in the number of instruments and the lag structure applied to the endogenous variables. Dynamic panel-data estimation, two-step system GMM. * p<.1, ** p<.05, *** p<.01*

Annex B3: Robustness checks

Static panel and pooled regression methods

We tested multiple model specifications to assess the validity of static panel data models. **Table B9** presents the test results for different specifications, including fixed and random effects models, both with and without instrumental variables. Models 1 and 2 are likely subject to omitted variable bias. Models 5 to 8 incorporate employment growth and interest rates, which are statistically significant in Models 5 and 6. However, these models do not account for potential endogeneity in public R&D. Models 7 and 8 incorporate instrumental variables to correct for endogeneity, but the key variable—public R&D—is not statistically significant and the coefficients don't align with theoretical expectations. If the instruments used are valid and sufficiently strong, this may suggest a weak or null causal relationship in these particular specifications. Alternatively, the results may reflect weaknesses in instrument strength or model misspecification. Overall, this robustness check supports the case for using dynamic, system-based estimators that better account for the persistence of investment behaviour and the extended time horizon over which the effects of public R&D are likely to emerge. This robustness check reinforces the exploratory non-definitive nature of our analysis, emphasising the need for additional research in this area

Nickel bias

We also used dynamic panel methods. Hsiao (1986) states that OLS estimates of lagged dependent variables are biased upwards, while Nickel (1981) claims fixed effects models are biased downwards. Blundell and Bond (1998) suggest valid parameter estimates should fall between these biases. **Table B10** shows our dynamic panel results align with this expectation, lying between the fixed effect and OLS estimates.

Restricting the sample

Table B11 displays the econometric modelling outputs and test results for models estimated using various subsets of the dataset. Our findings indicate that trimming the data in this manner does not alter the conclusions. Leverage rates for the UK and other countries, as well as the level of persistency, remain statistically significant and demonstrate meaningful magnitudes.

Bias due to individual countries skewing the results

We tested if a single country biased our results by re-running Model 3 from **Table B6** excluding one country each time (see **Table B12**). The median coefficients from these tests closely match those in **Table B6**, indicating no single country biases the panel results.

Weighted regressions

We tested weighted regression models using public R&D, GDP, and total R&D investment (GERD) as weighting factors (see **Table B13**) and found that the results closely aligned with those of our preferred models. This consistency suggests that our preferred specifications are not biased by the implicit equal weighting of large and small countries.

Controlling for GDP

We also tested an alternative specification by including real GDP growth in place of employment growth as a control variable. As shown in **Table B14**, the results remain closely aligned with our preferred estimates, suggesting the findings are robust to this change in specification.

Changing Instrumental variables

We conducted robustness tests by incorporating different instrumental variables to verify the stability of our results. First, we introduced gross expenditure on R&D funded by the business sector as an instrumental variable to further assess robustness. As shown in **Table B15** (Columns 1 to 4), the inclusion of this instrument does not alter our key findings, either in terms of the magnitude or statistical significance of the coefficient associated with public R&D.

Second, we tested the sensitivity of our results by including the stock of high-tech patents, which covers patents in Biotechnology and Information and Telecommunications technologies. The corresponding results, reported in Columns 5 to 8 of Table B15, indicate that the estimated elasticity for the UK remains within the range observed in our preferred specifications. This reinforces the reliability of our baseline estimates, suggesting that our findings are robust to potential endogeneity concerns related to public R&D and private capital investment dynamics.

Table B9. Static panel data regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Fixed effects	Random Effects	Fixed effects with IV	Random effects with IV	Fixed effects	Random Effects	Fixed effects with IV	Random effects with IV
UK Public R&D	1.03*** (0.18)	1.00*** (0.06)	-36.06 (61.75)	-2.84 (2.82)	0.54*** (0.14)	0.70*** (0.06)	-25.72 (47.03)	-1.88 (3.96)
Other Public R&D	1.10*** (0.03)	1.05*** (0.03)	2.77 (2.07)	1.77*** (0.27)	0.66*** (0.03)	0.71*** (0.03)	3.33 (3.11)	1.85*** (0.40)
Employment growth					0.74* (0.44)	0.98** (0.44)	7.47 (6.87)	4.72** (2.06)
Interest rate					-0.08*** (0.00)	-0.08*** (0.00)	0.07 (0.13)	0.01 (0.03)
Constant	2.32*** (0.21)	2.83*** (0.21)	1.86 (4.81)	-1.25 (1.53)	6.01*** (0.28)	5.60*** (0.24)	-5.30 (8.19)	-2.25 (2.34)
N	832.00	832.00	832.00	832.00	762.00	762.00	762.00	762.00
N_g	35.00	35.00	35.00	35.00	34.00	34.00	34.00	34.00

Standard errors in parentheses

Note: static panel data estimator.

* $p < .1$, ** $p < .05$, *** $p < .01$

Table B10. Sensitivity test: Nickel bias and alternate specifications

	(1) model1	(2) model2	(3) model3
Private capital investment (t-1)	0.97*** (0.02)	0.66*** (0.08)	0.81*** (0.05)
UK Public R&D	0.03** (0.01)	0.19*** (0.07)	0.46 (2.42)
Other Public R&D	0.03** (0.01)	0.26*** (0.06)	0.13 (0.20)
Employment growth	2.06*** (0.25)	2.29** (1.10)	2.15*** (0.51)
Interest rates	-0.00 (0.00)	-0.01 (0.03)	-0.00 (0.00)
Herfindahl-Hirschman Index	-0.02 (0.03)	0.70 (1.70)	-0.02 (0.23)
Constant	-4.36** (1.58)	-16.95 (11.29)	-9.43 (23.55)
N	701	701	701
N_g	34	34	34

Notes: Robust standard errors in parentheses. Note: Panel data estimator. All models include year effects.

** p<.1, ** p<.05, *** p<.01*

Table B11. Sensitivity test: Different sample coverage – by period

	(1) 1985-2005	(2) 1985-2010	(3) 1985-2015	(4) 1985-2022
Private capital investment (t-1)	0.71*** (0.16)	0.77*** (0.15)	0.74*** (0.14)	0.74*** (0.15)
UK Public R&D	0.21*** (0.07)	0.16** (0.07)	0.22* (0.13)	0.18** (0.07)
Other Public R&D	0.27* (0.15)	0.22* (0.12)	0.15* (0.09)	0.22*** (0.08)
Employment growth	4.53*** (0.84)	3.92*** (1.12)	1.40 (1.31)	2.23 (1.37)
Interest rates	0.06*** (0.02)	0.05 (0.03)	-0.04 (0.03)	-0.02 (0.04)
Herfindahl-Hirschman Index	-0.42 (0.80)	-0.23 (1.44)	4.15** (1.73)	-1.49 (1.52)
Constant	-41.10*** (8.43)	-35.26*** (10.95)	-11.70 (10.44)	2.80 (14.28)
Observations	219.00	219.00	497.00	672.00
Number of countries	32.00	32.00	33.00	33.00
Instruments	16.00	19.00	19.00	19.00
AR2 p-value	0.07	0.12	0.05	0.20
Hansen P-value	0.60	0.50	0.42	0.11

Notes: Robust standard errors in parentheses. Note: Dynamic Panel data estimator, two-step system GMM. All models include year effects.

** p<.1, ** p<.05, *** p<.01*

Table B12. Sensitivity test: dropping a country at a time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Excluding Australia	Excluding Austria	Excluding Belgium	Excluding Canada	Excluding Chile	Excluding Colombia	Excluding Costa Rica	Excluding Denmark	Excluding Estonia	Excluding Finland
Private capital investment (t-1)	0.66*** (0.07)	0.65*** (0.09)	0.66*** (0.08)	0.62*** (0.07)	0.64*** (0.07)	0.66*** (0.08)	0.66*** (0.08)	0.66*** (0.08)	0.65*** (0.08)	0.65*** (0.08)
UK Public R&D	0.20** (0.08)	0.19** (0.07)	0.18** (0.07)	0.22*** (0.07)	0.22*** (0.08)	0.19** (0.07)	0.19** (0.07)	0.18** (0.07)	0.20*** (0.08)	0.19** (0.08)
Other Public R&D	0.26*** (0.06)	0.26*** (0.07)	0.26*** (0.06)	0.29*** (0.07)	0.29*** (0.07)	0.26*** (0.06)	0.26*** (0.06)	0.26*** (0.07)	0.28*** (0.06)	0.27*** (0.07)
Employment growth	2.26** (1.05)	2.25** (1.06)	2.24** (1.08)	2.02** (0.90)	2.44** (1.06)	2.29** (1.10)	2.29** (1.10)	2.22** (1.06)	2.26** (1.04)	2.14* (1.27)
Interest rates	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.02 (0.02)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)
Herfindahl-Hirschman Index	1.16 (1.82)	0.55 (1.70)	0.86 (1.70)	2.13* (1.28)	1.29 (1.57)	0.70 (1.70)	0.70 (1.70)	0.45 (1.65)	0.64 (1.66)	0.88 (1.61)
Constant	-16.24 (11.84)	-16.26 (11.63)	-16.89 (11.70)	-13.23 (10.81)	-17.46 (12.85)	-16.85 (11.69)	-16.85 (11.69)	-15.18 (11.26)	-16.49 (11.53)	-17.34 (12.83)
Observations	690.00	674.00	682.00	667.00	686.00	701.00	701.00	678.00	686.00	686.00
Number of countries	33.00	33.00	33.00	33.00	33.00	34.00	34.00	33.00	33.00	33.00
Instruments	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
AR2 p-value	0.09	0.11	0.11	0.08	0.13	0.11	0.11	0.13	0.10	0.11
Hansen P-value	0.29	0.27	0.29	0.41	0.36	0.25	0.25	0.29	0.28	0.25

Notes: Robust standard errors in parentheses. Note: Dynamic Panel data estimator, two-step system GMM. All models include year effects.

* $p < .1$, ** $p < .05$, *** $p < .01$

Table B12. Sensitivity test: dropping a country at a time – continuation...

	(11) Excluding France	(12) Excluding Germany	(13) Excluding Greece	(14) Excluding Hungary	(55) Excluding Iceland	(16) Excluding Ireland	(17) Excluding Israel	(18) Excluding Italy	(19) Excluding Japan	(20) Excludi ng Korea	(21) Excluding Latvia
Private capital investment (t-1)	0.66*** (0.07)	0.65*** (0.08)	0.66*** (0.08)	0.63*** (0.08)	0.66*** (0.08)	0.66*** (0.08)	0.72*** (0.15)	0.66*** (0.08)	0.66*** (0.08)	0.68*** (0.08)	0.63*** (0.07)
UK Public R&D	0.18** (0.07)	0.19** (0.08)	0.18** (0.07)	0.20** (0.09)	0.19*** (0.07)	0.19** (0.07)	0.18* (0.10)	0.19** (0.07)	0.18** (0.08)	0.16** (0.06)	0.21* (0.12)
Other Public R&D	0.26*** (0.06)	0.27*** (0.07)	0.26*** (0.06)	0.29*** (0.07)	0.26*** (0.06)	0.26*** (0.06)	0.21* (0.13)	0.26*** (0.06)	0.26*** (0.07)	0.23*** (0.06)	0.27*** (0.08)
Employment growth	2.20** (1.06)	2.30* (1.18)	2.21** (1.01)	2.23** (1.13)	2.30** (1.14)	2.29** (1.10)	2.86*** (1.02)	2.29** (1.10)	2.28** (1.11)	2.40** (1.19)	1.79*** (0.64)
Interest rates	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)	0.01 (0.02)	-0.01 (0.03)	-0.01 (0.03)	-0.00 (0.03)	-0.02 (0.02)
Herfindahl-Hirschman Index	0.56 (1.67)	0.26 (1.87)	0.72 (1.57)	0.98 (1.69)	0.68 (1.78)	0.70 (1.70)	0.64 (1.69)	0.70 (1.70)	0.38 (1.86)	0.57 (1.84)	1.50 (1.31)
Constant	-15.51 (11.29)	-14.39 (11.70)	-17.16 (11.08)	-18.55 (16.00)	-16.36 (11.43)	-16.85 (11.69)	-22.96** (11.25)	-16.85 (11.69)	-15.68 (11.83)	-18.01 (12.37)	-13.40 (10.49)
Observations	672.00	673.00	675.00	682.00	678.00	701.00	676.00	701.00	683.00	674.00	674.00
Number of countries	33.00	33.00	33.00	33.00	33.00	34.00	33.00	34.00	33.00	33.00	33.00
Instruments	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
AR2 p-value	0.12	0.13	0.10	0.08	0.13	0.11	0.09	0.11	0.11	0.12	0.07
Hansen P-value	0.34	0.29	0.28	0.26	0.29	0.25	0.12	0.25	0.24	0.27	0.61

Notes: Robust standard errors in parentheses. Note: Dynamic Panel data estimator, two-step system GMM. All models include year effects.

* $p < .1$, ** $p < .05$, *** $p < .01$

Table B12. Sensitivity test: dropping a country at a time – continuation...

	(22) Excluding Lithuania	(23) Excluding Luxembourg	(24) Excluding Mexico	(25) Excluding Netherlands	(26) Excluding New Zealand	(27) Excluding Norway	(28) Excluding Poland	(29) Excluding Portugal	(30) Excluding Slovak Republic	(31) Excluding Slovenia
Private capital investment (t-1)	0.74*** (0.08)	0.66*** (0.08)	0.69*** (0.10)	0.65*** (0.09)	0.67*** (0.08)	0.66*** (0.08)	0.67*** (0.07)	0.64*** (0.07)	0.66*** (0.09)	0.67*** (0.07)
UK Public R&D	0.20** (0.10)	0.19** (0.08)	0.19*** (0.07)	0.20** (0.09)	0.21*** (0.08)	0.19** (0.07)	0.18*** (0.07)	0.19** (0.08)	0.19** (0.08)	0.18** (0.07)
Other Public R&D	0.26*** (0.09)	0.27*** (0.07)	0.25*** (0.08)	0.27*** (0.08)	0.27*** (0.08)	0.26*** (0.06)	0.25*** (0.05)	0.27*** (0.06)	0.26*** (0.07)	0.26*** (0.06)
Employment growth	3.62*** (1.04)	2.24** (0.91)	2.21* (1.18)	2.40** (1.09)	2.46** (1.04)	2.30** (1.09)	2.28** (1.11)	2.04** (0.87)	2.32** (1.14)	2.26* (1.28)
Interest rates	0.03 (0.04)	-0.01 (0.03)	-0.02 (0.04)	-0.01 (0.03)	0.00 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.02 (0.02)	-0.00 (0.03)	-0.01 (0.03)
Herfindahl-Hirschman Index	-1.41 (1.54)	0.47 (1.58)	-0.17 (1.87)	1.22 (1.76)	0.44 (1.64)	0.63 (1.85)	0.72 (1.76)	1.28 (1.33)	0.56 (1.85)	0.76 (1.83)
Constant	-19.33 (18.62)	-16.24 (11.03)	-7.40 (13.33)	-18.07 (13.26)	-20.04* (11.27)	-16.70 (11.67)	-15.70 (10.96)	-15.62 (10.59)	-17.72 (12.52)	-15.56 (11.94)
Observations	680.00	680.00	688.00	693.00	681.00	689.00	683.00	678.00	674.00	679.00
Number of countries	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00
Instruments	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
AR2 p-value	0.17	0.11	0.14	0.10	0.05	0.11	0.12	0.08	0.12	0.12
Hansen P-value	0.11	0.27	0.07	0.30	0.18	0.27	0.29	0.44	0.25	0.31

Notes: Robust standard errors in parentheses. Note: Dynamic Panel data estimator, two-step system GMM. All models include year effects.

* $p < .1$, ** $p < .05$, *** $p < .01$

Table B12. Sensitivity test: dropping a country at a time – continuation...

	(32) Excluding Spain	(33) Excluding Sweden	(34) Excluding Switzerland	(35) Excluding Türkiye	(36) Excluding United States
Private capital investment (t-1)	0.65*** (0.09)	0.66*** (0.08)	0.65*** (0.08)	0.65*** (0.08)	0.62*** (0.06)
UK Public R&D	0.21*** (0.07)	0.20*** (0.08)	0.19** (0.08)	0.19** (0.07)	0.26*** (0.07)
Other Public R&D	0.27*** (0.07)	0.27*** (0.07)	0.26*** (0.06)	0.27*** (0.06)	0.29*** (0.06)
Employment growth	2.42** (1.22)	2.36** (1.16)	2.19** (1.00)	2.26** (1.09)	1.93** (0.88)
Interest rates	-0.00 (0.03)	-0.00 (0.03)	-0.01 (0.03)	-0.01 (0.03)	-0.02 (0.02)
Herfindahl-Hirschman Index	0.47 (1.77)	0.82 (1.67)	0.47 (1.66)	0.68 (1.77)	1.29 (1.38)
Constant	-20.08* (11.42)	-19.09 (11.96)	-14.62 (11.41)	-17.16 (12.20)	-13.45 (10.10)
Observations	681.00	675.00	687.00	692.00	693.00
Number of countries	33.00	33.00	33.00	33.00	33.00
Instruments	19.00	19.00	19.00	19.00	19.00
AR2 p-value	0.12	0.11	0.10	0.11	0.08
Hansen P-value	0.28	0.33	0.27	0.24	0.38

Notes: Robust standard errors in parentheses. Note: Dynamic Panel data estimator, two-step system GMM. All models include year effects.

* $p < .1$, ** $p < .05$, *** $p < .01$

Table B13. Sensitivity test: dynamic panel - weighted regressions

Dependent variable

Dependent variable: Private capital investment (log). Monetary variables specified in USD and deflated using CPI.

	(1)	(2)	(3)	(4)	(5)	(6)
	Public R&D as weight	Public R&D as weight	GDP as weight	GDP as weight	GERD as weight	GERD as weight
Private capital investment (t-1)	0.78*** (0.07)	0.76*** (0.07)	0.83*** (0.05)	0.83*** (0.05)	0.84*** (0.07)	0.88*** (0.08)
UK Public R&D	0.24*** (0.07)	0.22*** (0.06)	0.17*** (0.04)	0.19*** (0.07)	0.17* (0.09)	0.12 (0.09)
Other Public R&D	0.22*** (0.06)	0.22*** (0.05)	0.18*** (0.04)	0.17*** (0.04)	0.17*** (0.06)	0.12** (0.06)
Employment growth	2.80*** (0.33)	2.77*** (0.37)	2.46*** (0.42)	2.53*** (0.54)	2.34*** (0.45)	2.47*** (0.64)
Interest rates	0.01 (0.02)	-0.01 (0.04)	0.02 (0.03)	0.04 (0.03)	0.01 (0.04)	0.00 (0.07)
Herfindahl-Hirschman Index	1.55 (1.13)	1.00 (1.08)	1.05 (1.46)	0.37 (0.88)	1.91 (1.69)	1.25 (1.18)
Constant	-18.34** (7.37)	-13.40 (14.22)	-18.70* (10.32)	-25.74** (11.85)	-15.83 (17.16)	-12.12 (19.72)
Observations	701.00	701.00	701.00	701.00	671.00	671.00
Number of countries	34.00	34.00	34.00	34.00	34.00	34.00
Instruments	19.00	17.00	22.00	17.00	22.00	17.00
AR2 p-value	0.57	0.48	0.37	0.42	0.39	0.47
Hansen P-value	0.91	0.53	0.56	0.30	0.74	0.69
Number of lags used						
Private capital investment (t-1)	2–6	2–4	2–8	2–4	2–8	2–4
Other public R&D	1–2	1–3	1–2	1–3	1–2	1–3
UK public R&D	1–4	1–3	1–5	1–3	1–5	1–3
Employment growth	1–1	1–1	1–1	1–1	1–1	1–1

Notes: Robust standard errors in parentheses. Note: Dynamic Panel data estimator, two-step system GMM. All models include year effects. Models 1 and 2 share the same specification but differ in the number of lags and instruments used for endogenous variables, see bottom of the table. The same distinction applies between Models 3 and 4, and 5 and 6.

** p<.1, ** p<.05, *** p<.01*

Table B14: Panel results using different control variables

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.

	(1)	(2)	(3)	(4)	(5)	(6)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Private capital investment (t-1)	0.67*** (0.11)	0.59*** (0.08)	0.59*** (0.09)	0.77*** (0.08)	0.66*** (0.05)	0.66*** (0.06)
UK Public R&D	0.19** (0.08)	0.25* (0.13)	0.26* (0.13)	0.15** (0.06)	0.26*** (0.08)	0.26*** (0.08)
Other Public R&D	0.25*** (0.09)	0.31*** (0.08)	0.31*** (0.09)	0.18*** (0.06)	0.25*** (0.05)	0.25*** (0.05)
Real GDP growth		1.52*** (0.56)	1.55*** (0.55)		2.05*** (0.27)	2.09*** (0.32)
Interest rates		-0.01 (0.03)	-0.01 (0.03)		-0.01 (0.01)	-0.01 (0.02)
Herfindahl-Hirschman Index		-1.41 (1.93)	-1.47 (1.88)		-0.04 (0.77)	0.02 (0.77)
Constant	-12.80 (6.54)	-12.67 (12.86)	-11.89*** (12.38)	-12.97*** (4.43)	-15.06*** (4.68)	-19.33*** (5.68)
-19.33***						
Number of countries						
Instruments	804.00	716.00	716.00	804.00	716.00	716.00
AR2 p-value	35.00	35.00	35.00	35.00	35.00	35.00
Hansen P-value	22.00	19.00	19.00	22.00	22.00	19.00
Number of lags used						
Lag of private investment	2–8	2–5	2–6	2–8	2–8	2–6
Other public R&D	1–2	1–2	1–2	1–2	1–2	1–2
UK public R&D	1–5	1–5	1–4	1–5	1–5	1–4
Real GDP growth		1–1	1–1		1–1	1–1

Notes: Robust standard errors in parentheses. Dynamic Panel data estimator, two-step system GMM. Private capital investment (t-1), public R&D, GDP growth are treated as endogenous and instrumented. Patents linked to public funding are an external instrumental variable. HHI is exogenous. Year trends are included in all models. Models 2 and 3 share the same specification but differ in the number of lags and instruments used for endogenous variables. The same distinction applies between Models 5 and 6. Dynamic panel-data estimation, two-step system GMM. * $p < .1$, ** $p < .05$, *** $p < .01$

Table B15. Sensitivity test of changing instrument: dynamic panel – Business funded R&D as IV (1-4) and high technology patents (5-8)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	model1	model2	model3	model4	Model5	Model6	Model7	Model8
Private capital investment (t-1)	0.78*** (0.07)	0.76*** (0.07)	0.74*** (0.08)	0.72*** (0.08)	0.79*** (0.07)	0.74*** (0.07)	0.73*** (0.08)	0.60*** (0.08)
UK Public R&D	0.15** (0.06)	0.17*** (0.06)	0.17*** (0.06)	0.18*** (0.06)	0.15** (0.07)	0.17** (0.07)	0.18** (0.07)	0.22** (0.10)
Other Public R&D	0.18*** (0.06)	0.21*** (0.06)	0.22*** (0.07)	0.24*** (0.07)	0.16*** (0.06)	0.22*** (0.05)	0.23*** (0.06)	0.15 (0.16)
Employment growth		3.28*** (0.61)	3.65*** (0.71)	3.66*** (0.72)		3.15*** (0.59)	3.43*** (0.72)	2.62*** (0.61)
Interest rates		-0.00 (0.01)	0.01 (0.02)	0.01 (0.01)		-0.01 (0.01)	0.00 (0.01)	-0.00 (0.02)
Herfindahl-Hirschman Index		1.27* (0.70)	1.40 (0.85)	1.42 (0.96)		0.93 (0.58)	0.99 (0.79)	0.75 (1.60)
Constant	-11.06*** (3.90)	-14.79** (7.29)	-21.12*** (7.41)	-22.51*** (8.18)	-10.20** (4.05)	-10.75* (6.04)	-15.45** (7.67)	-27.49** (13.10)
Observations	804.00	701.00	701.00	701.00	799.00	696.00	696.00	701.00
Number of countries	35.00	34.00	34.00	34.00	35.00	34.00	34.00	34.00
Instruments	23.00	23.00	20.00	18.00	23.00	23.00	20.00	15.00
AR2 p-value	0.01	0.12	0.12	0.13	0.01	0.13	0.14	0.07
Hansen P-value	0.19	0.68	0.75	0.59	0.17	0.62	0.54	0.98
Number of lags used								
Lag of private investment		2–8	2–5	2–6		2–8	2–6	2–4
Other public R&D	1–2	1–2	1–2	1–2	1–2	1–2	1–2	1–3
UK public R&D	1–5	1–5	1–5	1–4	1–5	1–5	1–4	1–3
Δ Employment	1–1	1–1	1–1	1–1	1–1	1–1	1–1	1–1

Notes: Robust standard errors in parentheses. Models 2, 3, and 4 share the same specification but differ in the number of lags and instruments used for endogenous variables. The same distinction applies between Models 6, 7, and 8. Dynamic panel-data estimation, two-step system GMM. All models include year effects.

* $p < .1$, ** $p < .05$, *** $p < .01$