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Catapulting Firms into the Innovation System: Analysing Local Knowledge Spillovers from Catapult Centres

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Catapulting Firms into the Innovation System: Analysing Local Knowledge Spillovers from Catapult Centres

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EXECUTIVE SUMMARY

Previous studies have provided evidence of the positive effects on business growth of working with the Catapults. In this report we explore the local spillovers from Catapult centres, i.e. the effects on businesses not themselves working directly with the Catapults. We investigate how through the Catapults knowledge spills over through space and along the supply chain to unsupported firms located nearby the centres and industrially related to the Catapults technological specialisation.

We also assess to what extent Catapults-supported firms generate local spillovers themselves for other unsupported local firms. In particular, we want to identify if there are demonstration effects or other types of knowledge spillovers from Catapult-supported firms to other local businesses operating in related sectors.

Our analysis suggests four key results:

(1) Local knowledge spillovers from Catapult centres increase the likelihood that co-located, but un-connected firms will collaborate in the future with the Catapult network and are more likely to receive public R&D funding from UKRI. This type of dynamic benefits have been noted elsewhere in the context of regional R&D and innovation support measures (Roper and Vanino, 2023). We see strong evidence of distance decay in these effects, which are particularly strong for businesses located in the immediate proximity of the Catapults centre, within a 1-kilometer radius, as the magnitude of the effects decreases as distance increases.

(2) Local knowledge spillovers from Catapult Centres also lead to improvements in employment and turnover growth, and an increase in labour productivity. Interestingly, we also find that Catapults stimulate the birth of new start-ups in the immediate proximity of their Centres.

(3) Indirect spillovers through supported firms are also evident in stimulating unsupported firms to engage with the Catapult Centres. This could be seen as a demonstration effect, i.e. un-supported firms see other local firms engaging and benefiting from engagement with the Catapult network and this encourages them then to engage.

(4) Indirect spillovers through supported firms also have a positive impact on the productivity of unsupported businesses, increasing their efficiency as a result of these indirect externalities.

In sum, Catapult centres generate positive local spillovers both directly and indirectly through the firms they work with. This evidence on the positive spillovers – both direct and indirect – from Catapult Centres reinforces the positive findings of earlier studies which suggest the positive effects of Catapult engagement on supported firms.

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Catapulting Firms into the Innovation System: Analysing Local Knowledge Spillovers from Catapult Centres

1. INTRODUCTION

A large literature has looked at the importance of different policy tools to spur research and development (R&D) investment and innovation among firms. Several studies provide strong evidence that R&D tax credit policies are powerful and efficient tools to encourage private R&D. Similarly, other tools financing directly innovative firms through research grants have been found to efficiently stimulate innovation and business growth among directly targeted firms, and to generate substantial spillovers both across geographical and technological spaces.

One of the key UK support measures is the Catapult network, a group of nine technology and innovation centres supported through Innovate UK and private funding. Initially introduced starting from 2011, the Catapult network provides physical R&D facilities to collaborate with and support business innovation across a range of sectors including life sciences, semiconductors, transports digital technologies, renewable energy systems, and satellite applications.

Previous studies have provided evidence of direct positive effects of this type of innovation support on businesses working with the Catapults[1]. Building on that evidence, we investigate here the indirect, local spillover effects of the Catapult network, in terms of stimulating start-ups, future engagement with the public science system, and eventually the productivity growth of unengaged firms located nearby. In particular, we consider two main mechanisms through which local spillovers may occur from Catapults and the firms they support:

- First, we investigate how through the Catapults knowledge spills over through space and along the supply chain to unsupported firms located nearby the centres and industrially related to the Catapults technological specialisation.

[1] Roper, Stephen and Enrico Vanino. 2023. "Exploring spatial and sectoral complementarities in public support for innovation: Two UK experiments". ERC Insight Paper, forthcoming.

- Second, we assess to what extent Catapults-supported firms generate local spillovers themselves for other unsupported local firms. In particular, we want to identify if there are demonstration effects or other types of knowledge spillovers from Catapult-supported firms to other local businesses operating in related sectors. This consists in a geographical analysis of Catapult-assisted firms and their local impact.

We use longitudinal granular data on the location of Catapult centres, supported and unsupported firms, and on their R&D activities and business performance over the period 2010-2019. We apply a novel approach of the fuzzy regression discontinuity design, where we consider the discontinuity in the distance from the Catapults centre, or in the statistical significance of the spatial agglomeration of Catapults-supported firms.

Our results show that Catapults innovation centres provide a source of knowledge externalities for unsupported businesses located nearby, mainly by increasing the likelihood of firms to collaborate with Catapults and receive public R&D funding. This in turn stimulates the birth of new start-ups and the economic performance of businesses in terms of employment and productivity.

After controlling for the spillovers from Catapults themselves, we also identify positive externalities from Catapults-supported firms. These operate mainly through the stimulation of unsupported firms to engage with the Catapult network, encouraging productivity growth.

The rest of the report is structured as follows. The next section discusses the data and methodology applied in our study. Section 3 reports the main findings, while section 4 concludes presenting the policy implications.

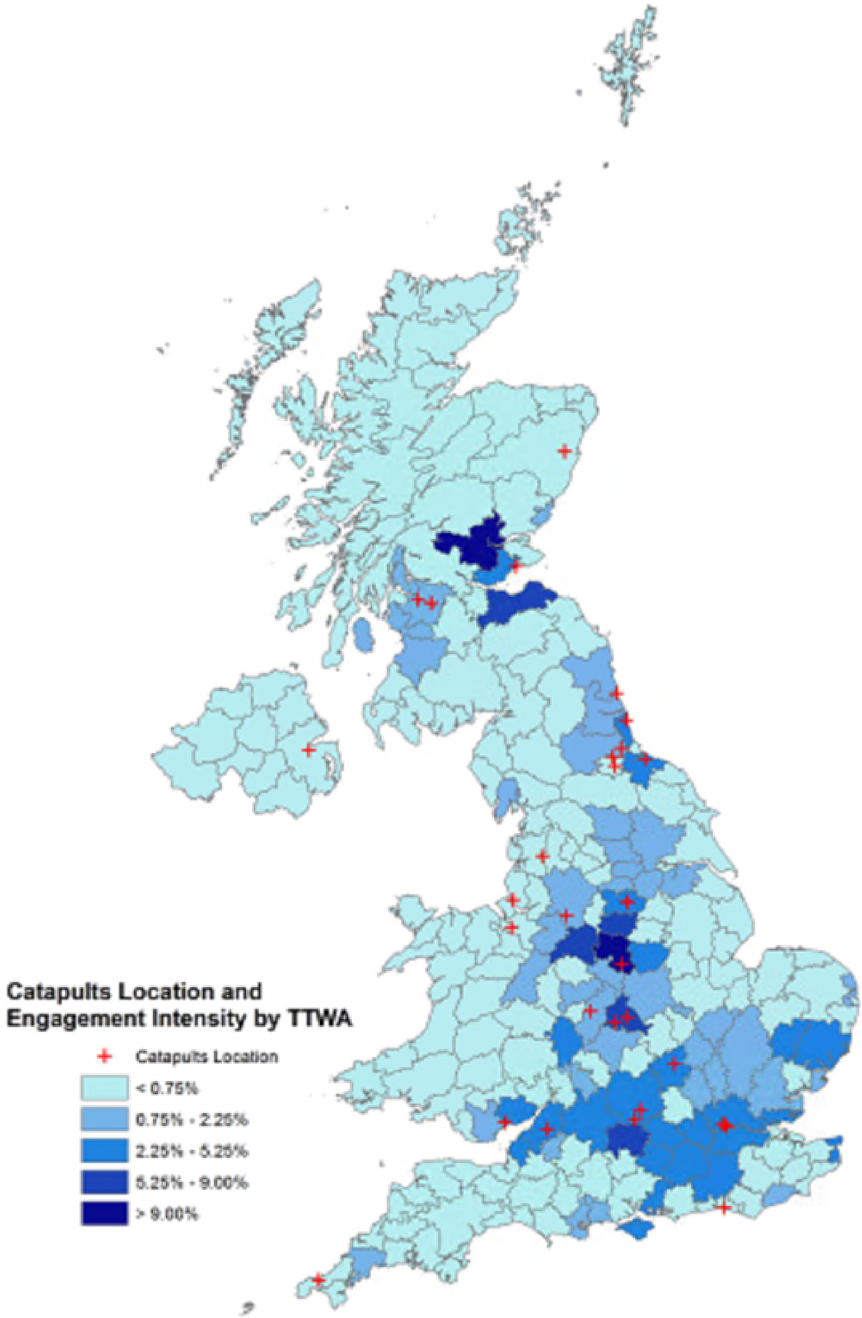
2. DATA AND METHODOLOGY

For our analysis we draw on administrative data provided by the Catapult network on the list of businesses that have engaged with each single Catapult over the period 2010-2019, listing the time and intensity of engagement (Roper and Vanino, 2023). In addition, using a unique corporate reference number, we link this to public funding and partnership data from the Gateway to Research (GtR) database, which provides information on all R&D public funding provided by the UK Research and Innovation agency UKRI over the 2004 to 2016 period. The GtR data provides information about approximately 34,000 organisations that participated in publicly-funded innovation and R&D projects, including details on the number and value of funded projects, the number and characteristics of partners, the topics and outcomes of the research projects, the value of grants awarded per year, the Research Council providing the funding, and information about each projects' leaders (Vanino et al., 2019). Finally, we merge these two datasets with data on business performance taken from the Business Structure Database (ONS, 2022), which provides longitudinal data and information for all firms in the UK, including employment, turnover, location, industry classification, age, foreign ownership, group affiliation, and other firms characteristics.

The Catapult network is a group of nine technology and innovation centres supported through Innovate UK and private funding initially introduced starting from 2011. The network provides physical R&D facilities to collaborate with and support business innovation across a range of sectors including life sciences, semiconductors, transports digital technologies, renewable energy systems, and satellite applications. There are currently operating 9 centres spanning over 50 locations across the UK, including the High Value Manufacturing (HVM), which was the first to open in Warwickshire in 2011, the Cell & Gene Therapy (CGTC), the Digital Catapult (DIG), the Offshore Renewable Energy (ORE), the Satellite Applications (SAC), the Energy Systems (ESC), the Medicines Discovery (MDC), the Compound Semiconductor Applications (CSA), and the Connected Places (CPC) that opened last in 2019. Each centre received "core" funding of £10 million per year for five years via Innovate UK, with the long-term intention that the budget would be one-third core funding, one-third commercial funding, and one-third collaborative (public and private) R&D funding.

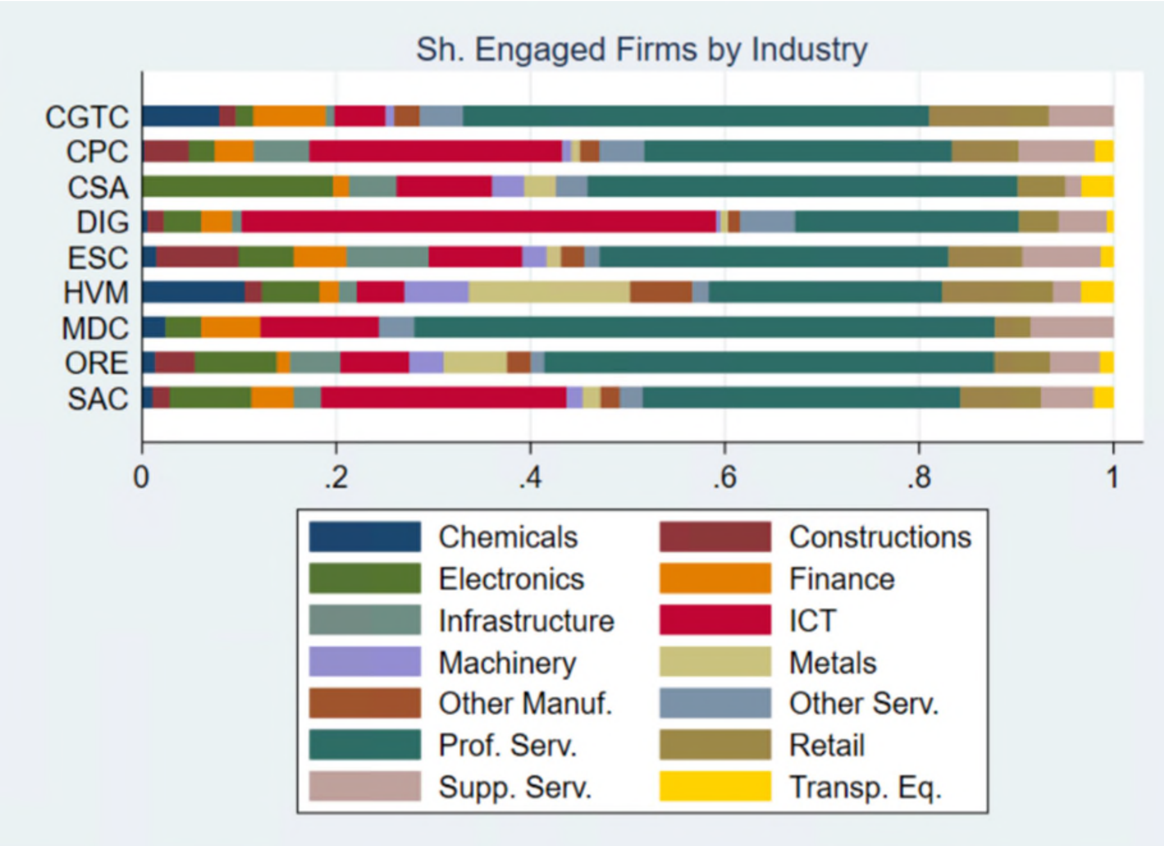
As seen in Figure 1, while Catapults are scattered across the country in multiple locations, supported firms tend to be highly spatially clustered in specific areas, probably reflecting industrial districts and comparative specialisation of some areas in specific sectors, and only in some instances they tend to cluster around certain specific Catapults. The uneven distribution of supported firms is not only spatial, but as shown in Figure 2 also from an industrial point of view, reflecting the sector and technology specialisation of specific Catapults activities. For example, the high concentration of ICT companies engaging with the Digital Catapult (DIG), firms operating in electronics collaborating with the Compound Semiconductor Applications (CSA) Catapult, or the main focus of the High Value Manufacturing (HVM) Catapult in supporting businesses in the chemicals, electronics, metals, machineries and other manufacturing sectors.

Figure 1: Spatial distribution of Catapults locations and firms' engagement intensity by TTWA over the period 2011-2019



Notes: Firms' engagement intensity measured as the total employment of Catapults-supported firms over total employment in the Travel to Work Area (TTWA).

Figure 2: Share of engaged businesses by industry for each Catapult over the period 2011-2019



Notes: Cell & Gene Therapy (CGTC), Connected Places (CPC), Compound Semiconductor Applications (CSA), Digital Catapult (DIG), Energy Systems (ESC), High Value Manufacturing (HVM), Medicines Discovery (MDC), Offshore Renewable Energy (ORE), and Satellite Applications (SAC).

In order to consider both the direct knowledge spillovers originating from the Catapult centres, and the indirect effects from Catapults-supported firms, we apply different methodologies based on the specific research question addressed. First, to estimate the spillovers from Catapults to nearby and industrially related unsupported firms, we start by identifying the location and time of opening of all Catapults premises. Then, using geographic information system (GIS) mapping, we identify businesses located with 1, 5, and 10 kilometres from the Catapults location. We then perform a difference-in-difference regression analysis as follows:

$$y_{it} = \alpha_0 + \alpha_1 Dist_{ic}^{k} \times Open_{ct} + X_{it} + \gamma_i + \gamma_n + \gamma_{zt} + \gamma_{st} + u_{it}$$

where we estimate the difference in several outcome variables y_{it} between firms *i* located within a 1-, 5- or 10-kilometres distance *k* from a Catapult *c* ($Dist_{ic}^{k}$) and those firms instead located further away but always within the same Travel To Work Area (TTWA) *z*, before and after the opening of the Catapults premises at time *t* ($Open_{ct}$).

We control for several firm-level and time variant characteristics X_{it}, including firm size, labour productivity, age, foreign ownership, and group affiliation, together with firm ideocratic time-invariant fixed-effects (γ_i). In addition, we include several fixed-effects to control for unobservable characteristics, such as neighbourhood Output Area fixed-effects (γ_n), commuting zone (TTWA) time trends (γ_{zt}), and SIC 2-digit industry time trends (γ_{st}). In addition, we also weight this spillover effect by the industrial relatedness of firms to the core technological focus of the different Catapult centres. To do this, we measure the share of firms engaged with each Catapult by industry as shown in Figure 2, and apply this weight depending on which is the closest Catapult to each business.

Second, to assess the local spillovers to unsupported firms generated from Catapult-supported firms, we start by identifying the location and time of engagement of all Catapults-supported firms using administrative data from the Catapults. Then, using GIS mapping techniques, we calculate the total employment of Catapults-supported businesses in each Middle Super Output Area (MSOA)[2] and year. Based on this, we calculate the level of spatial clustering of Catapult-supported firms across neighbourhoods using the Getis-Ord G statistics, indicating the presence and intensity of positive, negative or insignificant spatial clustering. The Getis and Ord (1995) local statistic G identifies if specific values of a variable cluster spatially. It does so by looking at each observation within the context of its neighbours. If an observation has a high value of a variable and is surrounded by observations with also high values of a variable, then it belongs to a cluster. Then, the G statistic constructs the local sum of values for all observations and their neighbours. In our case, the higher is the employment of Catapults-supported businesses in an area, and the closer they are located to each other, the larger will be the value of the Getis-Ord G statistics. The output of that summation is then compared to the summations for all observations. If the local sum is statistically different from the expected local sum, and if that difference is too big to result from randomness, a local cluster is identified. Given that

[2] Neighbourhoods are defined using the ONS Middle Super Output Area (MSOA) nomenclature reflecting on average 7,000 residents (3,000 residential buildings).

this statistic is normally distributed, a z-score higher than 1.65 indicates the presence of positive spatial clustering at the 10% significance level.

Following previous studies applying a similar methodology (Koster et al., 2012; Hidano et al., 2015), we use this information to follow a fuzzy regression discontinuity design (FRD analysis), where we consider as treated unsupported firms located in MSOAs with positive total employment of Catapults-supported businesses. The treatment is conditional on the level of spatial clustering of supported firms across MSOAs, depending on whether the z-score of the Getis-Ord G statistic is above or below the 1.65 significance threshold. Thus, as a consequence, we follow the fuzzy regression discontinuity design, by instrumenting in a first stage the treatment variable S_{nt} representing the total employment of Catapults-supported businesses in each Middles Super Output Area (MSOA) neighbourhoods *n* and year *t* with the z-score of the Getis-Ord G statistic:

$$S_{nt} = \alpha_0 + \alpha_1 I(z \cdot score_{nt} > 1.65) + u_{nt}$$

Then, in the second stage we finally estimate the impact of the spillover of Catapults-supported businesses on unengaged firms, by comparing treated firms with a suitable control group of untreated firms located in a neighbourhood with a similar level of Catapults-supported business employment, but with a level of spatial clustering which is immediately below the 10% significance level:

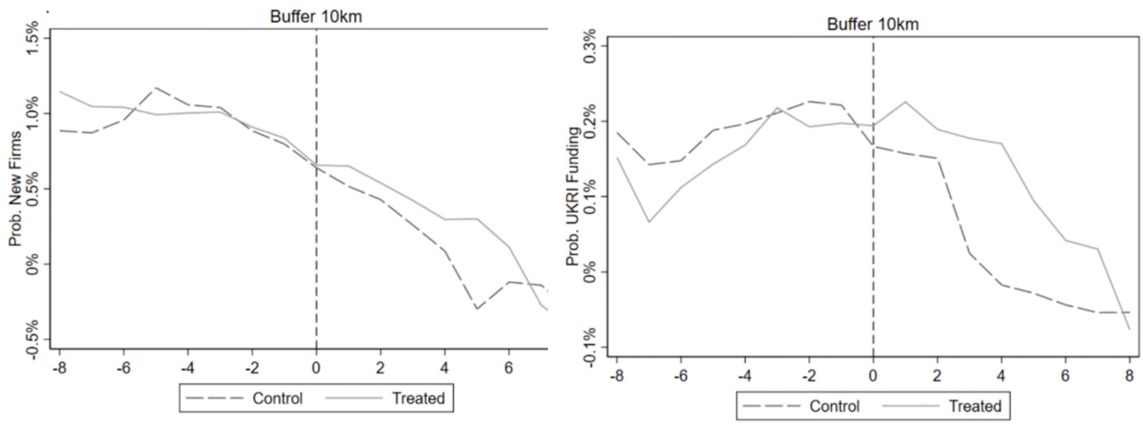
$$y_{it} = \alpha_0 + \alpha_1 \hat{S}_{nt-1} + X_{it-1} + \gamma_i + \gamma_{zt} + \gamma_{st} + u_{it}$$

Also in this case, we control for several firm-level and time-variant characteristics X_{it}, including firm size, labour productivity, age, foreign ownership, and group affiliation, together with firm ideocratic time-invariant fixed-effects (γ_i). In addition, we include several fixed-effects to control for unobservable characteristics, such as commuting zone (TTWA) time trends (γ_{zt}), and SIC 2-digit industry time trends (γ_{st}). In addition, as previously we also weight this spillover effect by the industrial relatedness of firms to the core technological focus of the different Catapult centres.

In both approaches, we take into consideration several outcome variables of interest, including business start-up rates, the likelihood of future engagement with the Catapults network, the number of UKRI-funded R&D projects secured, and several other measures of business performance including employment, turnover and productivity growth.

We perform several sensitivity tests to check the robustness of our results. First, we check in Figure 3 that the pre-treatment parallel trend assumption is met for some of the outcome variables when estimating in the first approach the difference between treated and control firms of the effect of the Catapult centre spillovers. Secondly, we weight the spillover effects from Catapult centres by the budget allocated to the Catapult, to better capture the scope and funding of the Catapult activities. Third, in the fuzzy regression discontinuity analysis we substitute the treatment variable S_{nt} representing the total employment of Catapults-supported businesses with a dummy variable equal to 1 if there is positive employment of Catapults-supported firms in the neighbourhood and 0 otherwise. Forth, we repeat both approaches by limiting the sample for the control observations, including in the first approach only firms within a maximum 20-kilometres radius from the Catapult centre, and in the second approach by keeping in our sample firms located in neighbourhoods with a z-score ranging from 1.95 (positive spatial clustering at the 5% significance level) to 1.44 (statistically insignificant spatial clustering - 15% significance level). Finally, we combine the two approaches in order to distinguish between the spillovers directly generating from Catapults centres, and those instead resulting from the interaction between Catapults-supported and unsupported firms. Identifying the two different sources of knowledge externalities would be particular important for those areas where there are both Catapult centres located and a high level of Catapults-supported firms' employment.

Figure 3: Differences in trends in start-up rate and probability of UKRI funding between treated and control firms before and after the opening of a Catapult centre.



Notes: Firms considered as treated if located within a 10-kilometers radius from a Catapult centre. Catapult centre opening year set at time *t=0*.

3. RESULTS

Tables 1 and 2 report the results of the first approach, estimating the spillover effects of Catapult centres on nearby unsupported businesses. In Table 1 we find evidence that Catapults innovation centres provide a significant source of knowledge externalities for unsupported businesses located nearby, mainly by increasing the likelihood of firms to collaborate in the future with the Catapult network, and by increasing their likelihood to receive public R&D funding from UKRI. We see strong evidence of distance decay in these effects, which are particularly strong for businesses located in the immediate proximity of the Catapults centre, within a 1-kilometer radius, as the magnitude of the effects decreases as distance increases.

From Table 2 we can observe that these knowledge externalities eventually translate into an improvement of business performance for firms that were initially unsupported, through both an upscaling in terms of employment and turnover growth, and an increase in labour productivity. Interestingly, we also find that Catapults stimulate the birth of new start-ups in the immediate proximity of their centres, although we are not able to distinguish whether these are the result of spin-offs and new entrepreneurial activities or simply the relocation of existing ventures.

Table 1: Effect of Catapult centres spillover on nearby unsupported businesses – Engagement with the public innovation system.

	(1) Catapult Eng.	(2) Catapult Eng.	(3) Catapult Eng.	(4) Catapult Eng.	(5) Prob. UKRI	(6) UKRI Projects
1km Spillover	0.00143***			0.00114***	0.000116	-7.62e-06
	(0.000187)			(0.000191)	(0.000328)	(0.000358)
5km Spillover		0.000716***		0.000433***	0.000325**	0.000322*
		(7.48e-05)		(8.52e-05)	(0.000149)	(0.000172)
10km Spillover			0.000477***	0.000201***	-7.20e-05	-0.000143
			(6.22e-05)	(7.02e-05)	(0.000113)	(0.000126)
Observations	15,819,067	15,819,067	15,819,067	15,819,067	12,232,670	12,232,670
R-squared	0.243	0.243	0.243	0.243	0.579	0.649

Notes: Estimation based on administrative Catapults data, Gateway to Research (GtR) and the Business Structure Database (BSD). Robust standard errors reported in parentheses. *** p<0.001, ** p<0.01, * p<0.05.

Table 2: Effect of Catapult centres spillover on nearby unsupported businesses – Start-up rates and business performance

	(1) Employment	(2) Turnover	(3) Productivity
1km Spillover	0.00761***	0.00549*	0.0253***
	(0.00248)	(0.00284)	(0.00411)
5km Spillover	0.00274**	0.00310**	0.0144***
	(0.00122)	(0.00143)	(0.00209)
10km Spillover	0.0110***	0.0128***	0.00585***
	(0.000901)	(0.00106)	(0.00157)
Observations	15,760,149	15,760,149	15,760,149
R-squared	0.923	0.969	0.848

New Firms	(1)	(2)	(3)	(4)
1km Spillover	0.0172***			0.0154**
	(0.00645)			(0.00649)
5km Spillover		0.00379***		0.00257*
		(0.00131)		(0.00139)
10km Spillover			0.00167*	0.000541
			(0.000863)	(0.000919)
Observations	2,065,366	2,065,366	2,065,366	2,065,366
R-squared	0.259	0.259	0.259	0.259

Notes: Estimation based on administrative Catapults data, Gateway to Research (GtR) and the Business Structure Database (BSD). Robust standard errors reported in parentheses. *** p<0.001, ** p<0.01, * p<0.05.

Addressing the question of spillovers through supported firms, Tables 3 and 4 present the results of the analysis of knowledge externalities arising from the spatial clustering of Catapults-supported businesses. After controlling for the spillovers from Catapults centres, In Table 3 we identify positive externalities also from the agglomeration of Catapult-supported firms, although weaker in magnitude, in particular for unengaged firms located nearby high clusters of Catapult-supported businesses. These externalities operate mainly through the stimulation of unsupported firms to engage with the Catapults network, although this does not translate in the short-term in an increased likelihood for unsupported businesses to receive publicly funded UKRI R&D funding.

From Table 4 we can observe that these spillovers do not promote the upscaling of the existing companies or any increase in start-up rates in surrounding areas. However, we do identify a significant positive impact on the productivity of unsupported businesses, increasing their efficiency as a result of these indirect externalities.

Table 3: Spillover effects of Catapult-supported businesses agglomeration on nearby unsupported businesses – Engagement with the public innovation system.

	(1) New Firms	(2) New Firms	(3) Catapult Eng.	(4) Catapult Eng.	(5) UKRI Projects	(6) UKRI Projects
Catapult-supported Cluster	0.00462	0.00455	0.000126***	0.000114***	-0.000221	-0.000132
	(0.00344)	(0.00344)	(2.01e-05)	(2.07e-05)	(0.000187)	(0.000136)
Catapult 5km Spillover		0.0136		0.000579***		0.000475***
		(0.0167)		(0.000103)		(0.000152)
Observations	84,764	84,764	11,875,024	11,875,024	11,875,024	11,875,024
R-squared	0.010	0.010	0.012	0.012	0.093	0.093

Notes: Estimation based on administrative Catapults data, Gateway to Research (GtR) and the Business Structure Database (BSD). Robust standard errors reported in parentheses. *** p<0.001, ** p<0.01, * p<0.05.

Table 4: Spillover effects of Catapult-supported businesses agglomeration on nearby unsupported businesses – Start-up rates and business performance.

	(1) Employment	(2) Employment	(3) Turnover	(4) Turnover	(5) Productivity	(6) Productivity
Catapult-supported Cluster	0.000309*	0.000305	0.000606*	-0.000103	0.00159***	0.00113***
	(0.000158)	(0.000159)	(0.000315)	(0.000319)	(0.000295)	(0.000298)
Catapult 5km Spillover		0.0157***		0.0328***		0.0213***
		(0.00113)		(0.00209)		(0.00197)
Observations	11,824,201	11,824,201	11,824,201	11,824,201	11,824,201	11,824,201
R-squared	0.017	0.017	0.113	0.113	0.003	0.003

Notes: Estimation based on administrative Catapults data, Gateway to Research (GtR) and the Business Structure Database (BSD). Robust standard errors reported in parentheses. *** p<0.001, ** p<0.01, * p<0.05.

4. SUMMARY AND IMPLICATIONS

Earlier evidence suggests that firms engaging with Catapults grow significantly faster in terms of both employment and turnover than similar firms which are not engaging (Roper and Vanino 2023). Here, we extend this earlier analysis to provide evidence on the positive spatial spillovers from Catapult Centres which arise both directly from the Catapult Centre itself and through locally concentrated Catapult engaged firms. Our analysis suggests four key results:

(5) Local knowledge spillovers from Catapult centres increase the likelihood that co-located, but un-connected firms will collaborate in the future with the Catapult network and are more likely to receive public R&D funding from UKRI. This type of dynamic benefits have been noted elsewhere in the context of regional R&D and innovation support measures (Roper and Vanino, 2023). We see strong evidence of distance decay in these effects, which are particularly strong for businesses located in the immediate proximity of the Catapults centre, within a 1-kilometer radius, as the magnitude of the effects decreases as distance increases.

(6) Local knowledge spillovers from Catapult Centres also lead to improvements in employment and turnover growth, and an increase in labour productivity. Interestingly, we also find that Catapults stimulate the birth of new start-ups in the immediate proximity of their Centres.

(7) Indirect spillovers through supported firms are also evident in stimulating unsupported firms to engage with the Catapult Centres. This could be seen as a demonstration effect, i.e. un-supported firms see other local firms engaging and benefiting from engagement with the Catapult network and this encourages them then to engage.

(8) Indirect spillovers through supported firms also have a positive impact on the productivity of unsupported businesses, increasing their efficiency as a result of these indirect externalities.

In sum, Catapult centres generate positive local spillovers both directly and indirectly through the firms they work with. This evidence on the positive spillovers – both direct and indirect – from Catapult Centres reinforces the positive findings of earlier studies which suggest the positive effects of Catapult engagement on supported firms.

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