Assessing the Impact of Science and Technology Parks on Firm Profitability: A Comparative Study of On-Cluster and Off-Cluster Dynamics

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Abstract: Science and Technology Parks (STPs) are pivotal in driving regional development, primarily through fostering innovation and enhancing regional wealth. However, the impact of STPs on regional development remains a contentious topic with inconclusive findings. This study digs into the contribution of STPs to the profitability of firms by conducting a comparative analysis of profitability and salary data between firms located within these parks (on-cluster) and those outside them (off-cluster). The research adopts a two-pronged approach: initially, it examines firm profitability and employee salaries at an aggregate level to understand the overall economic impact of STPs. Following this, it models the various factors that influence firm profitability, offering a nuanced understanding of the dynamics at play. The findings are revealing – being located within an STP (on-cluster) appears to significantly boost a firm's profitability, but only up to a certain size of the cluster. This suggests that the benefits of being in an STP diminish beyond a certain scale. At a more granular, micro level, the study finds that a firm's previous innovation output has a positive impact on its profitability. This underscores the importance of continuous innovation for sustained economic success within these clusters. Conversely, a larger firm size seems to negatively impact profitability within STPs, indicating a potential strategy for growing firms to relocate off-cluster to mitigate this effect. For firms operating outside STPs (off-cluster), the scenario differs. Here, innovation plays a partial role in influencing profitability, and interestingly, the size of the firm does not significantly impact its profitability. This distinction between on- and off-cluster firms highlights the unique economic ecosystems fostered by STPs and their varied effects on firm performance. Overall, this study contributes to the ongoing debate on the role of STPs in regional development, offering new insights into how these entities affect firm profitability and suggesting potential strategies for firms operating within and outside these parks.

Keywords: Science and Technology Parks (STPs); Firm Profitability; Innovation Output; Cluster Dynamics; Knowledge Management

1. Introduction

The foundational Resource-Based View (RBV) of firms stems from an industrial organization approach, positing that businesses operate within a tangible reality. Managers can collect and process information within this reality to make informed decisions and implement strategies (Wernerfelt, 1984). However, when it comes to fundamental innovation and change, the RBV stumbles, struggling to grasp these pivotal concepts. In contrast, the Knowledge-Based View (KBV) centres around a firm's dynamic capability to innovate and adapt, an area ripe with debate and exploration for knowledge management theorists (Grant, 2002).

Industrial clusters, specifically, have undergone a fascinating evolution over the last 40 years. Once primarily spontaneous and grassroots ("bottom-up"), clusters have increasingly become focal points of scholarly and governmental attention for spurring innovation and regional development, particularly since Porter highlighted their competitive advantage. These clusters, such as Science and Technology Parks (STPs), now often materialize through planned ("top-down") initiatives, sometimes fuelled by taxpayer investment, with firms choosing whether to join these hubs or remain independent (Mondal et al., 2024; Mondal et al., 2023; Porter, 2003).

There are generally three acknowledged types of industrial clusters. First, "pure agglomeration industrial districts" are characterized by proximity-based firm networks that facilitate free labour movement and knowledge sharing. Second, the "industrial complex model" is distinguished by supply-demand relationships between co-located firms, aiming to minimize transportation costs but at times risking inflexibility. Finally, "social network clusters" thrive on trust-building through formal or informal networks, fostering cooperative work and potentially reshaping the cluster's organizational structure through shared investments (Gordon and McCann, 2000; Kolehmainen, 2002; McCann et al., 2002).

Historically, clusters aimed to reduce transaction and transportation costs by streamlining the flow of information and knowledge. They also served to minimize the hurdles in knowledge transformation and cost savings, such as infrastructure and specialized labour availability, which in turn fostered an environment conducive to knowledge sharing and cooperation (Barkley and Henry, 1997; Cojocaru and Ionescu, 2016).

At a regional level, clusters are lauded for their potential to enhance wealth by supporting entrepreneurship, attracting multinational corporations, and boosting employment. However, such initiatives also carry risks and potential downsides, such as the possibility of economic "lock-in," space constraints, and the misallocation of financial resources (Barkley and Henry, 1997; Sunley and Martin, 2010; Breschi and Malerba, 2001; Tallman et al., 2004).

Regarding financial returns, the examination of Science and Technology Parks (STPs) across Europe, which employ significant numbers and represent a considerable investment, has been a major focus of scholarly inquiry (EU Commission, 2018). Studies have scrutinized various performance indicators, including employment growth and innovation outputs, to gauge the success and influence of clusters on regional economic vitality (Al-kfairy et al., 2017; Temouri, 2012; Porter, 2003).

This study seeks to illuminate the factors influencing the profitability of on-cluster firms by analysing financial data at both the aggregate and micro-levels. It endeavours to understand the interplay between innovation and profitability within clustered environments. By employing panel data analysis and contrasting on-cluster with off-cluster firms, the study aims to extract nuanced insights into the drivers of firm success within these unique ecosystems.

2. Related Work

Innovation expenditure and output significantly influence firm profitability, and their impact is often moderated by the firm’s location within or outside of industrial clusters such as Science and Technology Parks (STPs). This section explores how these factors interplay to shape financial outcomes for firms, emphasizing the distinctive effects of being situated on-cluster (within STPs) versus off-cluster (outside STPs).

Innovation expenditure, encompassing R&D spending, technology acquisition, and related investments, is a critical determinant of a firm's capability to develop new products and processes, which can lead to a sustainable competitive advantage (ÖZKAN, 2022). However, the immediate impact of such expenditures on profitability can be complex. Initially, high innovation expenditures might not translate into immediate profits due to the time lag between spending and the realization of benefits through commercialization (Schäper et al., 2023). This delay can be attributed to the development cycles required to innovate and subsequently market the innovations effectively. Previous studies have highlighted that while R&D intensity is a strong predictor of future revenue growth and market valuation, its direct impact on short-term profitability is often negative or neutral, as these investments take time to yield returns (Tung and Hoang, 2024).

Innovation output, typically measured by metrics such as patents, licenses, and product launches, directly correlates with enhanced firm performance, especially in technology-oriented sectors. Firms that successfully commercialize their innovations can secure substantial profits and market share. The effect of innovation output on profitability is more pronounced when these outputs are successfully aligned with market needs and are adequately protected through patents or copyrights, which prevent competitors from eroding the innovator’s market position. Empirical studies suggest a positive correlation between patent outputs and firm profitability, emphasizing that firms with higher patent counts tend to exhibit better financial performance, assuming these patents are of high quality and market relevance (Song et al., 2024).

Being located within an STP (on-cluster) can significantly affect a firm's profitability. STPs are designed to foster an environment conducive to innovation and business growth by providing infrastructure, networking opportunities, and access to knowledge and resources. Firms located on-cluster benefit from proximity to other innovative companies and research institutions, which facilitates knowledge spillovers and collaborative opportunities. These interactions can enhance the firms' innovation output and, consequently, their profitability (Aydemir, 2024).

Moreover, firms in STPs often have better access to funding sources, including venture capital and government grants, which can enhance their ability to invest in innovation. However, the benefits of being on-cluster might diminish as the cluster grows and becomes congested, potentially leading to increased competition for the same resources and talent, which might initially decrease profitability for some firms. This dynamic underscore the importance of managing growth within STPs to maintain an environment that continues to support each firm's profitability (Mondal et al., 2023).

In summary, both innovation expenditure and output play crucial roles in determining firm profitability, with these effects significantly influenced by the firm’s location within industrial clusters. The strategic benefits of on-cluster location can provide firms with competitive advantages through enhanced innovation capabilities and

access to collaborative networks and funding. Understanding these dynamics is essential for firms deciding on their location strategy and for policymakers aiming to foster successful innovation ecosystems within STPs.

3. Methodology

Using the dataset obtained from the Swedish database (Ratsit) for industrial code 62X, we collected firms' financial data for 2007-2015. The data includes on- and off-cluster firms for Linkoping Science Park (Mjardevi). Using porter's definition of business clusters, firms were either identified as on-cluster if they are either:

- Located inside the business cluster postcode area.
- Or is part of the STP organisations.
- Otherwise, they are considered off-cluster.

Then, we categorise the data every year and sum up the firms' profit using the following formulas:

$$Profit_y = \sum_{i=1}^{n} Profit_i \text{ , y is the year and } i \text{ is the firm.}$$

Equation 1

After that, the average profit-per-Employee and the average salary-per-employee, as well as the Average Patent and License income per-employee and Average R&D investments per-Employee, was calculated for both on and off-cluster firms in order to make a systematic comparison between on- and off-cluster firms. Then, we run a correlation analysis to understand the factors that influence the overall firm's profitability for both on- and off-cluster firms using SPSS.

Finally, we used Stata to build a fixed and random effect model using panel data analysis for both on- and off-cluster firms. Hausman test was used to choose between the fixed and random effect models (an approach similar to Al-kfairy et al., 2019b).

4. Results

After executing equation 1, we obtained the results in Table 1. Table 1 shows that the firms' total profit for on-cluster are much better than off-cluster at the aggregate level. This proves that, at the aggregate level, firms located on-cluster – financially - perform better than off-cluster firms.

Table 1: On- and Off-cluster Financial Data Summary (Salaries and Profit are measured as KSEK (thousands Swedish Krona)

Year	Number of Emps (Off-cluster)	Total Profit for all Firms (Off-cluster)	Number of Employees (On-Cluster)	Total Profit for all Firms (Off-cluster)
2008	466	91,775	1,203	781,009
2009	552	68,271	1,281	308,624
2010	607	-34,480	1,353	324,679
2011	696	64,703	1,340	207,752
2012	818	56,956	1,468	119,717
2013	863	87,420	1,610	273,235
2014	987	51,830	1,630	-80,207
2015	1,130	69,928	1,470	57,872
2016	1,145	71,075	1,463	-2,362

However, in order to get a better understanding of the obtained results, we calculate the average per-employee, which should give a better understanding of the firms' performance. Figure 1 shows that On-cluster outperforms off-cluster profit up to the year 2012, when the on-cluster profitability started to decline, and off-cluster firms become – on average – more profitable than on-cluster firms. Thus. We compared the growth in the number of employees to findout if the drop in the average profit is related to higher growth rate in the number of employees as shown in Figure 2.

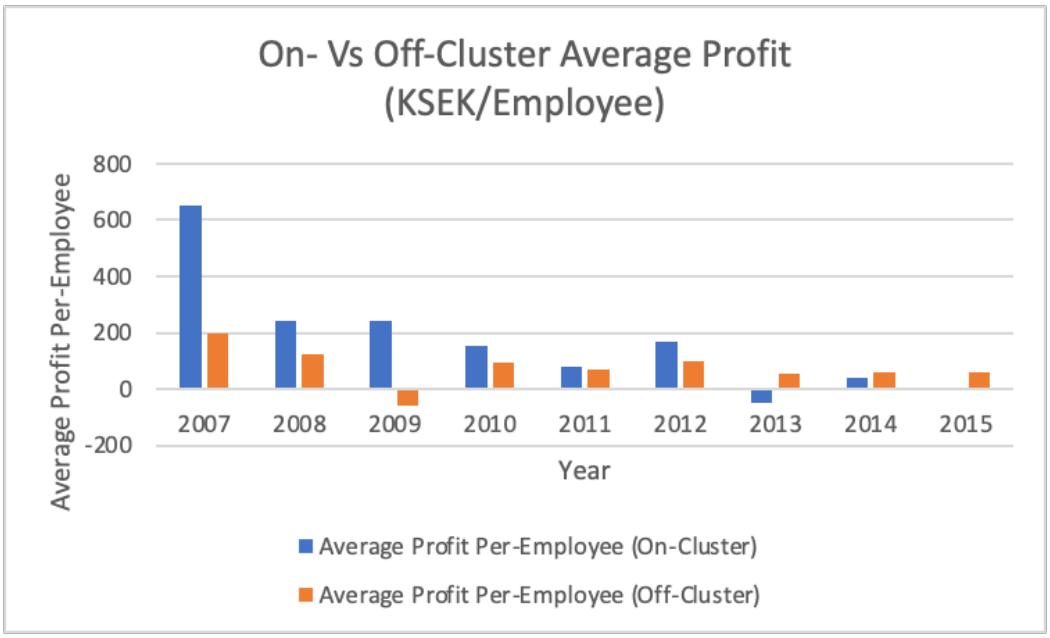

Figure 1: On-VS Off-Cluster Average Profit Per-Employee

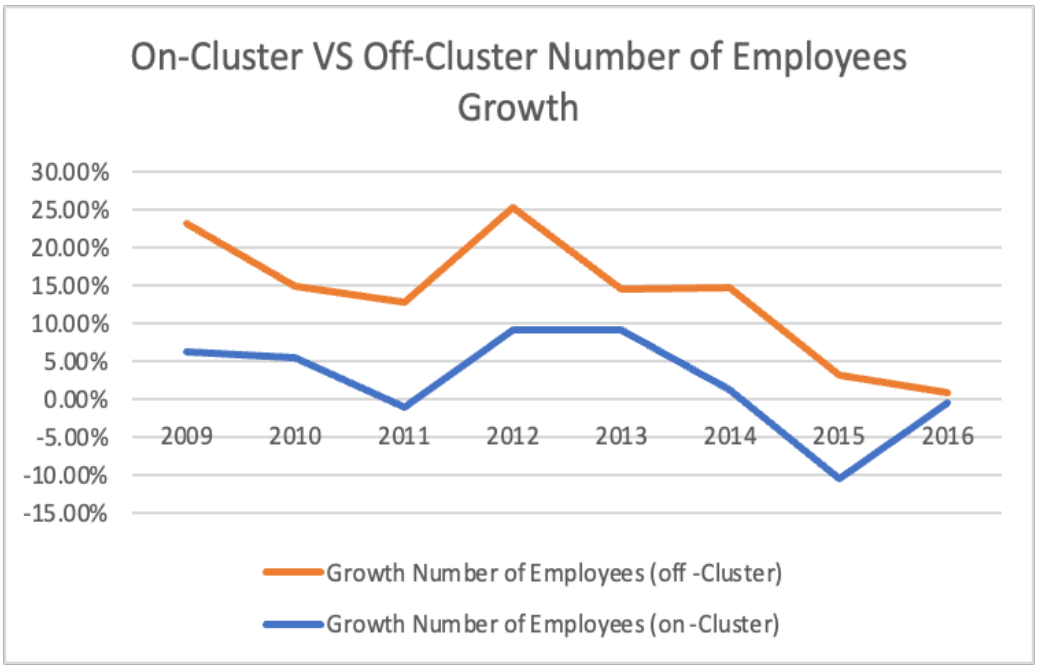

Figure 2: On-Cluster VS Off-Cluster Number of Employees Growth

Although the comparison shows that on-cluster firms – on average- are more profitable than off-cluster firms, the picture is still not clear, especially in understanding how time (age of the cluster) impacts the firms' profitability. Thus, SPSS was used to understand if there is a correlation between the growth in number of firms (size of the cluster) and firms profitability (in average). Figure 3 proves that there is an initial decline in the firms' average profitability as more firms are joining the cluster, which causes the average profit to decline, which is normally because firms take time to start generating profit. This can be explained by the lag between innovation generation and licensing innovation (Al-kfairy et al., 2019b).

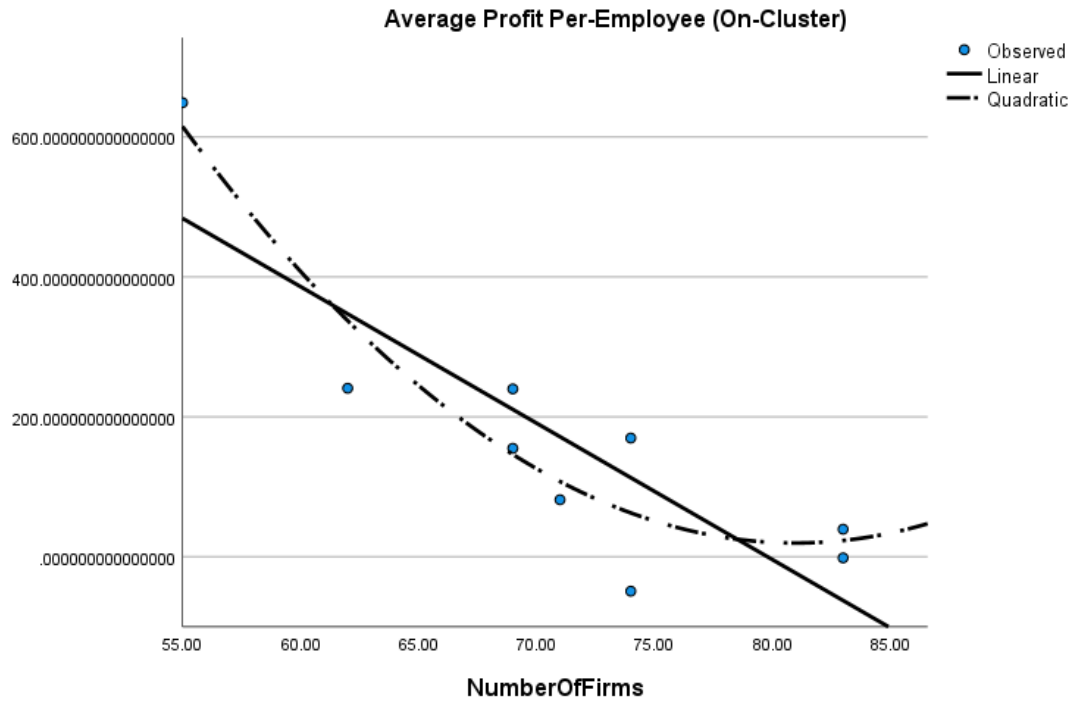

Figure 3: On-Cluster Number of Firms VS Average Profitability

Then, we analyzed the impact of the average innovation output on both on-cluster and off-cluster firms profitability, we run Spearman regression analysis between the average innovation output measured as patent and license income with firms profitability. Surprisingly, the results show a significant negative correlation between average patents and license income and firms' profitability for on-cluster firms (Rho = -0.783, p-value = 0.013). This indicates that the more innovation income the less profitable the company. However, as Al-kfairy et al., 2019b argued that there is a positive correlation between innovation output and Turnover, but a negative initial correlation, these results are compatible with their results, and the on-cluster firms will start benefiting from innovation output later in the cluster development. On the other hand, no significant correlation was identified between off-cluster firms' profitability and innovation output, which is again indicates that off-cluster firms financial return does not depend on how innovative is the firm, but on the nature of the firms' business which is most likely a consultation company.

Furthermore, we calculated the innovation capability per firm using the following equation:

$$Innov_{i,t} = \frac{P\&L_{i,t}}{Turnover_{i,t}}, i\ is\ the\ reporting\ firm, and\ t\ is\ the\ year\ (2007, 2008 \ldots 2015)$$

Equation 2

Then, we apply panel data analysis techniques with both fixed and random effect model to firms' profit data at both on-cluster and off-cluster firms. The final obtained regression model for on-cluster firms profit using fixed-effect model (Huasman test returned p-value of less than 0.001 and concludes that random effect model is not appropriate) is summarized in Equation 3:

$$Profit_{i,t} = C_1\ Innov_{i,t-1} + C_2 R\&D_{i,t-1} + C3GroupContribution_{i,t} + C4NumberofEmployees_{i,t} + Const$$

Equation 3: On-Cluster Firms Profit Regression Model

Table 2: Coefficient Values Obtained from the Regression Model (Equation 3)

	Coef	p-value
C_1	579.045	0.005
C_2	0.310	0.080

	Coef	p-value
C_3	0.520	0.001
C_4	-1139.154	0.000
const	21050.710	0.000

The model shows a positive lag effect of innovation parameters for Innov measured as patent and License outcome ratio to Turnover and the R&D investments. The model results support the results at the aggregate level, which shows no immediate effect of innovation output on the firms' profitability. Moreover, it shows a positive impact of firms' group contribution on firms' profitability, which further support the hypothesis that a firm is more likely to be profitable if it is part of a group. These results are in line with earlier results of Al-kfairy et al., 2019b, who shows a positive relationship between innovation and turnover for on-cluster firms.

In order to understand if there is a difference between the on- and off-cluster firms, we run the same model for off-cluster firms. The model shows a significant positive relationship between innovation (Patents and License Ratio to Turnover) as well as group contribution and firms' profitability, but no significant relationship between R&D investments and firm size (measured as a number of employees) and firms' profitability.

The previous results suggested that regardless of being on-cluster or off-cluster, innovation is always positively impacting the firms' profitability. However, one significant difference between being on-cluster and off-cluster is the R&D investment impact, which shows a positive effect in the case of being on-cluster. At the same time, no significant relationship was reported in case of being off-cluster. Thus, innovation is more influential in case of being on-cluster, which indicates that on-cluster firms are more innovation-driven than off-cluster firms.

Another significant difference is the size impact, which proves that on-cluster firms can be profitable but once it grows more, then it might need to move off-cluster to stay profitable as size does not have any significant impact on off-cluster firms.

5. Discussion

5.1 Theoretical Implications

This study enriches the theoretical landscape surrounding the Knowledge-Based View (KBV) of firms by elucidating the mechanisms through which knowledge management and innovation catalyze firm success within clusters. By highlighting the nuanced effects of on-cluster locations on innovation outputs and profitability, it offers empirical support for the KBV's assertion that proximity to similar and complementary businesses amplifies a firm's capacity to leverage external knowledge for competitive advantage. Additionally, the relationship between innovation outputs, such as patents, and firm profitability extends resource-based theories. This alignment underscores the necessity of not only possessing but also strategically deploying firm-specific capabilities and resources to achieve superior performance. The findings also contribute to cluster theory by illustrating how clustering benefits, like increased collaboration and access to specialized knowledge, impact firm profitability. This introduces a more balanced perspective on cluster dynamics, acknowledging potential drawbacks like resource saturation as clusters expand.

5.2 Practical Implications

From a practical standpoint, the insights from this study are invaluable for managers, policymakers, and entrepreneurs engaged with or considering involvement in Science and Technology Parks (STPs). Managers are advised to optimize their innovation strategies by aligning R&D investments with market demands and protecting intellectual property to fully capitalize on innovations. The study also informs location decisions, suggesting that firms evaluate the benefits and potential challenges of situating within an STP. While smaller firms and startups may find critical support in these environments, larger organizations might reconsider their placement as clusters become congested. For policymakers, these findings highlight the importance of designing and managing STPs to support sustainable firm growth and innovation, suggesting policies that adapt to the evolving needs of firms and the technological landscape. Furthermore, recognizing the diverse innovation profiles across different types of firms, both policies and management practices should be tailored to maximize the economic and competitive benefits of innovation activities within the cluster. These practical and theoretical insights collectively offer a robust framework for enhancing firm profitability through strategic innovation management and thoughtful engagement with STP ecosystems.

6. Conclusion and Future Work

STPs are considered as a regional tool for fostering regional development by stimulating regional employment and financial growth. During the last couple of decades, many regional authorities tried this tool. For example, IASP reported more than 350 members worldwide and more than 115,000 employees (IASP,2021). While the STPs organisation structure impact on firms' innovation has been well studied as in Al-kfairy et al., 2019a; Al-kfairy et al., 2020 and Al-kfairy and Mellor, 2020. However, the impact of STPs on financial growth is still debatable, especially if locating inside STPs will enhance the firms' probability to generate more profit. Thus, this study tried to uncover that by comparing on- and off-cluster firms' profitability.

The results indicate that locating on-cluster will increase the firms' profitability in general. However, as more firms join the STP over time, this will have a temporary impact on firms profitability which causes it to decline, then grow again. This conclusion which further support Al-kfairy et al., 2019b which indicated that STPs growth is not linear and moves between different stages. Furthermore, the results show that off-cluster firms provide better salaries on average to their employees than on-cluster, which can be explained by the fact that on-cluster firms spend more on innovation investment in the form of R&D than on employees salaries.

This study indicates that locating on-cluster will enhance the firms' profitability than selecting to locate off-cluster. However, the results show a positive impact of innovation for both on-cluster and off-cluster at the micro level, but this impact is partial on the off-cluster firms. Moreover, the firm size is negatively impacting firms' profitability in case of on-cluster firms, which means that cluster innovation impact on firms' profitability is temporary.

Although this study contributes to understanding how location can positively impact firms' profitability, it is crucial to understand firms' profitability for different industries as well as study business clusters at different development stages rather than a mature business cluster.

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