Science and technology parks: an annotated and analytical literature review

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Abstract:

This paper summarizes the extant literature on science and technology parks in an effort to provide a foundation to stimulate additional research in this globally important topic. We find from our review of published scholarship over the past 30 years that attention to science and technology parks has indeed increased, but it has not yet exploded. We also find that the current distribution of the country focus of this research is skewed toward China, the United Kingdom, Spain, and the United States. Emphasis on studies related to UK and US parks has been primarily due to data availability; in China and Spain the emphasis has been primarily on case studies.

Keywords: science park | technology park | clusters

Article:

In 2009, the National Research Council of the US National Academies assembled international scholars to confront issues related to science and technology parks from a global perspective. One important conclusion from that assemblage was (NRC 2009, p. 7): "Science and technology research parks are seen increasingly as a means to create dynamic clusters that accelerate economic growth and international competitiveness." Another important conclusion, and the one that motivates this paper, is that the academic and professional literature on the formation and performance of parks is "embryonic" (p. 33). Thus, the remainder of this paper summarizes the extant literature on science and technology parks in an effort to characterize what has been written and, based on that body of thought, to stimulate additional research on this globally important topic.

Before proceeding to review the literature, we summarize here alternative definitions of a science and technology park (STP). Perhaps the broadest definition has been offered by UNESCO:[1]

> The term "science and technology park" encompasses any kind of high-tech cluster such as: technopolis, science park, science city, cyber park, hi tech (industrial) park, innovation centre, R&D park, university research park, research and technology park,

[1] See, http://www.unesco.org/new/en/natural-sciences/science-technology/university-industry-partnerships/science-and-technology-park-governance/concept-and-definition/.

> science and technology park, science city, science town, technology park, technology incubator, technology park, technopark, technopole and technology business incubator.

Various park associations have their own definitions, and these definitions intersect in large part with what an association does for its park tenants and what the park tenants expect from their association. According to the International Association of Science Parks (IASP):[2]

> A science park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions.

The United Kingdom Science Park Association (UKSPA) defines a science park as:[3]

> … a business support and technology transfer initiative that: encourages and supports the startup and incubation of innovation-led, high-growth, knowledge-based businesses; provides an environment where larger and international businesses can develop specific and close interactions with a particular centre of knowledge creation for their mutual benefit; and has formal and operational links with centres of knowledge creation such as universities, higher education institutes and research organisations.

And, the American Association of University Research Parks (AURP) defines a university research park as:[4]

> … a property-based venture, which: master plans property designed for research and commercialization; creates partnerships with universities and research institutions; encourages the growth of new companies; translates technology; and drives technology-led economic development.

The common element in these definitions is that a park is an innovation-related infrastructure through which knowledge is exchanged, and a university is often a catalyst for that symbiosis.

Our annotated review of science and technology parks is in the "Appendix" to this paper.[5] We have identified 87 articles and papers, hereafter referred to simply as publications; 2 book chapters; and 4 books that focus on science and technology parks from around the world.[6] From that table we constructed a time line on the number of scholarly publications related to parks, by year of publication; we did not include book chapters or books. See Fig. 1.

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[2] See, http://www.iasp.ws/knowledge-bites.
[3] See, http://www.ukspa.org.uk/our-sector.
[4] See, http://www.aurp.net/what-is-a-research-park.
[5] Our effort to summarize the works and findings of the scholars listed in the "Appendix" table in a few sentences is without question an over-simplification of their due diligence. Our sincere apology if we have overstated or understated any key findings. Such was completely unintentional.
[6] Any omissions to the table in the "Appendix" are unintentional. We relied on references in other papers and on Internet searches to assemble the table. That approach to identifying the literature is biased against us finding all relevant book chapters and books. We hope that our review will stimulate others to expand on this literature review and to develop a taxonomy that characterizes it.

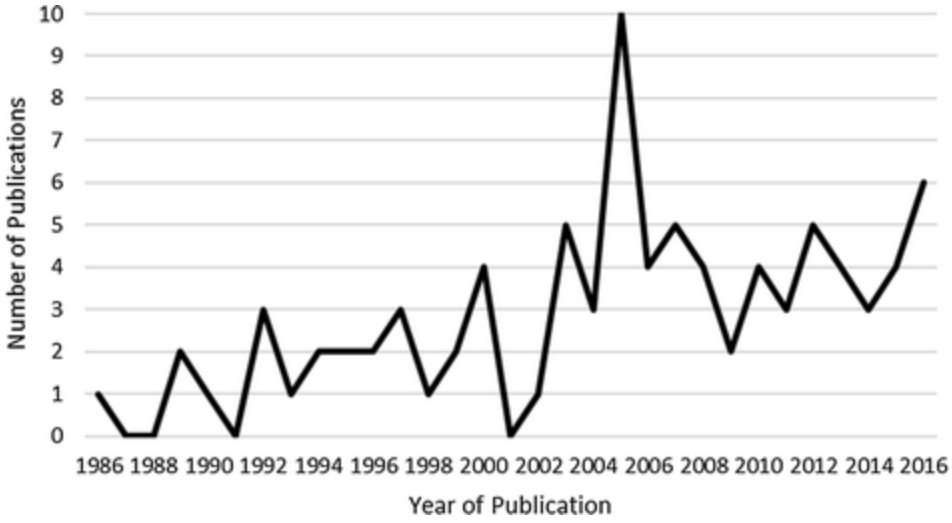

Fig. 1. Number of science and technology parks related publications, by year of publication

The pattern in Fig. 1 suggests that over the 30-year period identified by the references in the "Appendix", there has been an upward trend in the number of publications. Figure 2 divides the publications for the 31 years depicted in Fig. 1 into those published in a base period of 1986–1989 and then the following nine three-year periods. Fitting an exponential growth line to these data shows a growth rate of 17% per period. To the best of our knowledge, there was not a notable event or a pivotal publication that has dramatically stimulated research on science and technology parks over the past 30 years.

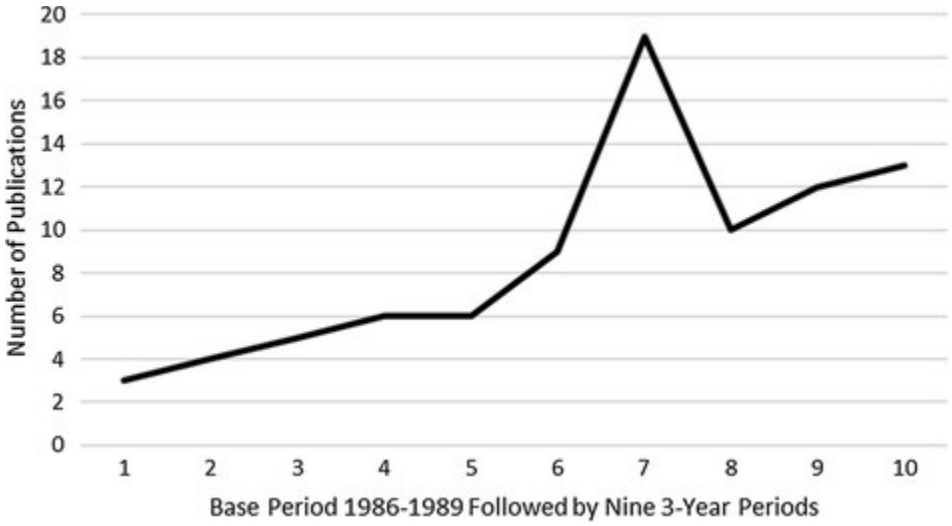

Fig. 2. Number of science and technology parks related publications, by 3-year period

Knowledge grows continuously, and the literature's growth can be thought of as new articles building on the earlier ones and so the cumulated articles grow from the earlier ones just as an investment grows with compound interest and with the interest compounded continuously. Just as the investor earns interest on the interest as well as the principal, the literature returns new articles from the older ones, and from the newer ones that built on the first contributions. Figure 3 shows the cumulative number of articles over the 31 years from 1986 through 2016.

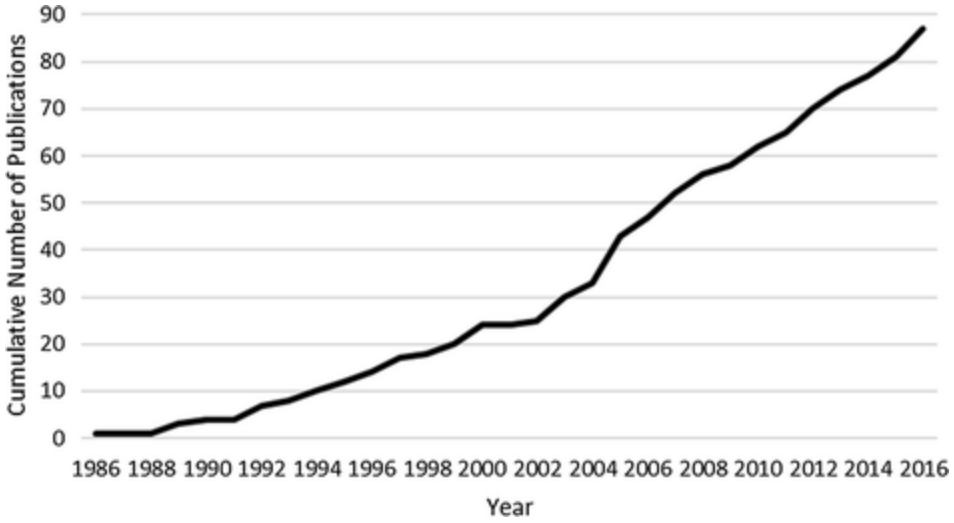

Fig. 3. Cumulative number of science and technology parks related publications over time

Figure 3 shows that publications have accumulated steadily. The time series of the cumulative publications can be used to estimate the annual growth rate of publications. Figure 4 shows that growth began at an annual rate of about 50% compounded continuously, and then the annual growth rate declined steadily to less than 20%.

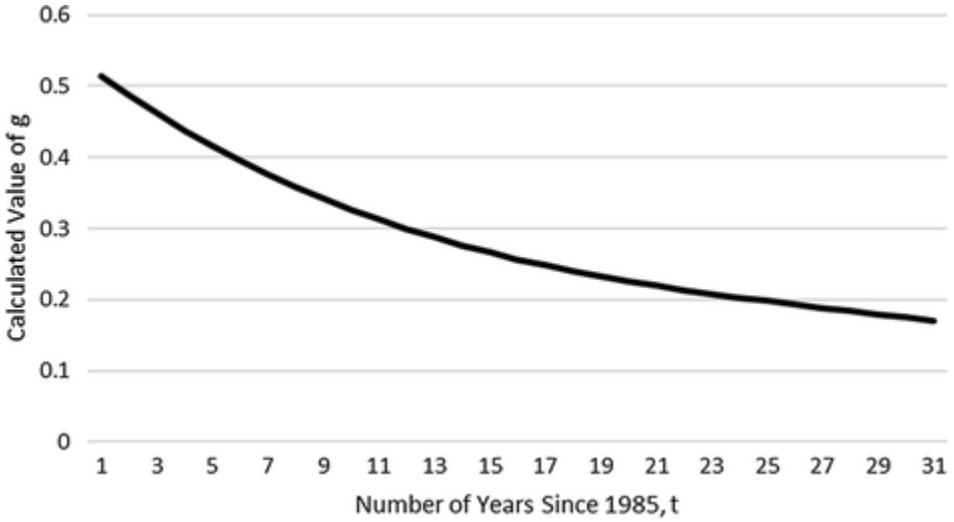

Fig. 4. Annual growth rate in cumulative number of science and technology parks related publications. *Note* $g = .542 - .0294 \times t + .000896 \times t^2 - .0000108 \times t^3$

The annual growth rate, allowed to vary over time, is estimated very well as can be seen by plotting the predicted number of publications using the estimated model in Fig. 4 with the plot of the cumulative number of publications. Figure 5 compares the actual and the predicted number of cumulative publications by year.

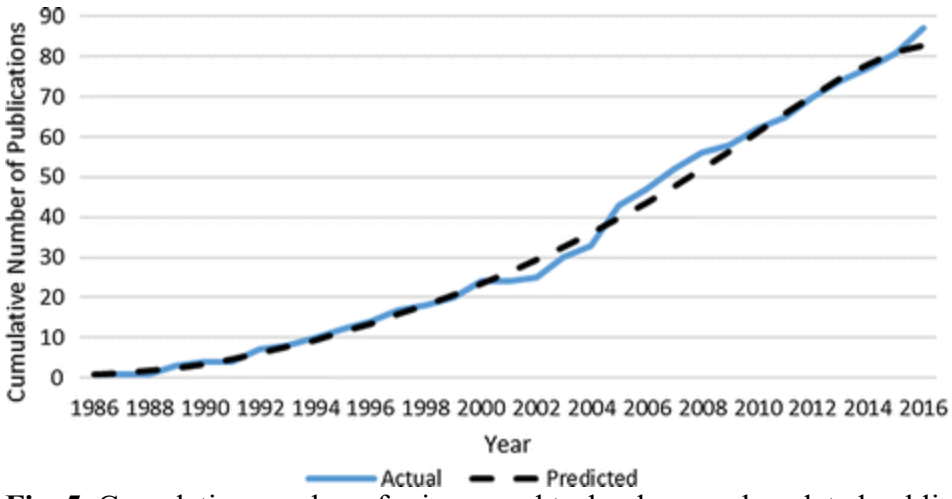

Fig. 5. Cumulative number of science and technology parks related publications over time: actual number versus predicted number

We grouped the 87 publications into five types of studies: empirical studies (35), case studies (34), theoretical or conceptual publications (10), literature reviews (5), and publications related to park evaluation methods (3).[7] See Fig. 6 for the plot of the number of empirical publications by year; see Fig. 7 for the plot of the number of case studies by year.

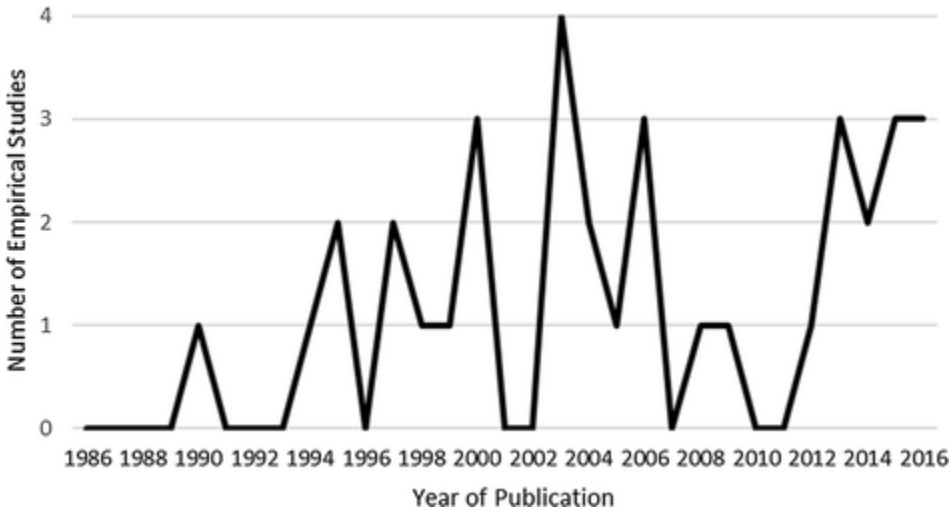

Fig. 6. Number of empirical science and technology parks related publications, by year of publication

Empirical studies and case studies are visually greater in the post-millennium period, although the overall number of studies is relatively small. Since 1986, the average number of publications related to science and technology parks of either an empirical nature or a case study nature is only about 2 per year.

[7] Future reviews might well construct alternative categories.

Of the 87 publications that we identified in Fig. 1 and in the "Appendix", 82 of them focus on a specific country or countries.[8] Figure 8 shows the distribution of the number of publications, by country. Studies related to China and the United Kingdom dominate in the figure. More than one-third of the literature relates to science and technology parks focused on these two countries. To generalize, the preponderance of studies in the UK have been empirical and those in China have been case studies.

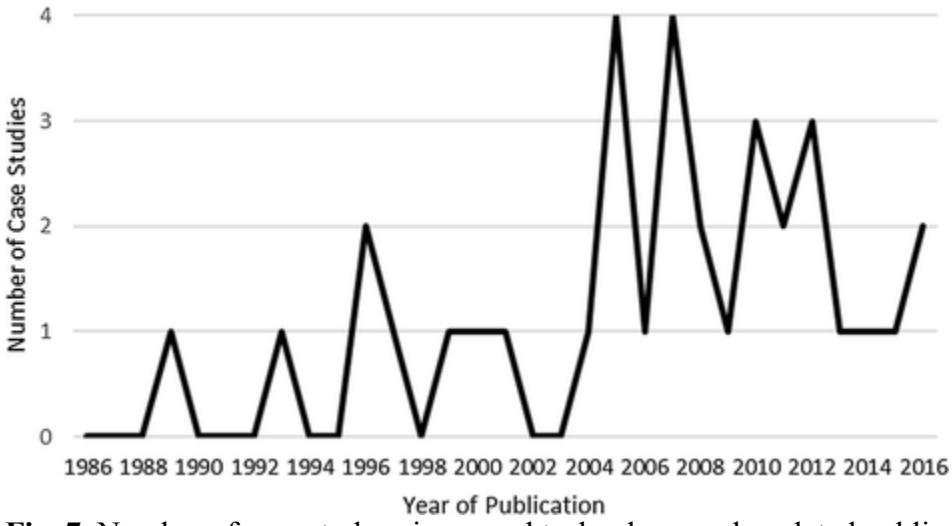

Fig. 7. Number of case study science and technology parks related publications, by year of publication

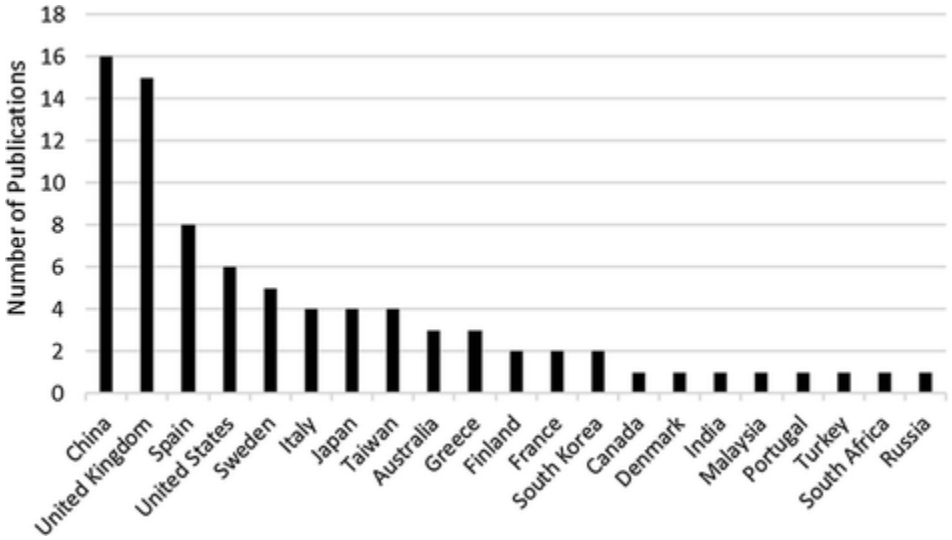

Fig. 8. Number of science and technology parks related publications, by country. *Note* Only publications (defined as articles or papers), not book chapters or books, are considered in this figure

We infer from Figs. 1, 6 and 7 that there has indeed been mild growth in scholarship over time related to science and technology parks, although as seen in Figs. 2 through 5 the annual growth

[8] Some case studies relate to parks in different countries, some literature reviews are not country specific, and those publications related to evaluation methods are not country specific.

in the cumulative number of publications has been substantial. Further, we infer from Fig. 8 that there is global interest in research on this topic. We would not be surprised if, over the next decade, the volume of research increases over that of the past decade, and the distribution of country focus becomes less skewed.

Regarding the impact of publications related to science and technology parks, Fig. 9 shows the relationship between the age of a publication and the number of Google Scholar citations to it as of September 28, 2016. Publication age was calculated as (2016—date of publication). From the figure, it appears to take about a decade for publications to begin to be highly cited, and that tendency seems to last for about another decade.[9]

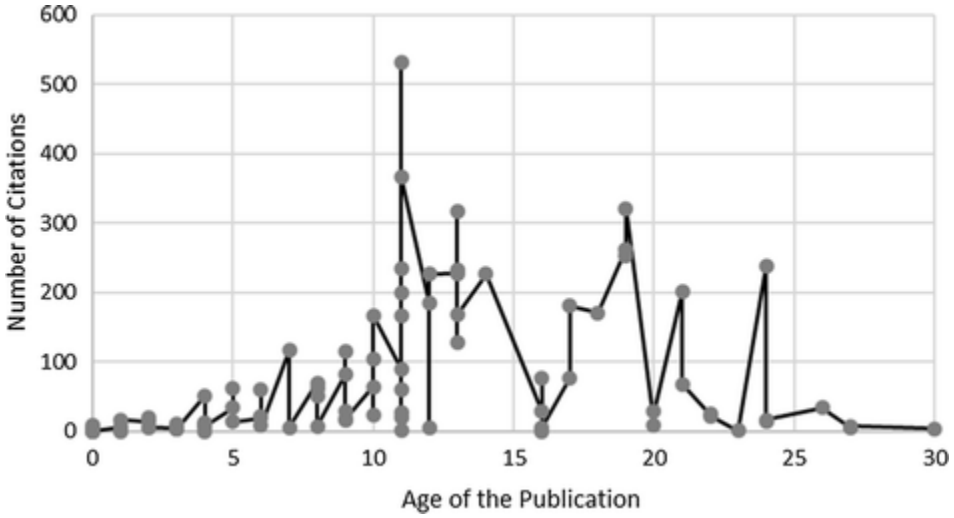

Fig. 9. Number of citations to science and technology parks related publications, by age of publication

Our conclusion is that, although there has been substantial growth in the literature, the science and technology park literature is, to repeat the National Research Council's term, still "embryonic." Perhaps when more academic leaders step forward to sponsor conferences or special issues of journals on the subject, this field of research will begin to develop more in an effort to keep pace with the growth of parks throughout the world.

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[9] This finding holds for empirical as well as case study publication.

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Appendix: Literature related to science and technology parks (authors listed alphabetically)

Author(s)	Category of study	Country(ies)	Findings
Albahari et al. (2013b)	Empirical	Spain	Finds that the more involved a university is in management of the park the more slowly firms move innovations to market products. Involvement is positively related to the propensity of firms to apply for patents; involvement does not affect the propensity of firms to cooperate with the university nor with the amount of R&D funding from the university
Albahari et al. (2010)	Literature review	Italy Spain	Literature review of the role that science and technology parks play in supporting R&D activities in both public research firms and other organizations
Albahari et al. (2013a)	Empirical	Spain	Analysis of Spanish science and technology parks. Finds that involvement of a university in the STP has a negative effect on tenant innovation sales but a positive effect on the number of patent applications
Bakouros et al. (2002)	Case study	Greece	Case study of three science parks in Greece. Appear to be no research synergies between the university and the park tenants in any of the parks
Carvalho (2009)	Case study	Portugal	Case study of the challenges that face new science and technology parks as reflected in the challenges faced by AvePark in Guimarães, Portugal
Chan et al. (2010)	Case study	South Africa	Case study of the Innovation Hub in Pretoria, South Africa. The conclusion is that the innovative performance of in-park firms and off-park firms is not different
Chan and Lau (2005)	Evaluation methods	China	Using a set of evaluation criteria, data from six technology start-ups in the Hong Kong Science Park are studied. Findings do not support the claim that incubators are effective in the development process for firms
Chen et al. (2013)	Case study	China	History of the development of Hsinchu Science Park in China over the past 30 years
Chou (2007)	Case study	Taiwan	International, national, and subnational forces caused a polycentric development of the Hsinchu science-based industrial park in Taiwan, which in turn has led to governance issues in the region
Dabrowska (2011)	Evaluation methods	–	Proposes a matrix of indicators to measure performance of science parks in order to create consistency in science park evaluations
Díez-Vial and Fernández-Olmos (2015)	Empirical	Spain	Shows that firms located on or near science and technology parks in Spain benefit the most from their location if they have had previous cooperative research agreements with universities and their research institutions
Díez-Vial and Montoro-Sánchez (2016)	Case study	Spain	Case study of firms in the Madrid Science Park in Spain finds firms that pursue formal agreements and informal interactions with the university tend to increase their innovative capacity, while firms that focus on their internal knowledge network tend to increase their innovative outputs
Druilhe and Garnsey (2000)	Case study	France UK	Comparative case study of the birth and growth of Cambridge (UK) and Grenoble (France) high-tech centers
Edgington (2008)	Case study	Japan	Case study of the history of the Kyoto Research Park in Japan and the park's current relationship with regional and local innovation systems
Eto (2005)	Theoretical	Japan	Identified cultural differences between the administration and businesses world and the science and technology (ST) world as a reason for Japan's successful outcomes of science and technology policy toward parks
Feldman (2007)	Case study	Sweden	Explores the political and economic origins of the science park in Linköping, Sweden. Generalizes that growth projects like science parks build on coalitions and networks that are focused on linking together innovative, political, and financial resources

Author(s)	Category of study	Country(ies)	Findings
Ferguson and Olofsson (2004)	Empirical	Sweden	Using matched pairs of firms, there do not appear to be any performance differences between on-park and off-park firms
Fikirkoca and Saritas (2012)	Case study	Turkey	Case study of the science park at Ankara University in Turkey. Discusses factors associated with the success of the park and concludes that the park has built itself by leveraging complementary resources
Fu (2016)	Case study	China	Case study of Tianhe Software Park (TSP) in Guangzhou, China, that chronicles the start-up stories of entrepreneurs that clustered in the park
Fukugawa (2006)	Empirical	Japan	Examines matched-pairs of firms on and off of Japanese parks and concludes that research linkages are more likely formed with universities if firms are on a park than off of a park
Fukugawa (2015)	Empirical	Japan	Shows, using data on Japanese science parks with incubators, that research cooperation with universities is positively related to whether the managers of the incubators have a broad scope of professional experiences
Gibson et al. (2012)	Theoretical	–	Suggests that the impact of a park on the local economy can best be understood in terms of the core activities of firms on the park and their inter-relationships
Gkypali et al. (2016)	Empirical	Greece	Argues that a latent knowledge production function is a useful tool for evaluating the performance of science and technology parks in terms of their regional impacts
Goldstein and Luger (1990)	Empirical	US	Based on a comparison of university-based and non-university based parks in the United States, concludes that a firm's decision about the type of park in which to locate is based on the firm's linkages to the university
Goldstein and Luger (1992)	Theoretical	US	Discussion of conditions, such as firm spinoffs, that are necessary for a park to have a positive impact on regional development. Conclusions based on a study of US parks
Gower and Harris (1994)	Empirical	UK	Examines sources of funding and investment dollars for UK science parks. Concludes from descriptive analysis that public sector support is the dominant source of funding
Guadix et al. (2016)	Theoretical	Spain	Based on characteristics of parks in Spain, models are suggested for identifying park strategies that lead to successful parks
Guo and Verdini (2015)	Case study	China	Firms locate in Cuiping Technology and Innovation Park in China mainly because of incentives such as tax subsidies and land support; of secondary consideration is the availability of human capital, infrastructure, and facilities
Guy (1996a)	Case study	UK	Overviews the formation and growth of Aston Science Park in the UK
Guy (1996b)	Case study	UK	Case study of the Oxford Science Park in the UK with an emphasis on how it has maintained linkages between the university and industry
Hansson et al. (2005)	Case study	Denmark UK	Two case studies. One was Symbion, a traditional science park near Copenhagen, and the other was the park at the University of Newcastle. Compares and contrasts, based on interviews, growth strategies of the parks
Hommen et al. (2006)	Case study	Sweden	Case study of the historical development of the growth of the Mjärdevi Science Park in Sweden
Huibing and Nengli (2005)	Theoretical	China	Offers a retrospective look at the development of China's science parks and argues that a strategy is needed in China for developing high-tech clusters
Jongwanich et al. (2014)	Empirical	China	Analysis of data shows that science parks have a positive impact on regional patenting and have acted as a stimulus to coordinating collaborative R&D efforts among firms
Joseph (1994)	Theoretical	Australia	Drawing on lessons learned about parks from the literature, an argument is set forth that parks should not be evaluated in terms of being just another

Author(s)	Category of study	Country(ies)	Findings
			element within a linear model of innovation. New evaluation methods are needed
Kharabsheh (2012)	Empirical	Australia	Based on interviews, key managerial characteristics associated with the success of technology parks are identified
Lai and Shyu (2005)	Case study	China Taiwan	Case study compares the innovation capacity of Zhangjiang High-Tech Park in China with the Hsinchu Science-based Industrial Park in Taiwan. Differences between the parks are found in research infrastructure and clusters
Lamperti et al. (2015)	Empirical	Italy	An analysis of on-park and off-park firms finds that location on a park is associated with more innovation and more investments in R&D, while location is not associated with the growth of firms
Larsen (2004)	Case study	Finland Sweden	Case study of two parks: Hermia in Tampere, Finland, and Kista Science City in Stockholm, Sweden. Drivers promoting better environmental management are identified
Leyden et al. (2008)	Theoretical	–	Model of park growth is developed under the assumption that parks invite firms to join a park based on their potential spillover benefits (i.e., knowledge spillover benefits) to existing park firms
Liberati et al. (2016)	Empirical	Italy	Analysis shows that firms entering a science and technology park did not generally improve their propensity to innovate when compared to being outside of the parks
Lindelöf and Löfsten (2003, 2004)	Empirical	Sweden	On-park and off-park firms view performance differently. On-park firms emphasize innovation and market measures (i.e., profitability) more so than off-park firms
Link (1995)	Case study	US	Case study of the early history of establishing Research Triangle Park in North Carolina
Link (2002)	Case study	US	Case study of the growth of Research Triangle Park in North Carolina
Link and Scott (2003a)	Empirical	US	Relies on the history of Research Triangle Park in North Carolina to illustrate the growth in tenants and employees in the park over time
Link and Scott (2003b)	Empirical	US	Analysis shows that the growth of park formations follows a Gompertz survival-time model; formal park-university relationships lead to increased university publication and patenting activity, greater extramural funding success, and enhanced ability to hire preeminent scholars
Link and Scott (2005)	Empirical	US	Examines the determinants of spin-off companies from university research parks. Findings are that the propensity is greater in older parks and in parks that are associated with richer university research environments
Link and Scott (2006)	Empirical	US	Develops a model to describe the growth, or productivity, of research parks. Findings are that parks closer to the university, operated by a private organization, and with a specific technology focus grow faster than average
Link and Scott (2007)	Literature review	–	Reviews the literature on science and technology parks to date and outlines an agenda for additional theoretical and empirical research on this topic
Link and Scott (2015)	Literature review	–	Updates the literature review in Link and Scott (2007)
Malairaja and Zawdie (2008)	Empirical	Malaysia	Matched pairs study shows that on-park firms have more research links with universities than off-park firms
Massey and Wield (1992)	Evaluation methods	–	Suggests that because the outcomes of science parks are so varied, no generalizations are possible about park success
Millar et al. (2005)	Theoretical	China	Identifies potential role of the state in pursuing the creation of technology districts, and outlines implications of these roles for what the authors refer to as China's "social market economy"

Author(s)	Category of study	Country(ies)	Findings
Motohashi (2013)	Empirical	China	Identifies the determinants of start-up firms in the Tsinghua Science Park in Beijing, China. Findings are that when firms' innovations are grounded in their own competitive advantage they perform better than firms that engage in formal R&D collaboration with the university in the absence of such advantage
Nahm (2000)	Case study	South Korea	Provides an overview of the science park movement in South Korea and examines the history, present, and future of the Digital Media City in Seoul, South Korea
Phan et al. (2005)	Literature review	–	Review of the papers in a special issue of *Journal of Business Venturing* on science parks
Phillimore (1999)	Case study	Australia	Case study of the Western Australian Technology Park. Presents a taxonomy of how firms interact within the park
Quéré (1989)	Case study	France	Presents an historical trace of the development of technopoles in France
Qunitas et al. (1992)	Literature review	UK	Examines the empirical literature on science parks relevant to the UK and concludes that the evidence does not support the contention that parks create linkages between academic research and industrial activity
Robertson (2007)	Case study	UK	Case study of public sector involvement in the creation of Genetic Knowledge Parks in the UK for the purpose of systematically integrating new genetics and genomics knowledge to develop new treatments and services
Russel and Moss (1989)	Theoretical	–	Makes recommendations for planning science parks in developing countries or in developing areas of developed countries
Rychev (1993)	Case study	Russia	Case study of Moscow University's Science Park and how the park has affected innovative activity in the country
Salvador (2011)	Case study	Italy	Case study of incubators and science and technology parks located in Turin, Italy. Concludes that lack of funding and lack of managerial experience are drivers for the lack of success in these parks
Shearmur and Doloreux (2000)	Empirical	Canada	Analysis of Canadian parks show that there is no link between the opening of a science park and employment growth in the regional high-tech sectors
Shin (2011)	Case study	South Korea	Overviews the development of Daeduck Science Park in Taejon, South Korea
Siegel et al. (2003a)	Empirical	UK	Matched pairs study of on-park and off-park UK firms. Research productivity of on-park firms greater than that of off-park firms
Siegel et al. (2003b)	Literature review	UK	Reviews recent evidence comparing the performance of firms located on- and off- science parks in the UK
Simmie and James (1986)	Theoretical	UK	Argues that innovation does not lead to long waves of economic growth and therefore the failure of employment outcomes at UK science parks was to be expected
Sofouli and Vonortas (2007)	Case study	Greece	Case study of the development and growth of science and technology parks and business incubators in Greece
Squicciarini (2009)	Empirical	Finland	Finds that the innovative performance of firms located inside a science park is greater due to knowledge spillovers
Sutherland (2005)	Case study	China	Case study of the development of China's strategy to develop science parks and business incubators in pursuit of institutional reform of its innovation system
Vaidyanathan (2008)	Case study	India	Case study of the institutional history of technology parks in India

Author(s)	Category of study	Country(ies)	Findings
Vásquez-Urriago et al. (2014)	Empirical	Spain	Analyzes the positive impact for firms located on Spanish science and technology parks in terms of the firms' ability to achieve product innovations
Vásquez-Urriago et al. (2016)	Empirical	Spain	Analysis shows that when firms locate in a science and technology park the likelihood of cooperation for innovation increases
Vedovello (1997)	Case study	UK	Case study of Surrey Research Park in the UK. The park has facilitated informal, but not formal, university–industry linkages
Wang and Liu (2009)	Empirical	Taiwan	Analysis shows that public R&D subsidies substitute for private R&D investments among firms in the Hsinchu Science-based Industrial Park in Taiwan
Watkins-Mathys and Foster (2006)	Empirical	China	Analysis of the performance of hi-tech companies situated on science and technology industry parks and those located outside of such parks. Based on interviews and focus groups in the Beijing and Shanghai areas. Findings are that being located in a regional industry cluster (in or outside a park), networking opportunities, entrepreneurial skills, and access to more financial sources and capital are essential for commercializing new technologies
Wessner (1999)	Case study	US	Overviews the background associated with Sandia National Laboratory's Science and Technology Park
Westhead (1995), Westhead and Cowling (1995), Westhead and Storey (1994, 1997), Westhead et al. (1995)	Empirical	UK	Matched pair comparison of on-park and off-park UK firm performance. Findings from the collection of papers are that the survival rate of on-park firms is greater than that of off-park firms
Westhead (1997)	Empirical	UK	On-park UK firms do not directly invest more in R&D than off-park firms, nor do they record higher levels of technology diffusion
Westhead and Batstone (1998)	Empirical	UK	Location on a UK science and technology park is driven by the firm's need to acquire research facilities and scientists at the university
Westhead and Batstone (1999)	Empirical	UK	Both managed and non-managed park firms appreciate the benefits of locating on a park; however, there are more perks provided to managed than non-managed park firms
Westhead et al. (2000)	Empirical	UK	Finds that the UK science parks make a contribution to both wealth creation and job growth
Yang and Lee (2000)	Empirical	Taiwan	Study of firms in Hsinchu Science Park, Taiwan. Availability and use of human capital has been critical for the growth of the park
Zeng et al. (2010)	Case study	China	Case study of the development of Qingdao Science Park in China
Zhang and Wu (2012)	Case study	China	Case study of Zhangjiang High-Tech Park in Shanghai, China. History of the park shows that the state action was critical in the initial stage of biotech concentration in the park; latter stage biotech development has been encouraged to become integrated with the global flows of knowledge
Zhou (2005)	Case study	China	Traces the institutional evolution of Zhongguancun Science Park in Beijing, China
Zhu and Tann (2012)	Case study	China	Discusses development of Zhongguancun Science Park in Beijing, China
Zou and Zhao (2014)	Case study	China	Case study of Tsignhua University Science Park (TusPark) in China. History shows that the success of TusPark depends on its entrepreneurial leadership to promote technology commercialization, innovative activities, and regional economic growth