Science and Technology Parks impacts on tenant organisations: a review of literature

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Abstract

Sixty years after the establishment of the first science park at Stanford University, Science and Technology Parks (STPs) have reached a worldwide diffusion. Many papers have discussed parks' role in promoting new technology-based firms (NTBFs) and their impacts on firms' performances, often drawing contrasting conclusions.

On the one hand, some authors believe that STPs have generally failed to foster the establishment and growth of NTBFs or to encourage technology transfer among firms and public research organisations. These authors' opinion on STPs is that those that are "successful" do nothing more than group successful firms together in the same area. According to other authors STPs are instead of actual added value to the on-park firms and to the territory in which they are located. The added value is measured for instance by the increased growth rate in turnovers and number of employees, greater resource diversification, and lower mortality rates. In particular, in some cases, science parks seem to be able to positively affect the innovative activities of tenant firms (in terms of R&D expenditure and intensity, number of patent applications, number of copyrights and publications, number of new products/services launched, etc.).

In this paper we comprehensively analyse the literature on STPs, emphasizing the role that parks play in supporting R&D activities both in public research organisations and firms, assessing, according to literature, the added value of an on-park location. Finally, we discuss the limits of the literature and provide suggestions for future research.

1. Introduction

Behind the concept of STP there is the belief that a park is an area which allows agglomeration of technological activities, leading to positive externality benefits to individual firm located on the park (Chan and Lau, 2005).

Although STPs have reached a worldwide diffusion and scientific literature has grown as fast as the STPs phenomenon, it is still unclear the impacts they have on tenant firms' performance.

This paper is structured as follows: first, in section 2, methodology is described. This paper is based on a deep literature review, so the methodology for searching papers is rigorously presented and followed, in order to ensure that no relevant paper is missed out.

In section 3 the main definitions of STPs are given and a distinction between STPs and others institutions (such as incubators and business innovation centres) is made; this should clear up the existing misunderstandings and confusion between different definitions.

Subsequently the findings of the review are detailed. Papers are divided into two categories: qualitative and quantitative. After shortly analysing qualitative papers, we will focus on quantitative papers, searching for any clear pattern in STPs impacts on tenant firms.

2. Methodology

Papers included in the review have been searched by keywords *in Thomson Reuters Web of Knowledge*[1] databases.

In order to narrow down the results of the search and to have a higher percentage of relevant papers resulting from the search, we have limited the *databases* used, the *document types* and the *subject areas* to those showed in Table 1.

Many terms have been used interchangeably in past studies on STPs (Chan and Lau, 2005). This is why twelve keywords have been used in the field "Topic" of the web platform[2]. Each keyword has been used in its singular and plural form, considering that this gives different results.

The keywords set has been repeatedly widened while papers were analysed.

Keyword used and the number of papers found with each keyword is shown in Table 2.

[1] Formerly known as *ISI Web of Knowledge*, is a research platform for information in the sciences, social sciences, arts, and humanities.

[2] Other available fields were: Title; Author; Group Author; Editor; Publication Name; Year Published; Address; Conference; Language; Document Type; Funding Agency and Grant Number.

Table 1 – Searching parameters used in Thomson Reuters Web of Knowledge search.

Databases[3]	
Science Citation Index Expanded (SCI-EXPANDED) – 1985 - present	
Social Science Citation Index Expanded (SSCI) – 1985 - present	
Document types[4]	
Articles	
Main Subject Areas[5]	
Behavioral Science	Information Science & Library Science
Business	Management
Business Finance	Multidisciplinary Sciences
Economics	Operations Research & Management Science
Education & Educational Research	Planning & Development
Education, Scientific Disciplines	Social Issues
Engineering, Industrial	Social Sciences, Interdisciplinary
Engineering, Multidisciplinary	Urban Studies

The total number of papers found at this stage of the methodology was 2.179. Obviously many of them were duplicated, considering that similar keywords have been used. After purging duplicated (using *Endnote Web*, a product of *Thomson Reuters*), a total of 1.191 papers have been selected manually.

Table 2 – Number of papers found for each keyword.

	Singular form	Plural form
Science Park	243	204
Science and Technology Park	87	104
S&T Park(a)	16	5
Research Park	262	184
Innovation Centre	115	124
Innovation Center	145	143
University Research Park	40	34
URP(b)	4	2
Technology Park	119	132
Technopole	7	6
Technopark	5	3
High-Tech Park	23	24

(a) S&T Park stand for Science and Technology Park.
(b) URP stands for University Research Park.

The last step has been the manual selection of relevant papers. At the end of the process a total of 114 papers were considered relevant to our research.

[3] Other available databases were: Arts & Humanities Citation Index (A&HCI); Conference Proceedings Citation Index – Science (CPCI-S) and Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH).
[4] Other available document types were: Editorial Material; Meeting Abstract; Letter; Proceeding paper; Book Review; Correction; Correction, Addition; Review and News Item.
[5] Other subject areas selected were: Asian Studies; International Relations; Area Studies; Industrial Relations & Labor and Education, Special.

3. Definitions

The great variety of existing experiences has generated many different interpretations of the concept of STP, to the extent that some authors have defined it as "nebulous" (Shearmur and Doloreux, 2000), pointing out that there has been no agreement on a universal definition.

This confusion on the definition of a STP has been also generated by the different terms used in the literature. Terms such as *science park*, *research park*, *technology park*, *science and technology park*, *business park*, *innovation centre*, *technopole*, etc. have been used interchangeably and extensively in past studies (Shearmur and Doloreux, 2000; Chan and Lau, 2005; Link and Scott, 2007; Sofouli and Vonortas, 2007). Often one term is more used than the others according to the country (e.g. STPs are often called *Technopoles* in the Francophone world, *Technopolis* in Japan, *Research Park* in the U.S., etc.) (Shearmur and Doloreux, 2000; Link and Scott, 2007; Suzuki, 2004). The European Union has tried to differentiate some of these terms (Scandizzo, 2005), but later literature has demonstrated that this attempt was unsuccessful.

In this paper we would like to point out that, although some authors and practitioners use the terms "STP" and "incubator" as synonymous, they play a different role in the technological innovation chain.

3.1 Science Park

The three most quoted definitions of STP were given by three important STPs associations:

- The *United Kingdom Science Parks Association* (UKSPA) defines a science park as a business support and technology transfer initiative that: (1) encourages and supports the start up and incubation of innovation-led, high-growth, knowledge-based businesses; (2) 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; (3) has formal and operational links with centres of knowledge creation such as universities, higher education institutes and research organisations (UKSPA, 2010).
- The *Association of Universities and Research Parks* (AURP) states that a university research park is a property-based venture, which: (1) Master plans property designed for research and commercialization; (2) creates partnerships with universities and research institutions; (3) encourages the growth of new companies; (4) translates technology; (5) Drives technology-led economic development (AURP, 2010).
- *The International Association of Science Parks* (IASP) defines a park as "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. To enable these goals to be met, a STP stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities" (IASP International Board, 6 February 2002).

This last definition given by the IASP in 2002 seems to be the broadest one, embracing all the existing experiences of STPs initiatives, both "physical and virtual" (Sofouli and Vonortas, 2007).

Although some authors have pointed out some difference characterising STPs in a specific geographic area or country (e.g. Sternberg (2004) in Germany, Chordá (1996) in France, Link and Scott (2007) and Siegel et al. (2003) in the U.S.), it is possible to state that STPs have some common characteristics (Colombo and Delmastro, 2002; Hommen et al., 2006; Chan et Lau, 2005):

- Have formal and operational links with a university or other higher educational institution or major centre of research;
- are designed to encourage the formation and growth of knowledge-based businesses and other organisations normally resident on site;
- have a management function that is actively engaged in the transfer of technology and business skills to the organisations on site.

3.2 Incubators

The *US National Business Incubation Association* (NBIA) defines the business incubation process as "a business support process that accelerates the successful development of start-up and fledgling companies by providing entrepreneurs with an array of targeted resources and services. These services are usually developed or orchestrated by incubator management and offered both in the business incubator and through its network of contacts. A business incubator's main goal is to produce successful firms that will leave the program financially viable and freestanding. These incubator graduates have the potential to create jobs, revitalize neighbourhoods, commercialize new technologies and strengthen local and national economies" (NBIA, 2010).

According to the *United Kingdom Business Incubation* (UKBI): "Business Incubation is a dynamic business development process. It is a term which covers a wide variety of processes which help to reduce the failure rate of early stage companies and speed the growth of

companies which have the potential to become substantial generators of employment and wealth. A business incubator is usually a property with small work units which provide an instructive and supportive environment to entrepreneurs at start-up and during the early stages of businesses. Incubators provide three main ingredients for growing successful businesses, namely an entrepreneurial and learning environment, a ready access to mentors and investors and visibility in the marketplace" (European Commission, 2002).
In other words, an incubator provides resources such as space, goals, marketing, management, structure and financing to knowledge- and technology-intensive NTBFs, providing an environment for the initiation and growth of these firms (AAboen, 2009; Markman et al., 2008; Chan and Lau, 2005; Löfsten and Lindelöf, 2001; Lindelöf and Löfsten, 2002).

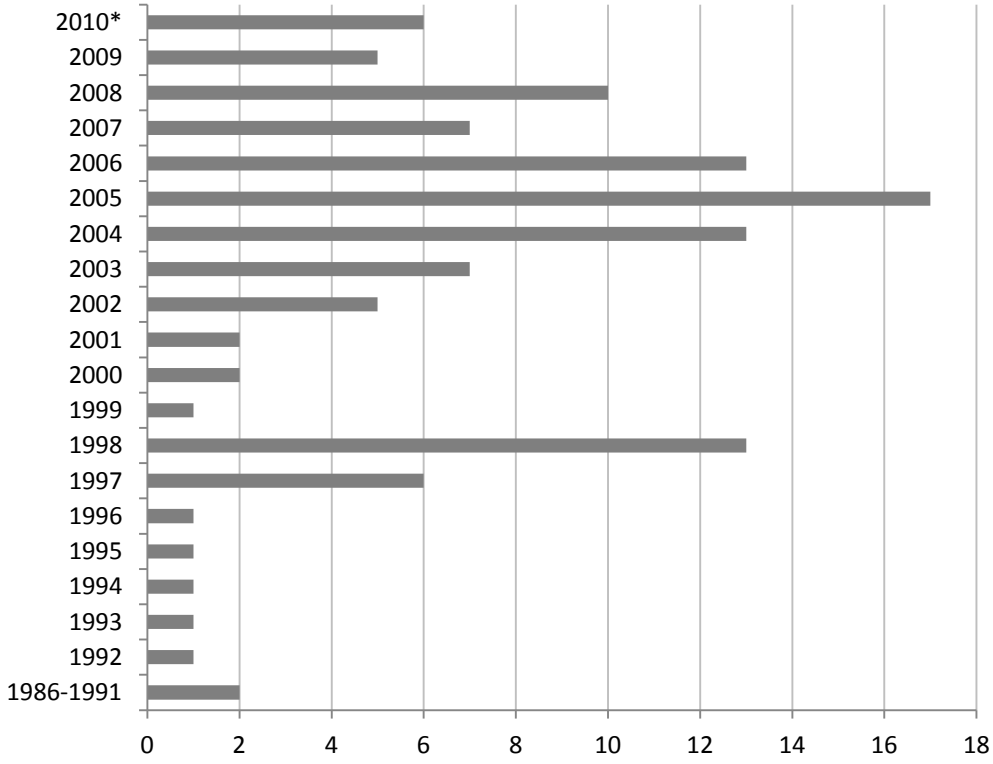
One difference between a STP and an incubator is the characteristics of client organisations. Unlike incubators, STPs are not dedicated only to start-up, early-stage companies (Markman et al., 2008), while incubators intended role is to nurture new technology based start-ups providing various forms of logistical support services and opportunities for collaboration (especially with regard to joint R&D activities with other firms and institutions in the local area) (Oakey, 2007). The time of tenancy for incubated firms is limited (according to a study of the European Commission (European Commission, 2002) this is 35 months on average), while there are no time limits for tenancy in STPs.
Furthermore, it is not a case that in most developed countries there are two different national associations for STPs and incubators, e.g. respectively AURP and NBIA in the U.S., UKSPA and UKBI in the U.K., TEKEL and IAFIN in Finland, etc.

3.3 Business Innovation Centre (BIC)
BIC are incubators joining the *European Business & Innovation Network*, founded in 1984 by the European Union, through the Directorate-General DG XVI (Colombo and Delmastro, 2002).
The EU (see UN Official Bulletin NC 186/51 printed in July 1990) defines a BIC as "centre housing, in a limited space, new enterprises. It offers them material (physical space, common facilities, network resources) and immaterial infrastructure (technical services, marketing support, management advise, financial counselling)".
BICs are therefore real incubators, although their focus is on the creation of new firms especially in depressed regions (Colombo and Delmastro, 2002).

4. Review results

Following the methodology illustrated in section 2, a total of 114 papers were selected for the review. Figures 1 and Figure 2 show the distribution of papers by year of publication and by publication name.

As Figure 1 clearly shows, scholars have shown a high interest in STPs phenomenon since late 90s and literature on STPs has rapidly grown.



* Data up to September 2010

Figure 1 – Papers by year of publication[6].

Selected papers have been divided into two main categories:

- *Qualitative papers*: papers whose authors base their analysis on qualitative information and qualitative research methods. We have included in this category also papers that use data and statistics in a descriptive way.
- *Quantitative papers*: papers whose authors base their analysis on quantitative methods.

On a total of 114 papers, 61 papers (54%) can be considered as qualitative papers, while 53 (46%) are quantitative papers.

[6] Peak in 1998 papers is due to a special issue published by the *International Journal of Technology Management*.

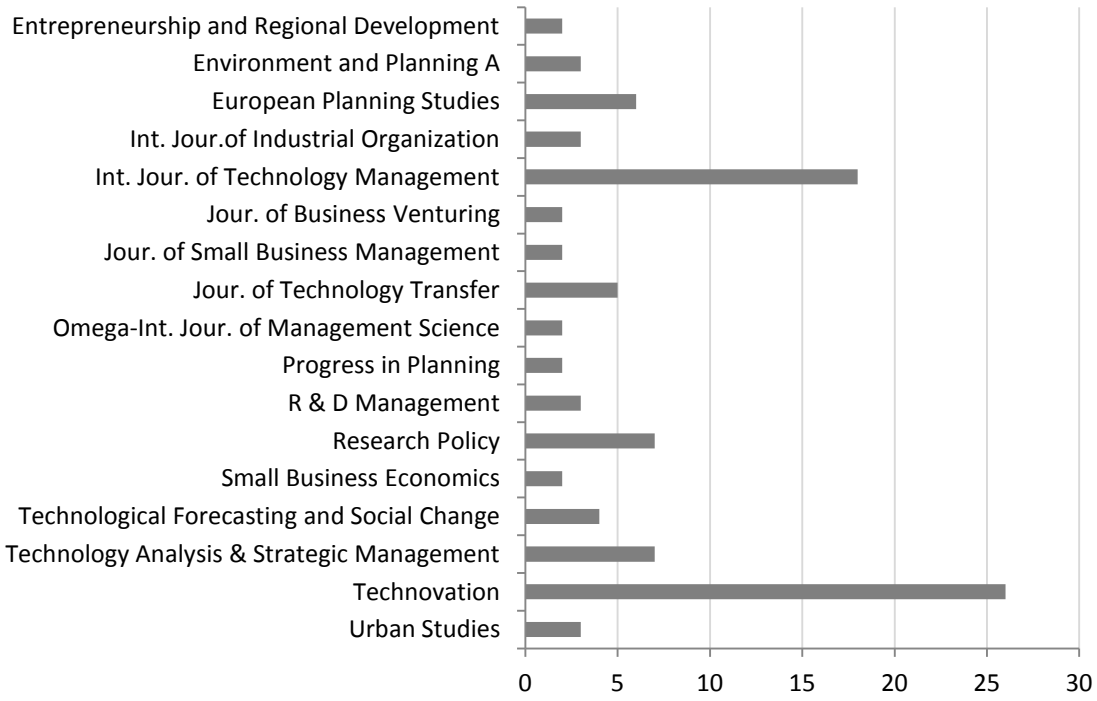


Figure 2 – Papers by publication name[7].

4.1 *Qualitative papers*

Qualitative works have been divided into 8 categories (Table 3), according to the aim of each paper.

Table 3 – Classification of qualitative papers.

Qualitative papers
a. Justification for STPs existence
b. Critical success factors for STPs
c. Best practices
d. Outcomes of a STP or a group of STPs
e. Evolution path of a STP or a group of STPs
f. Comparative case study between two or more STPs
g. Project hypothesis for the setting up of a new STP or a group of STPs
h. STPs performance assessment framework

Classification in these 8 categories is not to be intended as rigorous. Papers could fit in more than one category. For example Bakouros et al. (2002) present a comparative case study (group 6) on 3 STPs in Greece but also give information on the outcomes of these parks (group 4). In placing a paper in a category, we have considered the aim of the authors of the paper and the added value of the paper.

[7] Only journals with more than one publication are shown. There are 17 journals with only one paper.

a. Justification for STPs' existence

This category includes those papers that give reasons for STPs existence and diffusion.

Table 4.

Paper	Year	Region
Bartlett, W. and Čučković, N.	2006	Croatia and Slovenia
Bass, S.J.	1998	Japan
Biswas, R.R.	2004	Hyderabad, India
De Mello, J.M.C. and Rocha, F.C.A.	2004	Petropolis, Brazil
Hermosa, J.D. and Barroeta, B.	1998	Castilla-Leon, Spain
Hu, T. S. et al.	2005	Hsinchu, Taiwan
Kihlgren, A.	2003	St. Petersburg, Russia
Link, A. N. and Scott, J.T.	2007	-
Markman, G. D. et al.	2008	-
Massa, S. and Testa, S.	2008	-
Oakey, R.	2007	-
Pelkonen, A.	2005	Helsinki, Finland
Sternberg, R.	2004	Germany
Storey, D. J. and Tether, B.S.	1998	Europe
Vaidyanathan, G.	2008	India
Watkins-Mathys, L. and Foster, M. J.	2006	China
Xue, L.	1997	Taiwan

Most of these papers analyse STPs as an instrument of technology innovation policy:

- Bartlet and Čučković (2006) investigate the role of STPs in supporting knowledge transfer in Croatia and Slovenia.
- Bass (1998) studies STPs as a key implementation strategy of the Japanese technology innovation policy.
- Biswas (2004) explains the role of government IT policy in the creation of a technopolis in Hyderabad, India.
- De Mello and Rocha (2004) assess the impact on regional innovation and economic growth of a STP programme established in Petrópolis, in the state of Rio de Janeiro, Brazil.
- Hermosa and Barroeta (1998) study the STP at Beocillo as an instrument for regional development in Castilla-León, a structurally-underdeveloped region in Spain.
- Kihlgren (2003) assesses the impacts of the Russian state program "Technology Parks and Innovations" under which many STPs in Russia have been created.
- Link and Scott (2007) study the economics of STPs, that is, their trends and growth, their formation, factors affecting firm decision to locate on STPs, their impact on regional economic development, etc.
- Massa and Testa (2008) study the role of STPs as intermediary institutions in promoting innovation.

- Pelkonen (2005) examines the STPs formation in Finland as a measure of national technology, regional and economic policy measure.
- Sternberg (2004) analyses innovation centres in Germany, giving the economic justification for their existence, assessing their effectiveness and impact on high-tech regions.
- Storey and Tether (1998) analyse the creation of STPs as a public policy measures to support NTBFs in European countries.
- Vaidyanathan (2008) discusses the institutional history of Indian STPs.
- Xue (1997) analyse the development of Hsinchu Science-based Industrial Park in the context of an overall strategy to promote industrial R&D and high-tech industries in Taiwan.

Two papers focus on STPs as a commercialization strategy of technology:

- Markman et al. (2008) consider STPs as one of the modes of commercialization of technology.
- Watkins-Mathys and Foster (2006) qualitatively compare the commercialization strategy of technology between a group of high-tech firm on-park and a group off-park.

Other authors justify the existence of STPs with the agglomerative economic effects that would exist within a STP:

- Hu et al. (2005) analyse the effect of the proximity among companies at Hsinchu STP, Taiwan.
- Oakey (2007) explores collaborative advantages for R&D activities of firms by locating within a STP and other clusters.

b. Critical success factors for STPs

Papers in this category deal with those factors that underlie whether a STP is successful or not.

Table 5.

Paper	Year	Region
Cabral, R.	1998	-
Cabral, R.	2004	Kista, Sweden
Cabral, R. and Dahab, S.S.	1998	Rio de Janeiro, Brazil
Dahab, S. S. and Cabral, R. 1998	1998	Lund, Sweden
Durão, D. et al.	2005	Oeiras, Portugal
Echols, A. E. and Meredith, J. W.	1998	USA
Hansson, F. et al.	2005	Denmark and UK
Harper, J. C. and Georghiou, L.	2005	Manchester, UK
Koh, F. C. C. et al.	2005	Singapore
Ramasamy, B., et al.	2004	Malaysia
Ratinho, T. and Henriques, E.	2010	Portugal
Van Dijk, M. P.	1993	-

- Cabral (1998) refines the "Cabral-Dahab Science Park Management Paradigm" whose aim is to allow the evaluation of existing and planned STPs and apply it to the case of BIORIO, Brazil (Cabral and Dahab, 1998) and Kista, Sweden (Cabral, 2004). Echols and Meredith (1998) use it for evaluating the Virginia Tech Corporate Research Center.
- Dahab and Cabral (1998) outline the importance of consulting and services firm for STPs success.
- Durão, D. et al. (2005) argue that virtual and real-estate-based STPs are complementary business models for STPs and contain themselves strong mutual synergies.
- Hansson et al. (2005), based on two case studies in Denmark and the UK, suggest a new conceptual model for the success of STPs: a model without intermediary institutions.
- Harper and Georghiou (2005) within an exercise of application of "Success Scenario" methodology identify key factors for the success of STP and business-university links in the region of Manchester, UK.
- Koh et al. (2005) propose an analytical framework that explains the determinants for the development and growth of STPs and apply it to the case of Singapore.
- Ramasamy et al. (2004) identify the key elements that have contributed to the success of Silicon Valley as well as other STPs and use them to evaluate Malaysian STP.
- Ratinho and Henriques (2010) search for the success factors of Portuguese STPs.
- Van Dijk (1993) discusses which factors influence the success of an industrial science-based district in the third world.

c. Best practices

This category includes those papers whose main aim is to inform about a best practice (Hommen et al. (2006) on Mjärdevi STP in Linköping, Sweden; Tan (2005) and Zhu and Tann (2005) on Zhongguancun STP in Beijing, China) or to transfer best practices to other contexts (Wonglimpiyarat (2010) applies the cluster-based strategy of the US Silicon Valley to Thailand).

Table 6.

Paper	Year	Region
Hommen, L. et al.	2006	Linköping, Sweden
Tan, J.	2006	Beijing, China
Wonglimpiyarat, J.	2010	California, USA
Zhu, D. and Tann, J.	2005	Beijing, China

d. Outcomes of a STP or a group of STPs

Papers in this group give information about the results reached by a STP or a group of STPs in a territory, region or country. Where used, statistics are descriptive.

Table 7.

Paper	Year	Region
Chorda, I. M.	1996	France
Chou, T. L. and Lin, Y. C.	2007	Suzhou, China
Ku, Y. L. et al.	2005	Hsinchu, Taiwan
Lee, W. H. and Yang, W. T.	2000	Hsinchu, Taiwan
Phillips, S. A. M. and Yeung, H. W. C.	2003	Singapore
Sofouli, E. and Vonortas, N. S.	2007	Greece
Suzuki, S.	2004	Japan

Through these papers it is possible to obtain information on Kunshan Science Park in Suzhou, China (Chou and Lin, 2007), the Singapore Science Park (Phillips and Yeung, 2003) and Hsinchu STP in Taiwan (Ku et al., 2005 and Lee and Yang, 2000) and to have an insight of the situation of STPs in France (Chorda, 1996), Greece (Sofouli and Vonortas, 2007) and Japan (Suzuki, 2004).

e. Evolution path of a STP or a group of STPs

Papers in this category are case studies on the evolution, mainly from an institutional point of view, of STPs in different areas of the world. They give information about the path that these parks have followed from the origin to the level of development they have reached so far.

Table 8.

Paper	Year	Region
Cao, C.	2004	Beijing, China
Feldman, J. M.	2007	Linköping, Sweden
Freier, S.	1986	Israel
Mathews, J. A.	1997	Hsinchu, Taiwan
Williams, J. C.	1998	California, USA
Zhou, Y.	2005	Beijing, China

f. Comparative case study between two or more STPs

Papers in this group perform a comparative analysis between STPs with regard to different aspects.

Table 9.

Paper	Year	Region
Bakouros, Y. L. et al.	2002	Greece
Bruton, G. D.	1998	Russia
Garnsey, E. and Longhi, C.	2004	Cambridge, UK; Sophia Antipolis, France
Millar, C. et al.	2005	China
Schwartz, M.	2009	Germany
Smilor, R. et al.	2007	USA

- Bakouros et al. (2002) study the type of links between universities and firms in three Grecian STPs and the extent of synergies between on-park firms.
- Bruton (1998) contrasts Zelenograd STP (Russia) with university-related U.S. incubators.
- Garnsey and Longhi (2004) compare STPs in Cambridge (UK) and Sophia-Antipolis (France).
- Millar et al. (2005), comparing STPs at Silicon Valley, Cambridge, Sophia-Antipolis, Singapore and Taiwan, identify three different types of technology districts.
- Schwartz (2009) compares the survival rate of firms leaving five technology centres in Germany.
- Smilor et al. (2007) present three details case studies on research universities (the University of California, San Diego; the University of Texas at Austin; and the University of North Carolina-Chapel Hill, North Carolina State University, and Duke University in Research Triangle Park) examining the drivers that have led to the creation of university research parks.

g. Project hypothesis for the setting up of a new STP or a group of STPs

These papers present hypothesis for the creation of future STPs in Kuwait (Al-Sultan, 1998), Taiwan (Liu, 2006), Rome area (Cricelli et al., 1997) and Shangai (Ma, 1998).

Table 10.

Paper	Year	Region
Al-Sultan, Y. Y.	1998	Kuwait
Cricelli, L. et al.	1997	Rome, Italy
Liu, C. C.	2006	Taiwan
Ma, B. Q.	1998	Shangai, China

h. STPs performance assessment framework

Papers included in this group provide a conceptual framework for evaluating STPs' performances.

Table 11.

Paper	Year	Region
Bigliardi, B. et al.	2006	Italy
Chan, K. F. and Lau, T.	2005	Hong Kong

Eventually there are 3 papers that do not fit in any of the previous categories:

- Bozzo (1998) analyses STPs as an enterprise model.
- Eto (2005) indicates which are the main obstacles for the emergence of new STPs, ventures and technology clusters in Japan.

- Roberts (2005) informs about the importance of historical and cultural context in modelling innovation intense environments.

4.2 *Quantitative papers*

Papers based on quantitative methods have been divided into 4 groups (table 12).

Table 12 – Classification of quantitative papers.

Quantitative papers
a. On-off comparison
b. Mean values comparison
c. Based on surveys
d. Econometric analysis

Findings and the main variables used in these studies will be detailed in section 5.

As in the case of qualitative papers, groups are not intended to be as watertight. Overlaps between groups are possible. For example, Löfsten and Lindelöf (2001) perform an on-off comparison (group 1) and also use OLS techniques (group 4); Hu (2008) analyse data from surveys (group 3) with a regression analysis (group 4); Radosevic and Myrzakhmet (2009) compare the performances of an on-park sample with off-park firms (group 1) and also with mean values of Kazakhstan (group 2). When grouping papers the value added and the main aim of the paper have been taken into account.

a. On-off comparison

This category comprises papers that attempt to assess differences in firms' performances due to its location inside a STP (on-park) or outside a STP (off-park).

Papers analysed have used different methods to perform on-off comparisons.

One method is called "matched pairs sample": performances of two comparable groups of firms, one located *on-park* and the other one *off-park* are compared. The two groups are selected on the basis of selection criteria (e.g. industry, ownership type of the firm, age of the firm, location of the firm) (Westhead, 1997; Lindelöf and Löfsten, 2002).

Most papers in this group use matched pairs sample, sometimes along with other methods[8]: Chan et al. (2010), Colombo and Delmastro (2002), Dettwiler et al. (2006), Lindelöf and Löfsten (2002, 2003), Löfsten and Lindelöf (2001, 2002, 2003), Malairaja and Zawdie (2008), Quintas et al. (1992), Radosevic and Myrzakhmet (2009), Westhead (1997), Westhead and Batstone (1998), Westhead and Storey (1995) and Yang et al. (2009).

[8] E.g. Colombo and Delmastro (2002) also use Tobit model and Löfsten and Lindelöf (2001) use Spearman's rho.

Table 13.

Paper	Year	Unit of analysis	Region
Chan, K. Y. A. et al.	2010	Firm	South Africa
Colombo, M. G. and Delmastro, M.	2002	Firm	Italy
Dettwiler, P. et al.	2006	Firm	Sweden
Felsenstein, D.	1994	Firm	Israel
Ferguson, R.	2004	Firm	Sweden
Fukugawa, N.	2006	Firm	Taiwan
Lindelöf, P. and Löfsten, H.	2002	Firm	Sweden
Lindelöf, P. and Löfsten, H.	2003	Firm	Sweden
Löfsten, H. and Lindelöf, P.	2001	Firm	Sweden
Löfsten, H. and Lindelöf, P.	2002	Firm	Sweden
Löfsten, H. and Lindelöf, P.	2003	Firm	Sweden
Malairaja, C. and Zawdie, G.	2008	Firm	Malaysia
Quintas, P. et al.	1992	Firm	UK
Radosevic, S. and Myrzakhmet, M.	2009	Firm	Kazakhstan
Siegel, D. S. et al.	2003	Firm	UK
Squicciarini, M.	2008	Firm	Finland
Squicciarini, M.	2009	Firm	Finland
Vedovello, C.	1997	Firm	UK
Westhead, P.	1997	Firm	UK
Westhead, P. and Batstone S.	1998	Firm	UK
Westhead, P. and Storey, D. J.	1995	Firm	UK
Yang, C. H. et al.	2009	Firm	Taiwan

Another method consists in longitudinal (or duration) analysis. This method compares performances of the same group of firms while in STPs and after leaving STPs (or before joining it). Squicciarini (2008, 2009) and Ferguson (2004) have used this method.

The rest of papers in this category uses different methods for assessing differences in firms' performances located on- and off- park. Between them, Felsenstein (1994), Fukugawa (2006) and Siegel et al. (2003) use in their models a dummy variable "Science Park location".

b. *Mean values comparison*

Papers in this category assess the impact of STPs by comparing firms or STPs' performances with the mean values of the territory surrounding the parks.

Table 14.

Paper	Year	Unit of analysis	Region
Hu, T. S. et al.	2006	Firm	Hsinchu, Taiwan
Kim, H. Y. and Jung, C. M.	2010	Science Park	South Korea
Li, L. J. et al.	2004	Science Park	China
Park, S. C.	2004	Science Park	South Korea

c. Papers based on surveys

Papers in this group gather information through surveys.

Table 15.

Paper	Year	Unit of analysis	Region
Kaufmann, A. & Todtling, F.	2002	Firm	Upper Austria
Lai, H. C. & Shyu, J. Z.	2005	Science Park	Zhangjiang, China and Hsinchu, Taiwan
Liefner, I., Hennemann, S. & Xin, L.	2006	Firm	Beijing, China
Lindelöf, P. & Löfsten, H.	2005	Firm	Sweden
Mcadam, M. & Mcadam, R.	2008	Firm	Republic of Ireland and UK
Mukkala, K.	2010	Firm	Finland
Phillimore, J.	1999	Science Park	Western Australia
Reid, S. & Garnsey, E.	1997	Firm	Cambridge, UK
Sternberg, R.	1989	Science Park	Germany
Thierstein, A. & Wilhelm, B.	2001	Science Park	Switzerland

d. Econometric analysis

Many papers do not fit in any of the previous categories. All of them use different econometric approaches to assess the added value of STPs for tenant firms, universities related with the parks or the territory where parks are located.

Table 16.

Paper	Year	Unit of analysis	Region
Appold, S. J.	2004	Territory	USA
Chen, C. J. and Huang, C. C.	2004	Science Park	Taiwan
Chen, C. J. et al.	2006	Science Park	Taiwan
Hu, A. G. Z.	2007	Science Park	China
Hu, T. S.	2008	Firm	Taiwan
Jenkins, J. C. et al.	2008	Territory	USA
Leyden, D. et al.	2008	Firm	USA
Lin, C. L. and Tzeng, G. H.	2009	Science Park	Taiwan
Lin, G. T. R. and Sun, C. C.	2010	Science Park	Taiwan
Lindelöf, P. and Löfsten, H.	2006	Firm	Sweden
Link, A. N. and Scott, J. T.	2003	Universities	USA
Link, A. N. and Scott, J. T.	2005	Firm	USA
Link, A. N. and Scott, J. T.	2006	Science Park	USA
Löfsten, H. and Lindelöf, P.	2005	Firm	Sweden
Shearmur, R. and Doloreux, D.	2000	Territory	Canada
Sung, T. K., et al.	2003	Firm	South Korea
Wright, M. et al.	2008	Firm	China

5. Assessing the impacts of STPs on tenant firms

The main justification for the existence and diffusion of STPs has been the positive effects that STPs would have on tenant firms, in terms of employment, innovative output, economic results.

But is this belief supported by empirical results?

In this section, quantitative papers having firms as unit of analysis will be analysed. According to revised papers the most used variables and the impacts of STPs on these variables will be detailed in order to find any clear pattern.

Impacts that STPs have on tenant firms can be classified according to 3 dimensions (Figure 3): impacts on the economic performance of firms, impacts on innovative activities and impacts on firms' links with universities or public research centres or with other centres that creates knowledge.

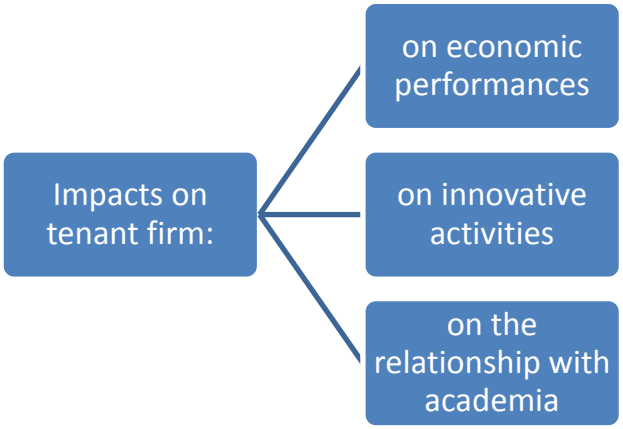


Figure 3 – Classification of STPs impact on tenant firms.

5.1 *Impacts on economic performances of tenant firms*

Table 17 shows the most used variable when assessing the STPs impacts on economic performances of Parks' firms.

Table 17 – STPs impacts on economic performances.

Variable	Positive effects	None/negative effects
Employment growth	Lindelöf and Löfsten (2003) Löfsten and Lindelöf (2001, 2002, 2003) Colombo and Delmastro (2002)	Ferguson (2004)
Sales growth	Lindelöf and Löfsten (2002) Löfsten and Lindelöf (2001,2002,2003)	
Profitability		Lindelöf and Löfsten (2002) Löfsten and Lindelöf (2001, 2002)

Clearly more empirical evidence is needed on the effects of STPs on firm economic performances in terms of employment and sales growth and profitability.

Where employment growth is concerned, Löfsten and Lindelöf (2001, 2002 and 2003) find that on-park firms have a rate of job creation which is substantially higher than that of off-park sample. This result is confirmed by Colombo and Delmastro (2002). On the other hand, Ferguson (2004) argues that STPs can have positive effects on employment growth of tenant firms up to a certain point, while on-park location represents a limiting factor for firms entering a development period characterised by high growth.

Löfsten and Lindelöf, in their papers, also suggest that in the off-park sample, the growth of sales is substantially lower than in the on-park sample, while there is no clear evidence of better performance of on-park firms when profitability is concerned.

5.2 *Impacts on innovative activities of tenant firms*

Where innovative activities are concerned, firms' performances have been assessed using variables shown in Table 18.

Table 18 – STPs impacts on innovative activities.

Variable	Positive effects	None/negative effects
R&D intensity (R&D expenditure on sales)	Fukugawa (2006) Lindelöf and Löfsten (2002) Leyden (2008)	Westhead (1997) Colombo and Delmastro (2002)
R&D productivity	Siegel et al. (2003) Yang et al. (2009)	Westhead (1997)
Type and number of links with other on-park firms		Radosevic and Myrzakhmet (2009) Chan et al. (2010)
Innovative activities output	Squicciarini (2008,2009) Yang et al. (2009)	Lindelöf and Löfsten (2002, 2003) Löfsten and Lindelöf (2002) Colombo & Delmastro (2002) Westhead (1997)
Workforce quality	Lindelöf and Löfsten (2002) Colombo & Delmastro (2002)	Westhead (1997)

Although wider empirical evidence is available when evaluating the impacts of STPs on innovative activities of tenant firms, evidence is contrasting on many variables.

While Lindelöf and Löfsten (2002), Fukugawa (2006) and Leyden (2008) demonstrate that on-park firms are more R&D intensive than off-park, Westhead (1997) and Colombo and Delmastro (2002) found no positive correlation between R&D intensive and the on-park location.

Siegel et al. (2003) define an R&D production function with three possible R&D outputs (namely the number of new product/services launched; the number of patents applied for or

awarded and the number of copyrights) and two R&D inputs (namely R&D expenditures and the number of scientists and engineers). They find that firms located on-park have slightly higher research productivity than equivalent off-park sample. This finding is confirmed by Yang et al. (2009), but contrasted by Westhead (1997).

Linkages among firms within the park are part of the value added offered to tenants. However Radosevic and Myrzakhmet (2009) and Chan et al. (2010) found that on-park firms are more likely to collaborate with off-park firms than with other firms inside the Park.

When assessing the impact of STPs on the innovative output of firms (e.g. patents, copyrights, new products/services launched to the market) Squicciarini (2008 and 2009) finds that STPs seem able to enhance the tenants' likelihood to patent, while Lindelöf and Löfsten (2002, 2003) and Colombo and Delmastro (2002) show that no statistically significant differences between on- and off- park firms were recorded with regard to patents/products launched and to copyrights.

Also the workforce quality (measured by the percentage of researchers and engineers on total workforce) generates contrasting evidence.

5.3 *Impacts on the relationship between tenant firms and academia*

The type and extent of interactions between tenant firms and universities or public research centres has been widely investigated by scholars. Also in this case opinions are contrasting (Table 19).

Table 19 – STPs impacts on economic performances.

Variable	Positive effects	None/negative effects
Extent of interactions	Felsenstein (1994) Vedovello (1997) Löfsten and Lindelöf (2002,2003) Colombo & Delmastro (2002) Westhead and Storey (1995)	Quintas et al. (1992) Malairaja and Zawdie (2008) Radosevic and Myrzakhmet (2009)
Joint research with HEIs	Fukugawa (2006) Colombo & Delmastro (2002)	

Felsenstein (1994) shows that the level of interaction between firms located on-park and local universities is generally low, but it is higher, however, than the level of interaction exhibited by companies off-park. Vedovello (1997) and Löfsten and Lindelöf (2002, 2003) find that STPs facilitate the establishment of informal link, while have no influence on the firms' capacity to establish formal links with HEIs.

On the other hand, Radosevic and Myrzakhmet (2009) surprisingly find that propensity in establishing links with HEIs is stronger in the off-park sample. Malairaja and Zawdie (2008) demonstrate that the level of interactions between firms and HEIs is generally robust, but there are no statistically significant differences between on- and off-park firms. Quintas et al. (1992) suggest that the extent of research links between academic institutions and the STP's firms appear to be no different from the academia links of similar firms located off-park.

Eventually Fukugawa (2006) and Colombo and Delmastro (2002) show that on-park firms exhibit a higher propensity to establish formal links and engage in joint research with research institutes.

6. Conclusions

This paper has performed a literature review analysis on the phenomenon of Science and Technology Parks (STPs), attempting at drawing some clear conclusion on the utility of the on-park location for firms.

Empirical evidence on the impacts of STPs on the economic performances of tenant firms is very limited and it is hard to draw any conclusion on employment, sales growth and profitability. More empirical evidence would be desirable. It would be also interesting to study the effects of an on-park location on other variables, such us the labour productivity and the survival rate of tenant firms.

Although wider empirical evidence is available when evaluating the impacts of STPs on innovative activities of tenant firms, evidence is contrasting on every variable analysed, with the exception of the collaborative attitude with other on-park firms, which seem to be lower than with off-park.

Eventually STPs seem to have a positive effect on the creation of informal links with universities and research centres, while it is unclear the repercussion they have on the creation of more formal links.

Assessing the impact of STPs is a difficult task. One of the major problems for researchers is trying to avoid selection bias. We should not forget that the firm's decision to join a STP (or the specular decision of the STP's management to admit a firm inside the park) represent *per se* a selection bias.

Analyses are complicated by the diversity in stakeholders' objectives and expectations.

Although the effort of scholars in assessing the contributions of STPs to tenant firms is appreciable, much is still to be discovered. In particular, more than whether STPs are effective

or not, it would be of vital importance to know when, and in which conditions, a STP is effective.

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