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Published in:
European Planning Studies

Link to article, DOI:
10.1080/09654313.2019.1679093

Publication date:
2020

Document Version
Peer reviewed version

Citation (APA):
Poonjan, A., & Tanner, A. N. (2020). The role of regional contextual factors for science and technology parks: a conceptual framework. *European Planning Studies*, *28*(2), 400-420.
https://doi.org/10.1080/09654313.2019.1679093

The Role of Regional Contextual Factors for Science and Technology Parks: A Conceptual Framework

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Abstract

Literature on science and technology parks (STPs) lack a systematic understanding of how regional contextual factors affect the performance of STPs. Most studies focus on park-internal factors and neglect the regional context and connections when evaluating STPs' performance. This paper provides new insight on the role of regional factors for STPs by combining and discussing existing studies on STP performance with literature on regional innovation systems. We conduct an exploratory, systematic literature review of 64 papers that refer to park-external factors in their studies of STP performance. We identify five regional factors (university and research institutes, industrial structure, institutional settings, financial support and urbanisation) and assess how these factors have been shown to play a role for STP performance in previous studies. Based on this review, the paper develops a comprehensive framework of how regional contextual factors influence the performance of STPs,which can be used in designing and/or improving STP-performance while taking regional characteristics and needs into consideration. We believe a dynamic and comprehensive understanding of these regional connections can help improve designs of STPs, and hereby their performance.

Keywords: Science and technology parks; regional context; systematic literature review; Regional innovation systems; Multiscalar STI policy

Word count: 7,118 (excl. List of references); 9,800 (incl. list of references)

Introduction

Science and technology parks (STPs) have gained significant academic and political interest for their potential to deliver high-tech innovations and entrepreneurial activities benefitting regional economic development. However, the positive impact of STPs is often questioned because empirical studies continuously demonstrate inconsistent results. While some studies have found positive results on firms located in STPs (e.g. Squicciarini, 2008, 2009; Yang, Motohashi, & Chen, 2009), others have not been able to confirm a positive, significant relationship (e.g. Colombo & Delmastro, 2002; Lofsten & Lindelöf, 2002; Siegel et al., 2003) and have questioned the effects of STPs on technological development, innovation and regional economic development (Rodríguez-Pose & Hardy, 2014). The unclear contribution of STPs has led scholars to search for factors and mechanisms that influence the performance capacity of STPs. However, most research has focussed on park-internal factors, such as the science park management, availability of qualified research and development personnel, marketing expertise, financial support as well as the park identity and brand (Cabral & Dahab, 1998; Lindelöf & Löfsten, 2002; McCarthy, Silvestre, von Nordenflycht, & Breznitz, 2018).

More recently, attention has been paid to park-external factors for STPs' ability to foster regional development (Etzkowitz & Zhou, 2018; Minguillo & Thelwall, 2015b). Minguillo et al. (2015, p. 712) argue that the external environment of STPs, such as 'the agglomeration of the critical mass of knowledge and capabilities' are more relevant for understanding the performance capacity of STPs. Similarly, Tsamis (2009) finds that science and technology parks in less favoured regions in Southern Europe remain primarily real-estate projects, with only marginal contribution to the regional technological development and poor records of creating new technology-based firms (NTBFs). Tsamis argues that the explanations are to be found within regional contextual factors, such as a pre-existing weak local technological base

and absence of sophisticated demand for the services of STPs. Also, in the case of successful STPs, Etzkowitz and Zhou (2018) provide an example from the USA and China, highlighting that innovation dynamics did not induce from the park itself but from University-Industry–Government interactions shaped by the regional context. This new interest in including regional contextual factors in explanations of STP performance is inspired by a diverse literature on territorial innovation models (Moulaert & Sekia, 2003), which sees regions as an important source of competitive advantage (Castells & Hall, 1994; Starr & Saxenian, 1995).

However, literature on the linkages between the performance of STPs and the regional context have been scarce and scattered (Goldstein & Luger, 1990; Mora-Valentín, Ortiz-de-Urbina-Criado, & Nájera-Sánchez, 2018). This paper aims to fill this gap by conducting a systematic, exploratory literature review of the relationship between STPs' performance and the regional context. Although many studies have acknowledged the importance of the regional context for STP performance (Castells & Hall, 1994; Comins & Rowe, 2008; Etzkowitz & Zhou, 2018; Minguillo et al., 2015), this is to the best of the authors' knowledge the first attempt to carry out a systematic review of how regional contextual factors influence the performance of STPs.

Based on the review and inspired by the regional innovation system literature, we develop a framework consisting of five broad categories of regional factors as well as extra-regional linkages and park–internal factors, all of which influence the dynamics of STP performance. These findings are important for the design and use of STPs in future regional and national science, technology and innovation (STI) policies.

The paper is structured as follows. In the next section we discuss different understandings of STP performance before situating the concept of STPs in the field of regional studies by zooming in on the regional context of STPs. The third section presents the method of the systematic literature review. The fourth section presents the findings of the literature review,

while the final section summarises the main conclusions and draw implications for policy and STP practitioners.

Conceptual Framing

Science and technology parks

The first formal science park was established in 1951 in Silicon Valley at Stanford University (Nahm, 2000) and subsequently ignited a rapid growth of STPs[1] across the world. Despite their popularity, STPs are heterogeneous in terms of size, geographical coverage and the infrastructure and service they provide; therefore, there does not exist a universal definition (Albahari, Pérez-Canto, & Landoni, 2010). However, STPs are often characterised (Hansson, Husted, & Vestergaard, 2005) as property-based organisations that bring together firms in one physical location. The key purpose of the STP management is to support the development of park tenants by providing different infrastructural support, set priorities and facilitate R&D-based technological activities and networks.

The heterogeneity of STPs and lack of standardised evaluation approaches are among the reasons for why it is difficult to measure and explain STP performance (Albahari, Catalano, & Landoni, 2013; Albahari, Pérez-Canto, Barge-Gil, & Modrego, 2017; Chan, Oerlemans, & Pretorius, 2011). The study by Phan et al. (2005) show that performance analysis of STPs can be categorised into four levels; the individual level (entrepreneurs involved in tenant firms); the park level; the firm level (tenants located in the park), and the systemic or regional level.

[1] Terms such as science park, research park, technology park, science and technology park, business park, innovation centre and technopoles are used interchangeably across the world — in Asia and continental Europe, the term 'Science parks' is more commonly used, in the USA and UK it is more common to use 'Research parks' and in Latin America 'Technology park' is a more commonly used term. In this paper we use the term STP to cover all the above variations.

In general, however, most empirical studies investigating the performance of STPs focus on the first three levels and assess whether STPs have been successful in promoting innovation, NTBFs, high-skill activities, economic performances among the resident firms and linkages between on-park firms and universities (e.g. Colombo & Delmastro, 2002; Fukugawa, 2006; Link & Scott, 2003; Lofsten & Lindelof, 2001,2002; C. H. Yang et al., 2009). Nevertheless, the results of studies on STP performance are inconclusive. While some studies have found positive results on firms located in STPs (e.g. Squicciarini, 2008, 2009; Yang, Motohashi, & Chen, 2009), others have not been able to confirm a positive, significant relationship (e.g. Colombo & Delmastro, 2002; Lofsten & Lindelöf, 2002; Siegel et al., 2003). This discrepancy has led to critical questioning of the value of STPs (Rodríguez-Pose & Hardy, 2014; Tsamis, 2009) and has initiated a search for explanations of the inconsistency.

Moreover, when it comes to understanding the value of STP performance across different regions it is important to assess STP performance in light of the regional context. We believe that the relative importance of STP outcome-based measures (e.g., patents, start-ups, NTBFs) differ across regions and time. Thus, the impact of an STP may be of greater importance in a less developed region even though the absolute value of STP performance measures are low (Albahari, Barge-Gil, Pérez-Canto, & Modrego, 2018). In consequence, STPs can be an important policy-tool in less developed regions, for example as part of a policy-supported path creation process in peripheral regions (Isaksen & Trippl, 2017). Also when the absolute performance measure look less impressive compared to STPs in economic strong regions. This understanding of performance underline the need to analyse STPs and STP performance in light of the regional context.

Furthermore, since we have seen an increase in papers that refer to park-external factors, we believe the literature lacks a systematic understanding of how regional factors may influence the performance of STPs. In this paper, we therefore aim to bring together insights from the

literature on park-contextual factors by conducting a systematic review of research that refers to park-external factors in their explanation of STP performance.

Why do regional contextual factors matter?

Since the 1980s, significant attention in economic geography has been given to various types of territorial innovation models (TIM) with the aim to explain the local dynamics for innovative behaviour (Moulaert & Sekia, 2003). A common feature of TIM is to look at regional development as a local or regional endogenous process combining economic, socio-cultural and political dimensions. The framework of regional innovation systems (RIS), one of the TIMs reviewed by Moulaert and Sekia (2003) deals exactly with the link between regional economies and innovation capacities (Asheim & Isaksen, 2002) which is of significant importance for understanding conditions for STP performance. The RIS framework views innovation as a systemic process carried out by a set of actors (e.g., firms, universities and research institutes, regulatory authorities, intermediary organizations such as STPs, policy-makers and financial institutions) who interact with each other (Doloreux & Porto Gomez, 2017).

The regional endogenous development approach resonates with a recent development in the literature on STPs (Etzkowitz & Zhou, 2018; Minguillo et al., 2015). As demonstrated by Tsamis, (2009) success factors for STPs can be categorised into two groups: internal factors (i.e. parks' ownership and organisation structure, finance, STP management and infrastructure) and regional contextual factors. As important contextual factors for STPs, Tsamis mentions a supportive institutional framework in relation to technology transfer cooperation and entrepreneurship, the availability of local resources to attract anchor tenants and a home market to support the growth of start-ups. Similarly, Comins and Rowe (Comins & Rowe, 2008) argue that STPs are likely to be more successful in regions that have the properties of a large

metropolitan, diverse and well-established developed economy, a strong research base, a culture of entrepreneurship, pro-active entrepreneurship management and actively engaged stakeholders including universities and research centres.

In the following, we introduce the regional contextual factors that we identify as important in the literature review. These count university and research institutes, industrial structure, institutional settings, financial support and urbanisation and will be discussed in light of extant literature from the field of economic geography.

Regional contextual factors

A key purpose of STPs is to facilitate learning and knowledge transfer between industrial and non-industrial knowledge partners in a region. Therefore the availability and capacity of *university and research institutes* to engage in knowledge networks are important for the innovative capacity of regions as well as for STP performance.

Besides engaging in knowledge networks, universities are perceived as a key knowledge resource for innovation — both in terms of R&D development and in developing skilled human labour forces. When firms raise their technological development level, they often need direct or indirect knowledge input from universities. This knowledge flow has been observed to be strong when the research interests between a university and local industries are matched (Yan, Chien, Hong, & Yang, 2018). In consequence, STPs can play an intermediate role to accelerate the process of knowledge flows between universities and industries when they build on technological domains that are relevant for existing industries.

The fact that regions differ with respect to their *industrial structure* has implications for regional innovativeness in more than one sense. First, industries exhibit different innovative behaviour and patterns (Pavitt, 1984) and therefore the industrial structure of a region implies that regions will differ in the type of innovations on a number of dimensions, such as

incremental vs radical, high-tech vs low-tech, user-driven vs technology-driven. Moreover, the industry structure of a region also affects new firm formation rates in regions; for example, new firms more frequently spin-out of business service industries than from mining industries (Bosma, Schutjens, & Stam, 2015).

In the past decade, the evolutionary turn in economic geography has contributed with new perspectives on regional diversification processes. In evolutionary economic geography, regional industrial specialisation and diversification patterns are perceived to be shaped by pre-existing resources (Boschma & Frenken, 2011; Neffke, Henning, & Boschma, 2011). Hence, regions are more likely to diversify into industries that are for instance technologically related to pre-existing industries or related through product markets (Tanner, 2014).

Taking the insights from evolutionary economic geography into consideration, it is reasonable to suggest that the process of establishing an STP should consider building it around technological fields that are related to the pre-existing industry in a region. Either upstream, where knowledge bases and scientific principles are cognitively related or downstream, where new technologies can be brought in and applied to renew existing industrial paths. Therefore, if innovation policy instruments such as establishing an STP in a region should contribute to the long-term economic development, and potentially restructuring of a region, it is essential to consider industrial patterns for innovative behaviour and regional diversification potential.

Regional economies are also constituted by the *institutional settings* that guide the behaviour of actors (Todtling & Trippl, 2005). As Lundvall (2007) argues, institutions shape and influence the innovative capacity at different levels – to understand the ‘micro-behaviour’ in the core of innovation processes but also the ‘wider settings’ that the innovative activities are shaped by.

Formal institutions such as policies and regulations express the underlying policy rationales that define the nature of public intervention for innovation support. Innovation policies can both shape incentives for economic actors to engage in innovation processes and at the same time create legitimacy for new path creation processes in the regional economy (Dawley, 2014). In that sense, policy support to demonstration projects or in this case field-specific STPs can create legitimacy for new economic activities in that field. Because legitimacy has been shown to be important for mobilising other resources (e.g., financial or knowledge creation) for new economic activities (Binz, Truffer, & Coenen, 2016), policy support is essential for STP performance.

The normative type of institutions (Scott, 2013) that are embedded in culture, norms and habits for interaction between people have been shown to matter in terms of improving innovation capacity of society (Efrat, 2014; Shane, 1993). Normative type of institutions influence the success of STPs by shaping the attitude and actions of entrepreneurs, venture capitalists, collaborative partners and park managers in all aspects ranging from taking risks, building trustful partnerships and seeing and searching for new information. Hence, some regions may be characterised by high levels of entrepreneurial culture (Beugelsdijk, 2007) and benefit more than others by the specific infrastructure an STP can provide to the entrepreneurial process.

In sum, institutions influence the performance of STPs both through formal institutions such as policy and regulations but not least through the informal institutions that guide behaviour and create trust in a society.

Another critical condition for the development of well-functioning RIS is the availability of *financial support* (Asheim & Isaksen, 2002). Access to finances is a fundamental part of all economic activities, allowing organisations to conduct research, adopt technologies necessary for inventions as well as develop and commercialise innovations. Hence, access to financial

support is important at all stages of innovation processes and thereby also to the key goal of STPs, namely supporting innovative activity.

Finally, *urbanisation* is perceived as a fundamental factor for favourable innovation systems to develop and grow. Urbanisation has been linked to high levels of regional innovative capacity because it represents a strong diversification of economic activities, an environment that encourage face-to-face interactions, well-educated workforce and easy market access (Iammarino, 2015; Shearmur, 2012). As Comin and Rowe (Comins & Rowe, 2008) argue, STPs in large metropolitan regions are less likely to be the major drivers of change, but can enhance the process of becoming a more knowledge-intensive economy because the innovative capacity of urban regions are higher than peripheral.

This section has introduced the factors that matters for regional innovative capacity and hereby the success of STPs. Put together, we believe that regions are diverse and evolve along their own characteristics influenced by the capacity of universities and research institutes, industrial structure, institutional settings, availability of financial support and degree of urbanisation. The intensity of these factors distinguishes regions into different types, such as metropolitan regions where the degree of urbanisation and social interactions are high and peripheral regions where the degree of urbanisation is lower, often lack financial resources and are characterised by a less diversified industrial structure (Todtling & Trippl, 2005).

Methodology

To examine the relationship between regional contextual factors and the performance of STPs, we conduct a systematic, exploratory literature review. Systematic reviews are used to improve the evidence base of a field and its subfields through a process of synthesizing research in a systematic, transparent and reproducible manner (Tranfield, Denyer, & Smart, 2003). Inspired

by Tranfield et al. (2003), we initiated our review with a scoping study to assess the relevance and size of the literature as well as to delimit the focus of the review. At this stage we studied literature on related and relevant concepts, including STPs, regional studies, evolutionary economic geography and smart specialisation policy, all of which identified the need for a review. Subsequently, we compiled a review protocol reflecting the conceptual discussion of the scoping study, the objective of the review and the significance of the problem.

A second step in the review process was to develop comprehensive, unbiased search parameters in order to identify the master sample of papers by using search parameters to include papers on STPs and performance. In the selection of papers we do not distinguish between different levels of performance or the relative importance of performance (for discussion of how to understand STP performance, see Section 2) but only capture STPs' performance as the papers report as either being positive, negative or absent.

We limited our search to the WoS, using the Social Science Citation Index (SSCI) and Science Citation Index (SCI) database for similar reasons as put forward by Mora-Valentin et al. (2018). We included only articles and reviews and left out book chapters and conference proceedings.

[Insert Figure 1 near here]

As illustrated in Figure 1, in Step 1 we identified the population of articles on STPs by using search terms. In Step 2, we identified the top 100 most cited articles in order to identify which terms are used in studies of STPs' performance. We found several search terms that was included in Step 2 to identify the population of journal articles that deal with STPs and performance.

Because we identified in the scoping study that the linkage between STPs and the regional context is rather under-investigated, we decided to qualitatively assess (in Step 3) whether a paper includes regional contextual factors or not, rather than attempting to include this

limitation of the sample through search parameters. We reduced the population of articles to 71 by screening Title and Abstract using a 3-step checklist. In the subsequent full text reading of the articles, a further seven studies were dropped, leaving the sample size of relevant articles to 64.

Synthesis method

Because the aim of this study is to shed light on a relationship which has not received pronounced attention in prior research, we follow an exploratory approach in synthesising the literature. We use thematic synthesis because most studies in our sample only relate partially to the regional context. Thematic synthesis is useful for understanding how different themes relate to a specific analytical unit and to handle contradictory findings on the relationship between concepts (Barnett-Page & Thomas, 2009). We follow an open-ended coding process where we initially coded every finding that points to the importance of a regional contextual factor under a label suitable for the given factor. The codes were initially organized into 11 categories that were subsequently grouped and regrouped by merging and splitting them. The coding process is shown in Appendix A and illustrates how two factors ‘central government’ and ‘innovation culture’ were grouped together as ‘Institutions’ and ‘Regional specialisation’ was merged with ’Industrial structure’, while the initial groupings of ‘local collaboration’ and ‘human labour’ were recoded based on the respective actor types (institutions, university and industrial structure), in order to capture more nuances. The result of the coding reveals five categories that relate to the regional context (urbanisation, financial support, university and research institutes, industrial structure and institutions) as well as extra-regional networks and STPs’ internal factors.

Concurrently, the findings on performance were coded for each paper to determine whether each specific study finds that the STPs have a positive or negative impact on the specific

performance measure that particular paper had in focus. Subsequently, we extracted reports that demonstrate how the different themes relate to the STPs' performance. These reports create the foundation for the next section, where we present the results of the literature review.

Results and Analysis

The 64 selected papers are distributed across 40 journals, which indicates that the field of STP study is interdisciplinary by nature and relates to a number of subjects. The top three journals are Technovation (20%), European Planning Studies (12.5%) and Environment and Planning C-Government and Policy (10%).

Figure 2 summarises the findings of the literature review of regional factors and their influence on the performance of STPs. A more detailed exposition of the review with a distribution of the papers across each of the seven factors is available in Appendix B. In the following section, we will elaborate on what the literature has reported with respect to the five regional contextual factors (left side in Figure 2) and their relationship to STP perfomance.

[Insert Figure 2 near here]

University and research institutes

This review confirms that STPs that have succesfully established strong collaborative ties to university scholars have higher levels of performance (e.g. higher patent application and number of firms on park) (Albahari et al., 2017; Díez-Vial & Montoro-Sánchez, 2016; Link & Scott, 2003; Minguillo & Thelwall, 2015a). We have identified three roles universities and research institutes play for STP performance: a source of knowledge creation and knowledge network; skilled human labour provider; and a place to encourage innovation culture and activities.

One of the fundamental premise of STPs is to strengthen the tie to university-based knowledge, where universities become a source of knowledge creation that links directly to R&D development in park tenant firms (M. C. Hu, 2011; T. S. Hu, Lin, & Chang, 2005; Jongwanich, Kohpaiboon, & Yang, 2014; Malairaja & Zawdie, 2008; Yan et al., 2018). High-quality and active R&D universities present more active and better quality collaboration with park tenants than medium- and low-ranked universities, which implies that university and research excellence is important for knowledge transfer between knowledge producers and private sectors (Minguillo & Thelwall, 2015a).

Furthermore, one important factor is the knowledge match between university research and firm requirements (M. C. Hu, 2011; Malairaja & Zawdie, 2008; Yan et al., 2018). A cognitive mismatch between university research and firm-specific knowledge requirements could hinder STPs performance, as shown in Lin & Tzeng (2009). Hence, it is important for university and/or research institutes to consider local capabilities in their research strategy in order to enhance local synergy, which potentially can lead to higher local economic impact through STP collaboration. To exemplify, the early development stage of Daeduck Science Park showed that little synergy between research institutes and local industries resulted in insufficient local economic impact (Shin, 2000).

Knowledge networks with universities through both formal and informal interactions also lead to the ability of identifying common research interests between universities and firms (Padilla-Meléndez, Del Aguila-Obra, & Lockett, 2013), access to human labour (Motohashi, 2013) or even venture capital and world-wide connections. For example, the well-performing Tuspark in China has built an active informal network through its alumni group, helping firms expand connections worldwide (Zou & Zhao, 2013).

Similar to knowledge input, firms require specific skilled human labour that match their need. Hence, a university that provides matching skilled labour reflects good synergy between the university and park firms (Pilar Latorre, Hermoso, & Rubio, 2017); if not, it could hinder park development, as in the case of IDEON science park, where tenant firms highlight that the local university could not supply relevant qualified labour (Jonsson, 2002).

Finally, universities are places to bring up and encourage entrepreneurial behaviour by internal academic staff and students, an approach which will reflect directly in STPs' performance measures. Universities that support entrepreneurial culture by encouraging students to spin off their research or appreciate extra research activities often link to well-performing STPs (Zou & Zhao, 2013). On the other hand, local universities that view entrepreneurial culture as low status and build on traditional academic goals hamper STPs' performance (Etzkowitz & Zhou, 2018; Hansson et al., 2005; Padilla-Meléndez et al., 2013). Newcastle Science City is an example of a stagnated STP, which partly occurred because of the local university's narrow view on entrepreneurial culture, where academics lacked provision for leave of absence or reduction in academic duties in order to explore entrepreneurial opportunities (Etzkowitz & Zhou, 2018).

Altogether, although it is a fundamental premise of STPs to strengthen the tie to university-based knowledge the literature reveal that the relationship is multifaceted and depends on the ranking, attitude and knowledge domains of the university. Local universities that provide matching research activities and skilled human labour are more likely to produce synergetic relationships to tenant firms. Similarly, the attitude of academics (e.g., internal entrepreneurial culture) and the cultural norms at the university towards firm collaboration link to the performance of STPs.

Industrial structure

The pre-existing regional industrial structure is a frequently occurring theme in the papers reviewed. Several studies confirm that in regions with strong industrial agglomeration or the presence of large high-tech firms, STPs tend to perform well, particularly if the STP's strategy relates technologically to the local industry (Hommen, Doloreux, & Larsson, 2006; M. C. Hu, 2011; T. S. Hu, 2008; Yun & Lee, 2013). Eindhoven high-tech development is an example of an STP that was initiated by local leading firms with the aim to sustain the performance of the high-tech industry by focusing on R&D related to the industry (Huang & Fernández-Maldonado, 2016). Specialised STPs allow parks to leverage their resources by providing common facilities and encourage collaboration among tenants with off-park firms (Vásquez-Urriago, Barge-Gil, Rico, & Paraskevopoulou, 2014). Hsinchu Science Park is a particularly good example of a park that connects to a favourable local industrial agglomeration, providing a competitive production network in the semiconductor sector (T. S. Hu et al., 2005; Lee, Lin, & Hsi, 2017).

However, in regions where there is no industrial agglomeration, and/or no high-technology leading firms, STPs show constrained performance levels in R&D (e.g., the case of Newcastle science park and Tsinghua Science Park (Etzkowitz & Zhou, 2018; Phelps & Dawood, 2014; Zou & Zhao, 2013)).

The regional industrial sector also influences STP performance with regard to number of spin-off firms because some sectors, such as information and technology or biopharmaceutical, may have a higher chance to create spin offs than other sectors, such as tourism and service (Salvador & Rolfo, 2011). Hence, STPs located in a region where there is a presence of high-tech industries or STPs that host high-tech sector-firms will have a higher chance to create spin offs.

In sum, regions that have strong industrial agglomeration, presence of high-tech leading firms and high-tech industry sectors are more likely to produce positive STP performance levels.

Institutions

Institutional contextual factors that together guide the behaviour of actors is a particularly broad category covering three sub-groups: the innovation and entrepreneurial culture and norms (3.b. in Figure 2) that characterise the region; the interplay between national and regional policies, namely multi-scalar science, technology and innovation (STI) policy; and the adjustment and integration of STI policy to match local context.

Innovation and entrepreneurial culture

The review reveals that the best practice STPs (e.g. Hsinchu, Kyoto and Mjardevi Science Park) are embedded in a favourable entrepreneurial culture which promotes trust and dense collaborative networks. The literature proposes that successful parks exhibit transaction-intensive linkages between on- and off-park firms and non-firms actors which support entrepreneurial activity (Edgington, 2008). Several studies point towards a particular culture that characterise the regions where STPs perform well, resulting in such dense network activity. This culture is often a starting point for innovation because it acts as an engine to create informal networks between firms that lead to knowledge exchange, access to funding and higher degrees of labour mobility (Edgington, 2008; T. S. Hu, 2008; Lee et al., 2017; Zou & Zhao, 2013). A weak entrepreneurial culture, on the contrary, reflects lack of trust and low levels of collaboration in the region (Miao & Hall, 2014; Zeng, Xie, & Tam, 2010), resulting in poorly performing STPs.

In sum, the normative type of institutions embedded in culture, norms and habits for interaction between people shape the attitude and actions of entrepreneurs, venture capitalists, collaborative partners, park managers etc. The review confirms that regions that exhibit

transaction-intensive linkages may therefore also benefit more from the infrastructure provided by the STP.

Multiscalar STI policy

For most of the reviewed papers, the regional initiatives related to STPs have been enabled by a national policy framework which assists with respect to funding, supporting infrastructure and building knowledge networks. These broader frames are complemented by decentralised regional policy initiatives that aim at building clusters, networks and partnerships in connection to the STP initiative (Edgington, 2008).

A comparative study by Huang and Fernández-Maldonado (2016) illustrates how the configuration and balance between national and regional policies differ tremendously across countries, resulting in highly different institutional settings for STPs to develop in. They compare the Netherlands, a flexible decentralised welfare society with the more hierarchical and centralised governed Taiwan, and their respective high-tech policy approaches (Huang & Fernández-Maldonado, 2016). The flexibility of STPs as a policy instrument means that both types of institutional environments can be associated with well-performing STPs.

The Hsinchu science park in Taiwan illustrates how national policies play a major driving force for its success, when the government established the dedicated agency (MOST) to take care of STI policy and give STP development a privileged position compared to other policy areas (Huang & Fernández-Maldonado, 2016; Yan et al., 2018). Similarly, for the Daedeok science park, South Korea, coordination between national and regional interests was decisive for a regionally well-performing STP (Kim, Lee, & Hwang, 2014). On the other hand, an incoherent and uncoordinated policy at national and regional levels may lead to an inefficient STP development, as shown in the case of the Kulim Hi-Tech Park, Malaysia (Phelps & Dawood, 2014).

Besides coordination and coherence between national and regional policies, stability is another important characteristic. Albahari et al. (2013) underline the importance of stable government policy in their comparative analysis of STPs in Spain and Italy. They find that Spanish STPs outperform Italian because of the coherent and steady set of Spanish policies that are specifically designed to support STPs, whereas policies in Italy have had a discontinuous character without a strong focus on STPs.

In sum, the relationship between national and regional policies is important for the development of STPs. In the best performing cases, the relationship is characterised by coordination, coherence and stability.

Integration and adjustment of STI to regional context

A final institutional sub-theme we identify in the review is requirement need to integrate and adjust infrastructure and entrepreneurial policy instruments to fit the local context. As Jenkins and Leicht (2018) puts it, high technology policies have to be adapted to fit existing high-tech resources and unique local strengths and weaknesses. Other studies propose that the problems of poor-performing STPs are caused by a lack of integration of resources from local actors, such as universities, industries and local government (Brooker, 2013; Kim et al., 2014; Shin, 2000).

The review supports that a strong commitment and active involvement from local government reflect a positive outcome for the park (Cheng, van Oort, Geertman, & Hooimeijer, 2014; Hommen et al., 2006; Zou & Zhao, 2013). To illustrate, the Daedoek Science Park was initiated by central government and lacked involvement of the local government in the early stages, thus hindering smooth park development. After the state took an active role to stimulate the link between the park and the local government, the performance of Daedok Science Park improved

significantly and became better integrated in the regional economy (Kim et al., 2014; Shin, 2000).

However, studies also point out that different types of regions require varying levels of support depending on pre-existing regional assets and characteristics. In other words. Etzkowitz and Zhou (2018) argue that before STPs can become self-sustainable, they go through a development process in which the allocation of resources is crucial. In peripheral regions, such resource allocation depends on support from both central government and an active regional government. Likewise, the type of policies need to be adjusted, for example for regions where the entrepreneurial culture is low, policy initiatives targeting new firm formation are more important than a massive infrastructure project (Etzkowitz & Zhou, 2018).

For regions where the innovative intensity is high, infrastructural support needs to be adjusted to an expressed need by potential park customers (local firms/entrepreneurs) rather than being offered blindly at excessively high costs (Tsai & Chang, 2016; Xiao & North, 2018). Other studies show how regions where industrial agglomeration and specialisation are strong, policy support aiming at specific sectors is considered to be more important (Kennedy, 2007).

Similarly, the empirical study by Yang et al. (2009) presents three different strategic coupling processes where local firms, state government and societal forces configure geographically varied patterns of science park-driven regional development. The role of the state differs depending on the regional characteristics. When there is a lack of strong local industry, the actions of the state become critical. On the contrary, in regions where the state has fewer resources and abilities to support the science park, the role of local firms is decisive for the STP development. In sum, regional differences reflect the need to adjust policy to fit the regional context.

Financial Support

The literature review confirms that availability of financial support, understood as both access to financial capital and guidance on how to access and manage funding, is important for STPs' performance. The review corroborates that access to financial resources plays a crucial role for entrepreneurs to start a new firm, perform R&D activities, initiate manufacturing, sale and marketing of products or services (Löfsten & Lindelöf, 2003; Mukkala, 2010; Watkins-Mathys & Foster, 2006; Xiao & North, 2018). Similarly, a large number of papers also show that on-park firms face difficulties in accessing financial support (Löfsten & Lindelöf, 2003; Mukkala, 2010; Salvador, 2011; Watkins-Mathys & Foster, 2006) mainly due to generic issues such as uncertainty and the ability of inexperienced entrepreneurs to start a business (Löfsten & Lindelöf, 2003; Mukkala, 2010). Similarly, the cost of financing relatively small amounts can be high due to a lack of economies of scale (Mukkala, 2010).

Literature demonstrating the role of the regional context for the availability of financial support is less clear. The study by Watkins-Mathys & Foster (2006) shows that STPs that are located in industry-dense regions, such as metropolitan areas, benefit from networking opportunities that lead to easier access to financial sources. Similarly, Salvador (2011) argues that the lack of information and collaboration in a region can cause firms to be unaware of opportunities for financial support.

In metropolitan regions, sources of finances are often much richer and more diverse, and the review confirms such regions to have an advantage over less developed regions regarding financial support. However, the literature also shows that information, communication and guidance on how to communicate with venture capitalists is equally important (Löfsten & Lindelöf, 2003; McAdam & McAdam, 2008). In this regard, it is interesting that in less developed regions, the financial support provided by STPs had a more significant impact on

firms, whereas the effect of STP support is more limited in urban regions due to the diverse availability of external venture capitals (Xiao & North, 2018).

Urbanisation

Although Comins and Rowe (2008) argue that large, diverse, metropolitan regions in well-established developed economies are one of the key factors that influence the success of STPs, we find in our review that the degree of urbanisation is rarely mentioned as an explanatory factor for STP performance, despite the fact that the majority of STPs are located in highly urbanised areas. For example, the study of Shearmur and Doloreux (2000) demonstrates that most of the Canadian STPs are located in large cities.

Nonetheless, the review supports that in most cases, location in urbanised areas is an advantage because of access to skilled human labour, financial investment, supporting institutions and easier face-to-face meetings with other high-tech companies (Edgington, 2008; Watkins-Mathys & Foster, 2006). Parks that are located in peripheral areas struggle to attract staff (Phelps & Dawood, 2014; Shin, 2000) and lack social facilities such as restaurant and leisure facilities, which are important for networking opportunities as in the case of KHTP in Malaysia (Phelps & Dawood, 2014) and the initial stage of Daeduck Science Park in Korea (Shin, 2000). However, urban density can also have a negative effect on STPs' performance if a plan and sufficient space for firm expansion are lacking (Edgington, 2008).

Discussion and conclusion

As an initial contribution to understanding the dynamics of STPs in their regional context we developed a comprehensive framework of regional factors that influence STP performance (Figure 2). The review of these factors draws lessons across all types of regions to better understand the key regional dynamics that influence STPs. Keeping in mind that the relative

importance of STPs in less developed regions often is higher than in core regions, we believe understanding these dynamic connections can help improve designs of STPs, and hereby their performance.

The review finds some general tendencies about the relationship between type of regions and the performance of STPs. In general, the review indicates that metropolitan regions are better equipped with regard to the benefits that come from an urbanised economy; better opportunities to receive financial support, to enter networks or partnerships, to attract skilled labour and access to related industries, whereas peripheral regions are on the contrary worse off when it comes to all of these parameters.

However, the review also pointed towards other regional contextual differences, which may not be ascribed to a metropolitan-peripheral dichotomy. For example, informal institutional settings, such as entrepreneurial culture, and inducing norms and practices for collaboration between universities and the private sector is generating dense network activity, which benefits STPs' performance.

Similarly, the characteristics of actors present in a region are important. Universities, research institutes and the local industry influence the possibilities of STPs to develop. The review confirms that STPs tend to perform well in regions where there is a strong link between universities and local companies, through skilled human labour flows, actively networking, spinoffs and start-up activities. Moreover, collaboration between universities and STP tenants is stronger if universities provide cognitively related research activities. Likewise, the review also indicates that the local industry also seems to better fuel the development of STPs when the firms' knowledge bases are technologically related to STP tenant firms. Consequently, when designing STPs, it is important to assess pre-existing competences and skills embedded

in industry and knowledge infrastructure to create STPs that can thrive on already existing related competences and networks.

These findings correspond with the EU Smart Specialisation policy (Piirainen, Tanner, & Alkærsig, 2017) and also to the broad thinking of evolutionary economic geography on path-dependent development. STPs can be integrated in the smart specialisation strategy development, as suggested by Nauwelaers et al. (2014), and by building on pre-existing strengths in the region, contributing to a knowledge-intensive diversification of regional economies. In particular in peripheral areas, STPs may play an important role in the entrepreneurial discovery processes in smart specialisation strategies (Fröhlich & Hassink, 2018).

A final dimension of regional endogenous factors with importance for STP development that we have identified in the review is the political decision-making at regional and national levels. In particular, two sub-themes appeared from reviewing the literature; the interplay between national and regional STI policy and regional policies targeting the adjustment and integration of the STP tool into the regional context.

We found that coordinated and coherent interplay between national and regional STI policy reinforces the conditions for STP development. Particularly in less favoured regions, national government policy is important in supporting the regional policy levels because these regions are less resourceful in terms of finance, scientific knowledge bases, skilled labour etc. Consequently, they depend to a larger degree on sufficient and stable framework conditions provided at the national level.

For regional STI policies, we find that they depend on the region’s innovative capacity. The review suggests that when using STP as a policy tool in peripheral regions, it is then all the more important to be aware of all the different points of park-external couplings, such as access

to funding, skilled labour, networking, quality of university research and scope and fit of university research to park identity. Similarly, in less favoured regions, policy should aim to encourage and induce collaboration with local firms as well as entrepreneurial behaviour.

We agree with Etzkowitz and Zhou (2018) that STPs are an adaptable empty box that can be adjusted to achieve various objectives in accordance with local situations at different stages of their development. This suggestion is also in line with Harper & Georghiou (2005), who argue that the development of STPs is context driven, resource dependent and competence based. Regional factors are preconditions that policy makers need to take into account when initiating STP development. Design and implementation of STPs therefore need to be adjusted to the specificities of the industrial context, innovation culture and governance structure of the region.

To the process of adapting STPs to its context the proposed framework can function as a guideline in future policy-making in order to improve the performance of STPs. In particular in less developed regions, where conditions are often poorer but the benefits can be relative more important, regional contextual factors should be assessed and fully understood before designing and establishing new parks. In this process it is important to be aware of how STP systems can benefit from and link to existing knowledge bases (both academic and industrial), how the regional innovative and entrepreneurial culture will reinforce or hinder the work of STPs, and finally how the interplay between national and regional policy can ensure a stable and supportive environment for the STP.

In case of existing STPs that seek to improve their performance, we believe the framework can contribute with a structured evaluation of park-external factors that act as obstacles to the park's development. This work can be centred on improving the commitment from local government, the entrepreneurial culture and the match between STP's strategic areas and the knowledge bases of industry, universities and research institutes. For the latter, work on

improving and sharpening the technological match can be carried out through participatory foresight exercises combined with bibliometric mapping.

To conclude, the aim of this paper has been to zoom in on the regional dynamics of STPs and on how different contexts results in different conditions for STP performance. In future work, it would be beneficial to carry out empirical studies of STPs following the proposed framework, in order to test its explanatory force and translate findings into a strategic tool for policy makers.

Acknowledgement:

This research is funded by the Thai Government Scholarship Program. The authors would like to thank Alberto Albahari for advice and Michaela Trippl, for her comments on an earlier version of this paper at the International PhD course on Economic Geography in Utrecht, 2018. The constructive comments from the anonymous reviewer on an earlier version of this paper were also most useful. The authors are listed alphabetically. All errors and shortcomings are of course our own.

References

Albahari, A., Barge-Gil, A., Pérez-Canto, S., & Modrego, A. (2018). The influence of Science and Technology Park characteristics on firms' innovation results. *Papers in Regional Science*, *97*(2), 253–279. https://doi.org/10.1111/pirs.12253

Albahari, A., Catalano, G., & Landoni, P. (2013). Evaluation of national science park systems: a theoretical framework and its application to the Italian and Spanish systems. *Technology Analysis and Strategic Management*, *25*(5), 599–614. https://doi.org/10.1080/09537325.2013.785508

Albahari, A., Pérez-Canto, S., Barge-Gil, A., & Modrego, A. (2017). Technology Parks versus Science Parks: Does the university make the difference? *Technological Forecasting and Social Change*, *116*, 13–28. https://doi.org/10.1016/j.techfore.2016.11.012

Albahari, A., Pérez-Canto, S., & Landoni, P. (2010). Science and Technology Parks impacts on tenant

organisations: a review of literature. *MPRA Paper*, (41914), 29.

Asheim, B., & Isaksen, A. (2002). Regional Innovation Systems: The Integration of Local "Sticky" and Global "Ubiquitous" Knowledge. *Journal of Technology Transfer*, *27*(1), 77–86. https://doi.org/10.1023/A:1013100704794

Barnett-Page, E., & Thomas, J. (2009). Methods for the synthesis of qualitative research: A critical review. *BMC Medical Research Methodology*, *9*(1). https://doi.org/10.1186/1471-2288-9-59

Beugelsdijk, S. (2007). Entrepreneurial culture, regional innovativeness and economic growth. *Journal of Evolutionary Economics*, *17*(2), 187–210. https://doi.org/10.1007/s00191-006-0048-y

Binz, C., Truffer, B., & Coenen, L. (2016). Path Creation as a Process of Resource Alignment and Anchoring: Industry Formation for On-Site Water Recycling in Beijing. *Economic Geography*, *92*(2), 172–200. https://doi.org/10.1080/00130095.2015.1103177

Boschma, R. A., & Frenken, K. (2011). Technological relatedness and regional branching. In H. Bathelt, M. P. Feldman, & D. F. Kogler (Eds.), *Beyond Territory: Dynamic Geographies of Knowledge Creation, Diffusion and Innovation* (pp. 64–81). Oxon, UK: Routledge.

Bosma, N., Schutjens, V., & Stam, E. (2015). Regional entrepreneurship. In P. Cooke, B. T. Asheim, R. Boschma, B. R. Martin, D. Schwartz, & To (Eds.), *Handbook of Regional innovation and growth* (pp. 482–494). Edward Elgar Publishing Limited.

Brooker, D. (2013). From ' wannabe ' Silicon Valley to global back office ? Examining the socio-spatial consequences of technopole planning practices in Malaysia, *54*(1), 1–14. https://doi.org/10.1111/apv.12001

Cabral, R., & Dahab, S. S. (1998). Science parks in developing countries: the case of BIORIO in Brazil. *International Journal of Technology Management*, *16*(8), 726. https://doi.org/10.1504/IJTM.1998.002693

Castells, M., & Hall, P. (1994). *Technopoles of the World: The Making of Twenty-first Century Industrial Complexes*.

Chan, K.-Y. A., Oerlemans, L. A., & Pretorius, M. W. (2011). Innovation outcomes of South African New Technology-Based Firms: A contribution to the debate on the performance of science park firms. *South African Journal of Economic and Management Sciences2*, *14*(4), 361–378. https://doi.org/10.4102/sajems.v14i4.34

Cheng, F., van Oort, F., Geertman, S., & Hooimeijer, P. (2014). Science Parks and the Co-location of High-tech Small- and Medium-sized Firms in China's Shenzhen. *Urban Studies*, *51*(5), 1073–1089. https://doi.org/10.1177/0042098013493020

Colombo, M. G., & Delmastro, M. (2002). How effective are technology incubators? *Research Policy*, *31*(7), 1103–1122. https://doi.org/10.1016/S0048-7333(01)00178-0

Comins, N., & Rowe, D. N. E. (2008). Success Factors for Science Parks in the Developed Wolrd and Emerging Economies, (1).

Dawley, S. (2014). Creating New Paths? Offshore Wind, Policy Activism, and Peripheral Region Development. *Economic Geography*, *90*(1), 91–112. https://doi.org/10.1111/ecge.12028

Diez-Vial, I., & Fernández-Olmos, M. (2017). The effect of science and technology parks on a firm's performance: a dynamic approach over time. *Journal of Evolutionary Economics*, *27*(3), 413–434. https://doi.org/10.1007/s00191-016-0481-5

Díez-Vial, I., & Montoro-Sánchez, Á. (2016). How knowledge links with universities may foster innovation: The case of a science park. *Technovation*, *50–51*, 41–52. https://doi.org/10.1016/j.technovation.2015.09.001

Doloreux, D., & Porto Gomez, I. (2017). A review of (almost) 20 years of regional innovation systems research. *European Planning Studies*, *25*(3), 371–387. https://doi.org/10.1080/09654313.2016.1244516

Edgington, D. W. (2008). The Kyoto Research Park and Innovation in Japanese Cities. *Urban Geography*, *29*(5), 411–450. https://doi.org/10.2747/0272-3638.29.5.411

Efrat, K. (2014). The direct and indirect impact of culture on innovation. *Technovation*, *34*(1), 12–20. https://doi.org/10.1016/j.technovation.2013.08.003

Etzkowitz, H., & Zhou, C. (2018). Innovation incommensurability and the science park. *R and D Management*, *48*(1), 73–87. https://doi.org/10.1111/radm.12266

Fröhlich, K., & Hassink, R. (2018). Smart Specialization and the Role of Universities and Science Parks. *World Technopolis Review*, *7*(2), 1–8.

Fukugawa, N. (2006). Science parks in Japan and their value-added contributions to new technology-based firms. *International Journal of Industrial Organization*, *24*(2), 381–400. https://doi.org/10.1016/j.ijindorg.2005.07.005

Goldstein, H. A., & Luger, M. I. (1990). Science/Technology Parks and Regional Development Theory. *Economic Development Quarterly*, *4*(1), 64–78. https://doi.org/10.1177/089124249000400108

Hansson, F., Husted, K., & Vestergaard, J. (2005). Second generation science parks: From structural holes jockeys to social capital catalysts of the knowledge society. *Technovation*, *25*(9), 1039–1049. https://doi.org/10.1016/j.technovation.2004.03.003

Harper, J. C., & Georghiou, L. (2005). Foresight in innovation policy: Shared visions for a science park and business–university links in a city region. *Technology Analysis and Strategic Management*, *17*(2), 147–160. https://doi.org/10.1080/09537320500088716

Hommen, L., Doloreux, D., & Larsson, E. (2006). Emergence and growth of Mjärdevi Science Park in Linköping, Sweden. *European Planning Studies*, *14*(10), 1331–1361. https://doi.org/10.1080/09654310600852555

Hu, M. C. (2011). Evolution of knowledge creation and diffusion: The revisit of Taiwan's Hsinchu Science Park. *Scientometrics*, *88*(3), 949–977. https://doi.org/10.1007/s11192-011-0427-5

Hu, T. S. (2008). Interaction among high-tech talent and its impact on innovation performance: A comparison of Taiwanese science parks at different stages of development. *European Planning Studies*, *16*(2), 163–187. https://doi.org/10.1080/09654310701814462

Hu, T. S., Lin, C. Y., & Chang, S. L. (2005). Technology-based regional development strategies and the emergence of technological communities: A case study of HSIP, Taiwan. *Technovation*, *25*(4), 367–380. https://doi.org/10.1016/j.technovation.2003.09.002

Huang, W. J., & Fernández-Maldonado, A. M. (2016). High-tech development and spatial planning: comparing the Netherlands and Taiwan from an institutional perspective. *European Planning Studies*, *24*(9), 1662–1683. https://doi.org/10.1080/09654313.2016.1187717

Iammarino, S. (2015). Regional innovation and diversity. In P. Cooke, B. Asheim, R. Boschma, B. R. Martin, D. Schwartz, & F. Todtling (Eds.), *Handbook of Regional innovation and growth* (illustrate, pp. 143–154). Edward Elgar Publishing, 2011.

Isaksen, A., & Trippl, M. (2017). Exogenously Led and Policy-Supported New Path Development in Peripheral Regions: Analytical and Synthetic Routes. *Economic Geography*, *93*(5), 436–457. https://doi.org/10.1080/00130095.2016.1154443

Jenkins, J. C., & Leicht, K. T. (2018). Do High Technology Policies Work ? High Technology Industry Employment Growth in U . S . Metropolitan Areas , 1988-1998 Differing Views on Location-

specific Technology Policies, *85*(1), 1988–1998.

Jongwanich, J., Kohpaiboon, A., & Yang, C. H. (2014). Science park, triple helix, and regional innovative capacity: Province-level evidence from China. *Journal of the Asia Pacific Economy*, *19*(2), 333–352. https://doi.org/10.1080/13547860.2014.880285

Jonsson, O. (2002). Innovation processes and proximity: The case of IDEON firms in Lund, Sweden. *European Planning Studies*, *10*(6), 705–722. https://doi.org/10.1080/0965431022000003771

Kennedy, L. (2007). Regional industrial policies driving peri-urban dynamics in Hyderabad, India. *Cities*, *24*(2), 95–109. https://doi.org/10.1016/j.cities.2006.06.001

Kim, H., Lee, Y. S., & Hwang, H. R. (2014). Regionalization of planned S&T parks: The case of Daedeok S&T park in Daejeon, South Korea. *Environment and Planning C: Government and Policy*, *32*(5), 843–862. https://doi.org/10.1068/c1269r

Lee, S. J., Lin, G. T. R., & Hsi, P. H. (2017). Industrial Cluster Development and its Contribution to Economic Growth in Taiwan - Hsinchu Science and Industrial Park (HSIP). *Journal of Scientific & Industrial Research*, *76*(5), 273–278.

Lin, C. L., & Tzeng, G. H. (2009). A value-created system of science (technology) park by using DEMATEL. *Expert Systems with Applications*, *36*(6), 9683–9697. https://doi.org/10.1016/j.eswa.2008.11.040

Lindelöf, P., & Löfsten, H. (2002). Growth, management and financing of new technology-based firms-assessing value-added contributions of firms located on and off Science Parks. *Omega*, *30*(3), 143–154. https://doi.org/10.1016/S0305-0483(02)00023-3

Link, A. N., & Scott, J. T. (2003). US science parks: the diffusion of an innovation and its effects on the academic mission of universities. *International Journal of Industrial Organization*, *21*, 1323–1356. https://doi.org/10.1016/S0167-7187(03)00085-7

Lofsten, H., & Lindelof, P. (2001). Science parks in Sweden - industrial renewal and development? *R and D Management*, *31*(3), 309–322. https://doi.org/10.1111/1467-9310.00219

Lofsten, H., & Lindelöf, P. (2002). Science Parks and the growth of new technology-based firms—academic-industry links, innovation and markets. *Omega*, *30*(3), 143–154. https://doi.org/10.1016/S0305-0483(02)00023-3

Löfsten, H., & Lindelöf, P. (2003). Determinants for an entrepreneurial milieu: Science Parks and business policy in growing firms. *Technovation*, *23*(1), 51–64. https://doi.org/10.1016/S0166-4972(01)00086-4

Lundvall, B. Å. (2007). National innovation systems - Analytical concept and development tool. *Industry and Innovation*, *14*(1), 95–119. https://doi.org/10.1080/13662710601130863

Malairaja, C., & Zawdie, G. (2008). Science parks and university-industry collaboration in Malaysia. *Technology Analysis and Strategic Management*, *20*(6), 727–739. https://doi.org/10.1080/09537320802426432

Martínez-Cañas, R., Sáez-Martínez, F. J., & Ruiz-Palomino, P. (2012). Knowledge acquisition's mediation of social capital-firm innovation. *Journal of Knowledge Management*, *16*(1), 61–76. https://doi.org/10.1108/13673271211198945

McAdam, M., & McAdam, R. (2008). High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources. *Technovation*, *28*(5), 277–290. https://doi.org/10.1016/j.technovation.2007.07.012

McCarthy, I. P., Silvestre, B. S., von Nordenflycht, A., & Breznitz, S. M. (2018). A typology of university research park strategies: What parks do and why it matters. *Journal of Engineering and*

Technology Management, *47*(August 2015), 110–122. https://doi.org/10.1016/j.jengtecman.2018.01.004

Miao, J. T., & Hall, P. (2014). Optical illusion? The growth and development of the optics valley of China. *Environment and Planning C: Government and Policy*, *32*(5), 863–879. https://doi.org/10.1068/c1270r

Minguillo, D., & Thelwall, M. (2015a). Research excellence and university-industry collaboration in UK science parks. *Research Evaluation*, *24*(2), 181–196. https://doi.org/10.1093/reseval/rvu032

Minguillo, D., & Thelwall, M. (2015b). Which are the best innovation support infrastructures for universities? Evidence from r&d output and commercial activities. *Scientometrics*, *102*(1), 1057–1081. https://doi.org/10.1007/s11192-014-1458-5

Minguillo, D., Tijssen, R., & Thelwall, M. (2015). Do science parks promote research and technology? A scientometric analysis of the UK. *Scientometrics*, *102*(1), 701–725. https://doi.org/10.1007/s11192-014-1435-z

Mora-Valentín, E. M., Ortiz-de-Urbina-Criado, M., & Nájera-Sánchez, J. J. (2018). Mapping the conceptual structure of science and technology parks. *Journal of Technology Transfer*, 1–26. https://doi.org/10.1007/s10961-018-9654-8

Motohashi, K. (2013). The role of the science park in innovation performance of start-up firms: an empirical analysis of Tsinghua Science Park in Beijing. *Asia Pacific Business Review*, *19*(4), 578–599. https://doi.org/10.1080/13602381.2012.673841

Moulaert, F., & Sekia, F. (2003). Territorial Innovation Models: A Critical Survey. *Regional Studies*, *37*(3), 289–302. https://doi.org/10.1080/0034340032000065442

Mukkala, K. (2010). The role of regional policies in promoting networking and innovative activity: Evidence from small Finnish high-tech firms. *European Planning Studies*, *4313*. https://doi.org/10.1080/09654311003744175

Nahm, K. B. (2000). The evolution of science parks and metropolitan development. *International Journal of Urban Sciences*, *4*(1), 81–95. https://doi.org/10.1080/12265934.2000.9693465

Nauwelaers, C., Kleibrink, A., & Stancova, K. (2014). The Role of Science Parks in Smart Specialisation Strategies. *JRC Technical Reporrs. Europen Commission*, (08), 1–25. https://doi.org/10.2791/8851

Neffke, F., Henning, M., & Boschma, R. A. (2011). How do regions diversify over time? Industry relatedness and the development of new growth paths in regions. *Economic Geography*, *87*(3), 237–265.

Padilla-Meléndez, A., Del Aguila-Obra, A. R., & Lockett, N. (2013). Shifting sands: Regional perspectives on the role of social capital in supporting open innovation through knowledge transfer and exchange with small and medium-sized enterprises. *International Small Business Journal*, *31*(3), 296–318. https://doi.org/10.1177/0266242612467659

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, *13*(6), 343–373. https://doi.org/10.1016/0048-7333(84)90018-0

Phan, P. H., Siegel, D. S., & Wright, M. (2005). Science parks and incubators: Observations, synthesis and future research. *Journal of Business Venturing*, *20*(2), 165–182. https://doi.org/10.1016/j.jbusvent.2003.12.001

Phelps, N. A., & Dawood, S. R. S. (2014). Untangling the spaces of high technology in Malaysia. *Environment and Planning C: Government and Policy*, *32*(5), 896–915. https://doi.org/10.1068/c1272r

Piirainen, K. A., Tanner, A. N., & Alkærsig, L. (2017). Regional foresight and dynamics of smart specialization: A typology of regional diversification patterns. *Technological Forecasting and Social Change*, *115*, 289–300. https://doi.org/10.1016/j.techfore.2016.06.027

Pilar Latorre, M., Hermoso, R., & Rubio, M. A. (2017). A novel network-based analysis to measure efficiency in science and technology parks: the ISA framework approach. *Journal of Technology Transfer*, *42*(6), 1255–1275. https://doi.org/10.1007/s10961-017-9585-9

Rodríguez-Pose, A., & Hardy, D. (2014). *Technology and Industrial Parks in Emerging Countries*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-07992-9

Salvador, E. (2011). Are science parks and incubators good "brand names" for spin-offs? The case study of Turin. *Journal of Technology Transfer*, *36*(2), 203–232. https://doi.org/10.1007/s10961-010-9152-0

Salvador, E., & Rolfo, S. (2011). Are incubators and science parks effective for research spin-offs? Evidence from Italy. *Science and Public Policy*, *38*(3), 170–184. https://doi.org/10.3152/016502611X12849792159191

Scott, W. R. (2013). *Institutions and organizations: Ideas, interests, and identities*. SAGE Publications.

Shane, S. (1993). Cultural influences on national rates of innovation. *Journal of Business Venturing*, *8*(1), 59–73. https://doi.org/10.1016/0883-9026(93)90011-S

Shearmur, R. (2012). Are cities the font of innovation? A critical review of the literature on cities and innovation. *Cities*, *29*(SUPPL.2), S9–S18. https://doi.org/10.1016/j.cities.2012.06.008

Shearmur, R., & Doloreux, D. (2000). Science parks: Actors or reactors? Canadian science parks in their urban context. *Environment and Planning A*, *32*(6), 1065–1082. https://doi.org/10.1068/a32126

Shin, D.-H. (2000). An alternative approach to developing science parks: A case study from Korea. *Regional Science*, *5*, 103–111. https://doi.org/10.5018/economics-ejournal.ja.2011-6.

Siegel, D. S., Westhead, P., & Wright, M. (2003). Science Parks and the Performance of New Technology-Based Firms : A Review of Recent U . K . Evidence and an Agenda for Future Research. *Small Business Economics*, *20*, 177–184. https://doi.org/10.1023/A:1022268100133

Squicciarini, M. (2008). Science Parks' tenants versus out-of-Park firms: Who innovates more? A duration model. *Journal of Technology Transfer*, *33*(1), 45–71. https://doi.org/10.1007/s10961-007-9037-z

Squicciarini, M. (2009). Science parks, knowledge spillovers, and Firms' innovative performance. Evidence from Finland. *Economics: The Open-Access, Open-Assessment E-Journal*, *32*, 0–29.

Starr, P., & Saxenian, A. (1995). *Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Contemporary Sociology* (Vol. 24). Harvard University Press. https://doi.org/10.2307/2076522

Tanner, A. N. (2014). Regional Branching Reconsidered: Emergence of the Fuel Cell Industry in European Regions. *Economic Geography*, *90*(4), 403–427.

Todtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, *34*(8), 1203–1219. https://doi.org/10.1016/j.respol.2005.01.018

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review *. *British Journal of Management*, *14*, 207–222. https://doi.org/10.1111/1467-8551.00375

Tsai, C.-L., & Chang, H.-C. (2016). Evaluation of critical factors for the regional innovation system within the HsinChu science-based park. *Kybernetes*, *45*(4), 699–716. https://doi.org/10.1108/K-02-

2015-0059

Tsamis, A. (2009). *Science and Technology Parks in the less favoured regions of Europe : an evaluation of their performance and the parameters of success*. London School of Economics and Political Science (United Kingdom).

Vásquez-Urriago, A. R., Barge-Gil, A., Rico, M. A., & Paraskevopoulou, E. (2014). The impact of science and technology parks on firms ' product innovation : empirical evidence from Spain, 835–873. https://doi.org/10.1007/s00191-013-0337-1

Watkins-Mathys, L., & Foster, M. J. (2006). Entrepreneurship: The missing ingredient in China's STIPs? *Entrepreneurship and Regional Development*, *18*(3), 249–274. https://doi.org/10.1080/08985620600593161

Westhead, P. (1997). R&D "inputs" and "outputs" of technology-based firms located on and off science parks. *R&D Management*, *27*(1), 45–62. https://doi.org/10.1111/1467-9310.00041

Xiao, L., & North, D. (2018). The role of Technological Business Incubators in supporting business innovation in China: a case of regional adaptability? *Entrepreneurship and Regional Development*, *30*(1–2), 29–57. https://doi.org/10.1080/08985626.2017.1364789

Yan, M. R., Chien, K. M., Hong, L. Y., & Yang, T. N. (2018). Evaluating the collaborative ecosystem for an innovation-driven economy: A systems analysis and case study of science parks. *Sustainability*, *10*(3), 1–13. https://doi.org/10.3390/su10030887

Yang, C. H., Motohashi, K., & Chen, J. R. (2009). Are new technology-based firms located on science parks really more innovative?. Evidence from Taiwan. *Research Policy*, *38*(1), 77–85. https://doi.org/10.1016/j.respol.2008.09.001

Yang, D. Y.-R., Hsu, J.-Y., & Ching, C.-H. (2009). Revisiting the silicon Island? The geographically varied "Strategic Coupling" in the development of high-technology parks in Taiwan. *Regional Studies*, *43*(3), 369–384. https://doi.org/10.1080/00343400902777067

Yun, S., & Lee, J. (2013). An innovation network analysis of science clusters in South Korea and Taiwan. *Asian Journal of Technology Innovation*, *21*(2), 277–289. https://doi.org/10.1080/19761597.2013.866310

Zeng, S., Xie, X., & Tam, C. (2010). Evaluating innovation capabilities for science parks: A system model. *Technological and Economic Development of Economy*, *16*(3), 397–413. https://doi.org/10.3846/tede.2010.25

Zou, Y., & Zhao, W. (2013). Anatomy of Tsinghua University science park in China: Institutional evolution and assessment. *Journal of Technology Transfer*, *39*(5), 663–674. https://doi.org/10.1007/s10961-013-9314-y

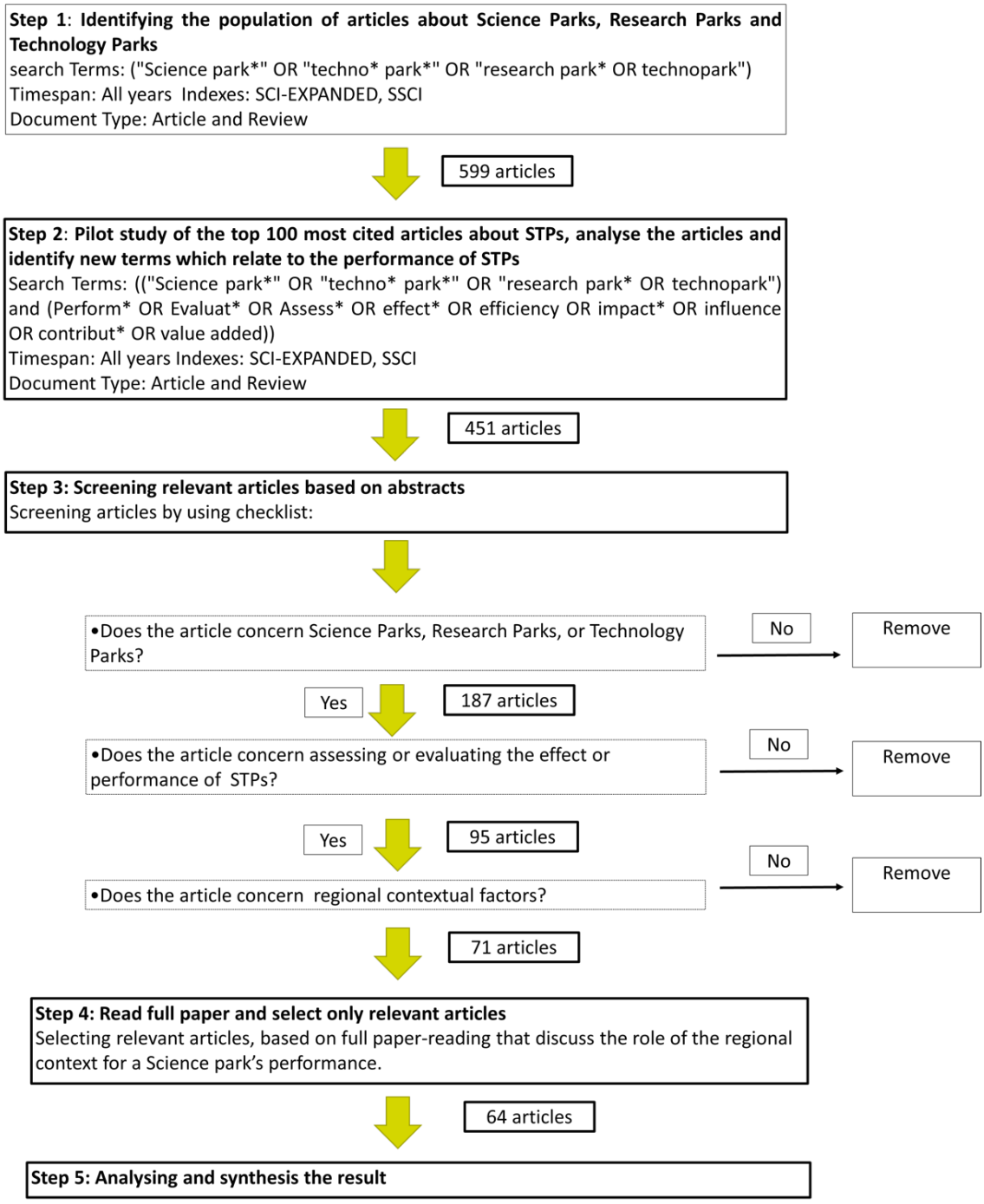


Figure 1: Literature search and process of selecting papers

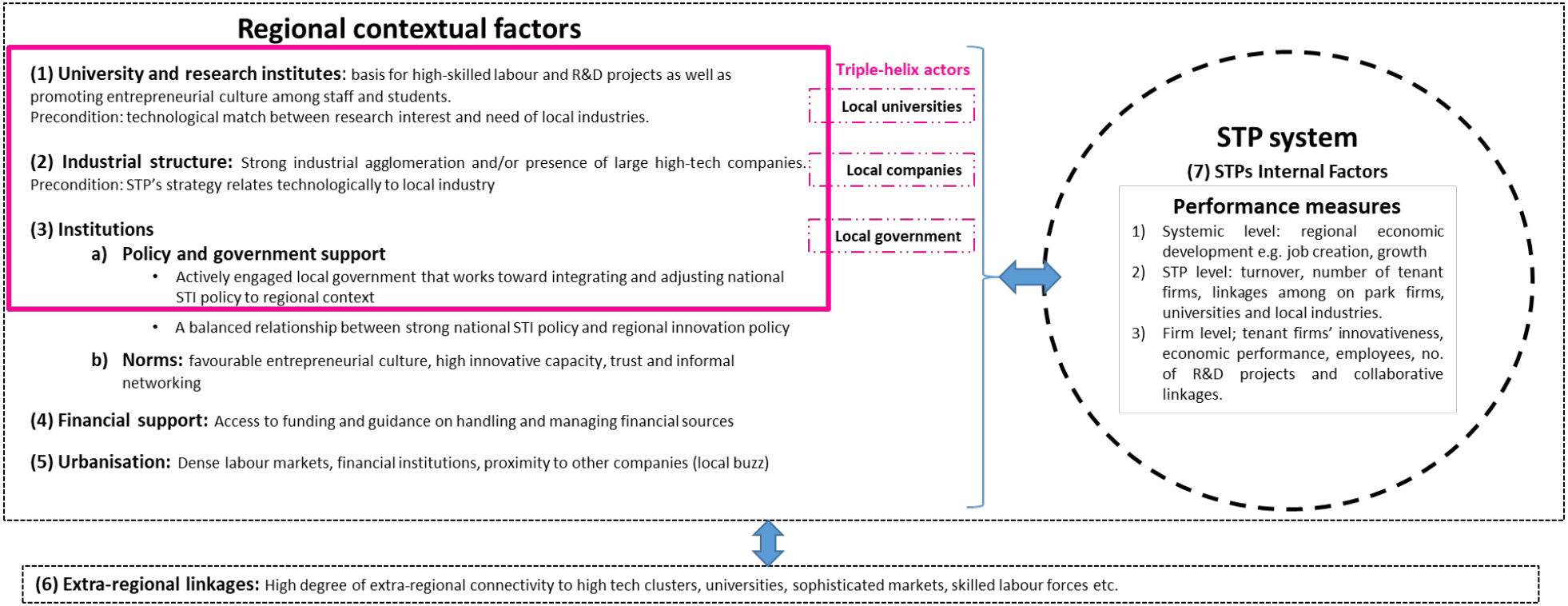
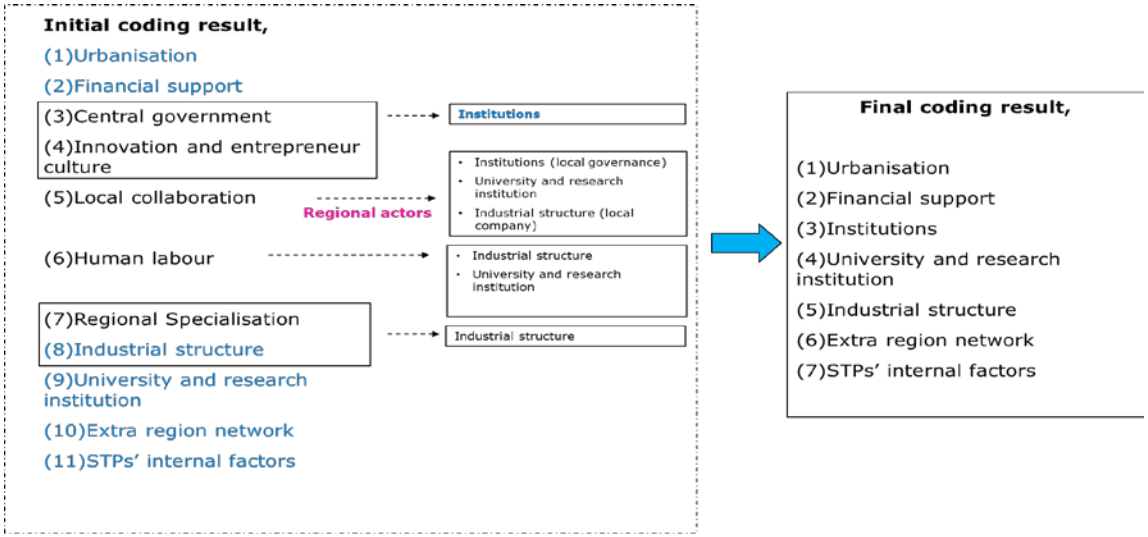


Figure 1: Framework for factors influencing STP performance based on literature review. Regional contextual factors (1-5), extra-regional connectivity (6) and STP's internal factors.

Appendix A: Coding process



Appendix B: Result table of literature review

The result table shows positive and negative connections bewteen regional contextual factors and STP performance. Last column list arrticles in the review that discuss the relevant topic.

Factors	Positive	Negative	Articles
University and research institutes	• Proximity nearby university has an impact on the success of STPs, it increases the growth of network (informal connection with academic staff and students) • Universities were mentioned as a resource for human capital • University policy should support innovation outcome e.g. encourage patent application and academic entrepreneur creation • Matching research interested between HEI and local industries leads to positive linkage and R&D collaboration	• Lack of integration between HEIs and property and facilities offered at technology parks resulting in weaknesses in getting ideas to market or patent to product. • Chance of knowledge transfer is low, if the level of research excellence is neglected. • University research needs to be integrated with local resources • University views entrepreneur as a low status. • Local universities cannot support qualified labour and scarcely provide the information about their research expertise	Albahari, Pérez-Canto, Barge-Gil, & Modrego, 2017 Appold, 2004 Bakouros, Mardas, & Varsakelis, 2002 Díez-Vial & Montoro-Sánchez, 2016 Etzkowitz & Zhou, 2018 Hansson et al., 2005 Hommen et al., 2006; M. C. Hu, 2011 Jongwanich, Kohpaiboon, & Yang, 2014 Jonsson, 2002 Kulke, 2008 Lee et al., 2017; Lin & Tzeng, 2009; Link & Scott, 2003; Löfsten & Lindelöf, 2003; Malairaja & Zawdie, 2008; Minguillo & Thelwall, 2015b, 2015a; Motohashi, 2013 Padilla-Meléndez et al., 2013 Phelps & Dawood, 2014 Pilar Latorre, Hermoso, & Rubio, 2017 Ricardo Martínez-Cañas, 2011 Romijn & Albu, 2002 Shin, 2000; T. S. Hu, Lin, & Chang, 2005 Watkins-Mathys & Foster, 2006 M. Yan, Chien, Hong, & Yang, 2018 Yun & Lee, 2013 Zou & Zhao, 2013;

Factors	Positive	Negative	Articles
Industrial Structure	• Strong industrial clustering mechanism can improve innovation outcome and strengthen knowledge network • High degree of specialisation relates to the efficiencies of providing resources to tenant firms and could attract firms in the specific specialised field. • Strong cluster creates a favourable innovation ecosystem by providing a sufficient specialised labour pool.	• Scattered industrial structure leads to a lack of core technology and R&D development focus. • Regions with poor industrial focus often also have unfocused and scattered university research competence. • Too narrow technological focus of STP eliminates potential tenants from other regions' industrial sectors.	Appold, 2004 Etzkowitz & Zhou, 2018 Guadix, Carrillo-Castrillo, Onieva, & Navascués, 2016 Hansson, Husted, & Vestergaard, 2005 Hommen et al., 2006 Hu, 2008; M. C. Hu, 2011 Huang & Fernández-Maldonado, 2016 Jenkins & Leicht, 2018 Jonsson, 2002 Ku, Liau, & Hsing, 2005 Kulke, 2008 Lee et al., 2017 McCarthy, Silvestre, von Nordenflycht, & Breznitz, 2018 Miao & Hall, 2014 Minguillo & Thelwall, 2015a Minguillo, Tijssen, & Thelwall, 2015 Mukkala, 2010b Padilla-Meléndez, Del Aguila-Obra, & Lockett, 2013 Phelps & Dawood, 2014 Romijn & Albu, 2002 Shearmur & Doloreux, 2000; Staudt, Bock, & Muhlemeyer, 1994 ; Salvador & Rolfo, 2011 Tamásy, 2007 Tsai & Chang, 2016 T. S. Hu, Lin, & Chang, 2005 Vásquez-Urriago, Barge-Gil, Rico, & Paraskevopoulou, 2014 M.-R. Yan & Chien, 2013 Yang et al., 2009 ; Yun & Lee, 2013 Zeng et al., 2010 ; Zou & Zhao, 2013

Factors	Positive	Negative	Articles
Institutional • Innovation culture and norm	• A strong entrepreneurial culture is favourable for innovation performance of STPs and generates informal networks that lead to knowledge exchange and/or labour mobility	• Weak innovation culture is related to the lack of trust and interaction between various components in the innovation system and hence leads to poor STP performance.	Edgington, 2008 Hu, 2008 Lee, Lin, & Hsi, 2017 Miao & Hall, 2014 Zeng, Xie, & Tam, 2010 Zou & Zhao, 2013
Institutional • Multiscalar STI policy and Integration and adjustment of STI to regional context	• Strong national STI policy support science Parks e.g. cluster promotion, triple helix collaboration, infrastructure, technical service and incentive R&D can influence the positive STPs' performance. • Bottom-up policy approach and active engagement by local government especially in the development phase of the park is highly mentioned for positive STPs' outcome	• Government bureaucracy and unstable political situation, the latter leading to discontinuity in policy • Lack of input from local resources, lack of local integration • Policy flaws o No protection for intellectual property rights o Mismatch policy between central government and local universities o Overemphasis on the infrastructure by ignoring the entrepreneur process o Lack of innovation in quality control	Albahari, Catalano, & Landoni, 2013 Benneworth & Ratinho, 2014 Biswas, 2004 Brooker, 2013 Cheng, van Oort, Geertman, & Hooimeijer, 2014 Edgington, 2008 Gkypali, Kokkinos, Bouras, & Tsekouras, 2016 Hommen, Doloreux, & Larsson, 2006 Huang & Fernández-Maldonado, 2016 Jenkins & Leicht, 2018 Kennedy, 2007 H.-Y. Kim & Jung, 2010 H. Kim, Lee, & Hwang, 2014 Lee et al., 2017 Lin & Tzeng, 2009 Malairaja & Zawdie, 2008 Miao & Hall, 2014 Mukkala, 2010b Phelps & Dawood, 2014 Shin, 2000; Tsai & Chang, 2016 Xiao & North, 2018 Yan & Chien, 2013 Yang et al., 2009 Zou & Zhao, 2013

Factors	Positive	Negative	Articles
Financial support	• Access to funding influences the innovation outcomes of STPs.	• Newer and smaller firms find it difficult to obtain financial support and the lack of financial aid can hamper technological commercialisation.	McAdam & McAdam, 2008 Mukkala, 2010b Löfsten & Lindelöf, 2003 Salvador & Rolfo, 2011 Watkins-Mathys & Foster, 2006 Xiao & North, 2018
Urbanisation	• Developed urbanised regions are characterised by higher degrees of investments, human labour accumulation and increase networking opportunity.	• Economically peripheral regions struggle to attract qualified human labour, financial support. • High urbanisation levels have consequences for high population density, congestions and insufficient space for company expansion.	Shearmur & Doloreux, 2000 Edgington, 2008 Phelps & Dawood, 2014 Shin, 2000 Watkins-Mathys & Foster, 2006

Additional factors			
Factors	**Positive**	**Negative**	**Articles**
Extra-regional connections	• Firms that have connections outside a region have greater opportunities in conducting research, new knowledge creation, human labour development and wider market distribution.	• Lack of outside regional connection means lack of market opportunity and may lead to decline of start-up firms • Lack of access to resources to upgrade cutting-edge knowledge	Edgington, 2008 Jonsson, 2002 Koh, Koh, & Tschang, 2005 Ku et al., 2005 Löfsten & Lindelöf, 2003 Milius, 2008 Park & Hu, 2011 Watkins-Mathys & Foster, 2006 Yang et al., 2009 Yun & Lee, 2013
Internal factors	• Park infrastructure and services that provide what firms require • Park management should have the ability to link industry and university, also other regional and national organisations that could support innovation	• Lack of management experience and not being familiar with small firms in local area. • Outdated infrastructure and inefficient administration system	Albahari et al., 2013 Bakouros et al., 2002 Lee et al., 2017 Malairaja & Zawdie, 2008 Milius, 2008 Minguillo & Thelwall, 2015b Phelps & Dawood, 2014 Staudt, Bock, & Muhlemeyer, 1994 Tamásy, 2007 Watkins-Mathys & Foster, 2006 Zou & Zhao, 2013

References

Albahari, A., Catalano, G., & Landoni, P. (2013). Evaluation of national science park systems: a theoretical framework and its application to the Italian and Spanish systems. *Technology Analysis and Strategic Management*, *25*(5), 599–614. https://doi.org/10.1080/09537325.2013.785508

Bakouros, Y. L., Mardas, D. C., & Varsakelis, N. C. (2002). *Science park , a high tech fantasy ?: an analysis of the science parks of Greece*. *22*, 123–128.

Benneworth, P., & Ratinho, T. (2014). Reframing the role of knowledge parks and science cities in knowledge-based urban development. *Environment and Planning C: Government and Policy*, *32*(5), 784–808. https://doi.org/10.1068/c1266r

Biswas, R. R. (2004). Making a technopolis in Hyderabad, India: The role of government IT policy. *Technological Forecasting and Social Change*, *71*(8 SPEC. ISS.), 823–835. https://doi.org/10.1016/j.techfore.2004.01.009

Brooker, D. (2013). *From ' wannabe ' Silicon Valley to global back office ? Examining the socio-spatial consequences of technopole planning practices in Malaysia*. *54*(1), 1–14. https://doi.org/10.1111/apv.12001

Cheng, F., van Oort, F., Geertman, S., & Hooimeijer, P. (2014). Science Parks and the Co-location of High-tech Small- and Medium-sized Firms in China's Shenzhen. *Urban Studies*, *51*(5), 1073–1089. https://doi.org/10.1177/0042098013493020

Edgington, D. W. (2008). The Kyoto Research Park and Innovation in Japanese Cities. *Urban Geography*, *29*(5), 411–450. https://doi.org/10.2747/0272-3638.29.5.411

Gkypali, A., Kokkinos, V., Bouras, C., & Tsekouras, K. (2016). Science parks and regional innovation performance in fiscal austerity era: Less is more? *Small Business Economics*, *47*(2), 313–330. https://doi.org/10.1007/s11187-016-9717-x

Hommen, L., Doloreux, D., & Larsson, E. (2006). Emergence and growth of Mjärdevi Science Park in Linköping, Sweden. *European Planning Studies*, *14*(10), 1331–1361. https://doi.org/10.1080/09654310600852555

Hu, M. (2011). *Evolution of knowledge creation and diffusion : the revisit of Taiwan's Hsinchu Science Park*. 949–977. https://doi.org/10.1007/s11192-011-0427-5

Hu, T. S. (2008). Interaction among high-tech talent and its impact on innovation performance: A comparison of Taiwanese science parks at different stages of development. *European Planning Studies*, *16*(2), 163–187. https://doi.org/10.1080/09654310701814462

Hu, T. S., Lin, C. Y., & Chang, S. L. (2005). Technology-based regional development strategies and the emergence of technological communities: A case study of HSIP, Taiwan. *Technovation*, *25*(4), 367–380. https://doi.org/10.1016/j.technovation.2003.09.002

Huang, W. J., & Fernández-Maldonado, A. M. (2016). High-tech development and spatial planning: comparing the Netherlands and Taiwan from an institutional perspective. *European Planning Studies*, *24*(9), 1662–1683. https://doi.org/10.1080/09654313.2016.1187717

Jenkins, J. C., & Leicht, K. T. (2018). *Do High Technology Policies Work ? High Technology Industry Employment Growth in U . S . Metropolitan Areas , 1988-1998 Differing Views on Location-specific Technology Policies*. *85*(1), 1988–1998.

Jonsson, O. (2002). Innovation processes and proximity: The case of IDEON firms in Lund, Sweden. *European Planning Studies*, *10*(6), 705–722. https://doi.org/10.1080/0965431022000003771

Kennedy, L. (2007). Regional industrial policies driving peri-urban dynamics in Hyderabad, India. *Cities*, *24*(2), 95–109. https://doi.org/10.1016/j.cities.2006.06.001

Kim, H.-Y., & Jung, C. M. (2010). Does a Technology Incubator Work in the Regional Economy? Evidence from South Korea. *Journal of Urban Planning and Development*, *136*(3), 273–284. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000019

Kim, H., Lee, Y. S., & Hwang, H. R. (2014). Regionalization of planned S&T parks: The case of Daedeok S&T park in Daejeon, South Korea. *Environment and Planning C: Government and Policy*, *32*(5), 843–862. https://doi.org/10.1068/c1269r

Koh, F. C. C. C., Koh, W. T. H. H., & Tschang, F. T. (2005). An analytical framework for science parks and technology districts with an application to Singapore. *Journal of Business Venturing*, *20*(2), 217–239. https://doi.org/10.1016/j.jbusvent.2003.12.002

Ku, Y. L., Liau, S., & Hsing, W. (2005). *The high-tech milieu and innovation-oriented development*. *25*, 145–153. https://doi.org/10.1016/S0166-4972(03)00074-9

Lee, S. J., Lin, G. T. R., & Hsi, P. H. (2017). Industrial Cluster Development and its Contribution to Economic Growth in Taiwan - Hsinchu Science and Industrial Park (HSIP). *Journal of Scientific & Industrial Research*, *76*(5), 273–278.

Lin, C. L., & Tzeng, G. H. (2009). A value-created system of science (technology) park by using DEMATEL. *Expert Systems with Applications*, *36*(6), 9683–9697. https://doi.org/10.1016/j.eswa.2008.11.040

Löfsten, H., & Lindelöf, P. (2003). Determinants for an entrepreneurial milieu: Science Parks and business policy in growing firms. *Technovation*, *23*(1), 51–64. https://doi.org/10.1016/S0166-4972(01)00086-4

Malairaja, C., & Zawdie, G. (2008). Science parks and university-industry collaboration in Malaysia. *Technology Analysis and Strategic Management*, *20*(6), 727–739. https://doi.org/10.1080/09537320802426432

Miao, J. T., & Hall, P. (2014). Optical illusion? The growth and development of the optics valley of China. *Environment and Planning C: Government and Policy*, *32*(5), 863–879. https://doi.org/10.1068/c1270r

Milius, P. B. (2008). Ten Years In The System of Entrepreneurship Stimulation. *Inzinerine Ekonomika-Engineering Economics*, *4*(4), 42–45.

Minguillo, D., & Thelwall, M. (2015). Which are the best innovation support infrastructures for universities? Evidence from r&d output and commercial activities. *Scientometrics*, *102*(1), 1057–1081. https://doi.org/10.1007/s11192-014-1458-5

Mukkala, K. (2010). The role of regional policies in promoting networking and innovative activity: Evidence from small Finnish high-tech firms. *European Planning Studies*, *4313*. https://doi.org/10.1080/09654311003744175

Phelps, N. A., & Dawood, S. R. S. (2014). Untangling the spaces of high technology in Malaysia. *Environment and Planning C: Government and Policy*, *32*(5), 896–915. https://doi.org/10.1068/c1272r

Shin, D.-H. (2000). An alternative approach to developing science parks: A case study from Korea. *Regional Science*, *5*, 103–111. https://doi.org/10.5018/economics-ejournal.ja.2011-6.

Staudt, E., Bock, J., & Muhlemeyer, P. (1994). Technology Centers and Science Parks - Agents or Competence Centers for Small Businesses. *International Journal of Technology Management*, *9*(2), 196–212.

Tamásy, C. (2007). Rethinking technology-oriented business incubators: Developing a robust policy instrument for entrepreneurship, innovation, and regional development? *Growth and Change*, *38*(3), 460–473. https://doi.org/10.1111/j.1468-2257.2007.00379.x

Tsai, C.-L., & Chang, H.-C. (2016). Evaluation of critical factors for the regional innovation system within the HsinChu science-based park. *Kybernetes*, *45*(4), 699–716. https://doi.org/10.1108/K-02-2015-0059

Vásquez-Urriago, A. R., Barge-Gil, A., Rico, M. A., & Paraskevopoulou, E. (2014). *The impact of science and technology parks on firms ' product innovation : empirical evidence from Spain*. 835–873. https://doi.org/10.1007/s00191-013-0337-1

Watkins-Mathys, L., & Foster, M. J. (2006). Entrepreneurship: The missing ingredient in China's STIPs? *Entrepreneurship and Regional Development*, *18*(3), 249–274. https://doi.org/10.1080/08985620600593161

Xiao, L., & North, D. (2018). The role of Technological Business Incubators in supporting business innovation in China: a case of regional adaptability? *Entrepreneurship and Regional Development*, *30*(1–2), 29–57. https://doi.org/10.1080/08985626.2017.1364789

Yan, M.-R., & Chien, K.-M. (2013). Evaluating the Economic Performance of High-Technology Industry and Energy Efficiency: A Case Study of Science Parks in Taiwan. *Energies*, *6*(2), 973–987. https://doi.org/10.3390/en6020973

Yan, M., Chien, K., Hong, L., & Yang, T. (2018). *Evaluating the Collaborative Ecosystem for an Innovation-Driven Economy : A Systems Analysis and Case Study of Science Parks*. https://doi.org/10.3390/su10030887

Yang, D. Y.-R., Hsu, J.-Y., & Ching, C.-H. (2009). Revisiting the silicon Island? The geographically varied "Strategic Coupling" in the development of high-technology parks in Taiwan. *Regional Studies*, *43*(3), 369–384. https://doi.org/10.1080/00343400902777067

Yun, S., & Lee, J. (2013). An innovation network analysis of science clusters in South Korea and Taiwan. *Asian Journal of Technology Innovation*, *21*(2), 277–289. https://doi.org/10.1080/19761597.2013.866310

Zeng, S., Xie, X., & Tam, C. (2010). Evaluating innovation capabilities for science parks: A system model. *Technological and Economic Development of Economy*, *16*(3), 397–413. https://doi.org/10.3846/tede.2010.25

Zou, Y., & Zhao, W. (2013). Anatomy of Tsinghua University science park in China: Institutional evolution and assessment. *Journal of Technology Transfer*, *39*(5), 663–674. https://doi.org/10.1007/s10961-013-9314-y