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How regional factors influence the performance of science and technology parks: A comparative analysis of regional science parks in Thailand

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Recent research on science and technology parks (STPs) has called for including regional contextual factors in studies of STP performance. However, no study has yet systematically assessed how regional contextual factors support or hinder STP performance. We apply a systematic framework to a comparative case study of three regional STPs in Thailand and analyse the effects of varying conditions along five dimensions: urbanisation, industrial structure, regional institutions and culture, university and research institutes, and financial resources in relation to the performance of each STP. The three Thai regions are similar in both size and levels of urbanisation and are governed by the same national programme for STP development, which provide a good methodological set-up for analysing the effects of varying regional contexts. Findings reveal that positive STP development is grounded in the presence of an innovative culture in regions driven by an active collaboration among local actors. Moreover, despite STPs being located in the same national innovation system, different regional contextual factors result in different levels of STP performance. A holistic understanding of these regional connections can help improve designs of STPs, and other supportive policies that are important for regional innovation development.

Keywords: Science and technology parks; regional context; regional innovation systems; developing countries; science, technology and innovation policy

Introduction

The inconsistency of science and technology parks' (STPs) economic contribution has led to a strong research focus on understanding both the factors and mechanisms favouring STP performance (Lecluyse, Knockaert, and Spithoven 2019). An increasing number of studies

argue that the performance of STPs relies both on STP-internal factors and the regional conditions where the STP is located (e.g. supportive infrastructure, local university, industrial systems, and their level of collaboration) (Castells and Hall 1994; Poonjan and Tanner 2020; Shin 2000). Nevertheless, regional conditions are often neglected in STP studies, especially in linking their strategy and evaluating their performance. This paper argues that one cannot explain differences in STP performance without first understanding the social and institutional context of the regional economy in which a specific STP is placed.

While the importance of context dependency has been evident in regional innovation policy studies, context-dependency has rarely been discussed and integrated in STP literature. Some scholars apply a qualitative, in-depth approach to understanding the connectedness between STPs and the regional context and how these linkages (or their absence) affect STP performance (e.g. Chen and Choi 2004; Edgington 2008; Kulke 2008). Nevertheless, these studies tend to be single-case studies following different methodological and theoretical approaches, making generalisation difficult. This difficulty likely results from the absence of an underlying methodological framework that would allow researchers to analyse STP performance in the context of a specific regional innovation system.

To overcome the particularities of single-case studies we apply a recently developed systematic framework (i.e. the regional innovation system-STP (RIS-STP) framework) (Poonjan & Tanner's 2020) to a comparative case study of STPs in three regions of Thailand: Songkhla, Chiangmai, and Khonkaen. We analyse the effects of varying regional conditions and the performance of the STPs.

The RIS-STP framework identifies five regional dimensions important for STP performance levels: the degree of urbanisation, industrial structure, regional institutions and culture, university and research institutes, and financial resources. The three Thai regions are similar in both size and levels of urbanisation and are governed by the same national

programme for STP development. This similarity provides a good methodological set-up for analysing the effects of varying regional contexts across regions where, on one hand, the structure and internal factors of each STP are similar and the national institutional settings are the same but, on the other hand, the regional factors (e.g. industrial structure and regional culture) differ.

The aim of this paper is twofold: i) to evaluate the usefulness of the RIS-STP framework for understanding differences in STP performance levels and ii) to provide an insight into specific regional contextual factors for the development of STPs in developing countries. We use the empirical findings to develop recommendations for policy-makers to use for strengthening the innovative capacity of the three provinces.

This paper proceeds as follows. The second section presents the RIS-STP framework and theoretical background for operationalising the five dimensions of the regional context. The third section outlines the methodological considerations and approaches. The fourth section describes the STP performance indicators, presents the comparative case study, and sets out its findings. The fifth section discusses the findings in a broader empirical and theoretical perspective. The sixth section concludes by summarising the paper's theoretical contribution and policy implications.

Regional contextual factors and STP performance

As this paper aims to insight into regional contextual factors' importance for STP performance, the theoretical under-pinning of such place-based approach is inspired by the regional innovation system (RIS) framework (Asheim, Smith, and Oughton 2011). The RIS framework is used for designing and assessing innovation policy at the regional level (Coenen et al. 2017). The RIS framework views innovation as a systemic process that involves various regional and non-regional actors (e.g. firms, university, intermediary organisations such as STPs, policy-makers and financial institutions) that interact with each

other. The variety of actors and their level of interaction vary across different types of regions (e.g. metropolitan region, lagging region, old industrial region and cross-border regions). The particular regional type corresponds with different levels of innovative capacity (Isaksen and Trippl 2016; Todtling and Trippl 2005). Consequently, policy interventions require a deep understanding of the regional context in order to provide the right response for regional specific problems.

Although the theoretical grounding of context dependency explicitly links to regional innovation policy interventions including STPs, there is still very little understanding of the effects of regional context on STP performance. A few researchers (Etzkowitz and Zhou 2018; Phelps and Dawood 2014; Tsamis 2009) have argued and empirically shown that the success or ineffectiveness of STPs is a result of the regional context. For example, many successful STP-cases are located in large, diverse metropolitan regions characterised by high levels of venture capital, competitive firms, strong research bases and actively engaged local stakeholders (Castells and Hall 1994; Comins and Rowe 2008). In contrast, more modest or ineffective STP-cases are often located in peripheral regions where the innovation actors are scattered, there is a lack of prominent research institutions and the presence of weak supportive institutions (Rodríguez-Pose and Hardy 2014; Tsamis 2009). Associated with this observation, we argue that there is a need to undertake a more comprehensive understanding of how regional context plays a role in STPs development (Poonjan and Tanner 2020). To this end, we use the RIS-STP framework as a systemic guideline to assess regional contextual factors and their influence on STPs performance.

The RIS-STP framework consists of five categories of regional factors: urbanisation, industrial structure, university and research institutes, institutions, and financial support, as

well as extra-regional linkages and park–internal factors (see Figure 1). The following section outlines our operationalisation of each factor in order to understand the relationship between the regional factors and STP performance as well as its empirical measurability.

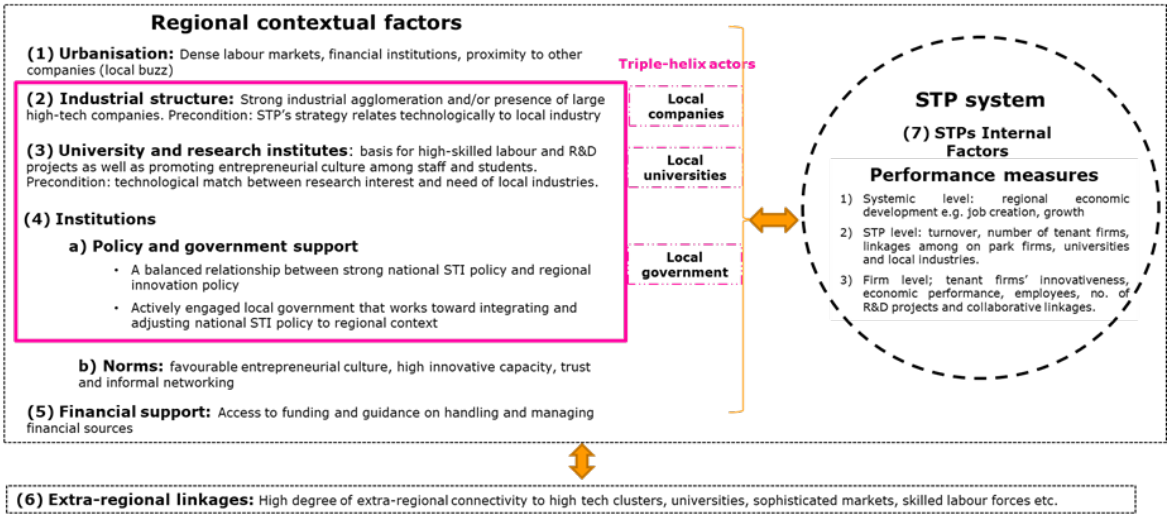

Figure 1. Framework for factors influencing STP performance: Regional contextual factors (1–5), extra-regional connectivity (6) and STP internal factors (7), adapted from Poonjan & Tanner (2020)

The first factor is **urbanisation**. Urbanisation is recognised as a fundamental factor that links to the innovation capacity in the region, since it is often reflected in the diversity of economic activities (Jacobs 1969), better venture capital support and proximity to supportive infrastructure and institutions (Shearmur 2012). Nevertheless, the degree of urbanisation is often neglected in STPs studies, although some studies suggest that successful cases are often located in urbanised areas, and more moderate cases are often found in less urbanised areas (Lecluyse, Knockaert, and Spithoven 2019). The degree of urbanisation can be understood through the measure of population density, supportive infrastructure (McGranahan and Satterthwaite 2014), the ratio of employment in high-tech jobs (Shearmur and Doloreux 2000) and/or in the agricultural sector (Hofmann and Wan 2013).

The second factor is regional **industrial structure**. In relation to STP development, the industrial structure refers to the existing local knowledge base that links to regional economic activities. STPs tend to perform well in regions with strong industrial agglomeration or large high-tech firms, especially if the STP strategy relates to local industries (Hommen, Doloreux, and Larsson 2006; Yun and Lee 2013). Moreover, the type of local industry is also associated with STP performance (in the form of number of spin-off firms and patents). For example, an intensive knowledge-based industry such as the biomedical industry might have higher numbers of spin-off firms than a service-based sector (Salvador and Rolfo 2011). Another important aspect is the collaboration patterns among local firms. High levels of collaboration encourage the flow of knowledge and skilled human labour, which positively influence STP performance (Saxenian 1996). Altogether, the industrial structure is broadly characterised by the dominant local industry (e.g. number and size of local firms and the presence of major local firms) and by collaboration patterns between a local firm. Such industrial dynamics can be captured through company and employments statistics as well as interviews.

The third factor is the **presence and quality of local universities and research institutes.** Literature has shown that well-performing STPs are associated with local universities that have high academic quality and provide cognitively matching research activities and skilled human labour with local industrial needs (Malairaja and Zawdie 2008; Minguillo, Tijssen, and Thelwall 2015). In addition, the attitude of university innovation culture (e.g. supporting university-industry collaboration and encouraging students to spin off their research) directly links to high STP performance (Etzkowitz and Zhou 2018; Hansson, Husted, and Vestergaard 2005; Zou and Zhao 2013). Universities' scientific performance can be obtained by bibliometric indicators, for example, the one provided by Leiden ranking (Leiden University 2019). The extent to which cognitive knowledge matching between the university and local firms, university innovation as well as university

entrepreneurial and innovation cultured mindset (e.g. provide student entrepreneur course and encourage internal and external collaboration) can be gleaned through interviews.

The fourth factor is the **institutions**, which is classified in three sub-groups: the multi-scalar science, technology and innovation (STI) policy; the adjustment and integration of STI policy to the local context; and the innovation and entrepreneurial culture in the region.

The first subgroup is the multi-scalar STI policy. As operating at the regional level under the broad national framework, well-performing STPs are often associated with coherent policy between the national and subnational level (Albahari, Catalano, and Landoni 2013; Edgington 2008), despite the nation having a centralised or decentralised approach (Huang and Fernández-Maldonado 2016). On this issue, the multi-scalar STI policy is represented by the quality of governance as well as adequate and coherent policy support between the national and subnational level.

The second sub-group is how well the STI policy is adjusted and integrated into the regional context. In relation to STP development, a strong commitment and active local government concerning innovation support, and a great match between national STI policy and local problems, often reflect in a good STP performance (Kim, Lee, and Hwang 2014; Shin 2000). In this respect, this subgroup is represented by the level of local government engagement and the matching between policy support and local issues.

The third sub-group of the institutional factors is the innovation and entrepreneurial culture. The majority of relevant STP literature points toward the importance of trust and interactive collaboration among local actors as a fundamental element of innovation processes (Edgington 2008; Hu 2008; Zou and Zhao 2013). In this regard, the measurement of the cultural dimension can be characterised by local business mindset, the awareness of adopting STI into the business, and the level of local collaboration.

The last factor included in the RIS-STP framework is the **financial support**, which is defined as access to financial capital and guidance on how to access funding and capital. The literature points out that the opportunity to access venture capital is more extensive in metropolitan regions (Watkins-Mathys and Foster 2006). In contrast, in less-developed regions (also in the case of developing countries: Wonglimpiyarat, 2011), the primary financial support is from government and extra-regional funding (Xiao and North 2018). The availability of regional financial support can be identified by a number of financial aid resources related to innovation activities, e.g. financial aid programmes provided by financial institutions, funding support from both public and private organisations, the availability of venture capital firms, angel groups and financial aid information.

Above, we have presented an analytical framework to assess the regional context of STPs in order to explain how these conditions influence STP performance. Another point to discuss is the operationalisation of STP performance. Research suggests that STP performance can be assessed at different levels (e.g. at the STP level and regional level) by different indicators (e.g. number of patents and number of job creation), and importantly under different conditions (e.g. their stage of development and different regional characteristics) (Lecluyse, Knockaert, and Spithoven 2019; Poonjan and Tanner 2020). However, as our aim is to compare three STPs to explore the influence of regional context on STP performance, we use economic and employment impact of the STPs as available in existing government reports.

Whilst, we ground the arguments on the importance of regional context in affecting STP performance, we do not neglect the importance of STP extra-regional linkages and STPs' internal factors as both factors can have an impact to STP performance. However, in this study, we focus on exploring the linkage between context dependency and STP performance, because regional characteristics in innovation performance tend to be prominent and persistent (McCann and Ortega-Argilés 2013; Todtling and Trippl 2005).

Thus, the discussion of STP extra-regional linkages and STPs' internal factors are not included in the scope of this paper.

Research method

We use a multiple case study approach as an empirical comparison among the regional innovation systems (Edquist 2011). Our level of regional context analysis is at the provincial level (below Thai state and regions and above districts). There are 7 regions and 76 provinces in Thailand. We chose the provincial level for our regional analysis because these are the primary local government unit. In addition, the provincial level also provides the best available comparable statistics at the subnational level. However, due to lack of consistent measures for STP performance at the STP or provincial level, we rely on the RTI International (2019) report for comparable indicators. The RTI International report measures STP performance as the economic effect of STPs at the regional level comprising several provinces for each of the following regions: northern, north-eastern and southern. Although the RTI International report draws together the result of all parks in the regions (northern, north-eastern and southern region), this disadvantage is surmountable, because most of the regional STP performance contribution came from the main branches, since the main branches are the only parks in growth state who provide full services (see section Science Parks in Thailand for description of main STP-branches).

The empirical cases consist of three different science parks in three different provinces. The Prince of Songkla Science Park in Songkhla[1] province is our main case study, which has been examined in-depth with a greater number of interviews. Chiangmai Science Park in Chiangmai province and Khonkean Science Park in Khonkean province are supporting cases, and they have been reviewed in-depth with fewer interviews due to limited time and

[1] The name of the university is spelled "Songkla", whereas the province name is spelled "Songkhla".

resources. We used government reports, international reports, and business articles to provide data for the cases. Further, we undertook semi-structured interviews to gain the necessary understanding of how these regional contextual factors influence the development and performance of the STPs. We conducted face-to-face and phone interviews of key interviewees from Songkhla, Khonkaen and Chiangmai provinces during February to July 2019. All the key interviewees were assessed to be credible sources who have experience from working in the province and fulfil different roles in the science park system, such as science park director, manager and staff, university director and researcher, local entrepreneurs and provincial government. The interview questions were derived from the RIS-STP framework. We deductively coded the interview data by identifying relevant themes from the RIS-STP framework. A list of interviewees are shown in Table 1. The analysis focused on exploring how the regional contextual factors support or hamper STP performance.

Table 1. List of key interviewees in each province

Interviewees' position	Interview code and number of interviewees in Songkhla	Interview code and number of interviewees in Khonkaen	Interview code and number of interviewees in Chiangmai
Science park director and manager	**SPM-S1** **SPM-S2** **SPM-S3**	**SPM-K1** **SPM-K2**	SPM-C1[2]
Science park staff	**SPS-S1** **SPS-S2** **SPS-S3** **SPS-S4** **SPS-S5**	-	-
University director and researcher	**UNI-S1** **UNI-S2**	-	-
Local entrepreneurs	**ENT-S1** **ENT-S2**	-	**ENT-C1** ENT-C2[3]
Local provincial government and ministry - administration	**LOC-S1** **LOC-S2**	-	-
Science park start-up entrepreneur	**SP-ENT-S1** **SP-ENT-S2**	**SP-ENT-K1** **SP-ENT-K2**	**SP-ENT-C1**
Employee from local big firm	**FIRM-S1**	-	-
Total number of interviews	**17**	**4**	**8**
Data collection period and method	From February to July 2019	In July 2019 via phone	In July 2019 via phone

Findings

This section begins with the background development of STPs in Thailand and compares the performance of three different STPs. Then we describe each of the regional contextual

[2] Group interview
[3] Group interview

factors of the three provinces. These factors are guided by the RIS-STP framework, starting with urbanisation, then moving to industrial structure, university, institutions and financial support.

Science parks in Thailand

In 2004, the Thai government executed the plan for regional science park establishment with the aim of stimulating economic activity in peripheral areas by combining STI with local knowledge. At the beginning, there were just three science parks embedded in three major local universities in different parts of Thailand (north: Chiangmai university, northeast: Khonkaen university, and south: Prince of Songkla university). These parks provided only soft services to local firms by means of technological consultancy, training and collaboration. During 2007-2011, the plan to develop science parks was temporary terminated. In 2011, the plan was resumed together with a large budget for the parks to set up new infrastructure in order to provide full functional services and enhance the regional STI perception level (Irawati and Rutten 2013). Now, there are 16 science parks across the country, 14 of them are operated in three different regions, one of the parks is in Bangkok and one is in the set-up phase in the eastern region (Figure 2). The three formerly established science parks have become the main branches of other science parks in the region. The three main parks are in transition from a start-up state to a growth state (European Commission 2013), moving from university buildings to the new dedicated infrastructure that enables them to provide additional facilities such as rental space and laboratories. Our empirical study will draw on the three main branches of Thai science parks: Prince of Songkla, Chiangmai, and Khonkaen University science parks.

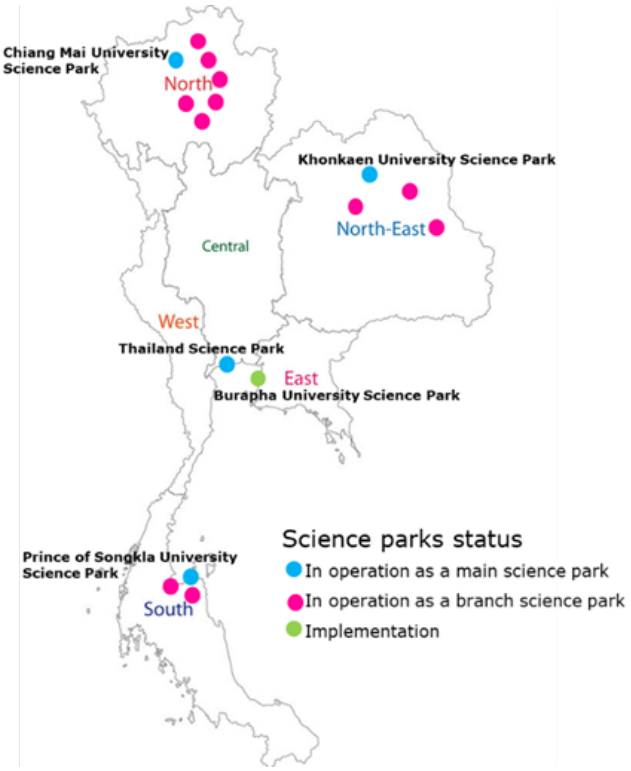

Figure 2. Science parks in Thailand, adapted from (Tridech 2016)

Performance of science parks in Thailand

We use the internal report of the long-term impact and operational guidelines of regional science parks commissioned by the Ministry of Science and Technology (RTI International 2019) as a source for STP performance measuring. The report presents the economic impact and job creation numbers initiated by STPs in three different regions from 2013-2017 (Figures 3 and 4).

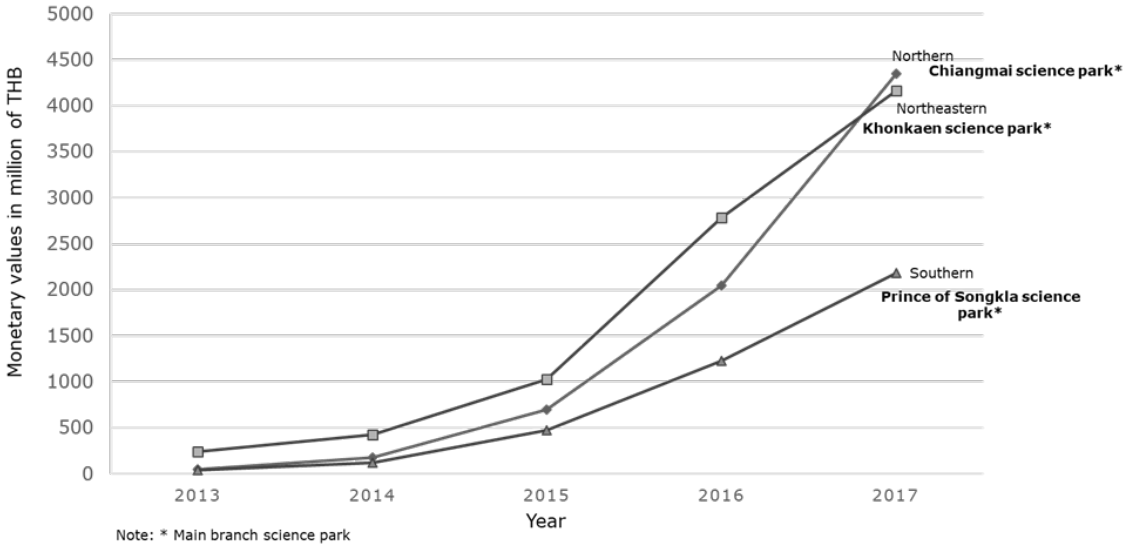

Figure 3. Economic impact of regional science parks in Thailand from 2013 to 2017. The chart was created by the authors using data from RTI International (2019).

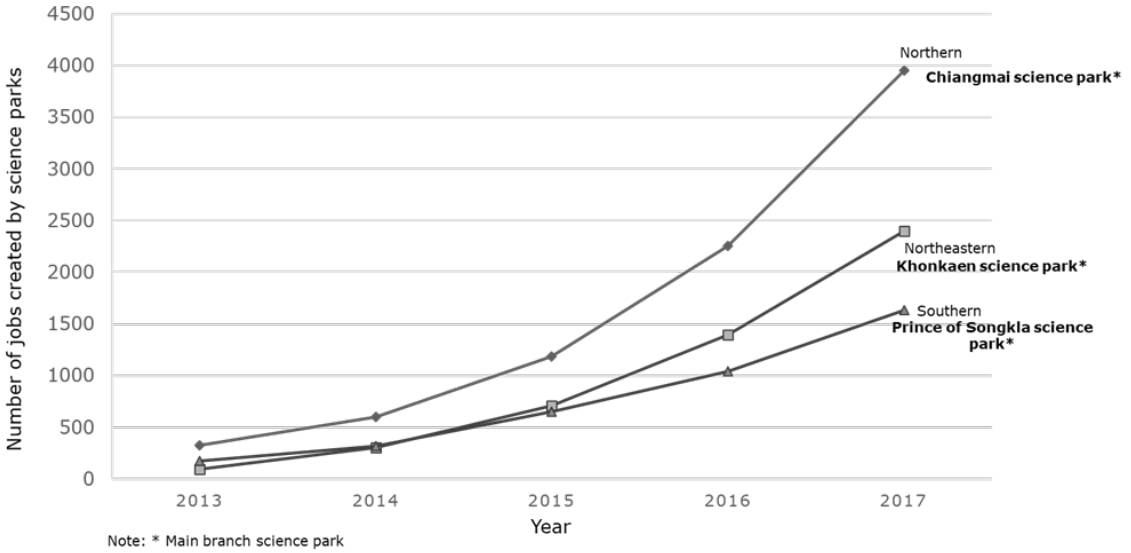

Figure 4. Employment impact of regional science parks in Thailand from 2013 to 2017. The chart was created by the authors using data from RTI International (2019).

As we see from the graphs, in 2013, the impact created by science parks was small, and it rose gradually until 2015. From 2015 onward, the trend dramatically increased. This was due to the expansion of park services. The northern science parks showed the best

performance, followed by the north-eastern and southern science parks. In consequence, these data indicate that the science park in Chiangmai performs the best, followed by Khonkaen and Prince of Songkla science parks, which is an interpretation that the majority of our interviews have confirmed. In the following section, we portray the regional context of each science park.

Regional contextual factors: Songkhla, Chiangmai and Khonkean

Urbanisation

Songkhla, Chiangmai and Khonkaen are the major secondary provinces in Thailand after Bangkok metropolitan area. These provinces' function as regional hubs for transportation, education and business (Bangkok Post 2020). Table 2 provides the basic socio-economic statistical data of the three provinces. The population figures show that Khonkean and Chiangmai are slightly larger than Songkhla, whereas Chiangmai is the largest province in terms of area. The large area of Chiangmai results in low numbers of total population density, while looking at the population density in urban areas Chiangmai city turns out to be the most densely populated area. The Chiangmai province also has the highest number of higher education institutions.

Moving into gross provincial product (GPP) data, Songkhla province has the highest GPP per capita, followed by Chiangmai and Khonkean. However, when comparing the ratio of labour force in the agricultural sector to their GPP contribution, Chiangmai has the lowest share of agricultural workers with the highest GPP contribution followed by Songkhla and Khonkean. Khonkaen has the highest GPP contribution from manufacturing sectors, while Chiangmai and Songkhla have relatively higher contribution shares from other sectors such as service sector (in Chiangmai) and oil and gas extraction (in Songkhla). Altogether, these data suggest that Chiangmai has slightly higher levels of urbanisation than the other two provinces.

Table 2. Basic socio-economic indicators of each province

Factor/Province	Songkhla	Chiangmai	Khonkaen
Population	1,417,440	1,735,672	1,801,753
Area (km2)	7,394	20,107	10,886
Population density (per km²)	192	86	160
Population density in urban area (per km2)	862	1,541	434
GPP per capita (THB)	153,505	126,976	107,607
Number of higher education institutions	5	7	2
The ratio of labour force in the agricultural sector to overall labour	33.30%	32.92%	47.30%
GPP from agricultural	13.46%	22.5%	11.00%
GPP from the manufacturing sector	19.35%	7.70%	36.60%
GPP from other sectors	67.18%	77.50%	52.40%
Dominant manufacturing sectors	Seafood, rubber and rubber wood	Plant-based and food processing	Non-metal, metal and food processing
Number of tourists (million)	5.5	7.7	2.9

Note: GPP = Gross provincial product

Source: (Chiangmai Provincial Statistical Office, 2017; Khonkaen Provincial Statistic Report, 2017; Songkhla Provincial Statistical Office, 2017; MOI Chiangmai, 2019; MOI Khonkean, 2019; MOI Songkhla, 2019;UniRank, 2020)

All data apart from number of higher education institutions and dominant manufacturing sectors are from the year 2016

The data on number of higher education institutions and dominant manufacturing sectors are from the year 2020

Nevertheless, each province has its own characteristics (Table 3) that may influence its economic activities and local innovation performance. Songkhla has the advantage of being the border province to Malaysia and was promoted as one of the Special Economic Zones (SEZ) targeted to stimulate trade and investment opportunities (The Board of Investment of Thailand 2017). Chiangmai is, on the other hand, characterised as being one of the most prominent tourist destinations in Thailand (Table 2) and is famous for its unique arts and crafts culture. Foreigners describe Chiangmai as one of the best places to stay because of the cheap cost of living, beautiful and relaxing atmosphere, several co-working spaces and a strong community of digital nomads (Hynes 2016). The combination of its appeal as a tourist destination and supportive infrastructure has attracted foreigners to stay in Chiangmai, which increases the cultural diversity in the province. Unlike the two

provinces, Khonkaen's special trait comes from the synergy among local actors, especially local businessmen (Khonkaen Think Thank Group, KKTT) who initiated the smart city project in 2013. The project reflects a better culture for collaboration, citizen participation approach that rarely occurs in Thailand (Smart Growth Thailand 2017; Taweesaengsakulthai et al. 2019). To sum up, all three provinces have a similar level of urbanisation, but their comparative advantages of location and local dynamic characteristics vary, making the three provinces useful for explaining how the local context can influence STP performance.

Table 3: Summary of regional contextual factors in each province

Factor/Province	**Songkhla**	**Chiangmai**	**Khonkaen**
Urbanisation			
Regional characteristic	Border region to Malaysia and special economic zone	Cultural diversity	Network-based, citizen participation
Industrial structure			
Specialised/diversified sectors	Specialised	Diversified	Diversified
Dominant sectors	Rubber, seafood processing and rubber wood products	Plant-based, food processing and tourism	Plant-based, food processing (e.g. sugar), and non-metal manufacturing (e.g. glass producing)
University			
Largest entity	Prince of Songkla University	Chiangmai University	Khonkaen University
Proportion of top 10% publications **(Leiden University 2019)**	4.30%	4.20%	4.80%
Proportion of collaborative publication with industry **(Leiden University 2019)**	2.70%	4.30%	3.20%
Cognitive matching between university research expertise and local industries	University research expertise broadly matched with local industries but linkages between academics and firms are weak.		
Innovation and entrepreneurial culture toward students and staff	Promoted entrepreneurial culture in students and slowly adopted innovation oriented for staffs management		
Institutions			
Multi-scalar policy balance	The top-down approach, government and policy instability, mismatch between innovation policy and problems at national and regional levels		
Integration and adjustment of STI to regional context	Rarely engage with local/provincial government	Actively engage with local/provincial government	Occasionally engage with local/provincial government
Norm and entrepreneurial culture	Low collaboration among local actors	Strong collaboration among local actors	Moderate collaboration among local actors
Financial Support			
The availability of financing in the province	Local banks provide loan programmes for start-up and SME businesses. Funds and grants for start-up, SMEs and university research activities mainly come from organisations outside the province.		

Industrial structure

Most of the economic activity in the three provinces is due to small and medium sized business (SMEs). The agricultural sector is still essential for the provincial areas in Thailand because it is a foundation for the other local industries, especially for food processing, in the form of raw materials and intermediate goods. Further, the number of labourers in the agricultural sector is noticeably high compared to their GPP contribution, especially in Khonkaen (Table 2).

The presence of firms shows that Songkhla is a specialised province in the rubber and seafood sector, unlike Chiangmai and Khonkaen, where the industrial structure is considerably more diverse. In Chiangmai, the major firms are in food processing, IT, tourism, textile, and furniture production. In Khonkaen, the major firms are in textiles, distilleries, sugar and paper production (MOI Chiangmai Province, 2019; MOI Khonkean Province, 2019; MOI Songkhla Province, 2019; Stafford, 2002; Startup Chaing Mai, 2019; Sudhipongpracha & Dahiya, 2019; Tsunekawa & Todo, 2019).

The problem of local firms lacking innovative capacity exists in all three provinces, but the problem seems to be larger in Songkhla where most of the interviewees expressed their concerns in this regard. Moreover, the collaboration among local firms seems to be limited in Songkhla. The rubber firm business owner illustrates this:

> ...there is lack of trust among firms, for example, among mid-stream raw producers and down-stream manufacturer firms. Firms don't want to share any knowledge because the rubber production formula are similar. Other firms might be able to replicate… (ENT-S2)

Further, the data from the Department of industrial works (n.d.) and interviews (SPM-S2, SPS-S3, SPS-S5,and LOC-S1) illustrates that firms in Songkhla are SMEs and

operate upstream or midstream in the value chain. They use low-level technology. The revenue is the biggest concern while the application of new technology is perceived as a complicated and unnecessary process. On the other hand, in Songkhla, the participants (ENT-S1, UNI-S2 and FIRM-S1) expressed that the downstream industries that apply advanced technology do not actively engage in knowledge sharing or technology transferring. In sum, Songkhla's industrial structure is less diverse compared to Chiangmai and Khonkaen. At the same time, the level of collaboration among firms in the Songkhla province is weak.

University

In a university-based science park model, the university possesses a major role in STP development. We assessed three STP host universities along three dimensions: university research quality, knowledge matching with local industries, and university innovation and entrepreneurial policy.

We used the Leiden ranking 2019 (Leiden University 2019) covering the period 2014-2017 to measure university research quality of top 10% journal publications and number of industrial collaboration publications (Table 3). The data indicate that the three universities have a similar research quality, although Chiangmai University has the highest numbers of publications published in collaboration with industry.

We asked the participants about their opinions on the university's cognitive matching with local industry. The majority of participants from all three provinces agreed that university research knowledge broadly matched the existing local sectors (15 out of 20 participants who answered this question). They (SPM-K1, SPS-S3, UNI-S1 and FIRM-S1) further suggested that the local firms do not require higher levels of technology; in this sense,

the university knowledge seems to be sufficient for firms' current capacity building. Nevertheless, most of the participants in Songkhla gave the impression that the level of collaboration between the university and firms is still limited. The arguments ranged from an insufficient number of researchers, lack of communication channels, to a critical attitude towards academic-industry collaboration. Several interviewees (i.e. SPM-S1, SPM-S3, ENT-S2 and UNI-S1) added that the university researchers and professors do not have business and entrepreneurial mindsets as described:

> University research expertise broadly matches with local industries but the communication mechanism with private firms are the problems. University researchers do not have business mind-set, they just want to do research while firms want an immediate solution. Further, university documentation processes are time consuming. (UNI-S1)

At the same time, the interviewees who disagree on the level of university cognitive matching with local industry argue that there is a need to better link university research and local demand. The interviewees ENT-S1 and SP-ENT-C1 noted that all three regions lack skilled labour in specific areas, such as design and programming. They further commented that there is no channel or platform to connect with the university. This argument is also in line with SPS-S2, SPS-S3 and UNI-S2, who expressed that many university–industry collaborations occurred by informal or alumni connections.

Finally, we assessed if the universities encourage innovation and entrepreneurial culture through their students and staff. In collaboration with the science park, the interviewees described that the three universities provide several platforms for student entrepreneurial activities. For example, the research to market project, which encourages students to use the research outcome and propose a market opportunity. Moreover, the interviewees (i.e. UNI-S1, SPM-K1 and SPM-C1) also indicated that in the past few years, there has been a shift in University evaluation process from traditional perspectives to an

innovative approach. For example, the university has an intention to address innovation related to the new measures by integrating private research collaboration and research commercialisation as one of the staff performance indicators.

In conclusion, the three universities have similar prospective in term of research quality, knowledge matching with local industries, and university innovation and entrepreneurial policy. At the same time, they also have common problems in linking between academics and firms.

Institutions

Multi-scalar policy and the integration and adjustment of STI to the regional context

Thailand has a centralised top-down approach. Thus, the three provinces share similar characteristics of policy and government support. Innovation policies was integrated as a part of Thailand's science and technology policy (STI) since 2001, yet the country still faces several challenges linking policy concepts into practice(Intarakumnerd and Chaminade 2011). The challenges come from the fragmentation of the innovation system, inefficient government bureaucracy, and government and policy instability (OECD 2013). Further, as argued by Chaminade, Intarakumnerd, and Sapprasert, (2012) systemic problems such as redundant policy structure and promoting innovation culture have rarely been mentioned in Thailand's STI policy approach.

The challenges of STI policy and government structure at the national level have affected STI policy adjustment at the provincial level twofold. First, the centralised top down approach limits local engagement and creates redundant functions among different organisations at the provincial level. This problem is rooted in Thailand‘s administrative structure. The provincial administrative structure is a dual system comprising two parallel government systems for the same geographical area: a provincial government is appointed and supervised by the central government and a local administrative government which

elected by local people. The terms ‘provincial’ and ‘local’ are frequently used in literature and reflect the two different administrative systems for the same geographical area. The provincial government agencies consist of several ministry organisations (e.g. Ministry of Interior, the Ministry of Agriculture and Cooperatives, the Ministry of Education, and the Ministry of Public Health) (Nagai, Funatsu, and Kagoya 2008). These organisations operate at the provincial level as branch offices of central ministries which sometimes create service redundancy and difficulty to collaborate among organisations (Nelson 2001). As expressed by an interviewee:

> Our system has a long vertical line; it slows the working process. At the provincial scale, each ministry organisation is independently busy with their own work that fits with the top-down orders. Thus, it is difficult to have horizontal collaboration at the provincial scale. I worked at the regional science ministry for many years; I have only just learnt in the last few years that the science park exists. (LOC-S1)

This comment indicates that the system poorly recognises the collaboration process at the provincial level.

Moreover, most of the interviewees from the three provinces suggested that the involvement of provincial and local governments could benefit science park development, as they are the best channels to reach local people and public organisations. However, several studies (Haque 2010; Nelson 2001; The world bank 2012) found that the dual system of appointed provincial government officials and elected local government representatives lacks effective mechanisms to coordinate works and functions. The local government which is elected by people in the province lacks autonomy both in making decision and accessing the financing and human resources (The world bank 2012; UNDP 2009). This problem is confirmed in the interviews (SPM-S1, SP-ENT-C1 and SPM-K1). The interviewees expressed that the local government has inadequate capacity in integrating STI development in their role. Practically, their main function concerns infrastructure development and

peoples' quality of life in general, and engaging in innovation activities is not their top priority. However, the level of local government engagement with STP activities vary across the three provinces and it seems to be weakest in Songkhla, where the interviewees (LOC-1, LOC-2 and SPM-S1) stated that collaboration between local and provincial governments has rarely occurred. In contrast, the Chiangmai and Khonkaen interviewees (SPM-C1 and SPM-K1) expressed that the collaboration with local and provincial governments is more common.

Second, the limitation of autonomy and challenges of STI policy at the national level addressing low levels of collaboration at province level results in policy mismatch between national government policy support and current issues in the provinces. This is best illustrated by the Songkhla rubber city project launched in 2016. The national government established the rubber city as a plan to leverage the rubber cluster from primarily a midstream towards a downstream dominated industry. However, the project has been criticised by the press as unpopular and suffering from a lack of interested investors (Bangkok Post 2018). This argument is confirmed by our interviews:

> The advertisement of the rubber city was really huge at the beginning, like a mega project. The ideal concept would benefit SMEs in the rubber industry. However, in reality the situation is totally different. The infrastructure provided and management process are disorganised. There are just 5-6 firms from the downstream rubber sector situated there, and some have already moved out. (SPS-S5)

This quote confirms that there is a mismatch between the policy support launched by the national government and the local needs at the provincial level, hence resulting in inefficient investment that is not meaningful to local development. In conclusion, the top-down approach, inefficient system at the national and provincial level has resulted in incoherent multi-scalar policy and restricted the integration and adjustment of STI to the regional context.

Norms

We observed regional innovation and entrepreneurial culture in the form of the local business mindset, the awareness of adopting STI into the business, and the level of local collaboration. The interviewees confirmed that all three provinces have a vibrant business environment in the sense that local people are familiar with doing business. However, most of the business activities are simple trade and/or have a low level of technology involved.

Moreover, interviews in all three provinces indicate that in the past few years, local people have increased their awareness of innovation. However, the situation is clearly different between Chiangmai and Songkhla. Interviewees from Chiangmai (ENT-C2) explained that the private sector and local people are very active in undertaking innovative activities and, together with the number of foreigners and people who move from big cities to live in Chiangmai, this has improved the local innovation ecosystem. Contrary the situation in Songkhla, where most of the interviewees expressed concern that local people still lack innovation awareness:

> On a scale of one to ten, our provincial innovation culture scores five... (SPM-S2)
> Local entrepreneurs have been aware of innovation/technology for a while but they don't know where to start. (SP-ENT-K2)

The local awareness and understanding of innovation reflect the dynamic and collaboration mechanism between local actors. In Songkhla, collaboration among local actors is limited by the lack of trust, especially among firms. Most of the interviewees noted that local firms exhibit a less innovative mindset of owning the business and technology rather than collaborating. ENT-S2 illustrated that firms see each other as competitors. Even though the province has many firms in the dominant sectors of rubber and seafood, there has been scarce to no collaboration among local firms.

On the other hand, all of the interviewees in Chiangmai expressed positive opinions

on the level of collaboration in their province. SPM-C1 described that the culture for collaboration was inherited from family-owned businesses that had built long-term relationships and networks, which younger generations of managers and staffs benefitted from. Level of collaboration had even better conditions now due to communication technology. All interviewees agreed that Chiangmai has strong and active local communities. SPM-C1 further highlighted that the vibrant collaboration in the Chiangmai province has made the support from the government more meaningful. All-in-all, a high level of collaboration and trust among local actors in Chiangmai has encouraged the ease of doing business and knowledge spreading, in contrast to the low level of collaboration and trust among local actors in Songkhla.

The availability of financing

The interviews revealed that the availability of financing in the three provinces mainly comes from two sources. First, local banks provide loan programs for start-ups and SMEs. Second, organisations - both public and private - provide funding and grants for start-ups, SMEs, and university research activities.

The encouragement of government innovation policy has recently prompted financial institutions and investment firms to become more active in investing in start-ups and technology-based companies. Yet, access to capital is a common challenge in all three regions. Entrepreneurs (SP-ENT-S2, SP-ENT-K1, 2 and SP-ENT-C1) highlighted that at the outset they used self-financing and/or borrowing from their family due to the complicated regulations of banks and the difficulty in obtaining financial support at the early stage. Besides, most of the funding for new firm formation targets high-performing start-up firms, of which only a few exist. Furthermore, interviewees from local firms and public officers agreed that the funding support from the government is inconsistent due to the fiscal year budget and slow processes, which hinder long-term finances. In general, the financial

situations of all three provinces are similar. They all share the problems in accessing capital.

Discussion

In this section, we discuss the findings on how regional factors influence the performance of science and technology parks. The comparative analysis has shown that all three provinces are challenged in terms of incoherent multi-scalar STI policy, lack of university industry collaboration and lack of capital and funding support. At the same time, we found that the three provinces differ on other factors, such as industrial structure and levels of trust and collaboration, which hence create different regional starting points for the STP activities.

The findings corroborate previous research on innovation system dynamics in Thailand (Chaminade, Intarakumnerd, and Sapprasert 2012; Schiller 2006). For example, Chaminade et al. (2012) identify several innovation system failures, which hinder innovation capacity building at a national level. The innovation system failures count network; capability; institutional; and infrastructural failures, which in turn require different types of policy responses (Klein Woolthuis, Lankhuizen, and Gilsing 2005; Smith 2000). Our study supports that these system failures at the national level also hinder innovation capacity building at the regional level, and thereby STP performance as a whole. Moreover, our analysis also shows how some of these system failures manifest differently across the three regions and in consequence require STI policy that is adapted or at least adjusted to fit the specific regional conditions. In the following, we discuss these findings.

To exemplify regional differences, network and capability failures seem to be larger in Songkhla province than in the other provinces. Especially in terms of industrial structure and norms, Songkhla's industrial structure is less diverse and firms have a lower level of innovative capacity than in Chiangmai and Khonkaen. The latter leads to capability problems being more severe for Songkhla province with low-tech firms upstream and

midstream in the value chain.

On network failures, the level of collaboration and trust among local actors in Songkhla is fairly low compared to the active local collaboration levels in Chiangmai. This lower network capacity of regional actors in Songkhla may have resulted in lower STP performance level. Our findings on varying levels of collaboration confirm the importance of a strong collaboration culture as a solid starting point for innovation creation (Trippl and Toedtling 2008). Even though Songkhla benefits from being a border region and from a supportive national policy aimed at the specialised rubber sectors, insufficient collaboration among local actors has limited the opportunities for knowledge flow and innovation creation and may therefore be the reason behind lower STP performance. One of the reasons may be that Songkhla's industrial structure is dominated by large foreign rubber companies with little incentive or need to collaborate with local firms or universities.

The findings reflect that despite being located in the same national innovation system, different regional contextual factors result in different levels of regional innovation system outputs and thus STP performance levels. This also stresses the importance of understanding the specific industry structure and dynamics in a given region, in order to discover possibilities for improving networking and knowledge sharing, which is the key aim of STPs. On this matter, our study corroborates that best practices often emerge in favourable entrepreneurial and innovation culture that supports local collaboration for learning and knowledge creation (Edgington 2008; Hommen, Doloreux, and Larsson 2006; Hu, Lin, and Chang 2005). These findings suggest that despite the similar context of national institutions, STP strategies across the country need to be articulated to fit with regional specificity. In regions with low levels of local collaboration, the focus should be on capability-building of concerned actors and strengthening networks among actors to enhance knowledge flows and encourage favourable collaboration practices (e.g. facilitating

access to partners with complementary assets). The question is if STP is the best policy response to network and capability failure in all regions and at least whether STP can stand alone in addressing these issues.

On the other hand, some problems seem to be similar to all three provinces, for example discontinuous financial support, incoherency in policy at the national and provincial level, and infrastructural problems, such as low levels of university-industry collaboration. Whereas the discontinuous financial support is indisputable a disadvantage for building innovative capacity, the importance of low levels of university-industry collaboration in developing countries has in the IS literature been questioned (Chaminade, Intarakumnerd, and Sapprasert 2012). It has been argued, that low levels of university-industry collaboration may not be a huge problem in developing countries because the industry is better characterised as traditional than science-based. In continuation hereof, our study also confirms that the role of universities still differs from the Western experience and that in some regions STPs may not be the most suitable policy instrument due to the institutional context of developing countries (Schiller, 2006). Since the key task of STPs is to improve the knowledge linkages between university and industry and because the need for university-industry collaboration may be lower due to a different industrial composition than in developed countries it may seem paradoxical that STP continuously is a highly prominent and STI policy instrument in Thailand. Instead, policies may aim more on strengthening other types of knowledge infrastructure at the regional level. For example, by utilising and boosting existing informal channels of knowledge sharing between university and industry (Schiller, 2006) and by improving the knowledge base of regions through increasing the quality and quantity of traditional university outputs such as number of graduates, publications and research projects fitting the regional needs.

Conclusion

This study set out with the dual aims of evaluating the usefulness of the RIS-STP framework in understanding differences in STP performance levels and providing an insight into specific regional contextual factors for the development of STPs in Thailand.

The theoretical contribution of this paper relates to how STP performance is influenced by regional contextual factors. We contribute to an emerging literature that calls for a better understanding of the effects of regional context on STP performance. By applying a systematic framework, this study expands the explanatory framework for understanding STP performance and confirms that despite being located in the same national innovation system, different regional contextual factors result in different levels of regional innovation system outputs and thus STP performance levels. While the importance of context dependency has been evident in regional innovation policy studies for a long time (e.g. Asheim, Smith, and Oughton 2011; Grillitsch and Asheim 2018; Isaksen and Trippl 2016; Todtling and Trippl 2005) regional conditions for STP performance has rarely been discussed and integrated in STP literature. In particular, the RIS-STP framework (Poonjan and Tanner, 2020) provides researchers with an underlying methodological framework that is comprehensive and systematic in assessing the mutual interplay between STP performance capacities and specific regional innovation systems. In consequence, this perspective support the idea that one cannot understand STP performance levels disconnected form the regional context.

We have also shown that the RIS-STP framework can provide a better understanding of specific STP development, for example in the case of the three Thai provinces as shown in this paper. Thus, the framework can also be used as a guideline assessment tool to design and adjust the STP strategy as well as other supportive innovation policies that fit the regional innovation situation.

In this particular case, the empirical findings show that despite a strong top-down, centralised approach, the three different provinces in Thailand configure different types of regional innovation systems and, thus, represent different levels of STP performance. However, in the Thai case, the national level plays an important role in improving regional innovation system capacity. Therefore, we draw two major policy implications for Thai government based on our findings.

First, STP's design and strategies should be carefully planned in response to regional specific problems. As seen in this study, understanding regional industrial structures are important, not only for providing the right technological knowledge input but also for addressing any potential network failures with the best type of policy instruments.

Second, there is a need to reduce the inconsistency in policy at national and provincial level in order to better meet the local demand for STI policy. It will be beneficial if the policy is formulated to give administrative autonomy locally to stimulate horizontal integration of local actors in addressing innovation system failures. Where innovation system failures are the same in the national and regional innovation system there is a need to tackle more systemic innovation issues at the national level, however, this does not diminish the need for greater decentralisation and reform of the bureaucracy allowing regional authorities to respond to regional needs more efficiently; actively promoting university-industry collaboration and providing sustainable financial support (Intarakumnerd, Chairatana, and Tangchitpiboon 2002; Intarakumnerd and Chaminade 2011b; World Bank Group 2018).

This paper is limited in the insufficiency of available data that would have permitted a deeper quantitative investigation of the issue. Future research can take note of this problem and examine more in depth the character of different types of innovation system failures

across regions where STPs are prioritised as an instrument to solve the specific failure. Moreover, the main focus of this paper has been on regional contextual factors for STP performance and an obvious next step would be to integrate extra-regional linkages and STPs' internal factors into a deeper understanding of STP dynamics. Further work on the internal management of STPs and their extra-regional linkages would most likely improve the conceptual model in designing and implementing STPs.

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