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The Role of Policy-Making towards Science Technology Parks and the Expected Impact in National Economies: An Illustrative Real-World Comparative Case Study and a System Dynamics Methodology

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Abstract

Nowadays, the globalised geopolitical landscape along with the continuous technological advancements and the turbulent business global environment highlight major challenges and emerging growth opportunities for enterprises hence rendering them more competitive and flexible towards change. Therefore, in order for corporations, especially in the Mediterranean region, to become financially viable and to expand within the concurrent economic recession period, they have to focus on innovative technologies and intensive knowledge sharing and management. This can be achieved through developing sound cooperations and synergies among enterprises, research institutions and societal stakeholders to foster research and development, diffusion of innovations and licensing. To that end, the concept of Science Technology Parks (STPs) has emerged. Science Parks provide a unique environment for accelerating technological innovation, nurturing new star-up firms, attracting investments and generating economic and social growth. Therefore, the need to dedicate funding schema towards STPs is critical.

During the last decade, the European Union (EU) supports a Cohesion Policy via the Community Structural Funds to promote the harmonious development of the EU, with a significant share of the aforesaid funds to be administered towards regional STPs. However, the existing body of literature is lacking of studies examining the funding schema of Science Parks, while benchmarking the STPs impact. Therefore, the aim of this study is to comparatively study the role and the exploitation of the EU Structural Funds towards the development of STPs in a national setting. Specifically, we first highlight the role of STPs within a national economic and social context, and we further present direct and indirect implications of STPs to Spanish and Greek economies, two countries that resemble in a number of socio-economic characteristics and which encountered similar economic challenges during the recent financial downturn period. Secondly, we briefly present the impact of inteventionary policies through elaborating the System Dynamics (SD) methodology, an approach that has been extensively used in the past to understand the behaviour of complex systems over time. We envisage that our research could assist public authorities and regulators towards the realization of the critical role of STPs at a national level and motivate additional research on the field.

Keywords: *Science Technology Parks, Policy-Making, System Dynamics, Innovation, Structural Funds.*

1. Introduction

Silicon Valley in California and Route 128 in Massachusetts are renowned regional concentrations of innovative firms that offer great paradigms of entrepreneurial success stories (Castells and Hall, 1994; Hu, 2007), particularly for spurring regional economic growth in terms of job and wealth generation, knowledge agglomeration and radical technological advancements' creation (Boschma and Frenken, 2011; Ratinho and Henriques, 2010). To that end, such prominent innovation clusters have fuelled policies and global incentives towards the formation of high-end Science and Technology Parks (STPs) to foster the creation of an entrepreneurial and innovative culture that promotes synergies and knowledge spillovers among enterprises, social stakeholders and academic institutions (Hansson, Husted and Vestergaard, 2005; Löfsten and Lindelöf, 2002; Saxenian, 1996). The aforesaid successful linkages are documented to promote the development of new firms and the commercialization of innovative services and applications (IASP, 2002; UKSPA, 2006). Today, indicative examples of STPs with worldwide appeal include the Sophia-Antipolis in France (Isaak, 2009), the Cambridge science district in the United Kingdom (Koh, Koh and Tschang, 2005), the Research Park Triangle in North Carolina (Link and Scott, 2003), the St. Petersburg Technology Park in Russia (Kihlgren, 2003; Nilsson et al., 2007; Trumbull, 2013), and the Hsin Chu Industrial Science Park in Taiwan (Sun, 2011).

In the existing body of literature, a plethora of research efforts highlight the role of STPs in improving regional economic performance indicators (Phan, Siegel and Wright, 2005; Siegel, Westhead and Wright, 2003; Yang, Motohashi and Chen, 2009). On the other hand, only a paucity of studies explore the key determinants for supporting the development of STPs. Indicatively, Monck et al. (1988) identify several constraints on the ability of Science Parks to fulfil their economic potential. Major obstacles encountered in the process of developing successful STPs include the limited access to funding sources and the lack of qualified labour (Eto, 2005; Lindelöf and Löfsten, 2002). Characteristically, Amirahmadi and Saff (1993) statistically prove the sufficient capital infusion as a key determinant for Silicon Valley's success.

Research on the field of STPs' funding is sufficient for developed countries (EC, 2002; Ratinho and Henriques, 2010) and developing nations (Al-Sultan, 1998; Ratinho and Henriques, 2010; Vaidyanathan, 2008). Nonetheless, the lack of a comprehensive study mapping the committed funding schema, while contemporarily assessing and benchmarking the resulting performance of STPs within converging economies in Europe is eminent (Ratinho and Henriques, 2010; Reggi and Scicchitano, 2014). Converging countries combine the infrastructure of developed countries, but do not excel in terms of innovation performance that could support economic stability in the recent financial downturn period, as in the cases of Spain and Greece (Abrahamsen and Hartwig, 2011; Hausman and Johnston, 2014). To that end, a significant portion of the European Union's (EU's) total budget is spent on the so-called Cohesion Policy via the Community Structural Funds with the aim to: (i) support the "overall harmonious development" of the EU, (ii) reduce disparities between the development levels of the country member-states, and (iii) strengthen the regional "economic, social and territorial Cohesion" (Article 158 of the Treaty on the Functioning of the EU) (Mohl and Hagen, 2010). Such a comparative study could reveal main underlying determinants for the success of STPs that may foster the convergence of particular member-states within the EU (Monfort, Cuestas and Ordóñez, 2013). To the best of our knowledge, the most notable study examining the funding scheme of Science Parks is that of Bigliardi et al. (2006). However, the aforesaid study is merely limited to the case of Italy.

Furthermore, a main drawback in comprehending the development of STPs is the lack of analytic tools that could capture the complex nexus and interrelations of key STPs' development determinants considering that agglomerations of businesses and institutions develop in an organic manner within a global and dynamic environment (Carayannis and Bakouros, 2010; Samara, Georgiadis and Bakouros, 2012). To that effect, System Dynamics (SD), a simulation-based technique which has been proven quite successful in policy-making and strategy decision-making, could be employed to model the feedbacks that both promote and limit STPs' growth and further provide important managerial insights about the merit of Science Parks for securing a robust and sustainable economic environment.

The present work extends the existing literature in a number of ways. First, it focuses on analysing current trends in STPs from two converging countries, namely Spain and Greece, which have been greatly affected by the global financial recession. Second, this study is the first to utilize a comparable study regarding the EU Structural Funds on STPs and their outcomes in terms of hosted companies and number of employees. Therefore, the aim of this study is twofold: (1) to highlight the role of policy-making towards STPs within a national economic and social context through presenting the cases of Spain and Greece, and (2) to briefly present the impact of interventionary policies through elaborating the SD methodology, an approach that has been extensively used in the past to understand the behaviour of complex systems over time.

The rest of the paper is organized as follows. Section 2 briefly reviews previous studies and empirical evidence on the role of STPs in a national context. Section 3 justifies the selection of Spain and Greece as the study research units and further presents the outlook of STPs in the two countries. In addition, we explain methodological issues related to the empirical work provided in this study. Section 4 demonstrates the results of our analysis and the role of EU Structural Funds as a key determinant to explain performance differentials between Spain and Greece. Following, the relational nexus of the of the involved research factors is modelled through the SD methodology. Finally, we sum-up with discussion and conclusions in Section 5.

2. Background

In this Section we build upon the work of others to investigate the role of financial aid in STPs. In this short review we first discuss definitions about STPs and their main characteristics. Following, we provide a historical brief on the expansion of STPs in a global setting. We then focus on the role of the EU Structural Funds as a key development constituent of successful STPs.

2.1 Definitions and Characteristics

Researchers and practitioners have articulated a myriad of definitions to delineate the term of STPs (Amirahmadi and Saff, 1993; Hansson, Husted and Vestergaard, 2005; IASP, 2002; Quintas, Phan, Siegel and Wright, 2005; Wield and Massey, 1992; Vedovello, 1997). Common themes at all the provided definitions are: the establishment and growth of technology-based enterprises, the formal and operational link to centres of business and technological expertise, and the provision of management support for tenant companies. STPs tend to support the establishment and growth of niche technology-based ventures (Amirahmadi and Saff, 1993) and to attract anchor firms to a given location (Felsenstein, 1994). Therefore, STPs mainly aim to support regional development (Amirahmadi and Saff, 1993) through highlighting regional technological strengths and enhancing the development of new ones (Castells and Hall, 1994; Link and Scott, 2003).

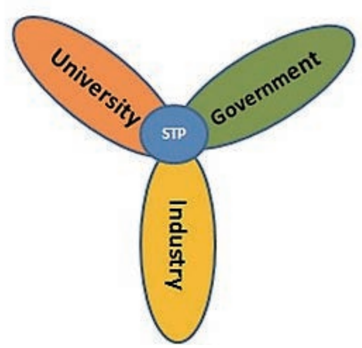

Figure 1: STP's Triple Helix model
[Source: Etzkowitz and Leydesdorff, 2000].

The key characteristic of STPs is that through their Research and Development (R&D) activities they encourage networking, information sharing and knowledge dissemination (Chyi, Lai and Liu, 2012; Hansson, Husted and Vestergaard, 2005), thus promoting a new form of global economic development, the so-called "knowledge revolution" (Ahamed, 2013; Kohl and Al Hashemi, 2011). Knowledge constitutes a prominent factor of corporate performance and a major driver of human capital (Afonso, 2013; Tseng, 2014). To that end, Etzkowitz and Leydesdorff (2000) specified the Triple Helix metaphor to emphasize the endogenous complex dynamics generated by the institutional relations and knowledge transfer among three individual societal sub-systems, i.e. public authorities, business community and research institutions (Figure 1). Therefore, the need to develop STPs in a Triple Helix archetype is strongly encouraged with the aim to develop appropriate investment funding schema and venture capitals (Wonglimpiyarat, 2007).

2.2 Historical Brief

The concept of STPs is rooted in the 1950s. The continuous global expansion of this phenomenon confirms that STPs are widely regarded as a useful and powerful tool for economic development, innovation-driven growth and radical technological advancements. Since 1980, the global STP industry has undergone an exponential increase; 19.3% of STPs were launched in the decade of 1980 while 24.4% of STPs opened in the 1990s and 52.1% in the 2000s (IASP, 2012). Figure 2 depicts the latest available data regarding the chronological evolution of the STPs' growth trend.

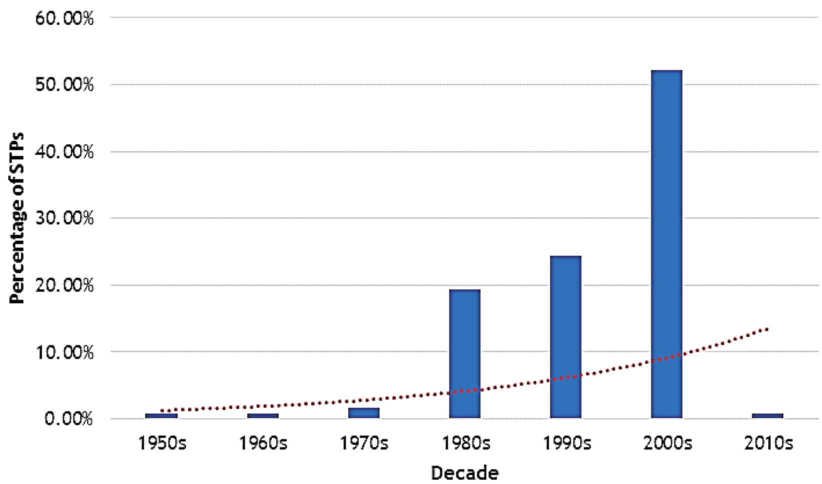

Figure 2: Establishment and growth trend of STPs [Source: IASP, 2012].

2.3 EU Structural Funds

The Structural Funds and the Cohesion Fund (both refereed as Community Structural Funds) are financial resources allocated by the EU to its member-states in order: (i) to support the underdeveloped regions of Europe, and (ii) to promote the integration of the European infrastructure. The most recent EU financial aid programs ended on the 31st December 2013 with a total budget of 277 billion euros for the Structural Funds and 70 billion euros for the Cohesion Fund. Table 1 below shows the funds committed by the EU for Spain and Greece via the last three related EU funding schema, from 1994 to 2013.

	1994-1999	2000-2006	2007-2013
Spain	10.7	24.7	20.4
Greece	22	54	35

Table 1: Funds allocated by the EU as CSFs in Spain and Greece in billion euros, 1994-2013 [Source: Eurostat, 2015].

3. Methodology

In order to investigate the role of STPs towards economies that confront similar challenges within the recent dismal economic situation, both qualitative and quantitative research was developed focusing on STPs from the two Mediterranean countries of interest, namely Spain and Greece. To that end, a structured questionnaire was developed and was then administered to the administrative or management authorities of the contacted STPs. Additionally, the SD methodology further allowed the mapping of the interrelations and the feedbacks among the critical factors that constitute an STP environment, and made it feasible to capture the dynamics of the complex nexus of factors related to STPs' development and growth. Overall, the primary research in Spanish and Greek STPs was conducted during the period February-April 2012. The statistical processing of the data followed and finally we concluded to the key constituents that determine the STPs growth thus drafting the related SD conceptual framework.

3.1 The cases of Spain and Greece

Several studies verify that STPs provide solutions to complex political, economic and social challenges (Autio and Klofsten, 1998; Nowotny, Scott and Gibbons, 2001). Therefore, the effective utilization of available funds and the respective national policy-making could provide managerial insights for Spain and Greece, two countries upon which the depth of the financial crisis is fully reflected (Rossignolo, Fethi and Shaban, 2013; Millán, Congregado and Román, 2014).

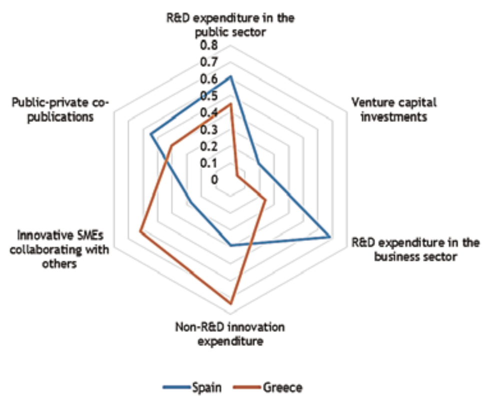

Figure 3: Innovation performance indicators for Spain and Greece [Source: IUS, 2014].

Spain and Greece have Gross Domestic Products (GDPs) that are highly correlated and the two countries further encounter similar economic challenges within the recent financial downturn period (Abrahamsen and Hartwig, 2011). In terms of innovation performance, according to the Innovation Union Scoreboard, Spain and Greece are classified as "Moderate innovators" meaning that their innovation performance is below the EU average, with the relative performance rates ranging between 50% and 90% of the EU average (IUS, 2014). Furthermore, the innovation growth performance of Spain and Greece in the period 2006-2013 is 1.44% and 1.24% respectively, below that of the EU (1.66%). Indicative innovation performance metrics for Spain and Greece are illustrated in Figure 3.

3.2 Questionnaire

To conduct the primary research of our study, a structured questionnaire was designed containing sixteen (16) qualitative and quantitative questions which are considered effective in assessing the impact of STPs in Spain and Greece (Roelofsen and Käki, 2010; Siegel, Westhead and Wright, 2003). The research utilizes three (3) key innovation performance indicators that were examined from both a qualitative and quantitative perspective, namely: (i) supportive indices, (ii) activity indicators, and (iii) system outputs. Supportive indices refer to the available funding schema, the existence of business incubators and the physical land area that STPs occupy. Furthermore, activity indicators tackle the issue of established collaborations with academic and business institutions, the total years of operations and STPs' maturity level. Moreover, system outputs are assessed in terms of number of employees and STPs' turnover.

The questionnaire includes only sixteen (16) questions in order to facilitate quick and easy responses. Specifically, the requested quantitative data include:

- The inauguration date of the STP.
- The total area the STP currently occupies.
- The total investments for the STPs (i.e. buildings construction costs and other infrastructure), along with the funding body.
- The existence of a business incubator and the provision of related financing instruments (for providing seed capital).

For the particular case of STPs with more than fifteen years of operations, further data was required with refer to:

- The number of companies operating in the STP.
- The number of employees in the STP.
- The estimated turnover of the STP management body.
- The estimated turnover of all businesses operating in the STP.

Expect for the data requested by both Spanish and Greek STPs, for the particular case of Greek STPs additional data was demanded including:

- The number of patents registered through the STP.
- The potential to collaborate with the regional Industrial Zone, the local academic institution and the Industrial Property Organization.
- The proposed measures that could foster innovation in Greece.

Therefore, two questionnaires were developed: one for the Spanish STPs and another, more extended, for the Greek STPs. The two questionnaires are inserted in the Appendix of the present study.

3.3 Data Collection

Research in Spanish STPs preceded chronologically. After the questionnaire had been completed, contact with the International Association of Science Parks (IASP, www.iasp.ws) followed. IASP headquarters is located in Málaga, Spain, at the Association of Science and Technology Parks of Spain (APTE). The General Secretary of IASP responded positively in the invitation to participate in the survey and dispatched the formulated questionnaire to all Spanish STPs which are accredited by APTE. A total of 49 completed questionnaires were retrieved. The main reason that the contact with Spanish STPs was established through APTE was to ensure the greatest possible participation of Spain STPs in the present research effort. The Spanish STPs that participated in the research are clustered in Table 2 based on the national historical community they are located.

Historical	STP 名称
Andalucia	1.Aerópolis Parque Tecnológico Aeroespacial de Andalucía 2.GEOLIT Parque Científico y Tecnológico S.A. 3.Parque Científico - Tecnológico de Almería (PITA) S.A. 4.Parque Científico y Tecnológico Cartuja 5.Parque Tecnológico Agroindustrial de Jerez S.A. 6.Parque Tecnológico de Andalucía 7.Parque Tecnológico de Ciencias de la Salud de Granada 8.Parque Tecnológico TecnoBahía
Aragón	1.Fundación Parque Científico Tecnológico Aula Dei 2.Parque Tecnológico Walqa 3.TechnoPark - Motorland
Asturias	1.Parque Científico Tecnológico de Gijón 2.Parque Tecnológico de Asturias
Canarias	1.Parque Científico Tecnológico de la Universidad de las Palmas de Gran Canaria
Cantabria	1.Centro de Desarrollo Tecnológico de la Universidad de Cantabria (CDTUC) 2.Parque Científico y Tecnológico de Cantabria
Castilla y León	1.Parques Tecnológicos de Castilla y León
Cataluña	1.22@Barcelona 2.ESADECREAPOLIS Parque de la Innovación Empresarial 3.La Salle Parque de Innovación 4.Parc Científic Barcelona, 5.Parc Científic I Tecnològic Agroalimentari de Lleida 6.Parc Científic i Tecnològic de la Universitat de Girona 7.Parc de Recerca UAB 8.Parque Científico y de la 9.Innovación. TecnoCampus Mataró-Maresme 10.Technova Barcelona
Extremadura	1.Parque Científico y Tecnológico de Extremadura
Galicia	1.Parque Tecnológico y Logístico de Vigo 2.Parque Tecnolóxico de Galicia
Islas Baleares	1.Parque Balear de Innovación Tecnológica (PARCBIT)
Madrid	1.Parque Científico de Leganés Tecnológico (Universidad Carlos III de Madrid) 2.Parque Científico de Madrid 3.Parque Científico y Tecnológico de la Universidad Politécnica de Madrid 4.TECNOALCALÁ Parque Científico - Tecnológico de la Universidad de Alcalá
Mancha	1.Parque Científico y Tecnológico de Albacete
Murcia	1.Fundación Parque Científico de Murcia 2.Parque Tecnológico Fuente Álamo S.A.

Historical	STP 名称
Navarra	1.Parque de la Innovación de Navarra
Pais Vasko	1.Parque Científico y Tecnológico de Bizkaia 2.Parque Tecnológico de Álava 3.Parque Tecnológico de San Sebastián 4.Polo de Innovación Garai S. Coop
Valenciana	1.Ciudad Politécnica de la Innovación 2.Espaitec. Parc Científic Tecnològic i Empresarial de la Universitat Jaume I de Castelló 3.Parc Científic Universitat de València 4.Parque Científico-Empresarial de la Universidad Miguel Hernández de Elche 5.Parque Científico de Alicante 6.València Parc Tecnològic

Table 2: Surveyed Spanish STPs.

Regarding the STPs in Greece, an informative message was dispatched to the secretary of every STP accompanied by a proposal to participate in the present research. Following the affirmative or negative response of each STP, the structured questionnaire was mailed to the administrator/manager of the Park to provide the required information. In several STPs the need to provide further clarification concerning the questionnaire was required. The Greek STPs that were contacted are: Thessaloniki Technology Park, Technology Park of Lavrio, Technology Park of Crete, Patra's Technology Park, Technology Park of Epirus, Demokritos National Center for Scientific Research, Technology Park of Thessaly and Technopolis of Thessaloniki. All Greek STPs agreed to participate in the survey except for the Patra's Technology Park. Furthermore, contact was established with the Corallia Clusters Initiative as it occupies a business incubator and promotes entrepreneurship, innovation and research. However, the cluster's administration refused to participate in the research.

3.4 System Dynamics

System Dynamics is a simulation methodological approach which is appropriate for the analysis and understanding of the development and behaviour of complex systems through the time. The SD approach was developed in 1956 by the MIT Professor Jay Forrester. Originally, the tool was used by Forrester (1961) to examine the instable employment environment in General Electric, while over the years SD was employed to model and simulate diverse scientific and engineering systems (Forrester, 1969). According to Roberts (1978), the feedback control characteristics of the SD approach render it as an appropriate tool for decision-making at a strategic level regarding a wide range managerial, socioeconomic and organisational issues.

The core concepts of SD are feedbacks, causal loop diagrams, and stock and flow maps. Feedback loops and structures are necessary because systems rarely exhibit linear behaviour due to the interactions among the physical and institutional configuration of the systems. Feedback structures are fundamental because they capture the real patterns or modes of systems' behaviour as they dynamically evolve through the time. Causal loop diagrams are used in order to capture the mental models which managers conceive of a system. Except for the latter remark, causal loop diagrams assist modellers in representing the feedback structures of a system. In a causal diagram, arrows describe the causal influences among the variables of the system (Sterman, 2000). Each arrow is assigned a polarity that indicates the relation between dependent and independent variables. A positive (+) polarity denotes that the effect changes towards the same direction as the cause (reinforcing feedback). On the other hand, a negative (-) polarity denotes that the effect changes towards the opposite direction of the cause (balancing feedback). Finally, the dynamic behaviour of a system arises when inflows are accumulated in stocks which provide the system with memory, thus enabling the systems' disequilibrium dynamics (Sterman, 2000).

4. Results

4.1 Innovation Funding and STPs in Spain

In the last few years, STPs have been recognized as a promising tool for the modernization of the Spanish innovation system. The expansion of STPs across Spain has been remarkable. According to data available from APTE, in the year 2000 about a total of 1,000 companies and research centres were based on Spanish STPs, while in 2013 the corresponding number increased to over 6,200 (APTE, 2014). Furthermore, the number of employees in STPs increased from 25,000 to over 147,000 employees for the respective time period (APTE, 2014). Meanwhile, during the aforesaid time horizon, the Spanish STPs' turnover increased from 3,500 to 21,000 million euros.

Regarding the STP financing options, two major funding schema exist in Spain (APTE, 2014): (i) the specific national budget provided for sciences, R&D and innovation, known as Action 46 (formerly Action 54), and (ii) the EU Structural Funds. Notably, the total government budget appropriations and outlays on R&D decreased significantly over the last years, by 4.5% in 2010, by 12.7% in 2011 and by 13.1% in 2012, reaching a budget of 6,300 million euros. Furthermore, data on the general government budget for R&D and innovation shows that public investments in R&D and innovation decreased in 2013 and amounted for 5,932 million, falling to the levels of 2005-2006 (Molero and de No, 2013).

On average, STPs in Spain started to be established in the mid-1997, while a period of 2 years is generally required in order to begin their operations. Regarding the occupied land area, STPs in Spain own a total area of 10,730,492 m2 (based on data from 36 STPs); however the total occupied area is limited to 32,086,917 m2 (based on data from 40 STPs). It is estimated that, on average, each Spanish STP occupies around 37% of its proprietary land area equalling to 802,172 m2.

Additionally, of the investigated 42 STPs only one does not provide incubator services (percentage of incubators equal to 98%). Considering the initial financing of the hosted companies in STPs, only the 36% of the firms are self-financed, whereas the 38% of STPs collaborates with external capitals to fund companies at their initial development stage. In total, the 74% of the companies in an STP have access to a funding mechanism at their early stage. Table 3 presents the correlation coefficients regarding the factors characterizing the Spanish STPs.

STP	Number of STPs	Number of Companies	Number of Employees	Turnover
Number of STPs	1			
Number of Companies	0.963972	1		
Number of Employees	0.875811	0.83551	1	
Turnover	0.969218	0.996325	0.822266	1

Table 3: Spearman correlation coefficients between performance indicators of Spanish STPs.

4.2 Innovation Funding and STPs in Greece

Initiatives for the development of STPs in Greece are dated back in 1989. The first STP in Greece was inaugurated in 1993, close to the city of Heraklion and the University of Crete (Bakouros, Mardas and Varsakelis, 2002). Technology Parks in the country began to grow in cities with major academic institutions as to facilitate knowledge sharing between academic and business sectors (Dardamani, 2009). In 1990, under the Third Community Support Framework, the first Operational Programme for Research and Technology was approved (also known as EPET 1) with a total budget of 101,522 million European Currency Units. Currently, eight STPs and a technology cluster operate in the country.

Following, we tried to include in our research data regarding the capital expenditure for the creation of the Technology Parks in Greece. In the cases were data was not available through the internet, the capital expenditure was calculated through using existing data. Specifically, we calculated the cost per square meter of the building area for the two Technology Parks where relevant information was missing. The calculations were made for the Technology Parks of Crete and Patra. Table 4 provides comprehensive information for the Technology Parks in Greece, like the foundation year and the year of commissioning, that were retrieved as part of our research.

STP	Foundation Year	Commissioning Year	Total Area (m^2)	Occupied Area (m^2)	Capital Expenditure (€)
Thessaloniki	1988	N/A	N/A	7,500	11,738,823
Lavrio	1995	2000	245,000	40,000	15,230,000
Crete	1993	1996	120,000	33,500	15,798,000
Patras	1989	1999	N/A	3,800	1,792,000
Epirus	1999	2003	17,018	4,689	4,500,858
Democritus	2009	2009	2,060	N/A	500,000
Technopolis	2001	2009	94,000	65,000	15,000,000
Thessaly	2001	2001	1,787	N/A	506,236

Table 4: Comprehensive information for the STPs in Greece.

4.3. Comparative Analysis

Previous sections confirm the lack of funding sources for the Greek STPs. It is evident that Greece is lagging behind in the number of Technology Parks and the corresponding number of companies and employees when compared to Spain. The main reason for this gap can be identified to the total funds invested for STPs in the two countries (Table 5). Indicatively, according to our calculations the total amount invested in STPs in Greece is 65 million euros while the respective amount in Spain is 4.858 billion euros.

	Spain	Greece
Population	49,000,000	11,000,000
GDP (for fiscal year 2012)	717,193,989,758 $	143,034,499,786 $
Number of STPs	49	8
Number of Companies	6,030	135
Number of Employees	154,187	774
Innovation Index	0.41	0.34
Investments in STPs	4,858,727,564 €	65,066,970 €

Table 5: Demographic and financing figures of STPs in Spain and Greece.

Following, the figures provided above were normalized and the results are depicted in Figure 4. Notably, the measures provided in Figure 4 follow a similar trend with the innovation performance indicators provided by the Innovation Union Scoreboard for the respective period during which the present research took (IUS, 2011). Indeed, according to the 2011 classification of the EU, Spain is just two places higher than Greece in the innovation performance ranking. The small divergence is justified by the fact that the Summary Innovation Index is influenced by factors other than STPs, such as education services where Greece presents a good rating.

Figure 4: Comparative analysis of STPs in Spain and Greece (normalized data).

The above figure shows that Greece lags in the number of employees and in the number of companies hosted in STPs. Compared to Spain, Greece has a comparable number of STPs, proportionally to the magnitude of the two national economies; however, the average size of an STP is ten times greater in Spain compared to Greece. Furthermore, Greece occupies 0.021% of the national labour workforce in STPs, while in Spain the number of employees in Technological Parks represents the 0.89% of the total workforce. In addition, our analysis reveals that Greece exploits only the 0.12% of the available EU Structural Funds for investments related to STPs, while the respective percentage for Spain is 4.3% (Table 6).

STP	Spain	Greece
Structural (European) Funds	111,000,000,000 €	55,800,000,000 €
Invested Capital	4,858,727,000 €	65,066,000 €
Percentage of Structural Funds for STPs	4.38%	0.12%

Table 6: Funds invested in STPs in Spain and Greece.

Evidence presented in Table 6 justify the fact that the employment rates and turnover in Greek STPs are lower compared to Spain. To this effect, Table 7 comprehensively presents the ratio of “cause-and-effect” indicators between Spain and Greece.

Cause	Ratio	Effect	Ratio
Structural (European) Funds	1.9	Number of STPs	6.1
Invested Capital	74.6	Number of Companies	44.6
Percentage of Structural Funds for STPs	37.5	Number of Employees	199.2

Table 7: Spain to Greece fraction of “cause-and-effect” indicators.

During the period 1994-2013, Spain received twice the funds from Community Support Frameworks than Greece. However, thus far, the investment of such funds in STPs has been 37 times greater in Spain than in Greece with the respective total monetary amount invested in STPs in Spain being 75 times higher compared to Greece. Following that, the number of STPs in Spain is 6 times larger than that of Greece, while the size of a typical STP in Spain being on average ten times larger than that of a respective Greek Park. Finally, the number of hosted companies in Technology Parks in Spain is 45 times higher than in Greece, while the number of employees is 199 times greater. These numbers may slightly differ from the current situation, but provide a clear representation of the differences between the two countries.

4.4. Sensitivity Analyses

Following the analysis above, an analysis can be performed to investigate sensitivity (“what-if”) scenarios about the STPs’ potential results in Greece, assuming that a strategy similar to the case of Spain had been pursued. Our analyses focus on rather generic assumptions, while elaborating proven mathematical approaches for their testing. To that end, two (2) scenarios were analysed, namely: (i) inverse investment funds scenario, and (ii) Structural Funds in STPs scenario.

4.4.1 Scenario I: Inverse Investment Funds

The first scenario assumes that the funds invested in Greece are inversely proportional to that of Spain by a factor of 4.57 which corresponds to the ratio of the Spanish to the Greek GDP. Therefore, the funds to be invested in Greece are estimated to 1,063 billion euros, corresponding to the 1.42% of the total available EU Structural Funds. Thereafter, assuming a linear relationship (through linear regression) we projected the number of companies and employees in Greek STPs. The number of potential Technology Parks calculated with this method is not realistic and thus it is excluded from our analysis. This is due to the fact that a Park in Greece has an average total area of about 80,000 m2 while its building infrastructure occupies an area of about 22,000 m2. The corresponding figures in Spain are 802,000 m2 and 298,000 m2 respectively, resulting in a ratio of about 1 to 10. In fact, this ratio is even greater because the average area of STPs in Greece is affected upwards by the Parks of Lavrio and Crete.

4.4.2 Scenario II: Structural Funds in STPs

The second scenario assumes that the ratio of the EU Structural Funds invested in Greek STPS is similar to the real case of Spain, i.e. 4.37%. Based on this percentage, the funds invested in Greek STPs is approximately 2.442 trillion euros. Projections regarding the number of employees and companies in Greek STPs were retrieved by linear interpolation. Overall, the sensitivity analyses results with refer to the percentage of the total EU Structural Funds invested in Greece are tabulated in Table 8.

	% Structural (European) Funds to Greek STPs		
	0.11%	1.42%	3.27%
% Structural (European) Funds	0.001166075	0.014251932	0.032741696
Projected Invested Capital	65,066,000 €	1,063,178,000 €	2,442,495,000 €
Projected Companies in Greek STSPs	135	1,650	3791
Projected Employees in Greek STPs	774	9,460	21,733

Table 8: Sensitivity analyses — % Structural Funds invested in Greece.

4.5. System Dynamics Framework

In Figure 5, the appropriate causal diagram illustrates the correlation of the factors and the variables that shape the complex social and economic environment that directly and indirectly affects the development of STPs at a national level. The provided SD conceptual framework clearly defines as major pillars for STPs' development the availability of public funds and investments, and the existence of valuable human capital.

National policy-making and expenditure have a central role in the wider STP ecosystem. Particularly, public investments affect positively the national education and innovation systems, hence nurturing a knowledge sector that could potentially support SMEs, business incubators and STPs. Thereafter, positive impacts arise at social and economic levels. On the other hand, taxes have an inhibitory role to the development of an entrepreneurial ecosystem and knowledge spillovers.

Notably, except for the crucial supportive role of public funding on STPs, the reinforcing loop R, indicates that the entire spectrum of national assets, i.e. human, social, financial, physical, equity, should be available to all business and societal stakeholders. Specifically, the positive polarity of the "inclusive" development to the employment and poverty reduction implies that the availability and accessibility to national assets encourage human capital development. Following, as supported by Afonso (2013), human capital is a key determinant that positively impacts the growth of STPs hence promoting the greater social prosperity as well.

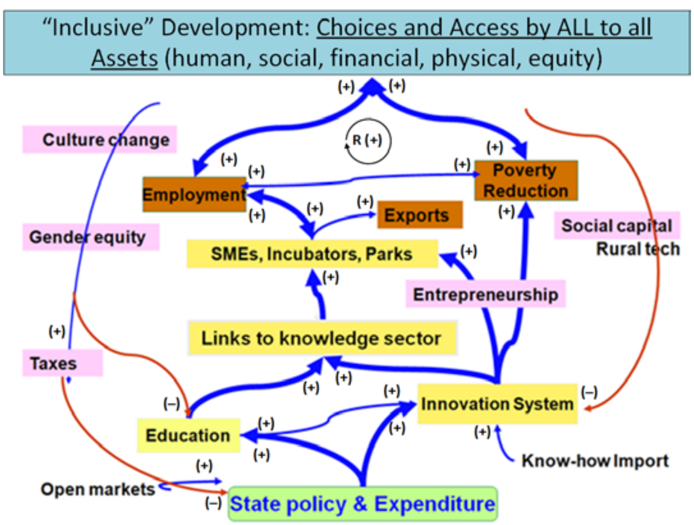

Figure 5: System Dynamics causal loop diagram of the wider STP ecosystem.

5. Discussion and Conclusions

To sum up, STPs have a substantial impact on the Spanish economy. Specifically, total investments of 4.85 billion euros over a period of 15 years resulted in 6,030 businesses in Technology Parks and created 154,187 job positions. Funds invested for R&D and innovation in Spain constitute the 4.37% of the total EU funding schema in the form of Structural Funds. In the case of Greece, 8 STPs exist in the country with an average area 10 times less than that of Spanish Technology Parks. According to the survey results, a total of 65 million euros have been invested thus far in Greek STPs. This amount accounts for the 0.12% of total EU Structural Funds since 1994. There are about 135 companies registered in Greek Technology Parks, while the related number of employees is only 774.

Through linear regression we calculated that in case the investments in Greek STPs were 1.063 billion euros, i.e. 1.91% of the total EU Structural Funds, there would have been developed 2,206 innovative companies and about 12,650 high-expertise job positions. Furthermore, in case the respective investments were 2.44 billion euros, i.e. 4.37% of the total EU Structural Funds, there would have been created 5,064 new enterprises and 29,055 high-expertise job openings.

Our research highlights the need to increase the available financial tools for STPs, especially in the case of Greece, in order for countries to be able to embrace innovation and develop an appropriate entrepreneurial culture. Following, other significant factors for the growth of STPs include the national policy-making, while being advocated by universities and research institutions. We envisage that our research might assist public authorities and regulators towards the realization of the critical role of STPs at a national level. Additionally, it is anticipated that the yielded research results motivate future research on the field and allow the drafting of effective and efficient policy-making interventions.

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Appendix

Questionnaire – Spanish STPs

	Question				
1.	Name of the Park				
2.	Contact person				
3.	Position of the person				
4.	Mail address / Website				
5.	Year of STP establishment				
6.	Year that the park started operating				
7.	Funds invested				
8.	Supporting entities / stakeholders				
9.	Total surface of the Park				
10.	Buildable area				
11.	Existence of incubator (Yes / No)				
12.	Existence of seed capital schemes				
	Establishment Date	12-15 years ago	10 years ago	5 years ago	Today
13.	Number of companies inside the Park				
14.	Number of people working in the Park				
15.	Total estimated turnover of the management company				
16.	Total turnover of companies within the Park				

Questionnaire – Greek STPs

	Question				
1.	Name of the Park				
2.	Contact person				
3.	Position of the person				
4.	Mail address / Website				
5.	Year of STP establishment				
6.	Year that the park started operating				
7.	Funds invested				
8.	Supporting entities / stakeholders				
9.	Total surface of the Park				
10.	Buildable area				
11.	Existence of incubator (Yes / No)				
12.	Existence of seed capital schemes				
13.	Number of registered patents in the STP				
14.	Measures that could foster the innovation growth in Greece				
15.	Collaboration with the regional Industrial Zone (Yes / No)				
16.	Collaboration with the local academic institution(s) (Yes / No)				
17.	Collaboration with the Industrial Property Organization (Yes / No)				
	Establishment Date	12-15 years ago	10 years ago	5 years ago	Today
18.	Number of companies inside the Park				
19.	Number of people working in the Park				
20.	Total estimated turnover of the management company				
21.	Total turnover of companies within the Park				