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ABSTRACT

Knowledge spillovers from Higher Education Institutions to emerging technological companies have been reported as being among the most important phenomena for regional social and economic development, contributing to the local technological entrepreneurial growth. Accordingly, we aimed to identify the contributions of an Innovative Entrepreneurial Ecosystem to regional development in Brazil, considering the Knowledge Spillover Theory of Entrepreneurship. We used qualitative and exploratory research approaches and collected the data by applying an experimental survey to twenty actors from the Porto Digital Science Park. We found twelve aspects related to entrepreneurial and innovative activities in the theoretical review, all of which were aligned with the scope of Porto Digital's activities and recognized as resulting from knowledge spillovers. The aspects found were associated with economic and social dimensions, such as the ability to generate wealth and improve the quality of life of the population. Our results assist in the formulation of public policies by the local Public Administration, highlighting the local advantages of establishing a public agenda that supports entrepreneurship, innovation, and regional economic development.

Keywords: Knowledge Spillovers. Technological Entrepreneurship. Regional Development. Knowledge Spillover Theory of Entrepreneurship. Innovative Entrepreneurial Ecosystem.

RESUMO

Estudos sobre a formação de aglomerações tecnológicas têm destacado o transbordamento do conhecimento das Instituições de Ensino Superior para as empresas tecnológicas nascentes como um dos mais vigorosos fenômenos para o desenvolvimento social e econômico regional, contribuindo para o crescimento do empreendedorismo tecnológico local. Para validar esta premissa, no contexto regional brasileiro, este artigo tem por objetivo identificar as contribuições de um Ecossistema Empreendedor e Inovador ao desenvolvimento regional, tendo como referência a Teoria do Empreendedorismo pelo Transbordamento do Conhecimento. Para tanto, aplicou-se uma pesquisa de natureza qualitativa e do tipo exploratório. A coleta de dados ocorreu por meio de uma *survey* de experiência, que contou com a participação de vinte atores ligados ao Porto Digital. Da revisão teórica apurou-se um conjunto de doze aspectos relacionados às atividades empreendedoras e inovadoras, as quais foram confirmadas no âmbito das atividades do Porto Digital e reconhecidas como decorrentes dos *spillovers* de conhecimento. Os aspectos identificados referem-se às dimensões econômicas e sociais, como a capacidade de gerar riquezas e melhorar a qualidade de vida da população. Os resultados da pesquisa oferecem indicações à formulação de políticas públicas pela Administração Pública local e apontam para as vantagens locais para estabelecimento de agenda pública de apoio ao empreendedorismo, inovação e desenvolvimento econômico regional.

Palavras - chave: *Spillovers* de Conhecimento. Empreendedorismo Tecnológico. Desenvolvimento Regional. Teoria do Empreendedorismo pelo Transbordamento do Conhecimento.

INTRODUCTION

The impact of higher education institutions (HEIs) on the surrounding society has been studied for decades. The ideas of Thorstein Veblen (1857 – 1929) has been highlighted as central to changes in consumption habits, in societies, and individuals, all decisive factors for socioeconomic development (Nunes, 2019). Nunes (2019, p. 18) considers that “the driving element of the change in the direction of development is the individual who carries new knowledge generated by the university [...] by the institution’s graduates and by individuals external to it and who are reached through university extension activities.”

Knowledge spillover from universities has affected socioeconomic changes in the city of São José dos Campos and Santa Rita do Sapucaí through graduates of the Technological Institute of Aeronautics (ITA) and of the National Institute of Telecommunications (INATEL), increasing the local attractiveness of the cities to large companies in sectors related to technical education and to those related with the technological knowledge generated by HEIs (Santos; De Paula, 2012). In addition, the flow of information from top-tier higher education institutions to economic the agglomerations of Silicon Valley and Route



128 was essential for the expansion of local technological entrepreneurship for being associated with new technological knowledge, the quality of interpersonal relationships, functional mobility, and other variables (Saxenian, 1996). Thus, it is possible for Public Management to promote regional development in a planned manner, including civil society, local economic agents, and HEIs in the decision-making process. In this scenario, the HEIs are hubs of knowledge generation, which includes knowledge spillovers and dissemination of information (Saxenian, 1996; Santos; De Paula, 2012).

Information flow is the central mechanism behind Knowledge Spillover, which is defined as “knowledge produced by established companies or universities that, when unused or underused, becomes a source of opportunity to the formation of new businesses” (Santos *et al.*, 2022, p. 2). Knowledge Spillover affects local entrepreneurship when a person accesses such underutilized or discarded knowledge, perceives a potential application, and decides to create a new company. Entrepreneurship through knowledge spillover is relevant for regional economic development for being closely related with innovative businesses, which in turn increases the availability of high-quality employment and heightens the technological evolution of industries (Jones; Ratten, 2020; Qian, 2018).

The Knowledge Spillover of Theory Entrepreneurship (KSTE; Acs *et al.*, 2009), describes knowledge as a source of entrepreneurial opportunities because companies are created based on its overflow and are thus an endogenous response to investments in knowledge (Acs *et al.*, 2009). For such response to happen, knowledge flows, interaction between economic agents, and contextual factors cannot be ignored (Qian, 2018) because when occurring simultaneously, these factors create an innovative and entrepreneurial ecosystemic action (Cetindamar; Lammers; Zhang, 2020; Audretsch, Belitski; Guerrero, 2022; Fischer *et al.*, 2022).

Knowledge spillovers explain the emergence of innovative technological agglomerations while also determining the formation of the Innovative Entrepreneurial Ecosystem (IEE) and innovation environments designed to benefit from the synergy between actors and interdependent factors present in the local context, favoring productive entrepreneurship (Stam, 2015). Thus, the logic of entrepreneurship through the spillover of knowledge in an Entrepreneurial and Innovative Ecosystem is based on the interactions between agents, tangible and intangible factors in a specific location that embody and shape entrepreneurship and development in a region (Fischer *et al.*, 2022; Lai; Vonortas, 2019)



The benefits generated by knowledge spillovers surpass the boundaries of the Entrepreneurial and Innovative Ecosystem to beyond the cities that host them and outweighs the generation of better jobs and salaries (Wicaksono; Ririh, 2021). Henderson (2007) reviewed the academic literature on the concept of knowledge spillovers in urban space considering city characteristics and, however scarce, concluded that knowledge spillovers are important for economic growth as well as for technological progress. Correlations between knowledge agglomerations and productivity exist, but do not confirm the existence of a direct causal relationship with technological progress (Henderson, 2007).

A study on information and knowledge transfer based on social network analysis in 16 regional innovation networks of 300 companies in Germany showed the importance of spatially close network links and that strong ties benefit the exchange of information and knowledge more than weak ties (Fritsch; Kauffeld-Monz, 2010). Innovation networks are based on direct relationships. Within networks, the exchange processes are affected by the very nature of knowledge and information, and thus may differ depending on the flow of information arising from Knowledge Spillovers. Knowledge Spillover takes place across a spectrum that ranges from obtaining information to reaching broader knowledge, due to mechanisms such as non-market interactions, technological proximity, labor mobility, social networks, and patent citations (Kekezi; Klaesson, 2020).

Empirical research seeking to clarify the relationship between regional knowledge stock, its repercussions, and local economic development is lacking (Audretsch *et al.*, 2020). In addition, there are few studies evaluating KSTE in emerging countries, as empirical tests of KSTE are focused on the context of developed countries, such as Europe and North America (Iftikhar; Ahmad; Audretsch, 2020; Mahn; Poblete, 2022). However, KSTE seems to be a promising theoretical lens for investigating the relationship between knowledge spillovers, innovation, and the creation of new business, despite the need to evaluate its applicability in different market configurations and economic contexts (Tsvetkova; Partridge, 2021).

From this perspective, the question arises: do the Knowledge spillovers of Porto Digital, analyzed through the lens of the Knowledge Spillover Theory of Entrepreneurship, strengthen the regional development of Recife? Considering the research question, the objective of this study is to identify the contributions of an Innovative Entrepreneurial Ecosystem to the regional development, having KSTE as a reference. It has been considered imperative to enable efforts aimed at promoting public policies and



strategies that favor the insertion of cities and regions in the Knowledge Economy (Spinosa; Krama; Hardt, 2018). Accordingly, this article aims seeks to (i) clarify the relationship between regional knowledge stock, its repercussions, and local economic development, and (ii) to study knowledge spillover and regional development, based on the interactions between agents in an Innovative Entrepreneurial Ecosystem in order to support public managers and public policy planners.

THEORETICAL REVIEW

The literature using territorial models of innovation and entrepreneurship to study innovative and growth-oriented entrepreneurship, and the relevant role of public policies in the endogenous development process are of increasing interest (Del Monte; Pennacchio, 2020; Fischer *et al.*, 2022; Wurth; Stam; Spigel, 2022). Stam (2015) supported by the KSTE, highlighted productive entrepreneurship as a product of the Innovative Entrepreneurial Ecosystem as means for economic development at the regional level. Accordingly, Wurth, Stam and Spigel (2022) also confirmed productive entrepreneurship in the focus of entrepreneurship and economic development research agendas, highlighting that the Innovative Entrepreneurial Ecosystem approach stimulated the emergence of finer investigations into which regional factors would support scalable entrepreneurial ventures.

Productive entrepreneurial activity can be perceived as the process by which individuals create opportunities that lead to valuable innovation (Stam, 2015). This entrepreneurial activity manifests itself through innovative startups, high-growth startups, and entrepreneurial employees. In turn, Wurth, Stam and Spigel (2022) define productive entrepreneurship as any entrepreneurial activity that contributes directly or indirectly to the net product of the economy or that can produce an additional product.

Fioravanti, Stocker and Macau (2021) define knowledge spillovers as the promotion and dissemination of knowledge on people, businesses, organizational fabric, and on the local space. KSTE discusses the relationship between knowledge spillovers and the generation of innovative entrepreneurial opportunities emphasizing the dynamics of economic growth, wealth generation, the factors that enable spillovers and the impact of this type of productive entrepreneurship on society (Ghio *et al.*, 2015).



From KSTE's point of view, the creation of a new company is an endogenous response to knowledge and ideas generated in the region, and not fully explored by their sources, such that entrepreneurs, especially former employees (Tsvetkova; Partridge, 2021), become a knowledge spillover channel (Audretsch *et al.*, 2020). KSTE recognizes knowledge as a driving factor for regional economic dynamism and development due to its direct relationship with the training of new innovative entrepreneurs (Audretsch *et al.*, 2020). The dissemination of knowledge creates technological opportunities, in addition to the diffusion of new knowledge within and among industries (Audretsch *et al.*, 2020).

Thus, entrepreneurship due to knowledge spillovers is directly related to the generation of knowledge-intensive, and innovation-oriented and technology-based companies. These companies increase job availability and the technological development of the regions where they are located (Audretsch *et al.*, 2020; Del Monte; Pennacchio, 2020; Jones; Ratten, 2020; Qian, 2018). Regional development should be understood as a process of structural, historical, and territorial change, characterized by socioeconomic dynamization and improvement in the quality of life of the population (Dallabrida; Rotta; Büttenbender, 2021).

According to Oliveira (2021, p. 207):

Authors recommend that regional development be driven by a state policy, along with organized civil society, with planning as a key element in the proposals of regional development policies, considering its geographical specialty, population pressure on natural resources, its social organization, religious structures, and mental and cultural contexts. In addition, its historical process of production and consumption is considered.

Still, regional development is a “multi- and interdisciplinary” concept that can be the object of multifaceted analysis (Oliveira, 2021). Our perspective in this article has the positive effects of knowledge spillover in an Innovative Entrepreneurial Ecosystem and KSTE as its theoretical foundation.

In the neo-Schumpeterian perspective, technological innovation and entrepreneurship are critical factors in the dynamics of economic development (Del Monte; Moccia; Pennacchio, 2020). Innovative activity is a cumulative process of interactive learning. This process requires a relationship between several actors, since the generation and diffusion of innovations requires constant interactions, facilitated by the spatial concentration of actors and the presence of informal institutions (Costa, 2010).

Productive agglomerations decisively influence regional development, creating a diversity of organizations that learn, innovate, and evolve (Costa, 2010). Therefore, knowledge spillovers promote a



positive synergistic effect on development beyond their territorial limits.

A new matrix for analyzing technology flow aims to assess whether spillovers lead to a more equal distribution in the sectors of industry and technological investment and considers that technological spillovers are necessary for economic growth to occur (Verspagen; Loo, 1999). Entrepreneurship plays an important role in urban and regional economic development, especially high-tech industry clusters, which positively influence the formation of new high-tech enterprises in regions nearby due to knowledge spillover (Liu *et al.*, 2021).

Innovation, development, and urban space are intrinsically related. Thus, focusing on the territorial approach to development, a reflection on the meaning of territories, valuing territorial dimension in the development processes is relevant (Dallabrida; Rotta; Büttenbender, 2021). Innovative Entrepreneurial Ecosystems represent prosperous environments for innovation dynamics and regional development, especially on the economic and sociocultural perspective (Spinosa; Krama; Hardt, 2018). On the economic perspective knowledge, innovation, and technology are essential and indispensable resources for cities, regions, and countries. Innovative Entrepreneurial Ecosystems imply the generation of productive economic activities, an increase in the level of high value-added jobs, as well as in the attraction and development of new economic activities for the region (Spinosa; Krama; Hardt, 2018).

Observing the effects on the territory, Oliveira (2021, p. 208) points out that:

New regions grow when the demands of other regions for products coming from companies located in their territory grows. Thus, regional integration can only be understood by analyzing the profile and diffusion of basic activities in the territorial space, which stimulates the insertion of the regional economy into the national economy.

Spinosa, Krama and Hardt (2018) suggest a relationship between the increase of intellectual capital, with the development of professionals in areas with intense production of knowledge and technology. The authors focus on knowledge workers, characterizing them as those who use knowledge as their main labor resource, and who deal with activities able to impact society (e.g., engineers, physicists, mathematicians, computer professionals, and scientists).

Kekezi and Klaesson (2020) highlighted the importance of examining the diffusion of knowledge from knowledge centers research when concerned with knowledge-intensive services.



Knowledge-intensive service firms benefit from knowledge spillover due to geographic concentration, although professional mobility facilitates the transmission of knowledge (Kekezi; Klaesson, 2020).

Knowledge and collective learning are protagonists in the concept of innovative territory, and specific resources for regional development. This territory would be sustained by an integrated vision of innovative processes, with the participation of various actors, including agents linked to the production, transmission, and use of knowledge, as well as existing institutions and infrastructures (Dallabrida, 2020).

Economic and sociocultural dimensions allow us to evaluate the relationship between the innovative territorial phenomenon and regional development. Therefore, variables such as rate of creation of innovative knowledge and technology-based businesses, number of research and development centers, income and employment generation, attraction and retention of talent, investments, multinational companies, industries, cultural identities influenced by the creative industry, and creation of innovative territory must be analyzed.

METHODOLOGICAL PROCEDURES

This is an exploratory study based on a qualitative approach, with the application of an experimental survey (Gil; Reis Neto, 2021) to capture the socioeconomic effects of the spillover of knowledge in an IEE on the regional development of where it is located. Experimental surveys were widely adopted as an exploratory research strategy throughout the 1950s to reach individuals with effective experience with the research topic, to deepen and refine the central problem, making it more specific, and allowing the improvement of research hypotheses and data collection (Gil; Reis Neto, 2021)

Qualitative methods enable the investigation of issues addressed by the KSTE (Lammers; Cetindamar; Maren, 2021). Qualitative research studies are needed for the dynamics of entrepreneurship through the spillover of knowledge to be comprehended by combining the process and its mechanisms with products and results (Audretsch; Belitski; Guerrero, 2022; Wurth; Stam; Spiegel, 2022), justifying our methodological choices. The exploratory nature of the phenomenon being studied further justifies our choosing of a qualitative study complementing quantitative approaches



present in econometric studies typical of the field of Spatial Economics and Economic Geography.

The IEE Porto Digital was selected for this study because it is a promising environment for innovation, joining in its territory agents linked to the government, to the private sector, and to academia, all committed to supporting the region's technological development. IEE Porto Digital represents a milestone towards the insertion of the city of Recife and the state of Pernambuco in the global context of the knowledge economy. The technology park, created in the year 2000 is linked to the revitalization of the central area of Recife and associated with retaining technological human capital in the region (Spinosa *et al.*, 2018; Chihanhe *et al.*, 2020). This is perhaps the main observable and documented variable on the IEE with a local influence factor.

The selection of research subjects was intentional, using the snowball method (Gil; Reis Neto, 2021; Vinuto, 2014), according to which, after familiarizing the interviewee with the research, the interviewee was asked to indicate other actors with experiences relevant to the phenomenon being studied. In addition, middlemen were contacted to facilitate access to the people whose profile was most suitable for the investigation.

The number of respondents was defined by the theoretical saturation point (Falqueto; Hoffmann; Farias, 2018; Gil; Reis Neto, 2021), using the validity and reliability criteria described in Falqueto, Hoffmann and Farias (2018). A total of 20 interviews were carried out, including subjects with multiple and diverse experiences at IEE Porto Digital.

The following professional experiences stood out concerning the interviewees: Fundação do Porto Digital, Academia do IEE (Teacher/Researcher); Scientists in a company or research and innovation entity within IEE; Work in the Porto Digital Management Center; Employees in IEE companies or startups; Managers in companies in Porto Digital; Entrepreneurs with companies or startups embarked on the IEE; Entrepreneurs with experience in startups that were not successful in the IEE; Venture capital or investment managers in startups; Managers in professional entities linked to Porto Digital; Managers in Government entities linked to Porto Digital and Managers in institutions and research and innovation centers.

People associated with IEE Porto Digital are used to digital means of communications, and to the new remote work routine established after the COVID-19 pandemic. Therefore, we conducted nearly all the interviews out using the Zoom digital platform. Only one was carried out in person, at the NGPD



headquarters. The interviews carried out digitally were recorded with the consent of the interviewees and lasted 45 to 115 minutes.

We chose to study the Regional Development dimension. The categories of analysis were delimited *a priori* based on the literature review, thus guiding the research and supporting the formulation of the survey (Gil; Reis Neto, 2021) (Figure 1).

Figure 1 | Dimension and categories of the survey

Objective	Dimension	Categories
Identify the contributions of an IEE to the regional development with the Knowledge Spillover Theory of Entrepreneurship as reference	Regional Development	<ol style="list-style-type: none"> 1. Generation of new companies in the local technology sector; 2. Development of new technologies and innovation to improve the city; 3. Training talent for the ICT sector (qualified human capital); 4. Generation of employment and income; 5. Digital transformation of the society and regional economy.

Source: Authors

The interview script was based on open questions derived from the literature review. A group of five experts on the subject validated the script considering accuracy of the terms used, ease of understanding of the questions asked, and average time taken to answer. All specialists had a PhD in Business Administration and a qualified academic production on the subject studied.

A survey of regional socioeconomic indicators in official data sources was also carried out to obtain the following variables: a) generation of new companies in the local technology sector, b) development of new technologies and innovation to improve the city, c) training of talents for the ICT sector (qualified human capital), d) generation of employment and income, e) digital transformation of local industries, and f) strengthening an entrepreneurial culture focused on innovation.

During the interviews we sought to explore the premise that regional development emerges from a process of social, economic, cultural, and political transformation that leads to economic growth and improves the quality of life and well-being of individuals in a locality. Therefore, the interviewees were asked the following questions:



1. What is your opinion regarding Porto Digital's contribution to the development of the Recife region?
2. How does the technological knowledge generated in Porto Digital spillover to surrounding companies? Does this spillover contribute to the development of these companies?
3. Is the knowledge generated at Porto Digital transferred to other cities or regions? Additional comments were requested by the researcher.
4. Do the activities held at Porto Digital (e.g., events, knowledge, and others) generate development beyond it? Additional comments were requested by the researcher.

The data were analyzed after the interviews, with the transcription of the recordings following Bardin (2011) and Gil and Reis Neto, (2021). The qualitative data analysis software ATLAS.ti9 was used as a supporting resource for organizing, sorting, and analyzing the empirical data collected.

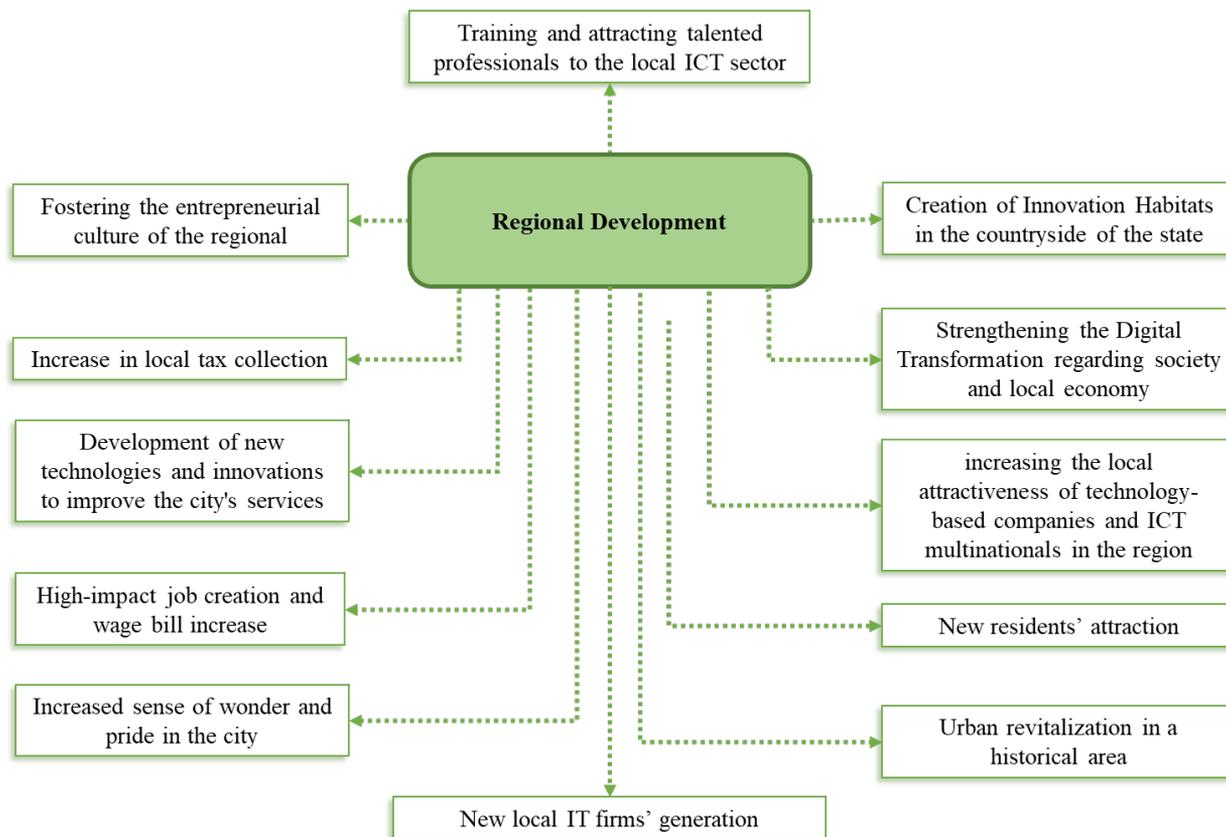
RESULTS AND DISCUSSION

The IEE offers adequate infrastructure and services for the establishment of companies in the ICT sector and for generating entrepreneurial opportunities focused on innovation. These opportunities stimulate and promote growth of the ICT sector to beyond the region where it is located.

The contributions of Porto Digital to the regional development that were identified cover economic and social aspects capable of generating wealth and improving the population's quality of life (Figure 2). At least twelve contributions were identified and recognized as resulting from knowledge spillovers, supporting the idea that companies with intensive knowledge services benefit from knowledge spillover due to geographic concentration (Kekezi; Klaesson, 2020). Labor mobility facilitates the transmission of knowledge, and over time, supports the formation of new ventures (Kekezi; Klaesson, 2020; Saxenian 1996). This explains the growth of Porto Digital observed even during the pandemic period, period when the data were collected.



Figure 2 | Observed elements for the Regional Development



Source: Authors

Of the elements present in the interview reports, those relating to the economic aspect of regional development were more evident, for example, the positive influence that Porto Digital companies exert: (1) in increasing tax collection, (2) in generating employment of high impact and income in Recife and (3) in the generation of new companies in the ICT sector. According to those interviewed, the revenue volume of the companies that make up Porto Digital has a significant effect on municipal and state revenue.

[...] is proven in several ways, by several indicators, by its revenue, by tax payments, although we have a reduction from 5 percentage points to 2 percentage points of ISS, a reduction of 60%, the IT sector or Porto Digital technologies is the third largest ISS collector for Recife City Hall, second only to health and civil construction. And see if two more years we will spend in construction and be the second collector [...]. In 2000 there were two companies, today we have 350 companies and research centers, with 14,800 employees. In 2018 there were 9,500. So in the middle of the pandemic, in 2019, there were 11,600 and we went to 14,803. (Interviewee 3)

What we were also able to see was the salary, the mass of salaries that we pay. There is also the consumption of this wage bill that is left within the city. (Interviewee 4)



According to data extracted from the January 2022 Economic Bulletin, released by the Secretariat of Economic Development, Science, Technology, and Innovation (SDECTI), of Recife City Hall, the ICT sector is responsible for 7% of the tax collection on services in Recife, with the revenue of companies located in Porto Digital representing over 80% of the revenue of ICT companies in Recife (XXXX). At the state level the Technology sector represents a relevant area for the Creative Industry of Pernambuco in terms of volume, accounting for 39.3% of the formal employment contracts in this sector in 2020 (Firjan, 2022). These technology professionals are divided between the R&D, ICT, and Biotechnology segments. Professionals in the Technology area earn an average income of R\$8,270.00 in Pernambuco (FIRJAN, 2022).

Reports support that Porto Digital promotes (4) the training and attraction of increasingly qualified human capital for the local ICT sector, which contributes to increasing the technological knowledge base available in the IEE. This strengthening of the supply of technological talent promoted by Porto Digital, in turn, ends up enhancing (5) the attraction of technology-based companies and ICT multinationals to the region.

Recife is considered one of the main centers of technological training in Brazil. We have several references universities that train personnel in large numbers. This is why large companies seek to locate offices in Porto Digital. It is an opportunity for qualified labor that is cheaper than in a large center, where the cost of living is higher, so that is one point (Interviewee 13).

I think the contribution is high in terms of providing the training of qualified staff, promoting the business model (Interviewee 5).

According to data from Recife City Hall, in 2021 (until November) over 15 thousand active jobs in the ICT area were recorded, representing an increase of 11% compared to 2020. At the end of 2021 Porto Digital had 355 companies and over 14 thousand professionals, a 10.5% increase in number of employees when compared to 2020 (Recife, 2022).

Thus, Porto Digital shows the generation of economic activities with high added value, with an increase in qualified jobs and in the attraction and development of new economic activities in the region. This reasoning also supports Spinosa, Krama, and Hardt (2018) in their findings concerning the role of the IEE in increasing human capital focused on knowledge-intensive areas.

The role of Porto Digital in favoring and boosting the entrepreneurial culture of its surroundings through knowledge spillovers must be highlighted. According to interviewee 6, the promotion of regional



entrepreneurial culture focused on innovation offered by Porto Digital can be seen in different types of events that seek to build and strengthen the desire of IEE agents to commercialize available technological knowledge. These events raise awareness and strengthen the culture of encouraging knowledge workers and academics to develop new businesses related to events, interviews, communication on social networks, podcasts, radio programs, training programs, and promotion of technological entrepreneurship.

In relation to culture, it's something we've been doing a lot digitally on social media, interviews. We now have partnerships with radio stations. In this case, we are also using podcasts to capture and sensitize people who still live next door but have no idea what Porto Digital is or what exists here. (Interviewee 18).

[...]it is obvious that the impact we see from this is mostly a direct economic impact, because it is business development, but if we stop to think more specifically, each of those people, they become [...] ambassadors of this innovative way of thinking. They come to know a universe of innovation. We can create new things, which brings new possibilities (Interviewee 19).

The relevance of entrepreneurship generated in Porto Digital for the urban development process and revitalization of the historic region of Recife was present in the interviews (Interviewee 7). According to reports, spillovers can be perceived as a success of IEE in restoring a historic part of the city with high-tech companies awakening and improving the feeling of admiration and esteem for the city, which becomes an inspiration for others regions (Interviewee 8). It also attracts new residents to the region (Interviewee 9), confirming previous reports on the existence of an intrinsic relationship between innovation, development, and urban space (Dallabrida; Rotta; Büttenbender, 2021). Porto Digital was established in a region that was completely degraded, accompanied by an urban revitalization project, thus strengthening the transformative aspect of the urban, social, and historical reality implicit in the innovation sites. The following reports were obtained.

On the other hand, and mainly this, in my vision as an urban planner, we are revitalizing a historic area in the center of Recife. We currently have 1,300 m² of historic properties that have either been restored or are being restored by Porto Digital. [...] So the spillover that I consider most important, [...] is for the city, for the revitalization of the historic center [...]. And even more so, [...], we mobilize passions and affections, I would say, of young people in relation to affective appropriation in the historic center of Recife, in the city of Recife [...]. So, this is an important dissemination. It is a dissemination of a narrative (Interviewee 3).

Porto is a reference for all cities in the State [...]. So, Porto Digital is not only a platform for developing people and businesses, but also an inspiration for the development of regional and national ecosystems too, you know? For us, it is very important to have Porto close by (Interviewee 13).



[...] the city's self-esteem of seeing this city being recognized worldwide as an Information Technology hub is really cool. This has gains that are not objective, they are subjective, and bring results even in attracting new talent and new residents to the city in general, so it moves the economy in a way that even we cannot measure (Interviewee 4).

From the group of respondents, it was evident that knowledge spillovers from Porto Digital can go beyond the territorial borders of the ERA. This overflow can be explained, among other aspects, by the large portion of customers of companies on board at Porto Digital belonging to locations different from the physical territory covered by the technology park.

Knowledge spillovers from Porto Digital to beyond its borders were also confirmed by the interviewees and were based on strengthening the digital transformation of the society and regional economy (Interviewee 10), the development of new technologies and innovations to improve the city (Interviewee 11), and creation of innovation environments within the state of Pernambuco (Interviewee 12). Accordingly, one of the most cited aspects was the role of Porto Digital in the process of internalizing innovation. The Garoa Habitat, for example, was created by talents trained at IEE Porto Digital with the purpose of connecting the main actors in the agricultural production sector to create businesses and innovative solutions.

There is a huge opportunity for using this innovation within the region. There is expansion too. There is a hub, for example, of Porto Digital now in Caruaru, which is a large city near Recife, two hours by car. There is a hub of creativity and innovation in Caruaru precisely to make this expansion further beyond the capital (Interviewee 19).

This process occurs gradually. When I say gradually, Camila, it's because there is groundwork that involves fostering a business culture of digital transition, for example. Or the adoption of innovation as a business value, which depends on other actors (Interviewee 5).

See, I think so, it does influence. An example came to mind. Local law firms, for example. I see the movement of these firms to be increasingly digital. And I think there is an influence of being here in Recife, in the land of Porto Digital, you know? So, I think yes, it ends up influencing other sectors (Interviewee 16).

So, the impact that Porto Digital can have, if it is not just Recife, it can be in Caruaru, Petrolina, Suape, Campina Grande, João Pessoa, Foz do Iguaçu, Manaus... (Interviewee 9).

A major challenge is to enhance the effects of these spillovers onto the local and regional economy, so that it can have a more relevant impact on professionals, industries, and entrepreneurs from outside the IEE. To this end, support from the government and other stakeholders was mentioned as necessary to encourage relationships and interaction with external stakeholders to facilitate the spread of knowledge.



And I think there is a big challenge. Porto Digital [...] has very clear boundaries [...]. In a way, what Porto Digital has achieved so far, in terms of promoting development, securing investment, is great. But there is a big challenge in making this development, this internalization, able to overcome the bridges that separate Porto Digital from the territory. Porto Digital is home to several restoration actions that take place in its jurisdiction. But nearby you have the Central Market, squares that played historical roles for Recife, for the city, for the State of Pernambuco, where you notice a clear abandonment. There is a disconnect. The Porto Digital experience was perhaps so successful that it creates a strong contrast with what is not physically inside Porto Digital. Thus, in this sense, I think there is an important challenge that does not necessarily belong to Porto Digital. It may be a public policy of the State Government to ensure that the success of Porto Digital extends beyond the bridges that provide access to it [...] (Interviewee 5).

I think people from other sectors and other activities end up having a vague idea of what Porto Digital is, you know? I think there is a distance, a more abstract thing [...]. I believe it spread, but it could be more (Interviewee 16).

On the other hand, people in the ecosystem do not know the language of these actors in the traditional economy. (Interviewee 8).

There seems to be a barrier for the ecosystem to be sustainable without being able to communicate efficiently with its surroundings. Still, reports maintain that the external factors generated by Porto Digital stimulate new combinations of means of production, enhancing the emergence of investment opportunities and new businesses, contributing to innovation and the growth of employment, especially qualified, beyond the limits territories of the technology park.

Thus, knowledge-intensive entrepreneurship is confirmed to represent an economic phenomenon that boosts the economic competitiveness and innovative capacity of the surrounding region (Fischer *et al.*, 2022).

Porto Digital seems to represent a driving factor for regional economic dynamism and development, as it has become a relevant channel for training new entrepreneurs and its dissemination has provided opportunities for the creation of technological opportunities, in addition to the dissemination of new knowledge within and among industries, as assumed by KSTE (Audretsch *et al.*, 2020). Reports indicate that Porto Digital appears to increasingly exert a determining influence on regional development, confirming Costa's (2010) indications that knowledge spillovers go beyond the territorial limits of the technology park, promoting a positive synergistic effect on local development.

Technological spillovers are a significant source for economic growth such that these spillovers lead to a more equal distribution in the sectors of the technological investment industry (Verspagen



and Loo, 1999). An increased attractiveness of Porto Digital, growth in technological industries, and the diversification of knowledge applications were also revealed in the interviewees' reports.

The interviewees' reports indicate a relationship between Porto Digital and the process of social, economic, cultural, and political transformation that leads to improvements in the quality of life and well-being beyond its geographic territory of operation, in addition to the structural, historical, and territorial changes (Dallabrida, 2020).

Therefore, according to the evidence, Porto Digital's contribution to the regional development of Recife and the region is intense and significant, which is aligned with previous findings (Spinosa, Krama, Hardt, 2018; Da Silva *et al.*, 2021), confirming Porto Digital as a key element for the technological development of Recife, and consequently, for the economic and social dynamics of the region.

CONCLUSION

Our objective was to identify the contributions of an IEE to regional development, based on the Knowledge Spillover Theory of Entrepreneurship. To this end, the research followed an exploratory qualitative approach, guided by an experimental survey. This survey enabled the incorporation of the experience and impressions of the main agents involved in the interviews.

IEE Porto Digital is an environment of innovation, with a strong impact on the local landscape, as it occupies a degraded area of the historic center of Recife that was recovered by the Local Public Administrators, in line with the demands of the companies involved. Porto Digital is recognized for its technological knowledge and has become an island of excellence in sophisticated and disruptive technologies, or rather, a successful IEE and a national and international reference.

We observed a relationship between knowledge spillovers from Porto Digital and Recife's economic development, which provides entrepreneurs with the ability to spillover new knowledge to stimulate economic development, strengthening relationships between agents and increasing innovation of the company. Porto Digital's knowledge spillovers seem to strengthen Recife's regional development, presenting positive relationships that go beyond success in generating innovation-oriented entrepreneurial opportunities.



This study contributes to understanding the strength of innovative environments, specifically orchestrated by civil society and public agents, in the form of an Entrepreneurial and Innovative Ecosystem generating technological progress and socioeconomic growth.

The results indicate that the IEE Porto Digital proved to be an example of a public policy that can be reproduced in different regions of the country where Higher Education Institutions, first class in the field of Natural Sciences, Engineering and Mathematics are present. Another peculiarity is that Porto Digital is managed by a private institution and has been installed in a degraded urban area that was revitalized and transformed it into one of the most important innovative business hubs. This combination of conditions had the effect of increasing the local attractiveness, as it is a Historic Center.

Our investigation provides a broad and updated dialogue on the prominence of technology-based entrepreneurship as a public policy tool to promote regional economic development, which can be a source of inspiration and reference for other Brazilian cities.

Our study was limited by the restrictions and discouragement brought by the Covid-19 pandemic, which brought tensions and postponements in data collection. However, it is important to emphasize that, with rare exceptions, academic research in Brazil is still little stimulated in the business environment. In addition some dimensions, such as diversity and information, such as company profits were not recommended. Therefore, some windows of opportunity opened for future studies, on possibly more sensitive topics.

We suggest that studies be replicated in other IEE. New research studies in different contexts will allow generalizations on the researched object. Thus, the following agenda for future studies was suggested: studies on the relationship between knowledge spillovers and the strengthening of the entrepreneurial culture in the region surrounding the IEE (Interviewee 1) and investigation into the role of the IEE in building a regional identity focused on innovation (Interviewee 2).



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