Role of science and technology parks in the Era of 4th Industrial Revolution: Innovation ecosystem, opportunity and challenges

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Abstract
Despite the science and technology parks (STPs) notion is for over 50 years, it is persistently evolving and changing, and accordingly new doubts, questions, and needs have come to light. Therefore, it is necessary to consider the impact of the 4th Industrial Revolution and STPs innovation to obtain a better understanding of their future. The primary role of STPs in the 4th Industrial Revolution can be the increase in the speed of networking as a growth engine of regional development. Next role of STPs in the 4th industrial revolution is related to carrying out new education programs or capacity-building projects to cope with hyper-intelligence, which is another key characteristic of the 4th Industrial Revolution.
An investigation into new articles of STPs is indicative of their goals and findings as well as the guidance on controversial subjects, and detects existing gaps, challenges, and chances for future researches. The results demonstrate that the diverse definitions of STPs create very high expectations about these parks. A great number of these articles indicate the positive contributions for both the region and tenant companies, and consequently, it is led to an intense link with universities. Besides, it is important that how technological knowledge obtained from universities can cause to increase the innovation by firms placed in the STPs. Science and technology parks and innovation strategies followed a major mission in driving innovative assets and supporting emerging industries, In contrast, the government-academia-industry cooperation and the formation of an ecosystem are essentials. The structure perception of an innovation ecosystem is vital for policy implementers and participants to determine growth strategies and lucrative implementation. For the sustainable development of STPs and innovation-driven economies, it is essential to recognize potential feedback structures in the ecosystems from a systems perspective. Hence, policymakers can recognize the suitable policies having a positive impact on the technological innovation, development of business, economic performance, and market competitiveness through an ecosystem of feedback loops. Efficient policy assessment and execution will further modify the promotion of STPs and high-tech industries, containing science and innovation policies, financial policies, and export development policies.
Keywords
Science and technology parks, 4th Industrial Revolution, Innovation ecosystem

1. Introduction

Nowadays developed countries of our world form a post-industrial information society, its main resources are creative, intelligent human potential and high technologies that people create. For successful state development in the current environment, the implementation of a continuous cycle has become necessary: education, science, production. Technological parks are the link where new technologies, developed at universities or scientific research institutes, find their commercial realization.

In spite of many years in activities, the participation of STPs is still not fully clear [1,2]. Analyses of Chinese STPs in the period from 1992 to 2000 and Greece STPs appeared that the formal links between universities-firms and industries are still not identified. Results from the investigation of NTBFs located in STPs in Japan between 1998 and 2003 indicate that STPs have a higher tendency to associate with research institutes [3-5]. The goal of this research is to explore the science and technology parks development in the era of the Fourth Industrial Revolution. This is so that future, focused consideration of the challenges facing science and technology parks and its place in economic development and government policies in the fourth industrial revolution can be considered more fully.

2. STPs and the 4th Industrial Revolution

The First Industrial Revolution was based on the use of water and, later, steam power to mechanise production; The Second Industrial Revolution used electric power to introduce mass production; The Third Industrial Revolution was based on the use of electronics and information technology to automate production. We are now living in the era of the 4th Industrial Revolution (Industry 4.0). This term was utilized for the primary time in 2011 to portray quick changes in society, industry and technology in common. The presentation of the Web of Things (IoT) and progressed software applications merged with the automatization of machines in the manufacturing environment has presented the fourth Industrial Revolution. The term picked up more consideration after the World Economic Forum utilized it in 2016, and it got to be part of the national plan of numerous progressed countries. Typically, the 'Industry 4.0' is employed to explain potential changes in the society and economy and inform stakeholders about what to provide for what's to come.

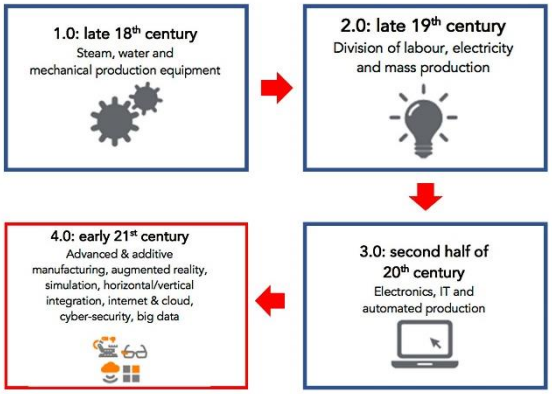

Fig. 1. Industrial revolutions. Source: adapted from World Economic Forum.

Industry 4.0 has a more extensive area. Occurring simultaneously there are waves of further breakthroughs in zones ranging from gene sequencing to nanotechnology, from quantum computing to renewables. The automatization and the connectivity of industry and society are assumed in the 4th industrial revolution, and it alludes to a future world based on the technological improvement of robotization, smart factories and artificial intelligence.

The effect of an Industry 4.0 is attended upon to be boundless, however, to a huge degree, this will rely upon nations' economic, cultural environments and social and their preparation to change and adapt. For instance, nations with adaptable economic structures will profit by the changes, while those without will confront more challenges. Today, the economic development design is distinct from that of the past. Therefore, the major challenge in the area of the 4th industrial revolution is in the industrial structure. The next challenge is associated with the labor market and employment issues. The labor market in some countries already suffers from polarization, with expanding relative destitution and pay disparity. Other challenges include the role of teaching and research in higher education. University researchers are often reproved for centralizing on short-term objectives like as the number of papers published, and that they don't collaborate with industry. They additionally may be resistant to information offering and knowledge

sharing with other sectors. Academics may follow trending research subjects or state policy-related subjects when they employ for grants, rather than searching new discovery areas and finding out their own specialities [6].

Generally, the main roles of the STPs were technology commercialization, leading R&D activities and supplying facilities for incubation and start-ups.

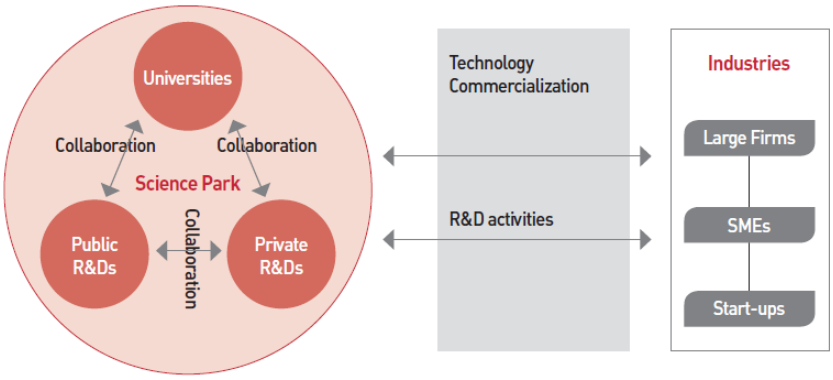

Fig. 2. Major activity links in the science and technology park

Anyway, the new roles of science and technology parks for the Industry 4.0 Era should be changed. For the Industry 4.0, it is important to invent and nurture a country's new growth engine from the convergence of ICT, manufacturing and service industries, since hyper-connection is one of the main features of the period of the 4th industrial revolution. The acceleration of networking as a growth engine of regional development could be the first role of science and technology parks in the 4th Industrial Revolution. The 4th Industrial Revolution is the concept of smart factories in which machines are enhanced with web networking connectivity and linked to a device that can imagine and make decisions on its own the entire supply chain.

We are confronting a range of new technologies that merge the biological, physical and digital worlds in this 4th Industrial Revolution. Economies, industries and all disciplines will be influenced by these new technologies and perhaps even challenge our notions about what it means to be human. In the era of the 4th industrial revolution, the networking capability of a science and technology park seems to have been an indeed critical factor. Competitive science and technology parks ought to establish an organizational framework in which networking is promoted and encouraged between universities, companies and tenants outside the park. The competitive advantage of science and technology parks relies on the growth of business and technological unions, partnerships and opportunities with analogous organizations in science and technology parks, and firms located worldwide.

It should be noted that the network of science and technology parks is focused on partnerships with the central government, local states, venture companies, large and medium-sized enterprises, universities and related institutes (endogenous networking). Networking among the local state and the management of the park helps to increase the efficiency of the park. Such international cooperation is a powerful axis of the positioning policy of the park. Science and technology parks often seek resources and skills above

national boundaries; hence, this can improve the technological innovation capacities of the local zone. Such international cooperation (exogenous networking) can operate via bilateral cooperation with one or more parks with same sectoral focus, via involvement in other parks' scientific or collaborative research projects, or with multilateral industrial enlargement initiatives. In the 4th industrial revolution, the second role of science and technology parks seems to be to executive new education plans or capacity-building projects to cope with hyper-intelligence, which is another main feature of the Industry 4.0. It is essential to use strategically the "Internet of Things" to prepare the future workforce for the challenges ahead of the Industry 4.0 [6,7].

3. Science and technology park: Future challenges

In the U.S; Science and Technology Parks (STPs) started in the 1950s. These types of parks have been introduced by several nations to grow and revitalize areas, foster high-tech industry segments, boost greater cooperation among industry and university, patronage new technology-based firms (NTBFs), and encourage academic spin-offs. While these parks have been in service for many years, there is no widely accepted description of the contributions of STPs to the area and tenant companies in the literature or consensus. STPs are a significant instrument for uniting university and industry. According to Dierdonck et al. [8] the slot among industrial technology stems and academic science from the assumption that industry and academia indicate two distinct worlds that are often contradictory of together. It is exactly in this sense that STPs stand out by establishing an atmosphere in which the interaction among research facilities and firms is encouraged. It should be noted that STPs build a climate that led to the knowledge interchange among park-based firms, universities, and the market. The two key goals of the STPs are to be a seedbed for innovation, which include promoting the growth and development of new technology-based firms (NTBFs), to boost the exchange of university know-how to tenant firms, and to encourage the development of faculty-based spin-offs. Next purpose is to be a driver for regional development via agitating economic growth and revitalizing urban zones [9].

The International Association of Science Parks and Areas of Innovation describes science and technology parks the STPs as follows:

Science and technology parks are an organization run by skilled professionals whose principal goal is to improve its community's prosperity via boosting an innovation culture and the competitiveness of its related companies and knowledge-based institutes. A science and technology park stimulates and manages the flow of technology and knowledge among academia, R&D institutes, markets and firms to allow these objectives to be achieved; promotes the development and growth of innovation-based firms by spin-off and incubation processes; and supplies other value-added services along with high-quality space and facilities [10]. STPs are anticipated to serve as a driver for growth in developing countries, supporting of the development and integration of newly constructed hi-tech companies, i.e., helping new companies to survive and attain market share and providing guidance for them to innovate their products and processes with regard to already existing firms. In developed nations, it is expected that such parks contribute to the development of an area or supposed to remove so-called "shadow areas" [11].

Small companies in the same area can through economic clustering, achieve economies of scale.

Also, a high focus in one geographical region of companies from the same industry will create an atmosphere that supports interaction and collaboration amongst them. The association with universities and research institutions is one of the parameters that distinguish STPs from conventional industrial clusters. As stated by Lofsten and Lindelof [12], a key feature of STPs is the relationship between tenant firms in parks and universities. Also represent that in economic development, small businesses and universities play a significant role. Ideally, the existence of a university nearby knowledge-based companies in an STP would make an atmosphere favourable to innovation, with knowledge and technology flowing in that atmosphere.

- Are the expectations of STPs too high?
- In certain cases, is the below-expected efficiency detected owing to deficiencies in the STPs' operations or the companies' low absorptive capacity?

Considering the first question, the results, a priori, indicate that yes is the answer. The assumption that the STPs will revitalize an entire area via producing economic development seems to be unrealistic. Despite a few deals of articles on the STPs and the traditional view of university knowledge overflow to the tenant firms, there is still scant information about the expectation of the STPs and how-to evaluation them. More precisely, studies should consider that external parameters (e.g., infrastructure, technology strategies and rewards, appeal for high-tech goods in a given area, etc.) and company internal parameters (e.g., working conditions, management style, etc.) may imply variant effects of STPs in companies and society [13]. Since 2007, the observation that SPs have shifted from being solely property management organizations to kiosks has been supported by more data. For example, this change can be supported by the fact that is added ‘areas of innovation’ to their full name, so it reads International Association of SPs and Areas of Innovation’. Some scholars identify areas of innovation' as SPs of the fourth generation or districts of innovation, focusing on the development and dissemination of knowledge to a broader community instead of providing space and supporting firms in well-defined physical boundaries. The emphasis of SPs of the next generation is not so much on the real estate aspect as on the tacit multi-disciplinary and trans-sectoral knowledge developed by management with a view to improving the creative potential of resident companies or even other companies in the local economy. Some SPs have also differentiated property services from knowledge-based functions and concentrate on knowledge creation to boost their client companies' innovation capacity. The above findings led to the offer a new concept of the next generation SP or so-called modern SP, which covers the aspects of expertise, interdisciplinary activities and its new position in the ecosystem of innovation. The emphasis is on the SP as an individual entity in this concept and not a spatial creation or assemblage of firms. Hence, a modern SP in this study is described as follows:

A mature, self-sustaining and collaborative organization operated by skilled professionals whose purpose is to raise the technological and economic assets of the zonal economy with supporting the development of its society. In order to promote the innovation potential of its customers, it supplies innovation support; improves knowledge sharing among knowledge generators and client firms; develops local, regional or

even international networks to exchange best practices and orchestrates the regional ecosystem of innovation. A modern SP offers access to quality services where synergies are encouraged. It also utilizes quality evaluation instruments to constantly learn and progress [13-17]. Davies [18,19] proposes that the success of SP should be assessed using a performance assessment method (PMS). Measurement of success, which helps to evaluate the efficacy and effectiveness of activities, has become a sector of the virtuous circle of continuous learning that increases organizational improvement and progress. According to the Economic Commission (2014), efficiency assessment is a continuous method of measuring how well or how poorly the company is doing in obtaining its pre-established objectives.

This includes the ongoing collection of data relevant to:

-Type of operations/resources utilized for generating outputs and results (input);

-Direct and instant outcome of an action (output);

-Medium-term or long-term output-related accomplishments (result/influence) [14,20,21].

New activities are primarily centered on the development of new knowledge, which is disseminated in the form of 'innovation services' (also known as ' innovation operation', 'innovation support', 'value-added services', 'knowledge-based services', 'business support services', 'SP interventions') and seeks to enhance client firms' capacity for innovation. As far as intellectual property is concerned, parks should not only concentrate on the number of patent registrations, but also a number of countries in which firms register such inventions and whether the patent has sole or shared ownership. Given the difficulty of recognizing the impact of patents on final revenue, studies should calculate the royalties that sales generate or the startups that emerge from this knowledge [22].

4. Technological Innovations and the Industrial Ecosystem of Science and Technology Parks

Science and technology parks include not only independent companies run by entrepreneurs, but also companies that could be part of a company and where the final ownership is outside the park. Science and technology parks and innovation strategies have the main mission in creating innovative resources and upbringing emerging industries, whereas partnerships among the government, university and industry and creating an ecosystem are important. Many activities around the world have led to the creation of science and technology parks, the acceleration of the transition and integration of technological and scientific accomplishments, and the efficient fostering of the growth and development of regional high-tech industries. Furthermore, sustainable innovation of ecosystem is recognized as an important driving agent for companies to contend and prosper under extremely intense global competition. Many researchers merge the theory of ecosystems with science parks, by contemplating corporations and organizations as members and key players in the ecosystem of the organization, and applying theoretical analysis and practical guidance to various laws and features of ecosystem growth. Competition and interaction amongst corporations and other entities shape an interconnected network based on the theoretical perspective of the ecosystem, in which the company and the park will be able to progress together. The government has a basic role in establishing and developing many science and technology parks. Hence,

government decisions are connected to the park's growth. Subsequently, the research on the progress of science and technology parks also requires to assess the efficacy of government policies.

The first time, the term of an innovation ecosystem was again deduced from a study released in 2004 by the US President's Council of Science and Technology. Keeping innovation ecosystem of the country, producing of information technology and competition, which suggests that the leadership in technology and innovation of the country relies on a vibrant and dynamic "innovation ecosystem" instead of a mechanical ecosystem. The ongoing reorganization of synergistic relationships of individuals, resources and knowledge, characterizes a dynamic innovation ecosystem. The innovation system is a system of resources, skills, institutes and foundation which integrates new technologies or opinions, processes of production and services [23]. The new economy is divided to three sub-economies by Yun et al. [24]: small and medium-sized corporations (SMEs) and start-ups, open and closed business innovation, big corporations, and socially open innovation. Various index systems are plotted to measure the park's innovation ecosystem according to different key parameters, but most assessment systems can be divided into two classes: one is the assessment of the park's input, production and park's flow parameter. The second is assessing the sustainability, stability, structure of the system, and full operation of the park system [25]. There is a department of innovation in science and technology parks, that is accountable for the following advancements:

(1) The establishment of demonstration parks for independent national innovation, the national demonstration park for Standardization, national torch innovation experimental city and the demonstration park for national intellectual property.

(2) presentation, operation and service of high-tech talents in the park, such as the establishment of a high-level foreign innovation and entrepreneurship talent base, the work of main contacts of the overseas Chinese affairs office, the talent apartments management, the building of biomedicine and information technology engineers training bases, management of the postdoctoral workstations and the joint postgraduate building of cultural fields.

(3) different technological and scientific operations organize in the park [23].

Since the innovation of technological alone doesn't ensure the economic success of a company, it has no inherent worth. It is not important that how fantastic technological progress is, it can't carry favorably profits to the company before commercialization. Determining key variables in the establishment of science and technology parks and potential feedback methods in the ecosystems of high-tech industries need to be necessary [26,27]. Five perceptual variables are regarded to be essential drivers of an economic ecosystem created by innovation: (a) innovation of technology; (b) industrial clusters' competitiveness; (c) modern business development; (d) economic efficiency; and (e) policy of the government.

First, the innovation of technology seems to be the first economic success of new technologies, a nonstop 'R&D-commercialization-diffusion' process. Industrial clusters' competitiveness consists of the relative comparative advantage of a peculiar industry cluster in order to drive innovation of technology and new market innovations. Third, modern business growth represents the degree to which technological

innovation is connected to the market and business model. There are patent conversion rates involved. Fourth, economic efficiency is also related to the size of the market and main business proceeds. Ultimately, policies of government consist of the science and innovation policy, fiscal policy and export promotion policy [28].

5. Conclusion

A science and technology park, ideally located next to a university, is a real-estate development. It aims to house two kinds of research-oriented companies: firms that have developed outside the university and want to retain close relations, and companies that want to place an R & D unit to a quasi-academic site. The prior sort of company requires to improve business alliances, collaborations and opportunities with same companies placed across the academia, because hyper-linked is one of the attributes of the Industry 4.0 era and this sort of company have a strong role in this. For a long time, science and technology parks have played an important role in guiding the development of national economic and laboring as a growth driver in industrialized countries. Science and technology parks worldwide seem to be facing a new movement dubbed "the Industry 4.0" with no plans for coping with this new surge. Since individual science and technology parks could be stand in a different place, no overarching tactics may be identified, some techniques, such as the expansion of networking, education to booster innovative and creative workforce, and the implementation of capacity construction projects would be essential for all science and technology parks.

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