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# Science parks' diversity and broadened roles: New concepts and grounds for evaluation

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## Introduction

There has been a fast growth of science parks in the US and the UK in the 1960s and 1970s, and this has inspired policymakers to adopt science parks in continental Europe, such as in Germany, Sweden, France, the Netherlands, and more recently in Southern Europe, for example, Spain, Portugal and Greece, and Eastern Europe (e.g. Sofouli and Vonortas 2007; Ratino and Henriques 2010). Since the early 1980s, Asian governments started to adopt science parks, such as in China, Taiwan and Singapore (e.g. Lai and Shyu 2005; Koh et al. 2005; UNESCO 2016). With this growing adoption, science parks have become more diverse in aim and practice, for example, concerning the type of target firms, the set of facilities provided and the stakeholders involved.

Policymakers tend to see science parks as effective instruments in enhancing knowledge-based regional growth and increasing regional domestic product. Accordingly, the creation of new jobs and of new high-technology firms, and the revitalization of the local and regional economy are among the positive impacts. In addition, the networks based on proximity within the park are seen as supporting the innovative power of on-site firms. In this sense, the concept of science parks fits into the stream of innovation studies on knowledge advantages from physical proximity, particularly localized knowledge spillovers (e.g. Autant-Bernard 2001; Varga 2000). It also fits into the stream of studies on Triple-Helix development in which arrangements between university, industry and government increasingly facilitate a blurring of the edges between activities and networking in knowledge creation and commercialization (Etzkowitz 2002; Ranga and Etzkowitz 2013).

The above positive images, however, contrast with the evaluation of the effects of science parks as found in the scientific literature (Luger and Goldstein 1989; Lindelof and Löfsten 2003; Siegel et al. 2003). Massey et al. (1992) argued that science parks contribute very little in promoting technology transfer and consider them as 'high technology fantasy', not more than prestigious real estate developments. Much of the evidence on science parks' impacts or goal achievement in this paper is mixed, either positive or no impact, often with uncertainty about causality. Despite this mixed evidence, science parks have remained popular as a policy tool, an apparent 'paradox' that can be understood by considering the characteristics of policymaking for knowledge-based economic growth, particularly the large uncertainty involved, a situation that calls for social capital (Hansson et al. 2005). However, the role of science parks is also broadening and getting more important, including a stronger entanglement with the university and with R&D through living labs and test labs encompassing a tighter customer and community involvement, including sustainability efforts (Goddard and Valence 2013).

The aim of the paper is to picture the diversity in science parks' development and the new implicit and broader goals, and to address new approaches in the evaluation of science parks that match the changing circumstances. Against this background, the following questions are addressed: What are the main differences between science parks, especially with regard to their goals, stakeholders and activities? Which are the outcomes of evaluation studies on achieving goals? What constitutes the science park 'paradox', and which new developments can be observed? What would be the implications for a more adequate evaluation of science parks' results? The paper draws on a study of the literature and on interviews with science parks managers and policymakers. This extended abstract has a focus on communalities and differences between science parks, results of evaluation studies of science parks impacts, new developments that are emerging, and it briefly indicates requirements for the design of an adapted evaluation/monitoring tool.

**What science parks have in common and what is different**

We take as a point of departure that science parks have three attributes in common: (1) a property-based initiative close to and connected to a place of learning (university or research institute), (2) the supply of high quality premises or units to businesses, and (3) a policy context of mixed public/private stakeholders with particular expectations on the knowledge-based economic results of the parks (Gower et al. 1996). The main differences between science parks can be summarized as follows (Van Geenhuizen and Soetanto 2008): type of stakeholders involved, the related targeted business activity, including size and supply of (incubator) facilities, and (operational) linkage with the university. Of course, there are also differences between science parks in regional location and time of origin ($1^{st}$ to $3^{rd}$ generation parks) but these differences remain beyond the paper.

The main stakeholders determine which goals and missions in individual science parks are to be achieved (Gower et al. 1996; Albert et al. 2002; Bigliardi et al. 2006; McAdam and Keogh 2006) for example, whether they are profit seeking or not and whether they have a specific objective in correcting a market failure, a specific mission in regional economic growth, or Triple/Quadruple Helix development (e.g. Benneworth and Charles 2005). The main stakeholders include universities, governments, real-estate developers and financial institutions, and resident firms. The US and the UK provide many examples in which the initiative to establish and operate science parks is at the university. The main goal of this involvement is to commercialize university's knowledge and enhance knowledge transfer to the business world, particularly to enable academics at the local university to commercialize research ideas. In some cases, the establishment of a park also serves to make idle land of the university productive. Governments involved in science park development may be national governments such as in Sophia Antipolis in France and many science parks in Asia, but also local (regional) governments perceiving opportunities from commercializing local knowledge or from positive images (prestige) of such parks. The goal is often to increase high-technology employment or, in specific cases, to restructure the local (regional) economy. A third category of stakeholders are real-estate developers and financial institutions *(*consortia). They usually see science parks as an investment opportunity, for example, gaining profits from renting or selling land and business units (manufacturing sites, laboratories, offices) and from providing financial capital to invest in on-site firms. The fourth type of stakeholder is the firm that prefers to be resident (or tenant) in the park, ranging from small university spin-off firms seeking “shelter” in incubator buildings to established multinationals seeking good image and access to networks with the university. When comparing the different goals, it becomes clear that the more stakeholders are involved and have equal stakes, the more complicated the multi-actor situation in a science park may be.

With regard to the targeted business activities*,* differences may be observed in three main aspects. First, with regard to R&D focus, many parks specialize in R&D or related activity, a few focus on manufacturing industry. Taedok City Science Park (Korea), for example, does not allow manufacturing processes to access the park and focuses on R&D. Second, with regard to the stage in the lifecycle of firms, some parks have a strong focus on the incubation of high-technology ventures, instead of attracting established firms, whereas others aim to attract a mix of these target firms or solely established firms. And, third, some science parks employ a selected technology in which the firms are active, whereas others aim at a mix of technologies. Examples of specialized parks are Leiden BioScience Park in the Netherlands (general and medical biotechnology) and Jokioinen Science Park in Finland (agriculture, food production). Further, a related set of attributes on which science parks may differ encompasses size, supply of land/buildings and particular facilities. Most important are incubators as these aim to enhance the survival and growth of start-up firms - often spin-offs from the university. Incubator facilities are offered by a part of the parks and in these cases there is also supply of managerial and business support, and rental space for next growth phases of these firms. In addition, the nature of the relationship between tenant firms and the university (research center) may also be different regarding facilities that the university provides to tenants and regarding collaborative agreements on sharing staff and joint research (Link and Link 2003; Philips and Henry 2003).

**Impacts from science parks**

The analysis in this section is limited to *ex-post* evaluation. Studies oriented towards such an evaluation are on three levels, i.e., the nation/region, the science park (and its management), and firms located on the science park. Overall, we observe that very few studies on impacts on the region have followed traditional evaluation schemes of spatial investments following the logic of impacts in the region, like direct, indirect and derived impacts. The study that comes closest is the one by Luger and Goldstein (1989). Of course such a comprehensive evaluation approach would use large amounts of data and these are often not available. Related is a type of evaluation of the extent in which science parks contribute to research and technology creation and diminish regional gaps in this respect, using bibliometric data (Minguillo et al. 2015).

Most studies, however, are on the level of the science parks, their performance as an organizational unit, and performance of on-site firms. Thus, the park is taken as the unit of analysis by evaluating whether the goals concerning supply characteristics, like type of business accommodation and services, or aggregate employment or profitable exploitation have been achieved. Also, stakeholders may be the unit of analysis, particularly in studies that evaluate the satisfaction with science parks’ and incubators’ development (for example, Mian 1997). We mention the first systematic investigation of employment growth of science parks in the US (Link and Scott 2006) as a study not designed to capture efficiency or important impacts of science parks but to identify parks with a particular profile being more productive than others: parks closer to universities, operated by a private organization and employing a specific technology focus tend to grow quicker than the average of the parks. A more recent schedule for evaluation that connects with the need for a more comprehensive evaluation and monitoring, is given by Dabrowska (2011). In addition, the EU has designed a model of evaluation that complies with goals and management (EC 2014).

Regarding the performance of the firms, some authors take a longitudinal approach and focus on one particular science park through time, while others compare various science parks at one point in time. Some studies fail to gather information concerning a control group, a situation that may obscure causality issues (Siegel et al. 2003), but most frequently applied is the on-site firm performance using a comparative analysis of on-site and off-site firms in a quasi-experimental approach. In such analysis, on-site firms are expected to be more innovative, grow quicker and have a higher survival rate, in particular, benefit from higher levels of networking with other on-site firms and the university. Such positive effects, however, are seldom unambiguously proved. Overall, the results tend to be mixed, that is, a positive effect or no effect, or not conclusive. Thus, the Westhead studies (1994-2003) did not find differences in performance between on-site and off-site firms except for R&D intensity and survival rate, while Colombo and Delmastro (2002) and Lindelöf and Löfsten (2003) found various positive impacts on on-site firms' performance. With regard to networking benefits, the outcomes tend to be equally mixed. Thus, Bakouros et al. (2001) found both positive impacts and absence of impacts concerning university-industry interaction, and modest on-park synergy impacts, while Lindelöf and Löfsten (2003) even found negative results, namely less collaboration by on-site firms. In addition, Fugukawa (2006) found a higher propensity of on-site firms to engage in joint research with knowledge institutes, but the linkages were not with the local science park tenants. An important observation is that the expected causality can often not be established. Colombo and Delmastro (2002) found overall positive results of a science park (incubator) but the partially better growth performance of the firms might be caused by a positive selection of on-site firms. The causality tested is accordingly concerned with the (positive) qualification of the selected entrepreneurs rather than the on-park location.

We may conclude this part as follows. Evaluation studies are rather different in the aspects of science parks that are subject to evaluation. The results are somewhat ambiguous concerning positive impacts and concerning the causality between on-site location and firm performance. More importantly, the fragmentary character of most studies seems not to comply with the broader roles of science parks and an increasing integration with campuses and living labs. Further, a clearly forgotten dimension in evaluation studies is growth of the park decomposed into different types of firms and/or other organizations, like locally established firms and existing firms attracted from other regions (i.e. from abroad), and national (public) research institutes, causing different growth dynamics.

**New developments**

Quite recently a new science park model/view has been forwarded concerning the links with the university, named the *campus model* (Hansson et al. 2005). In this integrated model, the university is the science park where all stages of innovation are centered, where one attempts to create entrepreneurs of students and to commercialize new technologies or research results. This model is said to be exemplified by Newcastle in the UK. A further integration is also taking place if science parks are combined with *living labs and test beds* in networks of open innovation in which customers of innovative products and processes play a strong role, potentially causing a partial substitution of in-company or in-university labs. Living labs are derived from the idea that customers can play an important role in the creation of innovations and in their improvement. Accordingly, in a delimited real-life environment, co-creation/design, testing and validation take place between researchers and mainly customer groups and communities (citizens), in sectors like medical care, sustainable energy, transport, sustainable housing, safety, etc. (Almirall and Wareham 2012; Van Geenhuizen 2013). Furthermore, another aim of science parks is emerging and that is the realization of sustainability or more specific, overall energy efficiency. For example, in Taiwan, the contribution of science parks is increasingly seen as a combination of economic growth and energy efficiency. Energy efficiency at science parks can be enhanced by the government by supplying shared facilities and imposing specific taxation and management models on the parks' tenants (Yan and Chien 2013). Another example is the policy for Hong Kong Science & Technology Parks, employing various sustainability visions and targets, like 'net zero carbon target' and 'green tech hub' acting as a catalyst for innovation and development of green technology use in the city and Pearl River Delta Region. In Europe, many regular science parks host some offices or parts of the park that are energy neutral or contribute to another sustainability goal, but the general goal of these science parks has seldom been formulated in terms of energy efficiency.

And finally, some new insights are being adopted in policymaking. Policymaking today is faced with manifold uncertainty. Uncertainty does not only originate from external factors that are beyond control of policy makers but also from changes in internal processes, including shifts in preferences and perspectives of actors. The influence of these uncertainties implicates that the overall outcomes of interventions and thus the reaching of aims, are uncertain to some extent (Walker et al. 2001; Albrechts 2004). Responding to uncertainty implies that policies allow for adjustment on the way to new realities with monitoring acting to identify if and what actions need to be taken to get policy measures better implemented or to correct them.

**Conclusion**

Past evaluation studies of science parks have produced outcomes that are either not conclusive or in part positive in terms of impacts on performance of on-site firms, and these studies are also rather fragmentary. In particular, the causality question has remained largely unsolved. Despite this situation, science parks, paradoxically, have remained very popular as a policy tool. The results indicate that this situation can be attributed to implicit goals (social capital) and emerging new goals of science parks in the knowledge-based economy, like closer integration with the university and collaborative research with user-groups and communities.

All above indicated circumstances have implications for the design of an adjusted evaluation tool. Accordingly, a list of requirements for such tool need to reflect a certain flexibility given a large uncertainty including causal relations, the multi-actor situation and the connected need for participatory evaluation, a process approach, an integrated approach taking implicit/new roles of science parks into account, and a spatial impact approach including growth mechanisms. However, designing a proper evaluation tool is dependent on the aim of the evaluation and on finding a balance between what is ideal and what is realistic given tight time schedules and constrained budgets in practice. Therefore, as a first act the evaluation agents need to propose priorities dependent on the evaluation goal and the specific local situation(s).

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