Performance Measures to Assess the Success of Contemporary Science Parks

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Abstract

Although the science park (SP) concept is more than 50 years old, it has been continuously evolving and changing and new doubts, questions and needs have come to light. In order to understand and talk about the future of SPs, it seems necessary to understand their actual level of success. It is not a straightforward task as SPs are multi-owner organisations and definition of success will vary from one SP to another. Moreover, SPs have developed new roles and activities that are not easy to measure. Thereby, the aim of this paper is to fill in the gaps that exist in the literature on measuring the extent of success of contemporary SPs as individual organisations providing support for the benefit of its community. The paper proposes to measure SP success by means of a performance measurement system (PMS). It offers a theory grounded tool to assess the effectiveness of SP actions and activities including knowledge-based activity. Additionally, the paper provides some strong evidence that SPs show characteristics in common with knowledge intensive organisations (KIOs) and therefore play an important role in orchestrating innovation ecosystems.

Keywords

Innovation services – Knowledge intensive organisations – Performance measurement – Performance measurement systems – Science parks
Arabic

قياس نجاح المجمعات العلمية المعاصرة

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المملص

على الرغم من أن مفهوم المجمعات العلمية قد مضى عليه أكثر من 50 عاما، فقد تطور باستمرار وظهرت شكوك وأسئلة واحتياجات جديدة. بات من الضروري فهم المستوى الحقيقي لنجاح المجمعات العلمية حتى تمكن من الحديث عنها وفهم مستقبلها. تعتبر أن هذه المهمة ليست بسيطة لأن المجمعات العلمية هي مؤسسات متعددة الشركاء، ويتغير تعريف نجاحها. بالإضافة إلى ذلك، قامت هذه التجمعات بتطوير أنشطة جديدة ليس من السهل قياسها. وبالتالي، يهدف هذا المقال إلى سد الثغرات في قياس نجاح المجمعات العلمية المعاصرة. يقترح المقال نظام لقياس الأداء وهو عبارة عن أداة نظرية لتقييم فعالية هاته التجمعات. بالإضافة إلى ذلك، يقدم المقال أدلة قوية على أن المجمعات العلمية المعاصرة تتمتع بخصائص مشتركة مع المنظمات الناشطة في مجال المعرفة المكثفة. ولذلك فإنها تلعب دورا هاما في تنسيق النظم الإيكولوجية للإبداع.

الكلمات المفتاح

مجمعات العلوم، خدمات الابتكار، قياس الأداء، أنظمة قياس الأداء، التنظيم القائم على المعرفة المكثفة

Chinese

衡量当代科学园的成功

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摘要

尽管科学园的理念已有50多年的历史，但它一直在不断发展，出现了新的质疑、问题和需求。为了理解和谈论科学园的未来，似乎有必要了解其成功的实际水平。这是一项简单的任务，因为科学园是多个所有者的组织，成功的定义会有所不同。而且，科学园已经开展了一些不容易测量的新活动。因而本文的目的在于填补衡量现代科学园成功与否的空白。提出通过绩效评估系统来评估科学园的成功。它提供了一种基本理论工具来评估科学园的有效性。此外，本研究还提供了一些有力的证据，表明科学园具有与知识密集型组织相同的特征，故而在协调创新生态系统中发挥着重要作用。

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French

Mesurer le succès des parcs scientifiques contemporains

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Résumé

Bien que le concept de parc scientifique date de plus de 50 ans, il n’a cessé d’évoluer et de nouveaux doutes, questions et besoins sont apparus. Afin de comprendre l’avenir des parcs scientifiques et en parler, il s’avère nécessaire de comprendre leur niveau réel de réussite. Ce n’est pas une tâche simple car les parcs scientifiques sont des organisations multipropriétaires et la définition de la notion de succès varie. De plus, les parcs scientifiques ont développé de nouvelles activités qui ne sont pas faciles à mesurer. Le but de cet article est de combler les lacunes sur la mesure de l’étendue du succès des parcs scientifiques contemporains au moyen d’un système de mesure de performance. L’article décrit un cadre théorique pour évaluer l’efficacité des parcs scientifiques. En outre, le document fournit des preuves solides que les parcs scientifiques présentent des caractéristiques communes aux organisations à forte intensité de connaissances et jouent ainsi un rôle important dans la gestion des écosystèmes d’innovation.

Mots-clés

parcs scientifiques – services d’innovation – mesure du rendement – systèmes de mesure du rendement – organisation à forte intensité de connaissances
Portuguese

Medindo o sucesso dos parques tecnológicos contemporâneos

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Resumo

Embora o conceito de parque tecnológico tenha mais de 50 anos, está em constante evolução e novas dúvidas, perguntas e necessidades tem surgido. A fim de entender e falar sobre o futuro dos parques tecnológicos, parece necessário entender o nível real de sucesso deles. Não é uma tarefa simples, tendo em vista que os parques tecnológicos são organizações de múltiplos proprietários e a definição de sucesso varia. Além disso, os parques tecnológicos desenvolveram novas atividades que não são fáceis de medir. Assim, o objetivo desse artigo é preencher as lacunas na medição da extensão do sucesso dos parques tecnológicos. O artigo propõe medir o sucesso do SP por meio de um sistema de medição de desempenho. O sistema oferece uma ferramenta fundamentada na teoria para avaliar a eficácia do parque tecnológico. Além disso, o artigo fornece fortes evidências de que os parques tecnológicos apresentam características em comum com organizações intensivas em conhecimento e, portanto, desempenham um papel importante na orquestração de ecossistemas de inovação.

Palavras-chave

Parques científicos – serviços de inovação – medição de desempenho – sistemas de medição de desempenho – organização intensiva em conhecimento
Оценка успешности современных научных парков

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Аннотация

Несмотря на то, что концепция научных парков появилась более 50 лет назад, она продолжает развиваться и порождать новые вопросы и задачи, которые должны быть решены. Для того, чтобы понимать и обсуждать перспективы научных парков, необходимо оценить их текущий уровень успешности. Это не такая простая задача, поскольку владельцами научных парков являются группы организаций, и, соответственно, критерии успешности могут различаться. Кроме того, научные парки реализуют новые виды деятельности, которые не так легко измерить. В этой связи, целью настоящей работы является заполнение пробелов, связанных с оценкой эффективности современных научных парков. В данной статье предлагается измерять успешность научных парков путем применения системы оценки эффективности. Это позволяет создать теоретический инструмент, позволяющий измерить эффективность научных парков. Дополнительно, в статье приводятся убедительные доказательства того, что научные парки имеют характеристики, схожие с наукоемкими организациями, и потому играют важную роль в управлении инновационной системой.

Ключевые слова

научные парки – инновационные сервисы – системы оценки эффективности – наукоемкие организации
Spanish

Medición del éxito de los parques científicos contemporáneos

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Resumen

Aunque el concepto del parque científico tiene más de 50 años, ha evolucionado continuamente y han surgido nuevas dudas, preguntas y necesidades. Para comprender y hablar sobre el futuro de los SP, parece necesario comprender su nivel real de éxito. No es una tarea sencilla ya que los SP son organizaciones de múltiples propietarios y la definición de éxito variará. Además, los SP han desarrollado nuevas actividades que no son fáciles de medir. De este modo, el objetivo de este documento es llenar los vacíos en la medición del alcance del éxito de los SP contemporáneos. El documento propone medir el éxito de SP mediante un sistema de medición de desempeño. Ofrece una herramienta basada en la teoría para evaluar la efectividad de SP. Además, el documento proporciona algunas pruebas sólidas de que los SP muestran características en común con las organizaciones intensivas en conocimiento y, por lo tanto, juegan un papel importante en la organización de los ecosistemas de innovación.

Palabras clave

parques científicos – servicios de innovación – medición del desempeño – sistemas de medición del desempeño – organización intensiva en conocimiento

1 Introduction

Science parks (SPs) have evolved over time and their spectrum of roles and activities has broadened (Nosratabadi et al. 2011; Hunjet et al. 2018). From accidental developments in the 1950s (Charles and Uyarra 2010) they became popular policy instruments across the world (Oh and Kang 2011) and play an important role in innovation ecosystems (Allen 2007). They have gained international reputation and major institutions such as the European Commission, the European Investment Bank and the United Nations have become
increasingly interested in evaluating success of SPs. However, the literature casts considerable doubt on the success of SPs. Various methodologies used to assess the additionality of parks have focused on assessing the performance of park firms rather than evaluating SPs’ own activities and actions.

As SPs have matured, a few academics have highlighted the need for them to achieve the status of financially sustainable businesses (Goldstein and Luger 1991; Allen 2007) and to ensure that they constantly measure progress towards their strategic goals (Davies 2013a). However, measuring progress towards goals within the SP sector is not a straightforward task (Vila and Pages 2008; Escorsa and Valls 1996; Nosratabadi et al. 2011). The goals may vary depending on park shareholders who have different agendas and expectations (Goldstein and Luger, 1991; Allen, 2007). Moreover, unique features that distinguish SPs from typical property management organisations make their success measurement even more complex.

There is no consensus on what is a successful SP and it is particularly difficult to properly compare these ventures (Dabrowska 2009, 2011; Ferrara et al. 2016). Measuring SP success has been a challenge for practitioners as well as academics for decades. This is mainly due to heterogeneity and complexity of their ownership model and varying expectations of different stakeholders. Additionally, SPs have developed new roles and knowledge-based activities which are not straightforward to measure.

In order to contribute to fulfill this gap, this paper discusses the SPs’ performance evaluation theme and proposes a new approach towards performance measurement system of SPs. Thereby, this paper encapsulates the outcomes of a research carried out between 2010 and 2017 to develop a better understanding of what a successful SP means to public, private and university owners as well as to client companies. The empirical part of the research has consisted of two steps, first an exploratory part with action research and second, a validation stage with survey research. The main outcome of the research is a flexible system, as a reference model, with suggested performance indicators which measure SP success at all levels of activity and consequently leads to demonstrate the impact of their actions in innovation ecosystems.

The article starts with Section 2 which presents the theoretical and conceptual framework that addresses issues related to the SP phenomenon. Section 3 discusses new roles and activities which SPs have been engaged in and which are not easy to assess. Section 4 demonstrates research problems and needs. The following section lays out the methodology used in the research (Section 5). Section 6 summarises the outcomes of the action research which is followed by results of the survey research (in Section 7) and presentation of the final performance measurement system (PMS) for SPs.
2 Understanding the SP Phenomenon

Although it is not clear what theoretical reasoning lay behind the SP phenomenon, with time, the conceptual position of SPs has been redefined. Clark (2003) demonstrates that SPs are not an outcome of a rational model of technology transfer grounded in economic theory. With time, SPs have gained interest within the European Union (EU) and are considered to be institutional instruments in science policy (Hansson 2007). SPs are a valuable instrument facilitating interconnections between the government, university and industry (catalyzing the triple helix model) within knowledge-based regional innovation systems (Etzkowitz 2008; Leydesdorff and Meyer 2003; Georgiou and Davies 2010).

A conceptual formulation for SPs is difficult to be fully consensual (Link and Scott 2003; Hansson et al. 2005). There are several typologies proposed in the literature and all can be useful depending on the object of analysis. In both, the literature and in practice different terms are used to describe the same phenomenon (Vila and Pages, 2008) i.e. SPs, research parks, technopoles, technopolis, science city, innovation centres, now even science partnerships. The SP movement started in the 1950s as an experiment rather than a well framed instrument of regional innovation policy (Charles and Uyarra 2010). It has its roots in the US (Bakouros et al. 2002; Isabelle 2013; National Research Council 2009) where the first SP was created by Stanford University in 1951 and followed by the Research Triangle Park, established in 1959. The concept was widely adopted across the world over the following decades, e.g. Sophia Antipolis was established in 1969 in France, followed by the Cambridge SP founded in 1972 in the UK.

The rationale behind the early SPs like Stanford Research Park or the Cambridge SP lay in the aspiration of universities to generate revenues from their land holdings and research activities. Based on the achievements of the first SPs, policy-makers saw their potential in terms of fostering economic and technological wealth. Consequently, more SPs were created in the 1980s and 1990s with the aim of generating a positive impact on regional economic growth. The SP movement in Europe appeared in the mid-1980s (Howells 1984; Kenward 1989; Carter 1989). However, the majority of existing SPs were established in the 1990s and later (iasp1 2012).

Over the years the concept of a SP has been reinvented and redefined as regional innovation and science policies have developed (Charles and Uyarra 2010). Charles and Uyarra (2010) describe the evolution of the SP creation in four main phases. According to them, phases II (mostly 1980s), III (mostly 1990) and IV (2000s) were heavily influenced by the policy environment.
Phase I SPs were considered experiments. Phase II SPs appeared at the time that universities were setting up technology transfer offices in order to realise revenue from their own assets, their intellectual property. SPs in this phase were often seen as a remedy to improve post-industrial economies. The model of phase II SPs (e.g. Mjärdevi SP in Sweden, Manchester SP in the UK – today known also Manchester Science Partnerships) was built on the observation of the achievements of phase I SPs (Macdonald 1987). The model of phase III SPs was influenced by regional innovation strategies focused on cluster development. SPs were considered as partnerships formed to provide services to clustered companies (Allen 2007). More recently, regional innovation policies have emphasized the importance of basic research in creating regional competitive advantage and consequently investments were made to form large science zones or science cities called phase IV SPs (Charles and Uyarra 2010).

SP organisations may have different legal forms (Marinazzo 1996). Some are non-profit organisations, some are companies with shared capital, some will be set as foundations or consortia, etc. It depends on contexts as well as on political arrangements which vary from country to country or from region to region.

According to Silveira (2004) the ownership structure is a key governance mechanism. Governance in the context of SPs relates to the structures established for strategic (e.g. boards) and operational decision-making (management) which are linked to ownership and funding and reflected in their legal structures (European Commission 2014). There are various SP governance structures around the world but there is no detailed classification available for those structures and the implications for success. What is known is the broad statistics relating to ownership which are discussed below.

SP ownership structures are often based on a partnership between regional or national governments (public sector) and universities although there are examples of SPs that belong to only one of them. In some countries private sector can also partner with government or universities. Those organisations, due to their different nature, become owners of parks for different reasons; they bring their skills and agendas to the table and therefore have different expectations from the park management teams.

Some SPs have reviewed their ownership structures over the years due to internal changes (strategic objectives of owners have changed) or external contextual change (the changing economic conditions and policy environment) (Davies 2013b). Three examples of SPs which recently changed their ownership structures are Birmingham SP Aston, Manchester Science Park and Warwick SP in the UK. Based on the observations from the IASP reports (IASP 2012; IASP 2015) it can be assumed that the public sector (including public
universities) still has a predominant place in the SP ownership composition (54.8%). However, the private sector presence in the ownership composition is growing and is more visible.

Furthermore, the IASP data illustrate that the percentage of the IASP member parks which belong to the public sector decreased from 55% in 2011 to 50% in 2014 (IASTP 2012, 2015). At the same time, the percentage of the IASP member parks wholly owned by the private sector also decreased by 2% between 2011 and 2014 (from 16% in 2011 to 14% in 2014). However, the mixed ownership of IASP member parks increased by 6% (from 29% in 2011 to 35% in 2014). Moreover, the split of the ownership majorities within mixed ownership IASP member parks changed. 63% of the IASP member parks with mixed ownership had a public sector which had a majority of the ownership in 2011. This percentage decreased to 57% in 2014. In contrast, 17% of the IASP member parks with mixed ownership had a private sector which had a majority of the ownership in 2011. This percentage increased considerably to 30% in 2014 (IASTP 2012, 2015).

Summarising, SPs are complex and unique constructs with many different elements. SPs operate in contexts which influence the ownership structures as well as their strategic objectives which are multiple. The flexibility of the phenomenon has advantages but also disadvantages. It makes assessment of SP success even more complicated.

3 Moving from Bricks to Brains

Over the years, SPs have developed new roles and activities (Nosratabadi et al. 2011) and academics started looking at SPs from a different perspective, not as real estates, property management organisations, development zones, home to innovative companies but as separate entities engaged in knowledge production and diffusion for the benefit of their communities. Hansson was the first who in 2007 compared SPs to Knowledge Intensive Organisations (KiOS). However, after carrying out an analysis he claimed that SPs fail to exhibit all the necessary attributes of KIOS.

However, since 2007 the parks have evolved and new papers have been published providing evidence of SP characteristics similar to attributes of KIOS (Allen 2007; Ratinho and Henriques 2010; Davies 2013a, 2013b, 2015; EC 2014; Bigliardi et al. 2006). Precisely in 2007, a ‘Third Generation SP Report’ (Allen 2007) was issued. In this report Allen observes that mature or so called third generation SPs show other characteristics not in common with property organisations. He, for the very first time, states that SPs moved from “bricks to
brains” (Allen 2007: 34) and their staff is heavily engaged in intellectual work for the benefit of their clients.

Some academics argue that SP organisations live in the shadow of industrial economy, focus mainly on the property aspect rather than on the knowledge creation aspect, generate limited economic impact and therefore are not real players within the knowledge economy (Hansson 2007; Shearmur and Doloreux 2000). They blame SPs of focusing on the firm as a single, independent business with an entrepreneur as a core who offers ideas/technologies as his own invention, not part of team work.

The above statements do not match Allen’s observation that 21st century SPs (third generation SPs) “are a significant part of the innovation ecosystem and a key to its success” or are “leaders in the development of the knowledge economy” (Allen 2007: 9). Furthermore, some academics argue that contemporary SP organisations drive and orchestrate the regional innovation system and are critical ingredients of a successful knowledge-based economy” (Davies 2013b; Oh and Kang 2011).

Over the years SP management organisations have changed their attitude towards knowledge production and management. Although traditionally the main function of SPs was indeed a real estate function, SP managers have learned by experience that they could create value to their resident companies by creating new knowledge-based services. Thus, they adapted to business support requirements of knowledge economy firms (Aaboen 2009; Ratinho and Henriques 2010) and currently produce highly valuable knowledge which is of competitive importance to the whole economy (Wong and He 2005).

Park management organisations went even further. There are examples of parks that provide innovation services to companies outside the park which are of competitive importance to them. Interactions of this type stimulate cross sector collaborations between companies at local level and further. The SP networking boundaries have moved from disciplinary and sector networking to multi-disciplinary and trans-sector networking, from local networking to national or even international. Best practice sharing, communication and connectivity with the external networks is one of the key activities for SP organisations (Ratinho and Henriques 2010). The park management actively encourages ‘happy accidents’ (Allen 2007). SP organisations play a crucial role in making the right connections at the right time within their communities and are able to apply design thinking to speed up the innovation process of tech companies. This is possible as SPs management organisations employ highly qualified professionals with a strong knowledge base who engage in the knowledge production process and its diffusion (Allen 2007).
Although there is some doubt as to whether networking can foster scientific collaboration (Oakey 2012) using a mix of different support mechanisms provided by the park management raises probability to enhance links with academia or other business partners.

Since 2007, there has been more evidence confirming the observation that SPs have shifted from being strictly property management organisations to KIOS. For instance, this shift can be supported by the fact that IASP added ‘areas of innovation’ to their full name so it reads International Association of SPs and Areas of Innovation. Some authors consider ‘areas of innovation’ as fourth generation SPs (Formica 2003, 2009) or innovation districts (Birch 2015) which concentrate on knowledge creation and distribution to a wider community rather than providing space and supporting companies within well-defined physical borders.

Hence, the focus of the next generation SPs is not on the real estate aspect so much as on the tacit multi-disciplinary and trans-sector knowledge created by the management with the view to improve the innovation potential of resident companies or even other companies in the local economy. Some SPs (e.g. Mjardevi SP in Sweden, Z-Park in China or 22@Barcelona in Spain) even separated property services from knowledge-based functions and concentrate on producing knowledge to improve the innovation potential of their client companies.

This shift was also discussed by Davies (2013b), who recognises that third generation SPs have developed further and have adapted themselves to a changing world becoming ‘areas of innovation’. According to Davies (2013b) areas of innovation have growing innovation activity which is visible and celebrated. Also, globally, SPs expand more in terms of services than in physical size. In 2013, 52% of SPs introduced new services in contrast to 29% of SPs that grew in size (IASP 2015). Hence, SPs can be regarded as a nurturer of innovation (Allen 2007), an important element of the knowledge economy.

The above observations lead to propose a new definition of a next generation SP or so called contemporary SP which encompasses knowledge aspect, interdisciplinary activities and its new role in innovation ecosystem. In this definition the focus is on the SP as an individual organisation and not a spatial development or assemblage of companies. Therefore, a contemporary SP in this research is defined as follows:

A mature, self-sustainable and collaborative organisation managed by qualified professionals whose aim is to enhance the technological and economic wealth of a regional economy by supporting the growth of its community. In order to improve the innovation capacity of its clients, it
provides innovation support; promotes knowledge exchange between knowledge generators and client companies; builds local, national or even international networks to share best practices and orchestrates the regional innovation ecosystem. A contemporary SP provides access to quality facilities where synergies are promoted. It offers visibility of their operations and is able to measure progress made to respond to the changing demands of the local knowledge economy. It also applies quality assessment tools to continuously learn and improve.

4 Problems Addressed and Research Need

Although first SPs have been considered as experiments (Charles and Uyarra 2010) since 1980s SPs have been widely discussed in the context of economic development, mostly being a tool of innovation policy and economic development initiatives (Gyurkovics and Lukovics 2014). Most of early SPs were founded using public money and today they have to demonstrate to investors and funders, how successful they have been in meeting their initial objectives and the impact on regional economic growth they generated. Especially in the last 15 years the public sector, under pressure from the electorate, became increasingly interested in measuring its own performance and that of organisations in which they have a financial interest (Thomas 2006).

However, “although SPs have been in existence now for over 50 years, there is no clear indication that science and technology parks actually meet their objectives” (Isabelle 2013: 70). Therefore, one of the overriding issues surrounding SPs is whether or to what extent they have been successful, what SP success is and how to measure this success. According to Etzkowitz and Zhou (2018), SPs take various guises and are neither a panacea nor a dead end. The authors argue that premature conclusions are sometimes drawn regarding SPs success and failure, relying on synchronic case studies, without taking into account potential for strategy change.

Considering whether or not SPs have been successful is very challenging as there are many contrasts amongst SPs and their organisational goals. This is due to the fact that those responsible for setting up and/or owning SPs have different expectations, and the role of SPs changed over time and according to different contexts (Massey et al. 1992). Moreover, while looking at the literature discussing SP successes or failures the researcher observed that academics focused mainly on evaluating on-park company performance rather than SP performance as independent organisations (Dabrowska 2011). An important part that was missed in those impact assessments and evaluation studies was the
measurement of the effectiveness and efficiency of the park as an individual organisation focused on providing support to its community. Focusing on measuring park organisational performance in order to assess its success seems justified as the park is unlikely to be successful if its operations are not effective and efficient.

An organisation or a project is successful if it achieves its agreed objectives and consequently meets or exceeds stakeholder expectations (Davies 2013a). This may become problematic for SPs as they are often multi-stakeholder organisations (Formica 2009) and various entities (public sector, private sector and/or universities) are involved in the ownership structure. Multi-stakeholder organisations have a multiple-goal nature and their goals may alter depending on stakeholders (Defourny et al. 2006). Since a successful park will mean something different to different stakeholders, it is difficult to assess the success or failure of SPs in a uniform way. Massey et al. (1992) claim that the diversity of SPs shows that there is no standard formula for the success of SPs.

Considering the presented context, it can be concluded that the proposal of a performance management model for SP is a complex task, due to the variety of actors and expectations involved, that cannot be generalised. Therefore, in this research the unit of analysis is SPs as individual organisations (a contemporary SP) managed by professionals and having their own goals, strategies, owners and clients.

Davies (2013a, 2013b) suggests that SP success should be measured by means of a performance measurement system (PMS). Performance measurement, which helps assess the efficiency and effectiveness of actions (Neely 2002) has become part of the virtuous circle of continuous learning which enhances improvement and progress (Oliver 2009) within organisations. According to Economic Commission (2014) performance measurement is an ongoing process of monitoring how well or how poorly the organisation is doing in achieving its pre-established goals. It involves continuous collection of the data related to:
- Type of activities/resources used to produce outputs and outcomes (input);
- Direct and immediate result of an activity (output);
- Medium-term or long-terms achievements that result from outputs (outcome/impact).

Following the trend of measuring performance within both private and public organisations in the early 21st century, SPs put by themselves ad-hoc performance measures to assess their performance. They used rather traditional indicators or operational (mostly space related) indicators paying limited attention to new SP activities and the role of knowledge within SP management organisations (Hansson 2007).
As seen in the previous section, new activities concentrate mainly on producing new knowledge, which is diffused in the form of ‘innovation services’ (called also ‘innovation support’, ‘innovation activity’, ‘business support services’, ‘knowledge-based services’, ‘value-added services’, ‘SP interventions’) and has the objective of improving the capacity for innovation of client companies. These services appeared gradually when SP managers have learned by experience that they can add value to their resident companies by creating and distributing new knowledge that meets the business support requirements of knowledge economy firms. Innovation services became the key activities of SPs that distinguish them from property management organisations (IAFP 2015). Those activities are based on knowledge produced by SP employees and have impact on performance of their clients. Innovation services are knowledge based activities similar to activities produced by KIOS, and due to their intangible nature, are not straightforward to measure. Nevertheless, SP owners ask for more evidence of how effective these activities are, what impact they have on on-park companies and how they contribute towards SP commercial performance.

Indicators related to internal knowledge production within SPs are not widely used despite the growing focus on knowledge in the new economy. A few workshops and conferences were organised by IASP and/or individual SPs around the subject of performance measurement, however as concluded by Bigliardi et al. (2006) no common methodology as to what to measure and how to measure has been developed.

Although no common approach towards SP performance measurement has been proposed, a range of generic PMSs has been developed over the last 30 years. Performance measurement revolution began in the 1980s and resulted in the development of new conceptual performance measurement frameworks or in other words performance measurement systems (PMS) such as Balanced Scorecard, Performance Prism, SMART Performance Pyramid, Performance Measurement Matrix, Results and Determinants, Business Excellence Model.

Taticchi et al. (2010) show that between 1970 and 2008 the most popular performance measurement tool was Balance Scorecard. Similarly, Neely (2005) claims that between 30 and 60 percent of firms have adopted Balanced Scorecard in the US.

Kaplan and Norton (1992) integrate four perspectives into their Balanced Scorecard, i.e. financial, customer, internal business and innovation and learning perspectives. The main objective of their work was to introduce new measures i.e. financial and non-financial, internal and external, leading and lagging and short and long-term measures and maintain a balance between them.
Balanced Scorecard puts strategy and vision in the centre of the system (see Figure 1). It has evolved from a measurement tool to become a strategic performance model (Savvar 2015).

Balanced Scorecard is based on a multi stakeholder approach. Kaplan and Norton (1992) identify two types of stakeholders: customers and shareholders. Although the Balance Scorecard takes into account the interests of those two groups of stakeholders, it does not include other possible stakeholders (Neely et al. 1995; Atkinson et al. 1997). Despite the shortcomings of the Balanced Scorecard (Lingle and Schiemann 1996; Brown 1996), no failures of the framework have been acknowledged (Hepworth 1998).

Based on the literature indications a weakness and strength analysis of the most popular PMS is proposed in Table 1.

All of the analysed PMSs address the limitations of traditional performance measures which were mostly financial based on traditional accounting. The financial dimension, though it is still an important indication of company performance and growth, was completed with other non-financial dimensions. The discussed frameworks indicate that organisational performance is to be
| PMS                        | Strengths                                                                 | Weaknesses                                                                 |
|----------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Performance measurement    | – Shows what the measures could look like                                 | – Does not include all dimensions of company’s performance such as customers dimension or human resources |
| matrix                     | – customer related measures are included on the framework                | – customer related measures are included on the framework                |
| Keegan et al. (1989)       | – gives some information about areas of performance to consider when designing a PMS, helps define goals | – does not provide a truly balanced view of performance                   |
|                            | – simple and flexible                                                    | – does not provide clear guidelines how to develop adequate measures     |
|                            | – helps define strategy                                                  | – designed for manufacturing industries                                  |
| Results and determinants   | – links results with determinants                                        | – does not provide clear guidelines how to develop a complete PMS with adequate measures |
| Fitzgerald et al. (1991)   | – designed for service industries                                        | – no mention of link between strategy and performance                     |
|                            | – Talks about capturing intangibility of service                         | – not considering interest of stakeholders                                |
|                            | – talks about innovation as one of the determinants of company’s success with generates impact on results (financial and market performance) | – helps formulate a clear vision, translates strategy into targets       |
| Balanced scorecard         | – helps formulate a clear vision, translates strategy into targets       | – does not provide information how to benchmark the results – difficult benchmarking |
| Kaplan and Norton (1992)   | – is a transparent multi-disciplinary and multi-dimensional communication and monitoring tool | – lack of guidelines which measures to use for each perspective and how to manage the process |
|                            | – gives a clear view on interconnection between company’s success and performance drivers | – some areas are difficult to quantify                                   |
|                            | – includes financial and non-financial dimensions of the business       | – complex tool needing commitment within an organisation towards accepting it |
|                            | – looks at performance from different stakeholders’ perspectives (customers and shareholders) | – balanced scorecard                                                    |
### Table 1  
Strengths and weaknesses table designed by the author (cont.)

| PMS | Strengths | Weaknesses |
|-----|-----------|------------|
|     | it is a self-assessment tool at company level | not considering interests of all stakeholders (lack of suppliers, competitors, HR, employees, regulators and community) |
|     | links between different dimensions of business performance together | |
| Business excellence model | is a comprehensive, self-assessment tool | no balance within dimensions |
|     | identifies strong and weak points of the company | criteria are general |
| European Foundation for Quality Management (EFQM) (2001) | encourages systematic performance measurement | is not directly linked to company’s strategy (not a strategic management tool) |
|     | allows sharing of best practices with order businesses | does not provide clear guidelines how to develop and manage adequate PMS |
|     | indicates measuring performance in the area of innovation and partnership development | |
|     | indicates public responsibility as one of the drivers of the company’s performance and impact on society as a result of company’s operations | |
| SMART performance pyramid | indicates to measure performance in the area of quality | aimed at manufacturing organisations |
|     | encourages to link overall business objective with operational objectives – is a strategic management tool | does not provide guidelines how to select performance indicators |
| Cross and Lynch (1998/1999) | highlights customers’ importance and quality of service provided | does not give details about form of measures |
|     | points to measure ‘waste’ – links company’s performance with corporate social responsibility with the aim to reduce waste | terms are so broad that is difficult to put in to practice |
|     | | customers and employees are main stakeholders considered in the framework |
measured using numerous parameters in a more balanced and multidimensional way. This holistic approach is essential to assess overall business health and organisational success (Neely et al. 2002).

Balanced Scorecard and Performance Pyramid are two excellent examples of strategically driven performance measurement frameworks. Interestingly, Business Excellence Model and Performance Measurement Matrix suggest measuring performance related to “innovation aspect”.

All of mentioned PMS have strengths and weaknesses (Striteska and Spickova 2012; Garengo et al. 2005). In general, the developed performance measurement models, although they have a clear and extensive theoretical background,
do not offer ready to use solutions or guidance as to how an organisation should develop their own PMS. They do not point out exactly what and how to measure and furthermore do not propose guidelines for a practical implementation at the operational level (Garengo et al. 2005). Moreover, the existing PMSs are too general, they are not sector specific. It is evident that each sector has different characteristics and contexts and therefore different aspects of business should be measured. The topic of performance measurement is still being explored and there is an obvious need to investigate how theoretical models can be translated and tailored to match the unique measurement needs of companies and other organisational forms (Striteska and Spickova 2012).

Although discussed PMS go beyond using only financial indicators, they concentrate mostly on tangible indicators which are not suitable to fully assess SP performance and show their broad impact on economy. Most of PMS use indicators that reflect strategies focused mainly on financial/product growth rather than on innovation strategies and economic impact.

Therefore, there seems to be a growing need in developing a more suitable performance measurement system for contemporary SPs that will include indicators reflecting their new roles and measuring the output and impact of knowledge intensive activities (intangibles). Moreover, there are significant advantages in applying a common approach to performance measurement across the international SP sector community (Monck and Peters 2009; Monck 2010; Luger and Dabrowska 2013; Link and Siegel 2007; Link and Scott 2007; Squicciarini 2008, 2009; Bigliardi et al. 2006; Ratinho and Henriques 2010).

5 Methodology

5.1 Aims of Research

The main aim of the research was to design a PMS for SPs, where SP goals are reflected by suitable indicators which measure SP success at all levels of activity and consequently leads to demonstrate the impact of their actions in innovation ecosystems. To address the above research aim, the researcher looked for answers to the following research questions: What does SP success mean to primary stakeholders? How can this success be measured (what indicators can be used)? What are the Key Performance Indicators (KPIs) for different categories of SPs based on their ownership structures?

5.2 Methods used

The nature of the investigation and the research aims influence the selection of an appropriate methodology, data collection methods and data analysis.
Johnson and Onwuegbuzie (2004) argue that research methods are supposed to follow research questions in the way which offers the best chance of obtaining useful answers. Therefore, mixed research methods were selected for this study and based on research questions and major aims. Selection of methods influenced the research strategy which consists of two phases, i.e. exploratory and validation phases. The research strategy is presented on Figure 2.

In the first part of the research, a qualitative method (action research) has been selected to undertake investigation of the meaning of the concepts (Van Esch and Van Esch 2013) of success for SPs. Action research brings together practice and research, allows one to learn from experience and apply that learning to bringing about change (Dick 1993) and a practical solution (Hart and Bond 1995). As the nature of this part is exploratory, the use of qualitative methods seems to be justified.

Argyris et al. (1985: 237) acknowledge that action research occurs when scientists “engage with participants in a collaborative process of critical enquiry into problems of social practice in a learning context”. Avison et al. (1999) argue that action research is an interactive process that involves researchers and practitioners acting together on a particular cycle of activities including problem diagnosis, action, intervention and reflective learning. Hence, action research is regarded in the literature as a cyclic called also a spiral (Dick 1993). Furthermore, in action research, there may be multiple cycles in one study. At each cycle it is possible to gain new knowledge and/or confirm or critique previous learning.

Based on literature indicators and to increase the reliability of information, the action research was divided into four cycles (see Figure 2).

- In the first cycle, the search conference that took place in Manchester, in 2010, was used to collect the data and propose an initial solution. Participants were involved in planning, acting, observing and reflecting on their work. The search conference helped identify what primary stakeholders and customers considered as success factors (organisational goals) for their SPs and how to measure them (selection of initial indicators to measure progress towards selected goals). It followed with a design of an initial generic PMS for SPs with indicators of inputs, outputs and outcomes/impacts.

- The second and third cycles consisted of post search conference meetings to complete and improve the initial PMS.

- The fourth cycle was to implement, test, verify and improve the PMS. The PMS was tested at Manchester SP for a year. Based on the feedback from the Park managers slight improvements were made at the end of the test period.
Figure 2: Research design

LITERATURE REVIEW AND RESEARCH PROBLEM IDENTIFICATION

FIRST PHASE: QUALITATIVE RESEARCH
ACTION RESEARCH
- 1st cycle: search conference in Manchester and case studies → identification of performance indicators and development of the initial PMS
- 2nd cycle: post search conference meeting in Bilbao → completing the initial PMS
- 3rd cycle: post search conference meeting in Berlin → improving the initial PMS
- 4th cycle: testing the framework at Manchester Science Park

EXPLORATORY

THIRD PHASE: QUANTITATIVE RESEARCH – SURVEY RESEARCH
- Identification of different ownership models within SPs
- Identification of the gap between what is measured and what should be measured within SPs
- Identification of KPIs for different categories of SPs based on the ownership structures
- Final improved PMS with methodology

VALIDATION

FINAL PERFORMANCE MEASUREMENT SYSTEM FOR SPs

CONCLUSIONS
Moreover, the action research allowed to put a common understanding and definition of innovation services and led to a formulation of a hypothesis that was tested at the second stage of the research, i.e. the survey research.

6 Results of the Action Research

The action research which consisted of a search conference and was followed by post search conference meetings in Bilbao and Berlin helped obtain answers to two research questions: What does SP success mean to primary stakeholders? And how can this success be measured?

As suggested by Luger and Goldstein (1991) in order to define SP success it is necessary to establish a set of goals/objectives against which to measure it. Therefore, the work started with primary stakeholders (owners) who first defined goals and objectives for SPs. Different stakeholders had different expectations due to the nature of their organisations and consequently the goals and objectives varied from one SP to another. Next, the conference participants identified indicators to measure progress towards identified goals and objectives. Selected performance indicators have been clustered in order to identify adequate performance areas.

Approximately 40 SP managers, academics and other primary stakeholders from 13 countries took part in the meetings in Manchester of which an initial PMS for SPs was a result. The initial PMS was then completed and improved at the meetings in Bilbao and Berlin in 2011. The framework was also presented to IASP and finally put in place at Manchester SP in 2013, tested for a year and improved.

The initial PMS for SPs was inspired by Balanced Scorecard, based on literature indications (strengths and weaknesses of other PMS frameworks) and on the information received at the action research stage. According to the findings of the action research, the initial PMS was divided into seven performance areas (called also perspectives as in Balanced Scorecard) to cover all aspects of the SP performance, i.e.

- commercial,
- on-park company participation (called also tenant participation or on-park company involvement in park activities),
- companies’ growth and innovation profile,
- international profile,
- brand and reputation,
- internal business processes,
- the park’s impact on regional economy.
'Commercial' and 'internal business processes' areas reflect perspectives suggested in Balance Scorecard by Kaplan and Norton (1992). The commercial perspective allows measuring financial sustainability required from SPs by Allen (2007) and Goldstein and Luger (1991) as well as by SP primary stakeholders. However, Skinner (1974) indicates that traditional financial measures lack strategic focus. Therefore, the remaining perspectives have been added as suggested by Jones (2011) to reflect other strategic priorities and provide multidimensional and balanced picture of the overall business performance (Kaplan and Norton 1992; Neely 2005).

Perspectives such as 'companies' growth and innovation profile' or 'on-park company participation', although assess customers’ results provide an indication of the park’s business performance (European Foundation for Quality Management 2001). These two perspectives help demonstrate the impact of the SP actions (Bourne et al. 2003). The indicators provide input as well as output and outcome/impact evidence which in turn allows to substantiate the value of SP services, especially in the area of innovation activity. The evidence of the value of this type of activity is required by the primary stakeholders, especially by the private sector shareholders to justify costs.

Additionally, a definition of innovation services was proposed as part of the work carried out at the action research stage. The definition was provided as follows:

Innovation services is knowledge produced and distributed by the SP staff that influences the innovation ability of its customers.

As mentioned before they are known also as innovation activity, business support services, value-added support, intelligent services, knowledge-based support, etc.

The last but not least outcome of the action research was the formulation of the hypothesis that the ownership model of a SP is a key determinant of its appropriate performance measures. This hypothesis was tested through survey research (validation stage) and the initial PMS for SPs was verified.

7 Results of the Survey Research

7.1 Survey Research: Ownership Models of SPs
The purpose of the survey research was to verify and complete the outcomes of the action research (qualitative research). It helped test hypothesis formulated at the action research stage and obtain answers to the third research question:
What are the KPIs for different categories of SPs based on their ownership structures?

A questionnaire was designed and distributed to approximately 220 SPs. The questionnaire was designed in a way to verify the initial PMS with suggested indicators and select KPIs. General information about each SP and its ownership model was also gathered through the questionnaire. The data were collected between February and October 2014. 60 SPs from 35 countries across 5 continents (Europe: 44 SPs from 22 countries; Asia: 8 SPs from 4 countries; North America: 3 SPs from 3 countries, South America: 3 SPs from 3 countries; and Africa: 2 SPs from 2 countries) responded to the questionnaire.

The first aim of the survey research was to identify different ownership structures within SPs. As seen on the pie chart below (Figure 3) seven ownership models of the SPs have been identified based on the questionnaire answers. The models are as follows: university SPs which represent 18% of the whole sample; public SPs which similarly represent 18% of the sample; private SPs which represent 12% of the sample; university-public SPs which represent 16%; triple helix SPs (including public-private-university shareholders) represent 16% of the sample; university-private SPs and public-private SPs represent each 10% of the whole sample.

**Figure 3**  The ownership models of SPs
The questionnaire data shows that there is no preferred ownership model that is the most popular within the SP movement. All three sectors (public, private and academia) are involved in different configurations in the SP ownership structure. The last two ownership types i.e. university-private and university-public seem to be the least popular within the examined set of the SPs. Mixed-ownership structures are quite common for SPs. The risks and expertise can be shared as well as benefits distributed within the different sectors (academia, public and private sectors). 52% of the analysed SPs have more than one organisation (either public sector or/and private sector, and/or university) involved in the ownership structure. It confirms that SPs are multi-stakeholder organisations.

7.2 Survey Research: The Gap

The second step of the survey research was to identify the gap between what is already measured and what should be measured within different ownership model SPs. Therefore, the managers were asked which performance areas were important to measure for their SPs, what indicators they already use and which of the proposed indicators they thought should be their KPIs. The questionnaire analysis shows a significant gap between what SPs already measure (performance indicators) and what they select as their five KPIs for each performance area.

It needs to be mentioned that there is a distinguishable difference between performance indicators and KPIs. As performance indicators measure the behaviour of a business process, KPIs are the key measures which determine stakeholder value and clearly match strategic objectives (Kennas 2014).

One of the most significant gaps between what is measured and what should be measured can be observed while looking at ‘on-park company participation’ perspective. SPs tend to measure links that companies have with a university or other knowledge-based organisation (current situation: 53% already use this indicator). However, they select as KPI number one ‘links to universities or other knowledge-based organisations as a result of SP interventions’. This indicator, although so popular is significantly less used by the SPs (34% of the parks already use it). Similarly, only 28% of the SPs measure ‘inter-company trading as a result of SP interventions’, however it was selected as KPI number two. ‘Inter-company trading’ indicator was not selected as a KPI by the whole sample although 31% of the SPs already use it.

Moreover, only 21% of the SPs measure ‘additional business or funding raised by companies as a result of SP interventions’, however it was selected as KPI number three. ‘Additional business or funding raised by companies’ was not selected as a KPI although it is currently used by 30% of the SPs. Other
mostly observable gaps between what SPs measure and what they want to measure are as follows:

- 14% of the SPs use ‘investment returns’ indicator to measure commercial performance however the parks selected it as one of the KPIs.
- 45% of the SPs use percentage of companies investing in R&D to measure ‘companies’ growth and innovation profile’, however it was selected as one of the KPIs.
- 44% of the SPs use ‘number of products/services developed by on-park companies’ to measure ‘companies’ growth and innovation profile’, however it was selected as one of the KPIs.
- 49% of the SPs use ‘number of companies in the SP network’ to assess ‘brand and reputation’ performance however it was selected as KPI number two.
- 8% of the sample use ‘number of companies whose technologies have been applied in other countries and generate considerable impact outside the country of origin’ to measure international profile. It was selected as one of the KPIs.
- 4% of the SPs use ‘number of requests to take part in studies and benchmarking exercises’ to measure international profile. It was selected as one of the KPIs.

This shows that the SPs want to measure the outcome/impact of their innovation activity rather than measure general performance of on-park companies. So far most of the studies concentrated on measuring on-park companies’ performance to show the success or failure of SPs (Kazuyuki Motohashi 2013; Leyden et al. 2007; Fukagawa 2006; Lindelöf and Löfsten 2002, 2003, 2004; Ferguson and Olofsson 2004; Siegel et al. 2003; Lindelöf and Löfsten 2002; Colombo and Delmastro 2002; Monck et al. 1988). The research demonstrates that there has been a growing interest within the SP sector in measuring SP performance as an individual business rather than through achievements of its on-park companies.

The discrepancy between current indicators and selected KPIs may be caused by inadequate selection of performance indicators and lack of a common methodology how to select performance indicators. Garengo et al. (2005) as well as Striteska and Spickova (2012) say that there is a lack of guidelines on measures to be used to assess different dimensions of the business performance and the lack of information on practical implementation of measures. By proposing a generic PMS for SPs (matrix with performance indicators for each performance perspective) and a common methodology that will enable a park to develop a customised PMS the researcher tried to overcome the limitations existing in the literature related to the lack of guidelines on practical implementation of PMSS.
Another reason for inadequate selection of performance measures may be a lack of clear strategic objectives for a SP. This may be due to the fact that SPs are often multi-stakeholder organisations and the communication between the shareholders or the shareholders and the management may not be efficient. Consequently, the strategy and objectives are not clear. It may also be due to the fact that the owners are not committed to the SP and the communication is not efficient. The aim of the proposed PMS is to enable a better communication between primary stakeholders and managers as well as a better definition and agreement on strategic objectives to be achieved.

7.3 Science Parks’ Performance Measure System

The survey research helped build the final PMS for SPs and propose a methodology to customise the PMS for individual SPs. As SPs have different goals and stakeholder expectations it is impossible to offer a one-fits-all model. However, by using the suggested matrix with indication of KPIs according to the ownership models the SP performance measurement will be more consistent and will allow for benchmarking. SPs will be able to control their progress, collect the data and show to the outside world their achievements or challenges.

The final PMS, as a reference model, consists of seven performance areas. They represent multi-dimensional and multi-owner character of the SPs. Each perspective consists of several performance indicators to choose from. The proposed indicators include input indicators, output and outcome/impact indicators. The outcome/impact indicators in particular will substantiate the value of the intangible knowledge-based activity of the SPs which make them unique on the market.

Lebas (1995) and Kaplan and Norton (1992) articulate that PMS can be expressed by complementary and contradictory performance indicators at the same time as long as it achieves the desired outcome. As SP owners have often contradictory expectations the proposed PMS includes complementary as well as contradictory indicators. It will be up to the SPs to decide which KPIs are the most relevant to them. However, the matrix already suggests which KPIs (from 1 to 5; 1 being the most important KPI) can be selected for each ownership model. The KPIs are an indication of what to measure or inspiration for SPs rather than a fixed proposition.

The tool gives SPs flexibility to choose the most adequate KPIs according to their ownership model and unique needs. Moreover, as SPs grow and mature or change their ownership structures they may want to modify their KPIs. The tool allows to do so. In order to carry out a performance measurement exercise using the proposed PMS for SPs, it will be necessary to establish a baseline
(column “baseline” on Table 2) to demonstrate the current situation and past performance as well as define targets (column “target” on Table 2). Targets should be agreed with current shareholders and the staff members (managers/owners of indicators).

Developing a customised PMS should involve SP owners and managers to work together in order to define/identify or clarify strategic objectives which will enable them to select KPIs. The idea of bringing the primary stakeholders together with the management of the park is to engage the owners in the SP life and for them to understand the SP operational challenges.

The suggested PMS framework allows SPs to benchmark the results and compare themselves (column “benchmark” on Table 2). As SPs vary considerably in terms of size, objectives, contexts, maturity stage, selection of a suitable benchmark is important. In order to find the most suitable benchmark, a SP can use for instance Strategigram\textsuperscript{4} or Aspire.\textsuperscript{5} Strategigram is an IASP software development tool that helps managers identify SP’s strategic profile. It helps discover the model of each SPs. Similarly, Aspire is a quality assurance programme developed by United Kingdom Science Park Association (UKSPA) which assesses SPs purpose, strategy, governance, business case/plan, policies and local context (UKSPA 2012).

Moreover, time scale, data collection process, data recording, data reporting will also have to be identified. Monitoring of indicators and collection of measures can be shared between staff and departments and may be linked to a staff reward system. SPs are complex and unique constructs with many different elements. Although, the research helped identify most of the performance measures, as SPs mature and evolve, it may be necessary to add new dimensions of performance.

The suggested PMS was designed in accordance with suggestions proposed by Bourne et al. (2003), Kaplan and Norton (1992) and Neely et al. (2002) and exhibits the following features:

– It provides a balanced and multi-dimensional overview of the business. The framework assesses multiple aspects of the SP performance including financial and non-financial aspects. The designed framework aims at satisfying all primary stakeholders’ needs in terms of measurement requirement in a balanced way.

– It is comprehensive. In order to effectively assess performance of a SP the maximum number of data will have to be gathered and compared with the data from other SPs or assessed against set targets and past results (baseline). The data collection must happen at regular intervals. Having a complete analysis of the operations will give a comprehensive picture of the performance and will identify any shortcomings.
### Table 2: Final PMS reference model for SPs

| Performance Perspectives | Categories of Performance | Key Performance Indicators for different ownership models of SPs | Proposed Performance Indicators |
|--------------------------|---------------------------|---------------------------------------------------------------|---------------------------------|
|                         | University                | Public Private Uni-public Triple helix Uni-private Public-private | Profitsability                    |
|                         | 5                         | 2 2 1 1 3 1 1 2                                              | Percentage of occupied space     |
|                         | 3                         | 1 3 3 2 3 2 1                                               | Turnover                         |
|                         | 4                         | 4 5 5 3 3                                                     | Sales                            |
|                         |                           | 5 3 5 3 5                                                     | Debt management                   |
|                         |                           | 2 5 4 3 5                                                    | Actual financial performance versus forecasted budget |
|                         |                           | 1 2 4 3 5                                                    | External funding raised by the park |
|                         |                           | 2 5 4 3 5                                                    | Investment returns               |
| Tenant participation    | University                | Public Private Uni-public Triple helix Uni-private Public-private | Participation in networking events |
|                         | 4                         | 5 3 4 3 2 3                                                 | Inter-company trading            |
|                         | 5                         | 5 5 5 5 5                                                     | Inter-company trading as a result of SP interventions |
|                         | 3                         | 2 3 3 2 4                                                   | Links to universities or other knowledge-based organisations |
|                         | 2                         | 4 4 3 2                                                    | Links to universities or other knowledge-based organisations as a result of SP interventions |
|                         | 1                         | 3 1 1 1 1                                                   |                                               |
| Measure                                                                 | Rank |
|------------------------------------------------------------------------|------|
| Additional business / funding raised by companies                      | 4    |
| Additional business / funding raised by companies as a result of SP interventions | 5    |
| Percentage of enquiries as a result of networking / innovation activities | 1    |
| Percentage of companies growing (turnover)                             | 2    |
| Percentage of companies growing (staff)                                | 3    |
| Percentage of spin-out/start-up companies                              | 4    |
| Percentage of companies which took more office/opened new branches      | 1    |
| Percentage of companies investing in R&D                               | 2    |
| Percentage of companies outsourcing R&D / involved in open innovation  | 3    |
| Percentage of employees having a post graduate degree                  | 4    |
| Number of products/services developed by tenant companies               | 5    |
| Number of patents issued/exploited by tenants                          | 3    |
| Number of products licensed in and out                                 | 4    |
| Number of publications                                                 | 1    |
| Number of inward investment companies coming to the park               | 2    |
| Number of companies carrying out international activities (buying or selling abroad) | 5    |
| Number of companies whose technologies have been applied in other countries and generate considerable impact outside the country of origin | 1    |
| Categories of Performance Perspectives | Key Performance Indicators for different ownership models of SPs | Proposed Performance Indicators |
|----------------------------------------|---------------------------------------------------------------|---------------------------------|
| Performance Perspectives               | University Public Private Uni-public Triple-helix Uni-private Public-private | Number of companies whose technologies have been applied in other countries and generate considerable impact outside the country of origin |
|                                        | 2  3  3  4  1  1  3                                           | Number of companies whose technologies have been applied in other countries and generate considerable impact outside the country of origin |
|                                        | 5  4  4  3  4  3  3                                           | Number of inward visits to the park |
|                                        |                                                            | Number of countries involved in inward visits |
|                                        |                                                            | Number of countries involved in inward visits |
|                                        |                                                            | Number of countries involved in inward visits |
|                                        |                                                            | Number of good quality invitations to speak or participate in seminar |
|                                        |                                                            | Number of requests to take part in studies and benchmarking exercises |
| Brand and reputation                   | 3  2  3  1  4  2                                           | Number of awards won by the park |
|                                        | 1  1  1  1  2  3                                           | Number of positive press releases about the SP or successful company based on the park |
|                                        | 5  4  4  3  2  5                                           | Number of neutral press releases |
|                                        |                                                            | Number of negative press releases |
|                                        |                                                            | Number of referrals from other organisations |
|                                        |                                                            | Number of companies in the SP network |
| Number of external companies attending events organised by the park | 4 5 5 2 3 4 |
| Percentage of enquiries from appropriate organisations | 4 5 |
| Level of employee satisfaction | 3 2 1 2 1 2 1 |
| Level of customer satisfaction * | 3 2 1 2 1 2 1 |
| Number of staff with a post graduate degree * | 5 |
| Number of employees being sick for more than average | 5 4 2 3 4 3 5 |
| Percentage of unforced billing errors | 2 1 1 1 2 1 2 |
| Time taken to fix tenants' complaints | 5 |
| Number of security incidents | 4 |
| Number of ICT outages lasting > 1 hour | 4 3 4 3 4 3 5 |
| Reduction of carbon footprint | 1 |
| Park's involvement in the community support* (number of charities supported, school projects undertaken, etc.) | 4 3 4 4 3 4 3 5 |
| Number of jobs created by companies | 1 4 3 4 3 4 3 5 |
| Survival rates of tenants that have passed through the SP | 1 1 1 1 1 1 1 1 |
| Length of life of the companies based on the park | 3 2 3 2 3 3 2 3 |
| Average salary paid by park's companies to their employees | 3 4 5 5 |
| Companies' turnover by sector | 4 4 5 |
| Gross value added per employee | 3 4 4 4 3 |
| Gross value added per sector | 4 |
| Value of companies' purchase | 4 |
| Total investment attracted by the park and its companies | 2 2 2 3 2 2 2 2 |

* Indicators added after the survey research. As they were not assessed by the questionnaire respondents (not included on the questionnaire), no KPIs have been selected for them. They are highlighted on the generic PMS.
– The matrix is designed in a clear way and provides anyone who may be using it with a concise picture of what to measure and how to measure. One of the motives to design a standardised performance measurement tool was to obtain a degree of homogeneity in relation to data collection and benchmarking within the SP community.

– The proposed PMS has been designed to integrate within the SPs processes at vertical (hierarchy) and horizontal (departments) levels to encourage consistency of objectives and actions. It also provides information for monitoring past performance as well as planning future performance.

SPs, as organisations involved in knowledge production, need to provide visibility of their operations, quality of service and progress made to respond to the changing demands of the local knowledge economy Hansson (2007). Using a quality assessment tool, such as the proposed PMS SPs, will enable learning and continuous improvement within the SP sector.

8 Final Considerations

The performance of SPs has been traditionally evaluated through the performance of resident firms. This is difficult to generalise because most of these researches are case studies. Another difficulty is associated with the fact that SPs have many shareholders (primary stakeholders) with different institutional missions. Furthermore, SPs have evolved over the years, as well as the ownership compositions and strategic goals which define SP success (Davies 2013a, 2013b). Despite all the difficulties and implications, performance needs to be evaluated, as a validation check on public policies or a performance evaluation process as a management tool. Thereby, by observing this evidence, the proposed PMS reference model seeks to include the contributions and expectations of key SPs stakeholders. This aspect makes this work unique in the literature. In this context, the PMS proposed here is not intended to provide a set of final indicators that tell conclusively whether a SP is successful. The concept of success or failure must be evaluated according to goals and targets set of each SP development process.

The final PMS reference model proposed as an outcome of the research allows for systematic data collection, exchange of information among SPs and benchmarking. By introducing homogeneity within the SP sector towards performance measurement, the data collection process and analysis will become more straightforward for the SP sector. Moreover, SP performance information will provide evidence of efficiency and effectiveness of actions (Neely et al. 2002) which can be used to communicate with owners, stakeholders, media
and policy makers. It gives SPs a better legitimacy as an innovation policy tool. Furthermore, the SP actions, achievements and challenges can become internationally visible, can give more credibility to SPs and therefore can attract foreign direct investments (FDI) and new funding opportunities for parks as well as their companies.

The employment of the PMS will enable SPs as well as IASP to have a better understanding and control on what progress has been made within SP organisations. It will professionalise the whole community of parks and will also promote continuous learning and effective knowledge management. By proposing a PMS reference model for SPs and a common methodology that will enable parks to develop customised PMSs, the researchers tried to overcome the limitations existing in the literature related to the lack of suitable PMS for SPs as well as guidelines on their practical implementation.

As mentioned by academics, SPs have changed roles and spectrum of their activities (Nosratabadi et al. 2011). Therefore, the empirical part of the research provided a common understanding of what these new knowledge based activities are and how to measure whether or not they have been effective. The representatives of the primary stakeholders and the customers, acknowledged that these new activities, i.e. innovation services are the core activity of the 21st century SPs and are considered as trademarks of SPs (IASP 2015).

Thus, this work challenges Hansson’s (2007) perspective and argues that science parks have shifted from bricks to brains (Allen 2007) and therefore should be considered as KIOS. SPs were established as experiments (Charles and Uyarra 2010) and in the early years the emphasis on property was evident and not surprising (Rowe, 2003). However, they have matured and adapted to the changing demands of knowledge-based economies. From accidental facilities of management organisations they became active partners in knowledge creation (Miles et al. 1995; Miles, 2005; Toivonen 2006; Dobrai and Farkas 2009) and therefore generate an impact on the whole economy (Bettencourt et al. 2002; Miles 2005; Makó et al. 2009).

SPs are complex and unique constructs with many different elements, including attributes of KIOS. Although the PMS reference model for SPs has been developed to include tangibles as well as intangibles and validated through the research further analysis may be needed to improve and test the tool. Therefore, the topic of performance measurement within SPs allows for additional investigations. Besides, more research on SPs as KIOS can be considered. Thus, the reference model established here is intended to be a management tool that enables managers and park stakeholders to conduct the planning and the actions for the future of the park, in a systemic and integrated manner.
Endnotes

1. Available at: https://www.iasp.ws/.
2. For the purpose of this research SP stakeholders are divided into two groups according to Thomlinson’s definition (1992), i.e. primary and secondary stakeholders. According to Thomlinson (1992) primary stakeholders have formal, official or contractual relationship and a direct influence on the organisation. In contrast, secondary stakeholders are not directly involved or engaged in the company’s economic activities but are able to generate influence or are affected by the organisation’s operations.
3. Search conference is an action research data collection tool introduced by Trist and Emery in 1959 (McDonald et al.-2009).
4. Available at: https://www.iasp.ws/activities/services/strategic-profiling.
5. Available at: http://www.ukspa.org.uk/our-association/ukspa-projects/ukspa-aspire.

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