THE INNOVATION CAMPUS: KEY CHALLENGES AND SUCCESS FACTORS IN DIFFERENT STAGES OF MATURITY

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ABSTRACT
The innovation campus is a new kind of innovation ecosystem. It is a physical location on a large organization's premises, with high quality real estate and shared facilities, with the aim to actively foster open innovation practices among its residents. To develop such a campus from inception to maturity in practice seems to be a difficult task. This study explores the specific characteristics of the emerging innovation campus concept and develops a maturity capability model. The model consists of four maturity stages and nine dimensions. We validated the model with 5 experts from different Dutch innovation campuses. We propose that there are necessary, as well as sufficient, conditions for maturity development, which enables decision makers to set better priorities for resource deployment. These results assist the different campus' stakeholders to align their roles and activities during transition over the maturity stages. Further, we suggest avenues for future academic research

INTRODUCTION
The open innovation paradigm (Chesbrough, 2006) has become mainstream in innovation literature and management practice. The main focus has been on individual firms and on regional innovation clusters. However, some large established firms start innovation clusters on their own company premises. This new and relatively underexplored phenomenon is known as an innovation campus (BCI, 2009; Kooij et al., 2014). We define an innovation campus as a physical location with high quality real estate and shared facilities, with the aim to foster open innovation practices supported by an active policy to facilitate knowledge exchange, collaboration, and new product development (Boekholt et al., 2009). An innovation campus takes an intermediate position between an incubator/start-up accelerator and an innovation cluster/business & science park. Examples of such innovation campuses are the High Tech Campus Eindhoven originally centered on Philips in the Netherlands, Brightlands Chemelot originally centered on DSM in the Netherlands, and Novartis Campus in Basel, Switzerland (Tödtling, Van Reine & Dörhöfer, 2011).

The innovation campus offers initiating firms and institutions several advantages. Due to close proximity of campus residents, innovation and entrepreneurship is stimulated. The key mechanisms are easier informal contacts between campus residents which create trust and knowledge exchange, increased business-to-business activities, supporting activities by the campus management, shared state-of-the-art research and test facilities, and increased access to talented staff.

Also, establishing an innovation campus can generate income from selling or renting out their own properties. (Boekholt et al., 2009).

However, the advantages are not that easily achieved in practice. In the Netherlands, the High Tech Campus Eindhoven was the first of its kind, established in 1998 as a Philips campus, inspired by the Apple Campus in Silicon Valley, but driven by cost-saving, re-focusing and image-enhancing strategies (Kooij et al., 2014). Since not all buildings were occupied by Philips, the campus opened up for other companies in 2003. Soon its real estate development with high quality architecture and landscaping became an example for other companies and cities, resulting in at least 14 campus developments in 2009 (BCI, 2009) to 39 in 2014 (BCI, 2014) in the Netherlands. However, most innovation campus initiatives are still in the development stage. According to consultancy firm BCI, only four campuses reached maturity in 2009 (including High Tech Campus Eindhoven) and only eight in 2014 (BCI, 2009, 2014). This seems to suggest that innovation campus development from inception to maturity is a rather difficult task.

Apparently, developing an innovation campus is difficult, despite the knowledge available on open innovation and innovation clusters. It appears that innovation campuses have specific characteristics and face different challenges over time. This observation leads to our research question: "What factors determine innovation campus growth and how do these factors change during campus' maturity stages?"

To answer this research question, we first define the main characteristics of an innovation campus to clearly delineate from incubators on the one hand, and innovation clusters and business & science parks on the other hand. Then, we develop a capability maturity model. From innovation management and innovation cluster literature, we derived nine critical success factors and we determined four maturity stages. Further, we validate the model with experts from five innovation campuses in the Netherlands.

We contribute to theory and practice in four ways. First, we clearly delineate and define the characteristics of an innovation campus to distinguish it from other innovation eco-systems to guide future research. Second, our capability maturity model for innovation campuses is, to our knowledge, the first that describes maturity levels at the eco-innovation system level. Although the empirical cases show that campus development is idiosyncratic and context-specific, we identify common capabilities across cases. We propose a distinction in necessary and sufficient capabilities that determine maturity levels. This enables decision makers to better set priorities in their resource deployment for capability development. Third, whereas some studies on innovation clusters argue that the relative importance of critical success factors decrease over time (e.g. Tavassoli & Tsagdis, 2014), our maturity model suggests that it is not the relative importance that changes, but that the capabilities' contribution can change per maturity stage. This implies that scholars and practitioners need to take a broader perspective on the capabilities in all maturity stages. Fourth, the maturity model can be used by practitioners as an audit tool to the different campus' stakeholders to identify the current stage, to discuss different perspectives on capability development, and to align their interests and business models (West & Bogers, 2014).

This paper is structured as follows. We first define the innovation campus and explain how it is distinctive from other innovation eco-system concepts. Then, we discuss maturity models and their application in innovation management. After explaining the research method, we design the capability maturity model for innovation campuses. We briefly describe the main findings from the five experts and their cases.

In the discussion we derive two propositions regarding the relative importance of the success factors for campus maturity. We conclude with new avenues for future research.

THEORETICAL BACKGROUND

The Innovation Campus

Although the innovation campus concept is emerging in literature, its distinctive characteristics are still ambiguous. The innovation campus is a specific kind of innovation ecosystem that takes an intermediate position between incubators and accelerators on the one hand, and innovation clusters and business & science parks on the other hand. Below, we discuss different dimensions of open innovation communities, clusters, campuses and incubators (summary in Table 1).

- *Strong focal firm*: the innovation campus is centered around a large focal firm, that takes the initiative and is the main property owner (at the start of the campus development). Also, the open community (where a firm launches an idea or a problem) and the incubator/accelerator center around one company. This is in contrast to the innovation cluster and the business & science park, where a focal firm can be present, but is not necessary.

- *Geographic proximity*: tenants of incubators and accelerators are often housed in the same building. The campus ventures' buildings are located on a clearly delineated geographic area, often located at a former industrial compound. Incubators and accelerators can be very well located at such an innovation campus. Business and science parks are generally more spacious, and innovation clusters can cover whole regions.

- *Real estate orientation*: the innovation campus has a clear real estate venture orientation. Owing to production outsourcing and concentration on core capabilities, large firms have unoccupied real estate that they look to sell or rent. Just like incubators, accelerators, and business & science parks the innovation campus offers facilities and housing services to its associated ventures.

- *Business development process orientation*: similar to incubators and accelerators, the innovation campus actively supports the growth of its residents. Specific programs are aimed at supporting the ventures' management, for instance with training and education and offering financing support.

- *Shared facilities*: related to the previous aspects, owing to geographical proximity and business development process orientation, incubators/accelerators, innovation campuses, and to a lesser extent business & science parks, offer shared facilities to their inhabitants. For instance, shared research and production facilities, or shared canteens to promote knowledge exchange.

- *Active management*: since the shared facilities need management, innovation campuses and incubators/accelerators have an active support organization and management. These management activities can be done by the focal firm, or by an independent support organization.

- *Knowledge diversity*: since an innovation campus needs a clear identity and is centered around a focal firm, knowledge diversity is limited. Mostly, it is theme-driven, such as biotechnology, nanotechnology, chemistry, food & health. In contrast, business & science parks, regional innovation clusters and incubators can be more diverse.

- *Partner diversity*: the diversity in companies and institutions - such as large firms, SMEs, start-ups, universities – is the highest in the regional clusters and business & science parks. Most innovation campuses are organized around large firms, leading

to less partner diversity. Housing an incubator or accelerator on campus grounds contributes significantly to more partner diversity. Within an incubator or accelerator partner diversity is low, since these are mostly all start-ups and small enterprises.

Dimension	Innovation community (open source)	Regional innovation cluster	Business & science park	Innovation campus	Incubator
Strong focal firm	√	X	0	√	√
Geographic proximity	X	0	√	√	√
Real estate orientation	X	0	√	√	√
Business development process orientation	X	0	0	√	√
(Shared) facilities	X	X	0	√	√
Active management	X	X	0	√	√
Knowledge diversity	√	√	√	0	√
Partner diversity	0	√	√	0	X

Table 1: Comparison of different innovation eco-systems. √ indicates that the dimension is present, 0 means that it is neutral, X indicates that it is absent.

Looking at Table 1, we conclude that the innovation campus shares commonalities with incubator/accelerators, as well as with business & science parks and innovation clusters, while at the same time being sufficiently distinctive from these innovation systems.

So far, only a few studies have addressed characteristics of the innovation campus. These have covered topics of spatial planning (Kooij et al., 2014; Kooij, 2015) and regional cultural differences (Tödtling et al., 2011). Furthermore, in the Netherlands a few consultancy firms have published reports for governmental institutions (BCI, 2009, 2014; Boekholt et al., 2009) that described the current state of innovation campuses. However, how innovation campuses develop remains unclear.

Use and Limitations of Maturity Capability Models

Maturity capability models measure the "as-is" capabilities to indicate their developmental stage, to derive and prioritize improvement measures, and to control progress (Pöppelbuss & Röglinger, 2011). Maturity models originated in quality management and the software industry with the Capability Maturity Model (CMM) being one of the most well-known (Paulk et al., 1993).

Maturity is often defined as "the extent to which a specific process is explicitly defined, managed, measured, controlled and effective" (Paulk et al., 1993). Maturity increases over time from initial stage to full capability development (Kazanjian & Drazin, 1989). By distinguishing multiple stages that represent different levels of capability development, maturity models can serve three different goals (Pöppelbuss & Röglinger, 2011). First, the model can be used for *descriptive* purposes. It indicates the

current as-is state, and serves as a diagnostic tool, Second, the model's purpose can be *prescriptive*, which means that the model provides guidelines on how to achieve higher maturity levels, through improvement measures and capability development. Third, the model can serve as a *comparative* tool to benchmark capabilities internally and externally.

Despite their abundant use, or arguably due to this, maturity models are subject to criticism (Fraser et al., 2002; Pöppelbuss & Röglinger, 2011). The models would be "step-by-step recipes" that oversimplify reality, suggest a "one best way", and lack empirical foundation. Related to this, maturity models suggest a sequential process to a desired end state, without taking the processes of evolution and change and contingencies into account. Other criticisms concern the lack of rigorous design of many maturity models and the multitude of almost identical models. To address this criticism, we will clearly explain the purpose and use of our model, outline our design process, and explain how our model differs from others.

Maturity Models in Innovation Management

In the innovation management literature, maturity models are gaining interest, because they suggest firms how to develop their (dynamic) capabilities. Initially, maturity models in innovation management were used to assess product design and new product development processes. Fraser et al. (2002) provide a review of several maturity models used in *product design and new product development*. They conclude that there are many maturity models for different purposes and uses. For instance, Chiesa, Coughlan and Voss (1996) developed a technical innovation audit to assess managerial innovation processes and performance. Moultrie, Clarkson and Probert (2006) created a maturity model for design processes in new product development for SMEs. Kahn et al. (2006) and Kahn et al. (2012) developed a new product development best practices framework, to benchmark internally (comparing against the highest level) or externally (comparing against competitors).

More recently, the focus has shifted form new product development towards innovation management capabilities. Essmann and Du Preez (2009) developed the *Innovation Capability Maturity Model* (ICMM). Their comprehensive three-dimensional maturity model includes five maturity stages based on Paulk et al.'s (1993) CMM (ad-hoc innovation, defined innovation, supported innovation, aligned innovation, synergised innovation), three innovation capability constructs (innovation process, knowledge & competency, organisational support) and five organisational constructs (strategy & objectives, function & processes, organisation & management, data & information, customers & suppliers). This model is used by Enkel, Bell, and Hogenkamp (2011) to develop their *open* innovation maturity model. Their model includes three dimensions, which are typically related to open innovation practices: partnership capacity, innovation climate, and systems and tools.

All mentioned maturity models take an organization-level of analysis. Instead, our study takes the innovation campus as level of analysis. Since innovation eco-systems have specific characteristics and capability development needs, we propose a specific maturity model for innovation campuses.

METHOD

We used a qualitative research method to develop the descriptive maturity model. This method is commonly used in literature (e.g. Enkel et al. 2011) and is appropriate since the maturity model is developed and tested according to existing notions of good practice, using experience-based principles and interviews (Fraser et al., 2002).

We applied design principles of Maier et al. (2012), Pöppelbuss and Röglinger (2011) and De Bruin et al. (2005) to develop a maturity model. We used a seven-step approach:

1. Determining the scope of the model in terms of purpose, target group, and class of entities under investigation.
2. Differentiating from related maturity models (this is explained in the foregoing literature section)
3. Determining design process and extent of empirical validation (which is explained in this methodology section)
4. Determining the maturity levels, based on literature
5. Determining the dimensions, based on literature
6. Determining assessment criteria, based on literature
7. Validating the maturity model with experts from five empirical cases

For the empirical assessment we consulted expert from five empirical cases. We selected five innovation campuses in the Netherlands based on their maturity level and diversity in characteristics. The cases have high maturity levels, according to BCI (2009, 2014), which enables us to explore the transition through the stages. To reach sufficient diversity, two cases are centered around a university (Leiden Bio Science Park and Wageningen Campus), two cases are centered around large firms (High Tech Campus Eindhoven – Philips, and Brightlands Chemelot – DSM), and one case is a hybrid of a university and a business park (Kennispark Twente). The main characteristics of these innovation campuses are listed in Table 2.

For each case, we studied secondary data, such as websites, campus brochures, presentations, and newspaper articles. Some cases have been described in academic research. Further, we took an interview with expert representatives of each case. The functions of these experts were directly related to the development of the innovation campus, such as campus developer, campus director, business developer or cluster developer. The interviews were semi-structured, took around seventy minutes each, and were recorded. The interview topics concerned: brief history of the campus development, success factors, development of these factors over time, encountered difficulties, assessment of dimensions derived from literature. The recordings were analyzed and transcribed in twenty-four pages of text. These were presented to the campus experts for validation, which led to only minor adjustments.

Name	**Leiden Bio Science Park**	**Wageningen Campus**	**Kennispark Twente**	**High Tech Campus Eindhoven**	**Brightlands Chemelot Campus**
Founding year	1984	1998	2006	2003	2012
Origin (Founding organization)	Academic (Leiden University)	Academic (Wageningen University)	Academic (University of Twente) and business	Business (Philips)	Business (DSM)
Theme	Life sciences	Agro, food, biobased and healthy living environment	Industrial innovation	Health, energy and smart environments	Materials, health, food, smart services
Number of participants	Organizations: 173 • 130 Companies: 93 Medical, 37 Other • 19 Research Institutes • 10 Healthcare organizations • 14 Others	Organizations: • 90 Companies • 9 Research Institutes	Organizations: • 400 Companies • 360 Start-ups	Organizations: 145 • 132 Companies • 13 Institutes • 36 Multinationals • 55 Start-ups	Organizations: 85 • 74 Companies • 11 Research Institutes
Total number employees	16,907	1,800 + ± 5,000 Wageningen UR personnel located in Wageningen (50:50 University and research insitutes)	5,741 + 3,000 University	10,000	1,540
Area (in hectares)	110	50	12 Ha campus, 20 Ha total	103	20
Reference year	2015	2014	2014	2014	2014

Table 2: Overview of main characteristics of cases

The Design of the Innovation Campus Maturity Model

Scope

As noted, our maturity model relates to innovation campuses. We define an innovation campus as a physical location with high quality real estate and shared facilities, with the aim to foster open innovation practices supported by an active policy to facilitate knowledge exchange, collaboration, and new product development (Boekholt et al., 2009). Our maturity model differs from others in the innovation management literature by taking the innovation campus as the level of analysis, instead of the firm-level. This makes our model useful for all stakeholders of the innovation campus, such as the focal organization, participating organizations, the campus support organization and governmental bodies.

The purpose of the model is descriptive. The model can serve as an audit tool to provide a common understanding and to build consensus among the different stakeholders. It is intended as an improvement tool, to identify gaps in capability development, rather than a normative performance measurement tool (Essmann & Du Preez, 2009; Fraser et al., 2002). Our descriptive maturity model is a first, yet necessary, step towards a prescriptive or comparative maturity model (De Bruin et al., 2005).

Maturity levels

The number of maturity levels generally varies between three and six (Fraser et al., 2002), where an increasing number of levels provides a more fine-grained understanding of maturity, but also increases complexity in delineating exactly the boundaries of the stages (Fraser et al., 2002). The design of the model has to meet the users' needs and requirements. We chose four levels of maturity for the following reasons. First, four stages are sufficiently distinctive and can be well-defined without getting unnecessarily complex . Second, four levels yield a logical progression through the stages (De Bruin et al., 2005). An innovation campus can be considered as an eco-system, which has a similar evolutionary character concerning four life-cycle stages of innovation clusters: birth, growth, maturation, adaptation (Arthurs et al., 2009; Martin & Sunley, 2011; Menzel & Fornahl, 2009) (and the fifth – decline – which we do not consider here), which corresponds well with a logical sequence of maturation. Third, the use of four stages in maturity levels has been used in innovation literature before, for instance by Arthurs et al. (2009) and Kahn et al. (2006).

In addition, the four levels are chosen based on repeatability and effectiveness (Arthurs et al., 2009; Fraser et al., 2002), which corresponds well with Paulk et al.'s (1993) maturity definition as "the extent to which a specific process is explicitly defined, managed, measured, controlled and effective".

- Level one: *Emergence*: a focal firm has real estate property and starts to develop an innovation campus. The concept is developed and the first residents are attracted. The focus is mainly on real estate development and on creating a physical infrastructure. Innovation processes are ad-hoc and incidentally managed by a rudimentary support organization.

- Level two: *Development*: the number of residents increases. The focus on real estate management starts to shift towards business and new product development. The support organization invests in linking organizations to stimulate knowledge sharing and opportunity recognition. Some common activities among campus residents are developed, but not systematically managed.

- Level three: *Established*: the number of residents has reached a critical mass. Next to the large firms, there is a mixture of SMEs, start-ups, and knowledge institutions. Spin-offs from campus firms are the proof of innovative and entrepreneurial collaborations and new business development. The campus supporting organization manages processes systematically. The campus is widely acknowledged and recognized as an innovation eco-system.

- Level four: *Transformational*: the campus residents and the campus organization are flexible to transform to changing technologies and market developments. The vision and strategy can be adapted to avoid stagnation and decay.

Dimensions

To determine the dimensions of innovation campus maturity, we conducted a literature review on innovation campus' and clusters' development indicators and critical success factors. Arthurs et al. (2009) developed a set of six main factors and sixteen sub-factors to indicate cluster development of Canadian innovation clusters. Tavassoli and Tsagdis (2014) reviewed the literature on ICT innovation clusters' critical success factors and identified 15 factors. Su and Hung (2009) identified five key success factors in bio-tech clusters. BCI (2009, 2014) used four dimensions to define innovation campuses in the Netherlands, and Enkel et al. (2011) distinguished three dimensions for open innovation maturity models. We analyzed these critical success factors and dimensions from literature, which finally resulted in nine dimensions (see Table 3):

1. *Involving an evident knowledge carrier/strong anchor actor*: is embodied by the presence of a large evident knowledge carrier who is physical and substantially involved and acts as the 'anchor tenant' at the campus, thereby taking responsibility and providing structure. There are several types of potential knowledge carriers, such as: a multinational, a university, an academic medical centre or a large research institute. The term 'evident' illustrates that the company or institute is of substantial size and has a strong reputation in relation to a specific theme or technological field.

2. *Establishing and maintaining a support organization*: an intermediary campus organization that facilitates campus promotion, establishes campus cohesion, provides guidance (finance, intellectual property, human resource management), manages shared facilities, stimulates inter-firm collaboration, provides training and coaching to entrepreneurs.

3. *Attracting diversity of campus residents*: a mix of thriving start-ups, SMEs, multinationals and research institutes is important to have a continuous inflow of new knowledge and to create dynamism. The diversity mix is critical since the residents need to have sufficient absorptive capacity (Cohen & Levinthal, 1990) to capture value from new knowledge.

4. *Developing a clear vision and brand name*: a clear vision and strong brand name attracts campus residents that fit the campus' profile, investments and venture capital, and skilled workers. A clear and shared vision among the campus residents creates commitment to the campus' longer term strategy, and offers legitimacy to external partners and policy makers.

5. *Attracting a talented workforce:* without a talented workforce, an innovation campus cannot develop and mature. Next to brand name and image, quality of place is important (Florida, 2005), but also close connections to schools and universities to scout talented and creative students.

6. *Developing an open innovation culture*: this concerns two aspects: 1) investing in an entrepreneurial and innovative climate, with high R&D capacity (knowledge, skills, facilities), and 2) investing in an open climate, that fights the 'not-invented-here-syndrome', and stimulates knowledge sharing among the campus residents and with regional and international partners.

7. *Providing access to finance/venture capitalists*: this is essential (especially for start-ups) for stimulating innovation. Financial support can be provided by the government, financial institutions, venture capitalists and business angels among others.

8. *Creating and maintaining campus cohesion*: campus residents take part in a small society. They work and live in close geographic proximity, which requires to align each other's and campus' interests. Cohesion is fostered through clear communication about vision and strategy, creating a campus identity, and building trust among the residents.

9. *Creating and maintaining physical infrastructure*: a good physical infrastructure includes good accessibility and basic services, such as energy and communication. Besides, the campus can also offer shared facility services, research laboratories and test facilities.

From the literature review, we derived two other success factors, which we consider to be contingency factors. The first is *regional attractiveness*, which relates to business climate (quality of local lifestyle, relative costs, relative regulations and barriers), local availability of suppliers and customers, government policies and programs, and the environmental competitiveness. The second is the extent to which there is *pre-existing knowledge*, for instance in certain technologies, due to established firms or knowledge institutes. This factor can be an important enabler to start an innovation campus.

Dimension in maturity model	Arthur et al. (2009) (Innovation cluster policy)	Tavassoli & Tsagdis (2014) (ICT clusters)	Su & Hung (2009) (biotechnology cluster)	BCI (2009, 2014) (innovation campus)	Enkel et al. (2011) (open innovation maturity model)
1. Involving an evident knowledge carrier/strong anchor actor	Responsibility and structure	Strong actor		Evident knowledge carrier	
2. Establishing and maintaining support organisation(s)	Innovation and firm support; Business and product development capabilities; Community support	Support organizations			Internal processes and tools (IP protection, managing processes)
3. Attracting diversity of campus residents	Critical mass (number and size of cluster firms, number of spin-off firms), Dynamism (growth of new firms and firm growth)	Entrepreneurship; Growing company base	Entrepreneurship; Strong science-industry base		Partner capacity (collaboration forms and structures; absorptive capacity)
4. Developing a clear vision and brand name	Identity (external awareness)	Right vision; Brand name			
5. Attracting a talented workforce	Human resources (access to qualified personnel, local sourcing of personnel)	Staff attraction			
6. Developing an open innovation culture	Export orientation; Internal linkages; Innovation (R&D spending, relative innovativeness, new product revenue)	Networking (collaboration); Innovation/R&D capacity; Entrepreneurship	Networking	Active open innovation; Focus on R&D/innovative activities	Entrepreneurial climate
7. Providing access to finance/venture capitalists	Local availability of capital	Finance providers	Finance supporting mechanisms		
8. Creating and maintaining campus cohesion	Identity (internal awareness)	Trust; Geographical proximity	Social capital		Partner capacity (commitment and trust; institutionalization and reputation of partners)
9. Creating and maintaining physical infrastructure	Transportation (quality of local and distant transportation)	Physical infrastructure		High-end physical business locations and research facilities	Internal tools and processes (research center and shared facilities)

Table 3: Overview of literature to identify capability dimensions

Challenges and Success Factors in Maturity Stages

In Table 4, we listed the success factors as assessment criteria for each dimension in each maturity stage. These assessment criteria are the result of the literature review and the empirical evaluation with the campus' experts. Below we will discuss the most relevant findings from the experts' evaluations.

Leiden Bio Sciences Park

Leiden could be classified as being in the development stage. The first two decades were characterized by organic growth in the emergence and development stages. Its main success factors are the strong presence of the Leiden University and the Leiden University Medical Center as main sources of new knowledge, technology and students. Their presence, together with a clear focus on life sciences, attracted large multinational firms and multiple start-ups.

However, these large multinationals also have a downside. An example is one large multinational with a strong presence at the campus. This multinational attracts a large share of the available talent and acquires many of the promising technologies. As a reaction, other campus members aim to protect their assets and intellectual property, which does not stimulate trust and campus cohesion. In addition, the campus struggles with its support organization. Currently, the campus has several organizations, such as 1) the campus foundation, 2) the park management, maintenance and joint facilities, 3) a start-up incubator, and 4) a knowledge exchange center. The campus management is currently investigating the opportunities to establish one support organization.

Next to lack of a strong and effective support organization and an underdeveloped open innovation climate, another challenge is the limited access to finance. Especially in bioscience, where technology development is costly, access to financial resources is important. Since universities have limited investment funds for new business development, private or governmental funds are needed. The absence of a regional investments fund was found to be a disadvantage in comparison to other regions.

Wageningen campus

This campus emerged from Wageningen University, which has a long lasting international reputation on agriculture, food and health. This combination of the university as eminent knowledge carrier and the strong brand name as an agriculture center of excellence, together with clear vision, appeared to be an important success factor in the early days.

Now, we position Wageningen campus in the development stage. One of the main reasons is that the open innovation and collaboration activities are only starting to develop. According to the expert, many companies settled on the campus to acquire academic knowledge, to attract talented students and staff, and to profit from the Wageningen brand. Since campus support and real estate management is still governed by the university, an independent campus support organisation is lacking. This strong position of the university might hamper further open innovation practices, due to different interests and limited campus cohesion. For instance, the expert indicated that universities have to publish their findings, while companies try to protect these for future commercialization.

Kennispark Twente

The University of Twente (founded in 1964) was the first Dutch university that was developed as a university campus with educational, living, working and sporting facilities at one location. The adjacent business & science park became the natural habitat of the start-ups that emerged from academic research. However, there was still a perceived distance between academia and business. This resulted in the formation of the Kennispark Twente Foundation, as a joint initiative of two educational institutions (among which the University of Twente) and three local and regional governmental bodies. A fly-over between the university campus and the business & science park was replaced by a level road-junction to emphasize unity and close physical proximity to each other. The Kennispark Twente Foundation acts as an independent intermediary organization and actively supports and guides start-ups and spin-offs from the university. We position Kennispark in the development stage.

Although the campus has a wide variety of organizations, such as large firms, SMEs, start-ups, and an university, it is still difficult to establish new collaborations, co-developments and joint-initiatives. In contrast to the other four cases, the Kennispark innovation campus does not have a clear technological focus or strong vision yet. Although, the University of Twente en Kennispark campus create most start-ups in the Netherlands, access to financial services for these start-ups is still problematic, and holds back further developments.

High Tech Campus Eindhoven

The High Tech Campus Eindhoven is the only case that we would position in the established maturity stage. Originated as the Philips campus, Philips management invested large amounts of money (500 million euros), to give the campus a kick-start. Owing to a clear vision and the campus' high tech profile, a diversity of campus residents were attracted, such as global firms, research institutes, service companies, SMEs and start-ups. After some years, a separate campus support organization HTCE Site Management was formed, which was responsible for maintaining and expanding the facilities, ensure campus promotion, improve campus cohesion, stimulate new business development and attract new residents. In 2012, Philips sold the campus to Ramphastos, which led to new investments and full independence of the supporting organization. According to the expert, this support organization is one of the key success factors by organizing hundreds of events per year, varying from arranging small direct partnerships between firms till large high-tech conventions to share new knowledge. Further, the campus profile is heavily guarded, and potential residents can be refused.

The expert stated three main challenges during campus development. The first was the dominant position of Philips during the emergence and growth stage. Since the initial idea of Philips was "to run the campus by and for themselves, through the attraction of firms that ought to take over parts of Philips product developments" (expert's quote), other firm felt threatened. This did not contribute to campus cohesion and an open innovation culture. Second, the support organization was also controlled by Philips, which limited its effectiveness. Third, in 2012, the campus needed new financial resources to sustain development, but Philips was not willing to contribute any more. The latter problem was solved by selling the campus to Ramphastos.

Dimension in maturity model	Emergence	Development	Established	Transformational
1. Involving an evident knowledge carrier/strong anchor actor	Strong anchor actor (university or multinational) taking a leading role: Investing in the campus intellectually, financially and setting up the campus organisation. Conduct selection and acquisition of new organisations fitting the profile. Building a plan. Focus is on real estate management.	Maintaining strong campus positioning, preferably aided by a campus intermediary. Attract new organisations from all different levels focuses on stimulating the campus. Beware of being to dominant (deterring effect). Keep investing if possible. Focus gradually shifts from real estate management to new business development	Preferably transfer the 'campus power' to intermediary/support organisation to avoid dominance deterring effect and to strengthen intermediary. Ideally now, there are more strong actors.	Other firms can become evident knowledge carriers, through changing technologies and market developments. The initial evident knowledge carrier is willing and able to hand over its leading role to other firms.
2. Establishing and maintaining support organisation(s)	Often starts with the evident knowledge carrier acting as an (unnatural) support organisation aiming to support campus start (see evident knowledge carrier)	When founded, the support organisation should aim to foster external promotion, social campus cohesion (through events, and programmes) and to focus on selection and acquisition of new organisations. Beware of strong actor dependency.	The campus intermediary, acts as thriving innovation factor. Responsible for dynamic company base, providing guidance for firms, linking innovation nodes, and promotional activities. If possible the organisation takes a proactive role and searches for new opportunities.	Facilitates the transition process, by defining new vision and strategy, attracting new kinds of residents, establishing new linkages internally and externally.
3. Attracting diversity of campus residents	These years form the start-up phase, making it difficult to already built a dynamic company base. Nevertheless, the initiator should start building a clear (profile fitting) company base. Real estate interests may precede over diversity interests.	Becoming increasingly important due to campus dynamics. Selection and acquisition fitting the profile appears to be of great importance. Possibly start with incubator or firm guiding programmes. Do not just focus on one type of organisation, but aim to attract all relevant parties.	Acknowledged as greatly important, since all parties benefit from one another (e.g. knowledge spill overs, sharing facilities, attracting talent, joint operations, etc.). Aim to attract varying parties keeping the campus 'healthy'. Firmly use the campus profile. Grow sideways with campus participants.	Transition to other type of residents can conflict with existing profile. Parting from residents that do not fit the campus' profile any more can be difficult.
4. Developing a clear vision and brand name	Setting a clear vision determines future activities and prospects. A too narrow vision might hamper speedy campus development, too broad vision might weaken brand name. Brand name initially depends on the reputation of evident knowledge carrier.	Vision is guiding principle throughout campus development. during selection and acquisition.. Brand name shifts from evident knowledge carrier to campus brand name.	Vision is guiding principle, but should perhaps be slightly altered. Evaluate the profile based on changes in the influencing surroundings. Brand name is clearly established and used in promotional activities. The campus is internationally recognized.	The vision needs change to adjust to changing market developments and technologies. The brand name is changed accordingly.

5. Attracting a talented workforce	Design of the campus facilities support 'quality of place', such as spacious and green surroundings. Connections with universities and schools are developed.	With more diverse campus residents, new talent and creative employees are attracted. Schools and universities deliver students for internships.	When sufficient trust is built, trainees and employees can work at different campus companies. Schools and universities have educational programs with campus residents. International talent is attracted.	A continuous inflow of talented and creative students and employees enable the transition to new technologies and markets.
6. Developing an open innovation culture	At the start, the evident knowledge carrier needs to have an open innovation culture and the willingness and ability to share knowledge. The selection of new residents should also be based on R&D intensity and an open innovation culture.	Initiating new collaborations between campus residents through stimulating inter-firm relationships, setting up meetings and presentations, stimulating sharing facilities and explaining the value of (joint) innovation. The results are some joint collaborations and new products and services.	Open innovation is mainstream on campus. New businesses and spin-offs are the proof of joint collaborations and effective open innovation practices.	The open innovation culture facilitates the transformation process. Established campus residents welcome new entrants.
7. Providing access to finance/venture capitalists	Initially, the evident knowledge carrier will have to invest in infrastructure, facilities, promotion, support, etc. Probably public funds are needed to get started. Need for finance through real estate development could attract residents that do not fit the profile well	Access to finance becomes increasingly important for campus participants, especially start-ups. Landing of incubators and accelerators is needed to facilitate start-ups. Obstacles in obtaining finances can greatly affect campus development.	Access to finance for start-ups and good business ideas is established. Connections with venture capitalists and financial organizations are established. The campus intermediary organisation can play a role in attracting capital for residents' initiatives.	Transformation to new technological domains requires risk-taking capital providers. An own campus fund can co-invest and lower risks for capital providers.
8. Creating and maintaining campus cohesion	Aligning campus interests is of key importance. Own interests of evident knowledge carrier can even foster distrust among other campus residents or repel potential residents. For academic-driven campuses 'cognitive distance' impedes aligning interests of both university and campus companies.	The supporting organization can facilitate interest alignment and cohesion by clear communication of the vision and creating a campus identity. Several campus events are organized. Less power of the dominant actor promotes trust and campus cohesion.	Campus identity is established. The campus residents have a general consensus about the campus direction, activities and responsibilities. A strong support organisation effectively bridges the different campus residents' interests.	Campus cohesion is endangered by the transformation process. Not all campus residents feel the same need and urgency to change. Different interests lead to tensions among residents. The support organization plays a key role in maintaining cohesion and trust.
9. Creating and maintaining physical infrastructure	The problem is mainly, what comes first: infrastructure or residents. The answer depends on existing infrastructure and investment capital. Basic infrastructure needs to be in place. Absence of high-end facilities can hamper campus development.	New and existing residents have general and specialized high end laboratories, test labs, etc. which can be used by campus residents. Especially start-ups can benefit from these facilities. The campus' infrastructure, architecture and landscaping are attractive.	The physical infrastructure is highly valued and residents increasingly use shared facilities..	Transformation requires new and improved infrastructure (basic and specific). Campus real estate is modernized. New laboratories and test facilities are created.

Table 4: Capability Maturity Model for Innovation Campus

Brightlands Chemelot Campus

The Brightlands Chemelot Campus was founded on the grounds of petrochemical company DSM and can be assigned to the development stage. The Campus has three stakeholders, which are DSM, the Province of Limburg, and the University of Maastricht. From the start, DSM and the province have invested quite some money in campus development. A key success factor was the willingness of the global companies DSM and SABIC (to which DSM had sold part of its activities) to engage in open innovation through co-creation and co-development. The vision was clear and ambitious: to be a world leading innovation campus. In the process, a strong campus support organization was formed, whose tasks is not only to manage the facilities and infrastructure, but also to create added value through a pro-active attitude and developing new business. This support organization creates dynamism through programs, trainings and events. They even create their own start-ups and scout companies all over the world for possible acquisition. Campus residents commitment to these activities is high and firms provide high quality mentors to support other firms and start-ups with finance, IPR, legal, management, etc.

Regarding the campus development, the expert mentioned two big challenges. The first relates to the relatively old and dilapidated buildings and complementary facilities at the start. This made attracting new residents quite hard and even resulted in unsuccessful attempts to interest prospects. The second challenge was the dominant attitude of DSM in the beginning. They regarded the campus as their own property, which did not coincide with the open innovation vision, and chased prospects away.

DISCUSSION

This study aimed to find the success factors that determine innovation campus development, and how these factors change during campus' maturation. We addressed this question by developing a maturity capability model. Building on existing literature we derived dimensions and maturity stages, and we validated the model with expert interviews from five cases.

From the cases we learn that the innovation campus comes in different appearances, that they start from different origins and serve different goals. This could lead to the criticism that a maturity model is inappropriate, due to the huge variety in development trajectories (Pöppelbuss & Röglinger, 2011). However, dynamic capability literature argues that, although capability development is organization-specific and idiosyncratic to some extent, there are also commonalities that can explain why some organizations perform better than others (Eisenhardt & Martin, 2000). In our cases we do observe such commonalities.

First, in the transition from the emergence stage to the transformation stage the, role of the evident knowledge carrier changes. In the early stages, this anchor tenant is needed to initiate campus development, provide funding, and to attract new residents. However, when this anchor tenant becomes too dominant, it might scare off potential residents. In the later stages, the anchor tenant needs to allow room for other evident knowledge carriers to develop, to strengthen the campus profile, to allow more diversity among residents, and to become less dependent on the initiating organization.

Second, a strong, active and independent support organization is important for innovation campus development. This organization not only takes care of campus management and facilities, but also actively facilitates open innovation activities, such

as campus meetings, conferences, and bootcamps. Particularly when the support organization is independent from the evident knowledge carrier, it plays an important role in establishing trust and campus cohesion.

Third, attracting a diversity of campus residents is essential for campus development. All cases show that a good mixture of large firms, SMEs, start-ups, knowledge institutes, and commitment of governments, helps to stimulate open innovation practices. Good selection of residents is key, since it is difficult to remove residents, particularly when they have become owner of the real estate. Here, the challenge for early stage campuses is to not to give in on short term real estate profits, but to bear long term innovation capabilities in mind. This requires the power to say no to prospective residents in the early stage where capital is more than welcome.

Fourth, a clear vision and good brand name attracts large capital-intensive organizations, attracts talented and creative people, attracts creative start-ups, and clearly presents its distinctive character compared to other campuses. The evident knowledge carrier's reputation can be important at the start (e.g. Philips or Wageningen University), but only when this organization embraces the open innovation management paradigm. After the initial developments, the campus needs to establish its own identity that is internally and internationally recognized.

From the expert interviews, these four dimensions were all listed among the most important and most critical ones for innovation campus success. Therefore we derive the first proposition:

> Proposition 1: The capability to (1) involve an evident knowledge carrier, (2) establish and maintain a support organization, (3) attract a diversity of campus residents, and (4) develop a clear vision and brand name, are *necessary conditions* for effective campus maturity development.

The experts acknowledged the relevance of the other maturity factors as well. Although these factors are not necessary to develop, they do stimulate and facilitate the maturation of the innovation campus and a lack of these capabilities could slow down campus development. Based on this observation we derive the second proposition:

> Proposition 2: The capability to (5) attract a talented workforce, (6) develop an open innovation culture, (7) provide access to finance/venture capitalists, (8) create and maintain campus cohesion, and (9) create and maintain a physical infrastructure, are *sufficient conditions* for effective campus maturity development.

Contributions to Theory and Practice

This study is a first attempt to explore the maturity development of a relatively new innovation eco-system: the innovation campus. Our first contribution to theory and practice is that we defined the boundaries of an innovation campus compared to other innovation-eco-systems, such as incubators, business & science parks, and innovation clusters. The innovation campus concept is emerging and well delineated boundaries contribute to adequate theory development.

Second, we developed a maturity capability model at the eco-innovation system level. This extends the many existing maturity levels at firm-level. Our model can be used by innovation campus management to map their current situation and to identify the capabilities that need further attention (Fraser et al., 2002). Our distinction between necessary and sufficient capabilities can assist decision makers to set the right priorities

to make campus development effective and efficient as possible. This distinction in relative importance of critical success factors is rarely discussed in innovation eco-system literature, such as innovation clusters (Tavassoli & Tsagdis, 2014).

Third, our capability maturity model shows that the critical success factors change over time and during maturity development. Only a few others studies have addressed this issue recently in innovation clusters (e.g. Tavassoli & Tsagdis, 2014), and here we notice some commonalities and differences. Our identified sufficient capabilities coincide well with the critical success factors that Tavassoli and Tsagdis (2014) identified to be relatively stable during innovation cluster development. However, where they argued that importance of other critical success factors, such as vision, strong actors, support organizations and a growing company base *decrease* during the cluster's life-cycle, we argue that these capabilities remain important in all stages, yet that their role changes, and some may even become more important. For instance, the role of the evident knowledge carrier changes from initiator in the emergence stage to facilitator in the maturity stage. Only in the transformation stage, its importance diminishes. Further, the role of the supporting organization becomes even more important during maturity growth in facilitating and stimulating open innovation culture and campus cohesion. These contradictory findings once again illustrate that the innovation campus has its own characteristics and dynamics, which are different from innovation clusters.

Fourth, since the innovation campus develops over time, roles and structures of the evident knowledge carrier, campus residents, supporting organizations, governments an finance providers change as well. This means that the actors need to be aware of the campus' maturity stage in order to align their roles and activities. Our maturity model can assist the campus' stakeholders in achieving a common understanding of the challenges and success factors that are currently at play, and to take appropriate action accordingly (Essmann & Du Preez, 2009).

LIMITATIONS AND FUTURE RESEARCH

This study is not without limitations. First, the empirical part of this study was conducted in the Netherlands. Although there seems to be consensus in the Western world about key success factors in new product development (Kahn et al., 2012), caution should be taken to generalize our findings. Therefore, we encourage studies on innovation campuses in other countries, to assess the critical success factors and their relative importance in each maturity stage.

A second limitation is that we developed the maturity model for descriptive use. However, the model can be refined for prescriptive and comparative use. To enable benchmarking, the next step is to develop more fine-grained measurement items for each dimension and maturity stage (Pöppelbuss & Röglinger, 2011). Then, studies in several different contexts, as well as more quantitative studies are needed to enable comparison of capability development and performance of different innovation campuses (De Bruin et al., 2005; Essmann & Du Preez, 2009). We hope that our study provides a solid foundation for these follow-up steps.

Third, since the innovation concept is relatively new, we did not have any cases in the transformation stage yet. While many life-cycle theories follow a deterministic approach from birth to decline, we follow an adaptive approach in which eco-systems can transform to adjust to new circumstances (Martin & Sunley, 2014). This would call for more attention to context-specific characteristics and would warrant more longitudinal case studies.

A fourth limitation is that we propose necessary and sufficient capabilities based on qualitative results. Due to the aim of this research and the limited number of cases, we did not perform any quantitative tests of these propositions. However, we encourage studies that would use a set-theoretical approach (Fiss, 2007, Ragin, 2008) with a qualitative comparative analysis (Rihoux & Ragin, 2009). We strongly believe that such holistic research method accounts for the complex relationships between the capabilities, and also provides empirical evidence for the relative importance of the capabilities in each maturity stage.

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