MASTER THESIS

COMPARING THE PERFORMANCE OF DUTCH BUSINESS AND KNOWLEDGE ECOSYSTEMS: EXAMINING THE INFLUENCE OF ECOSYSTEM PARTICIPANT ROLES AND CONFIGURATIONS

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Abstract

The goal of this study was to find the influence of different ecosystem leaders and supportive organizations on ecosystem performance. It was theorized that high participant diversity and the presence of different roles in an ecosystem leads to high performance. A configurational approach using QCA was taken to examine which combination(s) of ecosystem participants led to high performance and which led to low performance. Diversity was based on the presence of manifest companies, universities and institutes, high quality environment, investors and incubators or accelerators. Performance was operationalized through three measures: ecosystem growth in terms of firms, spin-offs, and employment. The results indicate that maximum diversity in the sense of participant roles is not always required to achieve high performance in an ecosystem. Furthermore, different needs for each of the manifest organizations to achieve high ecosystem performance have been found. Moreover, a manifest company was deemed sufficient for firm and employment growth in an ecosystem. Interestingly, the manifest university was not associated with spin-off or employment growth, and only with firm growth. An investor is found to be necessary for spin-off growth, confirming their need for funding to develop. Furthermore, the results indicate a conflict in certain combinations of multiple manifest organizations and found that more than one manifest organization in an ecosystem has only limited added value towards performance. Future research should take additional roles into account (e.g. regulator or dominator) as well as delve further into the activities manifest organizations undertake to increase performance and the conflict between them. Uncovering the primary needs of spin-offs and sources of employment growth in ecosystems could validate thoughts raised in this study.

Keywords: knowledge ecosystem, business ecosystem, participant roles, participant diversity, ecosystem growth, QCA

Authors' Preface

In the final months of my study I was tasked with the writing of a Master's Thesis, a work to show that I can independently conduct a scientific research and demonstrate my in-depth knowledge in the field of Business Administration. During this time there were, of course, a few 'bumps' in the road and the path to my (hopefully) success has been one of multiple turns, especially concerning the topic of this thesis.

In the early phases of this assignment we, the master students, were advised to select one of the topics that the supervisors had made available, and only proceed with searching an external research topic if the student was very confident he or she could manage to find one that was worthy in the eyes of the supervisors and university. As a result, my ambition to do my research elsewhere than the university to gain more practical experience was diminished, but with the help of my supervisor an interesting topic was found. However, somewhere halfway the assignment, an exciting opportunity arose when my supervisor called saying she found an external assignment and thought I would be interested. Indeed, I was. However, I was also already invested in the original assignment and time was limited. Furthermore, not all organizations behind the assignment were yet fully committed to it. However, my curiosity got the better of me and I accepted the assignment, hoping it would all go as promised. I could salvage some parts of my original work for the new assignment and go to work to add the parts that were missing. Unfortunately, as one could guess, the assignment got cancelled… My supervisor and I decided to do a similar study on our own so I could continue with my already adapted work, as time was running out. Working throughout the summer vacation I managed to finish my research and here before you lies the result of this journey.

Therefore, I'd like to thank everybody that has helped me in any way with the completion of this work. It has been a stressful and tumultuous ride, during which I was not always the social or friendly person I'd have liked to be. So thank you for bearing with me. In particular my girlfriend, whom helped me stay motivated during this whole endeavour and gave meaningful feedback. Furthermore, I'd like to extent my gratitude to my supervisors, whom have helped me with designing this study and really understanding the method I used to analyse the data. Moreover, the various ecosystem managers and directors whom I've contacted and their efforts to help me gain more insights into the development of the ecosystem.

All in all, it has been a great learning experience and I hope you all enjoy the following pages.

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1. INTRODUCTION

In the Netherlands, a coalition of almost thirty organisations comprising of knowledge institutes and business organizations have launched the Knowledge and Innovation Agenda (KIA) for the period of 2011 till 2020 (Rijksoverheid, 2010). One of their ambitions is to make the Netherlands one of the top five of countries in the area of knowledge and innovation, an ambition that is shared with the Dutch politics. The KIA coalition has formulated five priorities concerning education, research and innovation, formulated several goals and targets, and contains investment plans. As the name implies, KIA is an agenda and although such an agenda can be useful, it is very broad and has limited practical use for the actual organizations which form the ecosystem behind knowledge and innovation creation, such as universities and start-ups, on how to increase their performance. Fortunately, academics have been researching business and knowledge ecosystems and found diverse factors and roles that influence the performance of ecosystems.

Firstly, an ecosystem is a term first used in biology to describe a community of living organisms in conjunction with the non-living components of their environment, interacting as a system (Tansley, 1935). It was years later that this concept was used in a business context by Moore (1993) to describe that firms have complex relationships with each other, similar to nature. Any organization, institution or individual which impacts the fate of the ecosystem is considered a member of the business ecosystem and not just those involved with the direct value chain (Moore, 1993), as business ecosystems do not follow a linear value creation process and many of the participants fall outside the traditional value chain and are instead focused on niches (Iansiti & Levien, 2004b). Some of the advantages of business ecosystems are access to new resources and markets, risk and cost sharing, learning opportunities, and joint product and/or service development (Barringer & Harrison, 2000).

Secondly, an ecosystem similar to business ecosystems are knowledge ecosystems, which are focused around a focal organisation (e.g. a university or a research institute) and its participants, both production and use side, aim to develop new value through innovation (Autio & Thomas, 2014). The easy flow of people and ideas in a knowledge ecosystem are regarded as one of its primary sources of advantage (Clark, Feldman, & Gertler, 2000). Clarysse, Wright, Bruneel, and Mahajan (2014) found that business ecosystems and knowledge ecosystems differ in terms of focus, connectivity, and key players, which impedes the natural rise of a business ecosystem out of a knowledge ecosystem. However, policy makers have utilized this philosophy to stimulate business ecosystems, while it is still something that is unclear in the academic world if both ecosystems share the same success factors (Clarysse et al., 2014).

An example of a successful business and knowledge ecosystem is Silicon Valley, home of many current high-tech innovation giants such as Apple, Google, and Tesla. The success story of Silicon Valley has inspired many authors to write books about business and knowledge ecosystems, their characteristics and the supposed reasons for its success (e.g. Bresnahan & Gambardella, 2004; Kenney, 2000; Lee, 2000) and has been used as a benchmark for other innovation clusters or knowledge hubs by policy makers (Engel & del-Palacio, 2011). However, the great durability of Silicon Valley's innovative competence still remains to be fully unravelled (Ferrary & Granovetter, 2009).

As mentioned before, academics have shown interest in these kinds of ecosystems. Studies on various ecosystems has shown that there are factors that contribute to the success of ecosystems, such as partner diversity (Pangarkar & Wu, 2013; Powell, Packalen, & Whittington, 2010; von Raesfeld, Geurts, Jansen, Boshuizen & Luttge, 2012), the financing structure (Clarysse et al., 2014; Koh, Koh, & Tschang, 2005), and the presence of an anchor firm (Agrawal and Cockburn, 2003; Clarysse et al., 2014). Moreover, Hoffmann and Schlosser (2001) identified five critical success factors for alliances, which are precise definition of rights and duties, contributing specific strengths, establishing required resources, deriving alliance objectives from business strategy, and speedy implementation and fast results. Additionally, Hoffmann and Schlosser (2001) found that the perceived importance of those factors is lower among unsuccessful alliance participants compared to participants in successful alliances.

In line with participant diversity, Dedehayir, Mäkinen, and Ortt (2016) identified eleven roles to be played by ecosystem participants, which they divided into four categories. The first category is ecosystem leadership with the roles of ecosystem leader and dominator, and are of a governing and coordinating nature whilst also providing a platform for the other ecosystem participants. The second category is direct value creation with the traditional roles of supplier, assembler and user, and the complementor, which offers complementary services or products to the core platform of the other ecosystem participants. The third category is value creation support, which consists of the expert and champion roles, and the final category is entrepreneurial ecosystem, which entails the roles of entrepreneur, sponsor and regulator. The entrepreneurial ecosystem roles and the value creation support roles play a supportive role by assisting other participants by providing expertise, help them with networking related issues, and provide financing and regulations. Moreover, Aarikka-Stenroos and Halinen (2007) have identified twelve

roles that third parties can play in relationship initiation, and categorized them in four key processes: awareness, access, matching and specifying the deal. Holmen and Pedersen (2003) distinguished three mediating functions of third actors: joining, relating, and insulating.

Based on the aforementioned research, it becomes clear that the ecosystem participants can fulfil various roles to play in the ecosystem. However, what is missing from these studies is the necessity and importance the various roles have for the performance of the ecosystem, who should play them, and which configuration is most useful in terms of performance. Indeed, there is consensus that there should be an anchor or focal firm; however, is there a difference in ecosystem performance if a large multinational or a university leads? Or even better, a combination of the two? Dedehayir et al. (2016) also suggest further investigation of the combination of ecosystem leaders. Likewise, how do the various roles that support the direct value chain affect the performance of the ecosystem and which affect it the most? Furthermore, there could be different combinations of participants that all lead to a high performance ecosystem, as the roles have diverse functions that could complement or substitute elements that are missing, similar to the complementor role (Dedehayir et al., 2016). Or it could be that a certain role is required for high performance, while others have less impact. For example, Clarysse (2014) has shown that business and knowledge ecosystems have different goals and focal firms, which might also require different participants to complement the focal firms and collaborate towards the ecosystem's goal.

Therefore, this study aims to analyse Dutch business and knowledge ecosystems' participant characteristics and assess the effect various participants and their combinations have on the performance of the ecosystem. The research goal can be condensed into a research question, which is as follows:

"Which combination of ecosystem participants in Dutch knowledge and business ecosystems affect ecosystem performance?"

In order to answer the research questions, a comparison of the configuration of the participants of several Dutch knowledge and business ecosystems will be performed through QCA (Qualitative Comparative Analysis) based on publicly available data and the reports of Buck Consultants International [BCI] (2009, 2014). Through this analysis the characteristics (or commonly referred to as conditions in QCA studies) can be distinguished as necessary (i.e. the characteristic is always present in successful ecosystems) or as sufficient (i.e. when an ecosystem has the characteristic it is successful), both (i.e. it is the sole characteristic that leads to success) neither (i.e. the characteristic is in both successful and unsuccessful ecosystem). The characteristics that will be examined and which measures are used to determine ecosystem performance will be discussed in the methodology section of this study.

The results from this study will show whether or not the different roles suggested by theory required for ecosystem success are mandatory for creating a successful ecosystem and their effect on performance. Furthermore, it will reveal if the different characteristics are good indicators of high performance ecosystems, as unsuccessful ecosystems might also have a significant number of the success characteristics and vice versa. Moreover, with this knowledge practitioners involved with analysing and managing ecosystems (e.g. the KIA coalition or ecosystem leaders) will have further insights into which characteristics are relevant for the various performance measures used in this study and can assist them to adapt their activities accordingly to increase the performance level which they deem most valuable.

The following section, section 2, will provide a theoretical framework for this study, followed by section 3 which discusses this study's methodology. Section 4 will present the results, followed by section 5 with the discussion of the results. The final section, sections 6, will reveal the conclusions of this study, together with remarks on its limitations and directions for future research.

2. THEORY

The theory section will start with theory of ecosystems in a business context and knowledge and innovation ecosystems in a general context. The following section will provide an overview of the ecosystem roles, which functions as the backbone of this study. The subsequent sections will continue more specifically on three categories of roles that are deemed important in such ecosystems and will relate back to the research question proposed by this study.

2.1 Business Ecosystem

The first notion of an ecosystem in a business context was by Moore (1993) who argued that a firm can be seen as a part of an ecosystem rather than a member of an industry, as the interactions between firms and collective value

creation processes are much more complex then strategy frameworks implied. The ecosystem concept is broader, as it covers the community of organizations, institutions, and individuals that impact the fate of the focal firm and its customers and supplies, including complementors, suppliers, regulatory authorities, standard setting bodies, the judiciary, and educational and research institutions (Teece, 2007). Business ecosystems do not follow a linear value creation process and many of the players in such ecosystems fall outside the traditional value chain and can instead be considered niche players (Iansiti & Levien, 2004b). With complementary resources from other niche participants or the ecosystem leader they can focus their efforts on a narrow domain of expertise (Iansiti & Levien, 2004b). Instead, it is a network with many horizontal relations (Moore, 1996) between different companies cooperate to jointly deliver a product or service to a customer (Adner & Kapoor, 2010; Lusch, Vargo, & Tanniru, 2010). The members of such an ecosystem deliver value to end customers as an interrelated system of interdependent companies rather than as individual companies. Business ecosystems are nested commercial systems where each player contributes a specific component of an overarching solution (Christensen & Rosenbloom, 1995). In a business ecosystem, inter-organizational networks consist of both collaborative and competitive relationships which results in a "coopetition" structure (Moore, 1993). As a result, it is the competition among ecosystems, not individual companies, that largely fuels the next round of innovations. Innovation in business ecosystems goes beyond the focus on technological activity alone which is characteristic of knowledge ecosystems. Companies collaborate to create and deliver solutions that meet the full package of value to customers (Moore, 1993). In other words, business ecosystems allow firms to create value which no single firm could create by itself (Adner, 2006; Iansiti & Levien, 2004a; Moore, 1996). Companies in a business ecosystem co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies (Li, 2009; Moore, 1993). Hence, start-ups which can participate in such an ecosystem align their innovation function to the expectation of the leaders and move toward a shared vision (Moore, 1996). As a result, each member of an ecosystem ultimately shares in the fate of the system as whole (Li, 2009).

Iansiti and Levien (2004a) put forward two important ingredients that contribute to the success of business ecosystems. First, business ecosystems are characterized by a large number of loosely interconnected participants dependent on each other for their mutual performance. Each participant is specialized in a specific activity and it is the collective efforts of many participants that constitute value, while efforts individually have no value outside the collective effort. Rich networks sharing elements of both cooperation and competition emerge that link companies across products, services, and technologies. This variety of actors in an ecosystem as beneficial is confirmed by many other studies (e.g. Pangarkar & Wu, 2013; Powell, Packalen, & Whittington, 2010; von Raesfeld, Geurts, Jansen, Boshuizen & Luttge, 2012). For example, start-ups perform better with a diverse portfolio of alliance partners (Pangarkar & Wu, 2013). A second vital element is the need for a "keystone" company whose role is to ensure that each member of the ecosystem remains in good health. They consistently invest in and integrate new technological innovations of other participants and encourage the creation of new markets by developing new fundamental infrastructures (Moore, 1993). Keystone companies also create "platforms" such as services, tools, or technologies, which are open for other players in the ecosystems to enhance their own performance (Iansiti & Levien, 2004a). Consequently, keystone players are involved with the creation of value within the ecosystems as well as sharing the value with the other participants.

2.2 Knowledge and Innovation Ecosystems

Autio and Thomas (2014) define an innovation ecosystem as "a network of interconnected organizations, organized around a focal firm or a platform, and incorporating both production and use side participants, and focusing on the development of new value through innovation" (p. 3). The easy flow of people and ideas in a knowledge ecosystem are regarded as one of its primary sources of advantage (Clark et al., 2000). Next to external economies of scale from collective resources, local spill overs make technology development efforts in such an ecosystem more effective than those of their isolated competitors (Agrawal & Cockburn, 2002). Both linkages among firms and with universities and public research organizations as well as intense labour mobility across different players facilitate collective learning and increase the speed of innovation diffusion (Baptista, 1998). As a result, physical proximity to knowledge generators such as public research organizations, universities and large firms with established R&D departments typically have a positive influence on the focal firm's innovative output (Phelps Heidl, & Wadhwa, 2012). However, if the innovation output of the knowledge ecosystem can be commercialized by a global business ecosystem, a regional business ecosystem is not required. In this case, the region should develop links to global business players, but the region will lose local employment associated with the business ecosystem. This can be combatted by attracting global firms to settle in the region (Owen-Smith & Powell, 2004). Powell et al. (2010) considered two features and one mechanism to be fundamental in the development of knowledge ecosystems: diversity of organizational forms and presence of an anchor tenant as features, and cross-realm transportation as the mechanism. The diversity of organizational forms will result in an increased adaptive ability of the ecosystem (Baptista, 1998) and creates divergent rules and standards, which leads to competing benchmarks for success (Boltanski, & Thévenot, 2006). The second feature is the anchor tenant,

which assists assist in providing access to subsequent connections and field formation and hence actively spur economic growth (Agrawal and Cockburn, 2003). The anchor tenant does not directly compete with the other types of organizations that inhabit the community. Local universities or public research organisations can fulfil the role of anchor organizations in the knowledge generation process (Agrawal and Cockburn, 2002). The mechanism described by Powell et al. (2010) relates to the cross-realm connection between organisational forms to allow ideas and models to be transported.

After a literature review Clarysse et al. (2014) observed three important factors in which knowledge and business ecosystems differ. First, the primary activity in knowledge ecosystems is the generation of new knowledge whereas the focus in business ecosystems is on value for customers. Second, players in a knowledge ecosystem are typically connected in a dense, geographically clustered network while business ecosystems are represented by value networks which can be globally dispersed. Third, knowledge ecosystems are centred on a university or public research organizations whereas large companies are the leaders of business ecosystems.

2.3 Ecosystem Roles

Continuing on participant diversity and their different functions in the ecosystem, Dedehayir et al. (2016) did a literature review on the roles during innovation ecosystem genesis. They proposed four categories of roles: leadership roles, direct value creation roles, value creation support roles, and entrepreneurial ecosystem roles. The actor assuming the leadership role engages in governance related actions, such as designing the roles of the other actors, coordinate interactions between the other actors of the ecosystem, orchestrate the resource flows, and ensuring each actor can create or accrue value. The second leadership role is the dominator, which undertakes vertical and horizontal integration of actors. The direct value creation category consist of four types of actors: users, supplier, assembler, and complementor. The user defines a need or problem and can create innovative ideas. The supplier delivers key components to be used by others in the ecosystem. The assembler aggregates components, materials, and services and processes information supplied by the others in the ecosystem. The complementor extends the offering of suppliers and assemblers by being compatible with the core platform, but is not in the direct path of value creation. Complementary products and services are also required to function in conjunction with the offerings of other ecosystem actors and must be designed accordingly. The third category is the value creation support role, which consists of experts and champions. Experts provide knowledge, consultation, and encourage technology transfer and commercialization. Champions support by building connection between actors, interact between partners and sub-groups, and provide access to local and nonlocal markets. The final category is the entrepreneurial ecosystem roles, which entails entrepreneurs, sponsors, and regulators. The entrepreneur, often a start-up or individual, sets up focused networks of staff, suppliers, customers, and complementors, and coordinates collaboration between research and commercialization partners. As the entrepreneurs often lack resources, the sponsor role supports them and others by giving resources, finance low-income markets, purchase and co-develop offerings of firms, and link entrepreneurs to other ecosystem participants. The regulator supports the ecosystem by creating favourable economic, political, and regulatory conditions. Furthermore, Dedehayir et al. (2016) argued that certain activities are likely to be enacted ahead of others as the ecosystem unfolds, changing the activities of each role over time. In figure 1 an overview of all the roles and their related activities can be found.

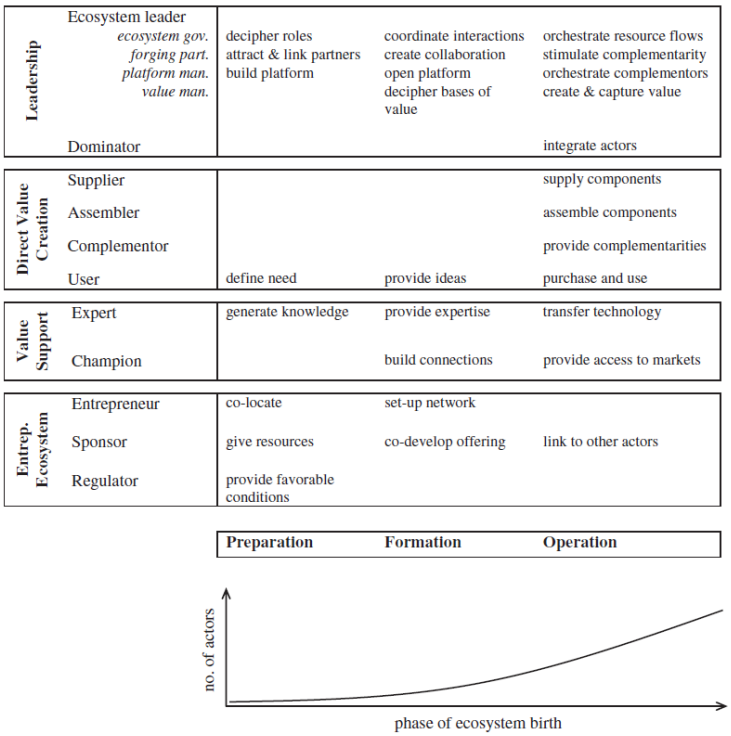
2.4 Ecosystem Leader

As described by Dedehayir et al. (2016), the ecosystem leader has a diverse activity package ranging from strategy, management and regulating the whole ecosystem to make sure value can be created, as still a staggering 70 per cent of business relationships fail due to managerial complexity and interfirm rivalry (Park & Ungson, 2001). The following theories describe various activities that are required of the ecosystem leader to ensure a good performing ecosystem.

Autio and Thomas (2014) suggest that when planning for value creation and value appropriation in an innovation ecosystem practitioners should consider several aspects. First, the control mechanism that enables firms to influence ecosystem evaluation and to use for levers for value appropriation. They give three examples of such systems: shared platforms, critical assets, and pre-emptive alliances. Secondly, one should pay attention to the value creation dynamics. How is value to be created within the ecosystem? The third item is control migration, this concerns the control mechanisms that migrate elsewhere as an ecosystem evolves. The firm needs to anticipate and adapt to the changes of the ecosystem. The fourth aspect is value externalities, or network effects that boost the overall value produced by the ecosystem, and are an important aspect of value creation in innovation ecosystems. Furthermore, Autio and Thomas (2014) propose that there are three architectures that are important to consider during the creation of the innovation ecosystem: technology, activity, and value. Technology architecture or the design principles of shared technological resources and platforms, will determine who will be

able to connect to the innovation ecosystem and in which roles. Activity architecture defines the composition and structure of the innovation ecosystem that may emerge around the core platform. Aspects of activity architecture include not only who and in which roles, but also, (co-)specialization drivers and coordination mechanisms. Value architecture describes the resulting value dynamic, as defined by the interplay between technological architecture and activity architecture. Lastly, Autio and Thomas (2014) propose that due to the complex nature of innovation ecosystems there are four strategic levels required: technology strategy (i.e. standardization strategies, open source strategies, and patenting and licensing strategies), economic strategy (i.e. choice, access, and promotion of complementary assets and associated investment strategies), behavioural strategy (i.e. tactics in the creation of initial network ties and alliances), and institutional strategy (i.e. ecosystem coordination, regulatory framework).

Figure 1: **Overview of ecosystem participant roles and their activities over time**



Source: Dedehayir et al. (2016)

Hoffman et al. (2001) did a study on success factors of strategic alliances for SMEs and distinguished five phases of alliance evolution and each phase contains factors that influence the success of the alliance. The first phase is called 'strategic analysis and decision to cooperate' and consists of four factors: high need for strategic flexibility and limited need for control; contributing specific strengths and looking for complementary resources; deriving alliance objectives from business strategy; and awareness of time requirements for alliance development. Phase two, 'search for a partner and partner selection', entails building on established trust-based relationships; partner excellence in field of co-operation; complementary contributions; and agreement of fundamental values and convictions. The third phase is 'designing the partnership', and has seven factors: precise definition of rights and duties; equal contributions from all partners; emphasizing the potential for joint value creation; keeping and protection core competencies; building trust; agreement on clear and realistic objectives; implementing plan with fixed milestones. The fourth phase is labelled 'implementation and management' and consists of an information and co-ordination system; establishing required resources; top management support; avoiding unwanted transfer of knowledge; capacity to learn from partners; speedy implementation of measures and fast results; and continual review of alliance performance. The final phase, 'termination of the partnership' has two factors, termination only upon approval of all partners and preparing for termination in the design phase. All the content-oriented factors are based on transaction-cost economics and resource- and knowledge-based strategy concepts, while the process-orientated factors are influenced mainly by inter-organisation theories and general leadership and management theories.

Furthermore, Hoffman et al. (2001) found eight critical success factors that determine the success or failure of the alliance. These factors concern ecosystem leaders as it is there task to manage the ecosystem, create regulation and rules, to make sure that the participants can create value (Dedehayir et al, 2016). Six out of eight factors are related to the first two phases of an alliance, strategic analysis and decision to co-operate and designing the partnership. Further analysis showed that there are five most important critical success factors, which are ranked

in importance: precise definition of rights and duties; contributing specific strengths; establishing required resources; deriving alliance objectives from business strategy; and finally, speedy implementation and fast results. The three critical success factors that were of lesser importance are deriving alliance objectives from business strategy, building trust by unilateral commitments and avoiding opportunistic behaviour, and speedy implementation and fast results. Compared to the perceived importance of the success factors by the SMEs, only three of the most critical success factors were labelled as very important: precise definition of rights and duties; contributing specific strengths; and deriving alliance objectives from business strategy. In table 1 an overview is presented of the perceived importance of the five most important critical success factors by successful companies compared to unsuccessful companies.

Table 1: Perceived importance of the five most important critical success factors

		Perceived as important by companies that are	
Rank	**Critical success factor**	**Successful**	**Unsuccessful**
1	Precise definition of rights and duties	54.5%	25.0%
2	Contributing specific strengths	63.6%	50.0%
3	Establishing required resources	34.5%	36.4%
4	Deriving alliance objectives from business strategy	40.0%	46.7%
5	Speedy implementation and fast results	30.9%	23.1%

Note: Adapted from Hoffmann et al. (2001).

The critical success factor ranked the highest, precise definition of rights and duties, is greatly underestimated by unsuccessful companies. The second highest critical success factor, contributing specific strengths, is also underestimated by unsuccessful companies, although the difference between them and successful companies is smaller than with the previous factor. It is striking that the two highest ranked factors are underestimated the most by the unsuccessful companies.

2.5 Value Support and Entrepreneurial Ecosystem Roles

Besides from the leadership and direct value creation roles, Dedehayir (2016) distinguishes two other categories of roles in an ecosystem: value support and entrepreneurial support roles. Both these categories contain roles that are not directly linked to the value chain, as their activities focus more on supporting and assisting the other participants of the ecosystem. Looking back at figure 1, Dedehayir et al. (2016) differentiate between six roles in the two categories of value support and entrepreneurial support roles. The associated activities belonging to these roles can roughly be divided into three subsets: providing favourable conditions, networking, and supplying resources and expertise.

2.5.1 Providing Favourable Conditions

Starting with providing favourable conditions, this is part of the regulator role and is tasked with creating favourable economic, political and regulatory conditions for the ecosystem to catalyse the formation of new ventures (Dedehayir et al., 2016). As the activities suggests, besides the ecosystem leader who can do some regulating and governing, these activities are mainly a task for the government and municipality where the ecosystem is located. A suggestion by Clarysse et al. (2014) for policy makers is that they should consider supporting dedicated innovation managers at large companies. The innovation manager should develop initiatives that promote collaboration with local, innovative start-ups and monitor the health of the network of the start-ups.

2.5.2 Networking

Second comes the networking activities and are part of the tasks of the champion (build connections and provide access to markets), entrepreneur (set-up network) and sponsor (link to other actors). With the formative work of Simmel and Wolff (1950) in mind, these activities belong to a party that joins, the tertius iungens. 'The third who joins' is a strategic behaviour of a third party that attempts to connect parties in their network by either introducing disconnected parties or facilitates new coordination between connected individuals (Obstfeld, 2005). Its opposite is the tertius gaudens, the rejoicing third that gains from keeping the other parties separated and maintain a structural hole between them (Burt, 1992, 2000).

Start-ups in the ecosystem are not always yet embedded in the pre-existing networks (Oukes & Raesfeld, 2016), while becoming embedded is crucial to start-ups' survival and growth (Bliemel & Maine, 2008), as they always build on the resource constellations, activity patterns and a web of actors in the pre-existing network (Snehota, 2011). The champion and sponsor can help with the development of the network and the network embeddedness of start-ups by initiating relationships for the entrepreneur (Oukes & Raesfeld, 2014; Styhre & Remneland-

Wikhamn, 2015; Yin et al., 2012), as the entrepreneur has limited resources and networking abilities (Kirkels & Duysters, 2010; Prashantham & Birkinshaw, 2008). Furthermore, they can expand the network horizon of the entrepreneur by offering access to their own network (Cohen, 2013; Holmen & Pedersen, 2003). Therefore, third parties can play a key role in forming and maintaining knowledge and business ecosystems by playing the part of an intermediator for establishing and developing network connections. This also provides competitive advantage for the whole network (Barringer & Harrison, 2000; Iansiti & Levien, 2004a).

A slightly different perspective comes from Holmen and Pedersen (2003) who distinguished three mediating functions of third actors: joining, relating, and insulating. The function of joining enables direct coordination on some aspects between the focal firm and the counterparty of the focal firm's counterpart. Relating enables coordination between the focal firm and a third party via the counterparty with them having knowledge of each other. Insulating enables coordination between the focal firm and the third party without them having any knowledge of each other.

Moreover, Aarikka-Stenroos and Halinen (2007) have identified twelve roles that third parties can play in relationship initiation, and categorized them in four key processes: awareness, access, matching and specifying the deal. Awareness involves identifying potential partners, building awareness among suitable partners and creating a need for a specific partner. Access refers to establishing contact among partners, speeding up the initiation process and delivering marketing information. Matching includes evaluating fit among partners, offering information about the trustworthiness of a partner and assessing the quality of partner. Specifying the deal contains providing prospects of the relationship outcome, offering risk-reducing information and making intangible services tangible. The twelve roles are not clear-cut, separate activities, but function often together supporting a relationship initiation. Furthermore, third parties can operate in one of four activity modes: passive, active, reactive, and hidden. In the passive mode, the third allows use of their name in marketing or access. In the active mode, the third party actively promotes the firm or spontaneously guides customers to them. In the reactive mode, the third party reacts on the request for information of a buyer or seller. The final mode is hidden, or silent, in which the third party's experience or relations could not be used.

2.5.3 Supplying Resources and Expertise

The roles that have supplying resources and expertise as part of their activities are the expert (generate knowledge, provide expertise and transfer technology) and the sponsor (give resources and co-develop offering), and are to support the other participants in the ecosystem, such as the entrepreneur (Dedehayir et al., 2016). The sponsor and expert provide all types of resources to enable the entrepreneur's start-up to mature and further assist them in this process, such as helping with product development, identify customer segments, and secure resources (Cohen, 2013; Hackett & Dilts, 2004; Kohler, 2016; Tötterman & Sten, 2005). Birkinshaw and Hill (2005) call ecosystem venturing a strategy used by large companies to build a business ecosystem around them, which entails incubating and accelerating start-up activities related to their innovation strategy. Moreover, Clarysse et al. (2014) argue that private financial agents and not public sector organisations should take the lead in the financial support network to facilitate the transition from knowledge to business ecosystem. Third parties like incubators, accelerators and business angels can help in that regard. Koh et al. (2005) also suggest more involvement of the private sector in terms of financing and the building of global relations to increase the performance of the ecosystem.

It is important to distinguish between accelerators and incubators, as they have several key differences (Cohen, 2013) and will allow for more precise ecosystem participant diversity. In essence, incubators tend to nurture start-ups by buffering them from the external environment to allow them to grow and mature safely, while accelerators speedup the market interactions in order to help the start-up to adapt quickly and learn (Cohen, 2013). More specifically, Cohen (2013) distinguishes five key differences in term of duration, cohorts, business model, selection, and education, mentorship, and network development between accelerators, incubators, and angel investors, see table 2. Starting with duration, accelerators provide only a limited time of assistance to start-ups, usually three months. Incubators do not have a predetermined time limit in which they provide assistance, it can last from one year up to five. Established timelines and strict graduation dates reduce the amount of co-dependence between start-ups and accelerators and force start-ups to face the selection mechanisms that operate in the market (Cohen, 2013). This results in a speed-up of the lifecycle, quicker growth or quicker failure. Although quicker failure might seem undesirable, it gives the entrepreneur(s) of the start-up the chance to focus their efforts and resources on higher-value opportunities (Cohen, 2013). Furthermore, the limited duration forces both start-up and accelerator to intensively work together and focus solely on the success of the program (Cohen, 2013).

Secondly, a very distinct characteristic of accelerators is the grouped start and exit of the program (Cohen, 2013). Similar to a school or summer camp, all participants of the accelerator enter the program at the same time and work together and help each other towards the common end goal of graduating the program. As a result, the start-

ups have forged strong bonds with each other, which continue to last long after the end of the program. In contrast, incubators have a less rigid program and start-ups join and leave ongoing and individually (Cohen, 2013). However, incubators can have a similar, although weaker bonding effect, as start-ups also develop relationships with each other during their time there (Cohen, 2013). Furthermore, incubators can adapt their mix of start-ups and connected third parties to improve synergies, which also improves the bonds between parties (Tötterman & Sten, 2005).

Table 2: Key differences between accelerators, incubators, and angel investors

	Accelerators	**Incubators**	**Angel investors**
Duration	3 months	1-5 years	Ongoing
Cohorts	Yes	No	No
Business model	Investment; some non-profit	Rent; non-profit	Investment
Selection frequency	Competitive, cyclical	Non competitive	Competitive, ongoing
Venture stage	Early	Early, or late	Early
Education offered	Seminars	Ad hoc, hr/legal	None
Venture location	Usually on-site	On-site	Off-site
Mentorship	Intense, by self and others	Minimal, tactical	As needed, by investor

Note: Adapted from Cohen (2013).

The third difference between an incubator and an accelerator is their business model, which comes forth from their difference in ownership (Cohen, 2013; Dempwolf et al.2014). Most accelerators are privately owned and take an equity stake in the participating start-ups. In certain cases the accelerator managers are also active as angel investors (see table 2) of participating start-ups (Cohen, 2013). However, incubators are mostly publicly owned and generally do not have their own investment funds (Hackett & Dilts, 2004). Cohen (2013) argues that due to this differences, accelerator directors have more incentive for the success of start-ups than incubator directors, as accelerator directors are also investors in the start-ups. In line, accelerators want growth that leads to a positive exit, while the best outcome for an incubator might be slower growth, which prolongs the tenant status of the start-up. Barrow (2001) found a similar difference between various third-parties in terms of goals of the third party, where some third parties are more focused on job creation, others' main goal are financial returns or faculty-industry collaboration. The assistance the third parties provide will be these main goals in mind.

Continuing with the fourth key difference, the selection process. Accelerators have a different selection method than incubators due to the accelerator program being of limited duration and the batch-like acceptance of start-ups versus the ongoing nature of incubators (Cohen, 2013). As a result, the accelerator focuses marketing and outreach around key dates. Moreover, the open application process attracts ventures from a wide, even global, pool. Ventures frequently relocate so they can participate in top programs and top accelerator programs accept as few as 1% of applicants (Cohen, 2013).

The fifth and final key difference is the amount of education, mentorship, and network development both third parties offer (Cohen, 2013). Accelerators are found to have more intense and extensive mentorship and education than incubators, and more often offer seminars. Furthermore, the intense mentorship includes meeting a large number of different mentors, who provide the start-up with a significant amount of opportunities for socializing and networking (Cohen, 2013). Start-ups in incubators however do not take full advantage of the available advice that is offered (Hackett & Dilts, 2004) and networking in incubators is challenging, as start-ups are busy with developing their business and opportunities for networking and socializing are scarce (McAdam & McAdam, 2006).

But not only the assistance provided by third parties differs, the quality of the third parties themselves varies (Cohen, 2013; Isabelle, 2013). In some extreme cases, the third party slowed down the development of the start-up (Hallen, Bingham, & Cohen, 2014). Furthermore, there are some negative effects as well, such as hostility and competitiveness between start-ups in an incubator (McAdam & McAdam, 2006). Therefore, it is vital for start-ups to not randomly join an accelerator or incubator, but to screen the incubator based on several selection criteria, namely the stage of the start-up, fit between the start-up's needs and mission of the third party, the selection and graduation policies, the nature and extent of services, and the network of partners, to maximize the benefits for the start-up (Isabelle, 2013). Furthermore, the reputation of newcomers' first partners exerts a positive influence on their future status, over and above intermediate network conditions (Milanov & Shepherd, 2013). This influence is even stronger for newcomers whose first partners have a history of strong cohesive networks.

2.6 Theoretical Overview

This section will now present a short summary of the two different foci on the topic of ecosystems and its participants. For an overview of the discussed theory see tables A-1 and A-2 in appendix A. The theory is grouped per subject in each table.

After analysing the two foci it becomes clear that the theory unanimously confirms that each ecosystem participant has a certain role in order to contribute to the ecosystem. Starting with ecosystem participants in general, Baptista (1998), Phelps et al. (2012), Iansiti and Levien (2004a,b), and Powell et al. (2010) all mention the advantage of diverse ecosystem participants, albeit there is some variation in the advantages themselves. Through diverse participants the diverse roles, see Dedehayir et al. (2016)'s categorization of ecosystem roles, can be filled. This is also reflected in the third party theory; the different functions and their advantages are confirmed by Holmen & Pedersen (2003), Oukes and Raesfeld (2014), Yin et al. (2012), Cohen (2013), Holmen and Pedersen (2003), Clarysse et al. (2014), and Aarikka-Stenroos and Halinen (2007), as third parties can provide assistance with a broad range of tasks. The need for an ecosystem leader is confirmed by Iansiti and Levien (2004a), Agrawal and Cockburn (2002, 2003), and Clarysse et al. (2014). However, while Owen-Smith, & Powell (2004) also acknowledge this need, they find that a leader need not be physical present in the ecosystem and can be replaced by a global research network. Furthermore, the ecosystem strategy levels, control mechanisms and ecosystem architecture Autio and Thomas (2014) speak of are functions or tasks that are required of the ecosystem leader or the regulator (Dedehayir et al., 2016). The financial systems Clarysse et al. (2014) and Koh et al. (2005) mention are the function of the sponsor role in Dedehayir et al. (2016) categorization.

Moreover, participant diversity similarly leads to ecosystem diversity, with diverse ecosystem leaders (i.e. a company, institute, university, or a combination thereof), and diverse supportive organizations (e.g. sponsors, networking organizations, incubators or accelerators) that complement the activities of the leader(s) and direct value creation roles and increases the ecosystem's performance. Furthermore, these organizations co-evolve their capabilities to align with the leader to improve their complementary roles (Li, 2009). Additionally, next to different leaders, ecosystems also have different goals (Clarysse et al., 2014), strategies and architectures (Autio and Thomas, 2014) which affect which complementary roles are required to be fulfilled by the ecosystems' participants to achieve high ecosystem performance, as it is the leader's task to look for complementary resources and partners that contribute specific strengths (Hoffman et al., 2001). Similarly, these complementary resources allows participants to focus their efforts on a specific domain to become experts in that area (Iansiti & Levien, 2004b). Altogether, this suggests that through this diversity ecosystems need specific participants that fit with its goal, but those participants need not be similar for all ecosystems.

However, the theory does not give an answer as to which combination(s) of organizations can fulfil the roles are that are required for high performance. For example, does a business ecosystem with a large multinational as leader require similar (supportive) organizations to be present as a knowledge ecosystem with a university as leader? More specifically, do the large multinational and university have similar capabilities to perform the task as ecosystem leader, or does one require additional organization to ensure their successful leadership? Of course, there could also be an institute present in the ecosystem, how does this affect the dynamics between the previous leaders and their assisting parties? Likewise, is the presence of a university and incubator or accelerator always necessary for start-ups to thrive, or can a large company with the aid of an investor also achieve this? Moreover, how does the goal of the ecosystem affect which participants are required? According to Clarysse et al. (2014) business and knowledge ecosystems have different foci of activities that could warrant different supportive organizations to achieve a high performance ecosystem. Furthermore, research primary focusses on situations where there is only one ecosystem leader present, the influence of multiple ecosystem leaders on ecosystem performance is lacking (Dedehayir et al, 2016). Therefore, this study aims to answer these questions by researching the following research question:

"Which combination of ecosystem participants in Dutch knowledge and business ecosystems affect ecosystem performance?"

In order to answer this question, this study will characterize several Dutch business and knowledge ecosystems based on their participants and performance. By analysing and comparing their configurations the goal is to distinguish combinations of organizations that lead to high or low performance. The following section will explain how this analysis will be done.

3. METHODOLOGY

3.1 Design

The goal of this study is to analyse and evaluate the characteristics and the performance of Dutch business and knowledge ecosystems based on BCI (2009, 2014) using QCA. This technique allows for the comparison of different configurations (i.e. combinations of different ecosystem participants) and their performance, and can distinguish common elements that lead to a specific outcome. Thus, in terms of this study, it allows for the detection of important ecosystem participants or different combinations thereof that lead to an ecosystem's high or low performance. Although the theory section mainly discusses ecosystem participant *roles*, the characterization is based on *actors*. The exploratory data analysis will establish a link between these two. The reports of BCI (2009, 2014) together with additional secondary data (e.g. company and ecosystem websites and news articles) that have been made publicly available provides data for the characterizing of the ecosystems. Furthermore, BCI (2014) has included data that will be used for three proxies to measure ecosystem performance: growth in terms of total amount of firms in the ecosystem (including spin-offs, but excluding universities, university hospitals, technology institutes and half-commercial organizations), the growth of the total amount of spin-offs in the ecosystem, and the growth of the total amount of employment in the ecosystem. The growth is based on a comparison of the data between 2012 and 2014. The first part of the analysis will be to analyse the usefulness of the data for the QCA and adapt it where necessary. This will result in a table with all ecosystems in the sample with their characteristics and their performance. The performance measures will be used to determine which cases have a positive outcome (i.e. high performance) or negative outcome (i.e. low performance). Then the data can be further analysed using QCA. The analysis will give insights into which characteristics affect the different performance measures and whether or not the characteristics are sufficient, necessary, both, or neither for an outcome. With these insights the academic world will have gained knowledge about the influence of the characteristics on ecosystem performance. Practitioners can utilize the gained insights to adapt their activities to better fit their strategies, based on which performance measure(s) they deem most valuable. Additional details about the sample and the analysis are discussed in the next sections.

3.2 Sampling

The sample will consist of knowledge and business ecosystems and its participants located in the Netherlands, which are already studied by BCI (2014). The selection will be based on the available data in this report and on the outcome of the QCA, and is not static (Rihoux & Ragin, 2009). The initial sample will be based on the reports of BCI (2014) and includes 27 ecosystems of which data on the three performance measures is gathered. Of this selection there are 21 cases, or 19 depending on the performance measure, with complete data. This sample contains both cases with a positive outcome as cases with a negative outcome, as suggested by Rihoux and Ragin (2009). An overview of the sample can be found in the column "Ecosystems" in table B-1 in appendix B.

3.3 Procedure

BCI (2014) has gathered their data using internal workshops at BCI, desk research and interviews via phone with representatives of the ecosystems. Talking points during the interviews were the current situation of the ecosystem, the focus on R&D activities, presence manifest knowledge carriers, real estate and research facilities, the status of the open innovation organization, the amount of established spin-offs and organizations focused on R&D and innovation and amount of employment compared to 2012, and the positioning and future plans of the ecosystem. Additional data will be gathered using the public websites of the ecosystem and their participants to find information about the presence roles as described in Dedehayir et al. (2016). More specifically, about the ecosystem leader and the value support and entrepreneurial ecosystem roles. However, there will be a discrepancy in time between the data that is gathered in BCI (2014) and the data collected during this study. To combat this discrepancy the organizations that perform the value support and entrepreneurial ecosystem roles will be checked for their existence during the time of the BCI (2014) report. Finally, the data from both sources will be codified and results in a table to be used in the data analysis. The next section will elaborate on how this table will be produced and analysed.

3.4 Exploratory Data Analysis

The first part of QCA is to perform an analysis on the data itself before continuing with the actual QCA. There are several good practices concerning the conditions in small- and intermediate-N research designs (Rihoux & Ragin, 2009). First of all, conditions must vary across the cases, or else it cannot help explain the difference between a positive and a negative outcome. Second, the number of conditions must be kept low, as too many conditions will individualize the cases and remove any regularity to explain the outcome. Therefore, a good balance between conditions and cases must be made. For an intermediate-N analysis (10 to 40 cases) four to seven conditions is common. Furthermore, each condition must have a clear link to explaining the outcome. This is done based on the

theory discussed in this study. Lastly, the outcome variable must be clearly defined and the threshold between a positive and negative outcome should be justified. Depending on the outcome of the exploratory data analysis one of the following techniques will be used, crisp-set QCA (csQCA), multi-value QCA (mvQCA) or fuzzy-set QCA (fsQCA). The data partially derived from BCI (2014) and it has evaluated the ecosystems based on five measures: development phase, R&D focus or technology driven activities, high quality business environment, manifest knowledge carrier, and active open innovation, see table B-1 in appendix B. The following paragraphs will discuss the results of the exploratory data analysis.

3.4.1 Development Phase

Development phase refers to the maturity of the ecosystem, the lowest score meaning the ecosystem is currently in the exploratory or feasibility phase, and the highest score means the ecosystem current has a large number of research institutes and R&D companies. As this says very little about the participants themselves, this measure is not used in the analysis.

3.4.2 Focus on R&D

The second measure, focus on R&D or technology driven activities refers to whether or not the ecosystem has such activities. This measure can be linked to the expert role, as its activities are concerned with the generation of knowledge (Dedehayir et al., 2016). However, all ecosystem of which performance data is available score positive on this measure, meaning this variable does not vary and has no use for the QCA (Rihoux & Ragin, 2009).

3.4.3 High Quality Business Environment

Thirdly, high quality business environment is defined as "the availability of physical space that offers high-quality settlement facilities for knowledge intensive activity and for lab, clean room and testing facilities" (BCI, 2014). This aligns with Cohen (2013) and Tötterman and Sten (2005) who suggests participants should offer such assistance to other in the ecosystem, and the ecosystem role of sponsor, referring to the activities of co-developing offering and giving resources (Dedehayir et al., 2016). Its dimensions are "yes, comprehensive", "yes, limited", "in development", and "no". As the selected sample contains only "yes, comprehensive" and "yes, limited" scores, this is a dichotomous variable with a 1 being "yes, comprehensive" and a 0 being "yes, limited". Bear in mind that when this condition is said to be missing in the ecosystem in the upcoming analyses this means that there is a high quality environment, but only in limited form. It not actually missing in the ecosystem.

3.4.4 Manifest Knowledge Carrier

Fourthly, a manifest knowledge carrier is described as "an anchor tenant that is physically and substantially performing research activities in the ecosystem" (BCI, 2014). This matches with Agrawal and Cockburn (2002, 2003), Clarysse et al. (2014), Iansiti and Levien (2004a) studies about an anchor tenant, and the roles of ecosystem leader (anchor tenant) and expert (generate knowledge) of Dedehayir et al. (2016). Its dimensions are "yes", "limited" and "no", although all ecosystems in the sample scored "yes" on this matter. Fortunately, this characteristic also contains data on which organization(s) is/are deemed to be the manifest knowledge carrier(s), which allows for the differentiation between multiple types of organizations and solves the problem of a variable that does not vary. In order to do so three different characteristics are devised to distinguish the sample: the presence of a manifest company, the presence of a manifest university (i.e. a university or university of applied science), and the presence of a manifest institute (i.e. a research hospital or research institute other than universities), for example TNO or the European Space Agency (ESA). All three characteristics are dichotomous and codified in such a way that a 1 (0) refers to the presence (absence) of the manifest organization.

3.4.5 Active Open Innovation

The final characteristic in BCI (2014) is active open innovation, "a dedicated open innovation organization that deals with collaborative relationships within and outside the ecosystem, knowledge valorisation, knowledge transfer, networking, business development and acquisition of companies. This broad range of activities are similar to the discussed third party activities by Cohen (2013), Holmen and Pedersen (2003), Iansiti and Levien (2004b), Oukes and Raesfeld (2014), and Yin et al. (2012). Furthermore, these activities fit with the roles of expert (transfer technology), champion (build connections and provide access to markets) and sponsor (co-develop offering and link to other actors) by Dedehayir et al. (2016). Again, all ecosystems in the sample safe for one score the same on this variable and therefore will not differentiate the sample. To compensate for this loss three other characteristics are devised, which were also missing in the analysis done by BCI (2014): the presence of an investor (funding activity of the sponsor), an incubator, and an accelerator. The latter two fulfil activities of the sponsor, expert and champion roles by providing financial and other resources, (business) knowledge and connections with the market. The presence of such roles in an ecosystem is determined based on secondary data gathered from the ecosystems websites and related news articles. The results of this analysis can be found in table B-2 in appendix

B. However, there seems to be low variation in these variables, especially the conditions accelerator and investor. Each condition is present in approximately 80% of the observations, while Ragin and Rihoux (2009) suggest that each option of the variable should appear at least in one third of the cases. To resolve this problem two measures are taken. First, although theory suggests to make a distinction between incubators and accelerators, such a distinction would result in two non-varying variables and are therefore combined. Thus, the incubator and accelerator are grouped as one condition for the analysis, meaning that when either or both are present, the condition incubator or accelerator is set to be present. Furthermore, to some degree the incubator and accelerator share the same role in an ecosystem, namely assisting start-ups with their development, further justifying their combination. However, the condition investor is kept as it play a distinct role. Second, the analyses will also be performed without these conditions to eliminate their possible distortion. Furthermore, this also resolves the time-discrepancy between the data from BCI (2014) and the secondary data gathered during this study.

3.4.6 Performance Measures

The performance data regarding firm, spin-off and employment growth in the ecosystems from 2012 to 2014 can be found in table B-3 in appendix B. The observations are split into two groups (i.e. low and high performance) for the analysis, based on a threshold. The threshold should make sense theoretically, although Rihoux and Ragin (2009) acknowledge this cannot always be indisputably done. Furthermore, the threshold may be adapted during the analysis, granted it is not used to manipulate the data to reach certain results. However, in this study the line between high and low performance seems clear: a positive outcome means the ecosystem displays growth in terms of the performance measure (i.e. high performance). No growth or a decline in the performance measure leads to a negative outcome (i.e. low performance). In table 3 an overview of the thresholds is presented. Considering that the conditions and the outcome are all dichotomous, csQCA will be used for the analyses (Rihoux & Ragin, 2009).

Table 3: Outcome thresholds

Performance	**Growth of total amount of**		
	Firms	**Spin-offs**	**Employment**
High	Growth > 0	Growth > 0	Growth > 0
Low	Growth ≤ 0	Growth ≤ 0	Growth ≤ 0

3.4.7 Overview

Table 4 presents an overview of the different characteristics and performances measures along with their associated theory. Furthermore, while all different characteristics only measure a singular operationalization, as a whole they measure the participant diversity of the ecosystem, which is also beneficial for the ecosystem (Baptista, 1998; Iansiti & Levien, 2004b; Phelps et al., 2012; Powell et al., 2010). The amount of characteristics that are measured (six) in combination with the number of cases in this study (19-21) fall within the recommended range by Rihoux and Ragin (2009) of four to seven conditions for studies with a N between 10 and 40 cases.

The only roles missing from Dedehayir et al.'s (2016) categories of value support and entrepreneurial ecosystem are the entrepreneur and the regulator. As all ecosystems in the sample contain spin-offs, this also means they all got entrepreneurs. Furthermore, as discussed in the theory section, the activities of the regulator can be split among the ecosystem leader and the government, thus this role is partially covered. Moreover, as the whole sample is located in the Netherlands with the same government, its influence will be similar for all ecosystems. However, the regional governments (i.e. the municipalities) could have varying policies that influence the performance of the ecosystem. Nevertheless, gaining insights into the municipalities' policies which affect ecosystem performance and any agreements the municipalities have (privately) made with the ecosystem is difficult to achieve, and adding an additional condition will lead to increased individualism of the cases and removes the analysis further from its goal to obtain a parsimonious solution. Therefore, this condition is omitted from the analysis.

3.5 Data Analysis Procedure

Following the exploratory data analysis is the QCA done using specialized software called Fuzzy-Set/Qualitative Comparative Analysis 3.0 (Ragin & Davey, 2016). The philosophy behind QCA is to use multiple case studies to obtain both an in-depth understanding of each case, while also allowing for generalization, or as Rihoux and Ragin (2009, p. xviii) explain: "to allow systematic cross-case comparisons, while at the same time giving justice to within-case complexity, particularly in small- and intermediate-N research designs." Each case has a certain configuration of conditions and an outcome, which is either positive or negative. Using QCA one can determine which condition(s) are necessary (i.e. the characteristic is always present in successful ecosystems) or as sufficient (i.e. when an ecosystem has the characteristic it is successful), both (i.e. it is the sole characteristic that leads to success), or neither (i.e. the characteristic has no influence on the outcome). The logic behind QCA is the

systematic analysis of the conditions to determine whether or not the condition has an effect on the outcome. Furthermore, it allows for "multiple conjunctural causation", where multiple combinations of conditions can lead to the same outcome (Rihoux & Ragin, 2009, p. 8). For csQCA, the starting point of QCA as a whole, Boolean minimization lies at its core; to reduce a complex expression into a shorter, more parsimonious expression by keeping only the necessities. In order to do so, there are six steps: building a dichotomous data table, construct a truth table, resolve contradictory configurations, Boolean minimization, bringing in the logical remainder cases, and interpretation (Rihoux & Ragin, 2009).

Table 4: Ecosystem characteristics to be used in the analysis

Theory	Author(s)	Operationalization BCI (2014)	Dimensions
Presence of physical facilities	Cohen (2013) Dedehayir et al. (2016) Tötterman & Sten (2005)	High-quality business environment	Yes, comprehensive Yes, limited
Keystone/anchor/ industrial leader	Agrawal & Cockburn (2002, 2003) Clarysse et al. (2014) Dedehayir et al. (2016) Iansiti & Levien (2004a)	Manifest knowledge carrier	Presence (absence) of a manifest: • Company • University • Institute
Investor	Clarysse et al. (2014) Koh et al. (2005)	-	Presence (absence) of an organization that provides funding
Incubator or accelerator	Cohen (2013) Dedehayir et al. (2016)	-	Presence (absence) of an incubator or accelerator program
Ecosystem performance	BCI (2014)	Magnetic action	Growth (no growth) of the total amount of: • Firms • Spin-offs • Employment

The first step entails converting the data on the conditions and outcome to become dichotomous. This step requires justification for the threshold between high and low for each condition and outcome. The next step, construct a truth table, requires grouping the observed cases based on their configuration and is done using the software. Several good practices to check during this step is the mix of positive and negative cases, presence of counterintuitive cases, cross-condition diversity and enough variation in the variables (Rihoux & Ragin, 2009). In the event that a configuration contains both one or more cases with a negative outcome and one or more cases with a positive outcome, it is deemed contradictory and must be resolved in the next step. Resolving contradictory configurations can be done using one or more of the following strategies: add conditions, replace one or more conditions, check condition operationalization, reconsider the outcome variable, re-examine the cases, reconsider case population, recode contradictory configuration to a negative outcome, or use frequency data to orientate the outcome (Rihoux & Ragin, 2009). The use of each of these strategies must be justified based on empirical and/or theoretical grounds. However, the use of these strategies will not guarantee the disappearance of the contradictions. Then, one should consider to either proceed with the csQCA with or without the contradictions, use mvQCA, fsQCA or other techniques, or stop with the analysis. Additionally, the condition consistency and coverage can be calculated to reveal the necessity of the conditions. The consistency of a condition gauges the degree to which the cases sharing the condition agree in displaying the outcome (Ragin, 2008). When a condition has a consistency of 0.80 or higher it can be considered necessary for the outcome (Ragin, 2008). However, if that same condition is necessary for both outcomes it means that it does not matter for the outcome if the condition is present. Likewise, if the absence of that condition is necessary for both outcomes, its absence does not affect the outcome. Coverage is the degree to which instances of the condition are paired with instances of the outcome.

The next step is the Boolean minimization which is to be performed using the software. This step has to be done for the negative and positive outcome separately, as causal symmetry is not expected (Rihoux & Ragin, 2009). The software will produce three solutions based on three complexity levels: complex, intermediate, and parsimonious (Ragin, 2010). This distinction is based on whether or not any remainders in the truth table (i.e. the configurations that are not observed) are incorporated into the minimization process (Ragin, 2008). The complex solution prohibits the use of remainders to simplify the truth table, while the parsimonious solution permits the use of all missing configurations to simplify, without any evaluation of their plausibility. The intermediate solution is often preferred, as the user can give the software input on how the conditions should be connected, which guides

the selection of configurations used for the minimization (Rihoux & Ragin, 2009). This will result in the solution that is most interpretable as it strikes a balance between complexity and parsimony based on the knowledge of the user (Ragin, 2008). Furthermore, the severity of contradictory simplifying assumptions (i.e. configurations used to simultaneously explain both the positive and negative outcome) is "much less severe if one uses the intermediate solution" (Rihoux & Ragin, 2009, p. 137). However, it is possible that before the intermediate solution can be found, a prime implicant tie has to be resolved. A prime implicant tie indicates that there are multiple minimizations for a configuration, its then up to the user to choose those minimizations that are most justifiable (Ragin, 2010). The next step is to calculate the coverages and consistency of the solution(s) to assess its importance (Ragin, 2008). The software provides these values when the solutions are generated. The final step of QCA is to interpret the generated results in combination with case-knowledge to uncover the narrative behind the results.

3.6 Ethics

On the subject of ethically sound research, this study will not gather any data that could be considered unethical nor does the sample have to perform unethical tasks. The data gathered will be through public sources (e.g. the ecosystems' websites) and such data is made available with consent of the owning party. Furthermore, several telephonic interviews will be taken with managers and directors of the ecosystem to gain insights into possible causes for their performance. Any personal information of those interviewed will not be made public.

4. RESULTS

The goal of this study was to examine the ecosystem participant characteristics of Dutch business and knowledge ecosystems to evaluate the participant combinations that affect the ecosystems' performance (i.e. growth in the total number of firms, spin-offs or employment). The three performance measures used to perform the QCA will be presented separately and will start with the growth of the total number of firms in the ecosystem, followed by the analysis based on the growth of the total number of spin-offs in the ecosystem, and lastly, the growth of the number of jobs in the ecosystem. Whenever the intermediate solutions were generated, the software asked for the causality of the conditions on the performance. In all analyses the conditions were set to contribute to high performance when present and to low performance when absent. Moreover, table C-1 in appendix C contains the prime implicant ties that were found and the prime implicants that were selected for the analysis.

4.1 Growth of the Total Amount of Firms

In this analysis the performance of the ecosystems is measured by the growth or decline of the total amount of firms in the ecosystem. All growth leads to a case having a high performance, no growth or a decline results in a case having low performance.

4.1.1 Dichotomous Data Table

The first step of the analysis was to create a dichotomous data table of the gathered data, see table 5. At first glance, it is noticeable that out of the twenty-one cases only four cases are considered to have low performance. Thus, most ecosystems do grow in terms of total amount of firms. Furthermore, it appears that there is cross-condition variation, meaning that no two conditions have the same outcome in each case and each condition therefore adds unique information. As the other two analyses with different performance measures use the same conditions, this means they also have cross-condition variation. Moreover, most cases have the investor or the incubator or accelerator characteristic, as detected during the explorative data analysis, indicating that they have one or more participants fulfilling the role of sponsor or sponsor, expert and champion respectively. Additionally, even though Green Chemistry Campus, Healthy Aging Campus and Novio Tech Campus only score positive on one or two conditions they still have high performance. This is contradictive with what the theory section predicted, as participant diversity and supportive roles are supposed to be important factors for the success of an ecosystem. Additional examination of the data revealed that none of these ecosystems is in the mature development phase. Further inspection of table 5 reveals that all of the cases with low performance have a manifest university in the role of (one of the) ecosystem leader(s) and an incubator or accelerator performing the roles of sponsor, expert and champion, while most cases with high performance the role of sponsor is fulfilled by an investor.

4.1.2 Condition Consistency

The necessity of the conditions can be assessed based on their consistency. The consistency of a condition is calculated for both performance levels and for both the presence and absence of a condition. When a condition has a consistency of 0.80 or higher it can be considered necessary for the outcome. Looking at table 6, which contains the condition consistencies and coverages for this analysis, this means that the presence of an investor, with a consistency of 0.82, is presumed to be necessary for an ecosystem to have firm growth. Its corresponding coverage of 0.82 (i.e. 82% of the instances where an investor is present, it is in an ecosystem with firm growth) gives

empirical weight to this necessity. Thus, for high ecosystem performance it is necessary to have an investor playing the role of sponsor. In the case of low performance, it appears that a manifest university as (one of the) ecosystem leader(s) and an incubator or accelerator fulfilling the roles of sponsor, expert and champion are necessary as their consistencies are both 1.00. However, both conditions also have a low coverage, meaning that most cases with a manifest university or an incubator or accelerator present do have high performance, thus reducing the relevance of their necessity. This also shows signs of asymmetrical causality, missing a condition could lead to low performance, but its presence does not immediately guarantee high performance.

4.1.3 Truth Table and Conflicting Observations

The next step was to create a truth table containing the observed cases, which combines the ecosystems with the exact same configuration, see table 7. Notice that as this analysis (and the others as well) uses six conditions the truth table should contain 2^6 or 64 rows, but only fourteen are shown. The remaining fifty rows are logical remainders, configurations that do not have an observed case and are omitted in the table for the sake of clarity. This, however, does not automatically mean that the logical remainders are omitted from the minimization. Furthermore, two rows contain contradictory outcomes, rows 7 and 14, as their consistency is below 1.00. This means that these configurations have cases that lead to low performance and other cases that lead to high performance. Rihoux and Ragin (2009) give eight strategies to deal with these contradictions and multiple strategies can be combined. However, the strategies require a justification based on theoretical and/or empirical ground and are not guaranteed to work. The first solution offered by Rihoux and Ragin (2009) is to add a new condition to the model (e.g. split incubator or accelerator into two conditions: incubators and accelerators).

However, this increases the complexity and adds even more logical remainders as the number of possible configurations doubles. With already limited diversity, this solution would only further individualize the cases and misses the purpose of creating parsimony. Moreover, only three ecosystems have an accelerator program meaning that this condition will not vary much and would not help explaining the outcomes. One could also replace conditions with another, possible reducing the number of contradictions without increasing the complexity. However, no additional conditions could be formulated. Another suggestion by Rihoux and Ragin (2009) is to reconsider the outcome variable. However, as performance is based on whether or not an ecosystem showed growth in terms of total firms in the ecosystem (i.e. no growth or shrinkage results in low performance, all growth results in high performance) there is little justification to adapt this definition. Furthermore, two alternative measures for performance are already present in this study. Moreover, a sensitivity analysis is performed which contains new thresholds to define outcome membership using fsQCA.

A different option by Rihoux and Ragin (2009) is to examine the cases involved more in-depth and qualitative to find evidence to justify a change in the configuration or outcome of the cases. Starting with row 7, further inspection of the data shows that Leiden Bio Science Park, focused on biomedicine, has low performance (0% growth) despite having all conditions present in its ecosystem. The number of firms in the ecosystem was stable at 122. Its contradictive observation was Utrecht Science Park, which grew from 60 to 80 firms. Further inspection of the data revealed that both have a research hospital present in the ecosystem. According to their website (Facts and figures, n.d.) the current size of Leiden Bio Science Park is 195 organizations, of which 152 are companies. During the period of 2012-2013 they indicate a decrease in the number of organizations in the ecosystem, but the subsequent years show an average increase of 14 organizations per year. This indicates that only in 2013 there was a lack of growth during which BCI (2014) did their research. Furthermore, after inquiring Leiden Bio Science Park explains that due to the financial crises one of the companies went bankrupt. Moreover, two firms were taken over by another firm and they also took over the name of that company. As a result, they were counted as one firm. This, combined with its growth rate being on the cut-off value, suggests that Leiden Bio Science Park's low performance and the negative effect associated with having all conditions can be dismissed. As a result Leiden Bio Science Park is now considered to have high performance regarding firm growth in the ecosystem and the contradiction is resolved.

Similarly, Maastricht Health Campus in row 14 is focused on medical and biomedical research had low performance (-20.75% growth); its contradictive observations had an average growth of almost 20 firms, with original ecosystem sizes varying from 12 (Space Business Park) to 108 (TU/e Eindhoven). Their configuration is having five of the six conditions present in the ecosystem, only missing a manifest company. Interestingly, Maastricht Health Campus is the only ecosystem with a research hospital present. The number of firms in Maastricht Health Campus dropped from 53 to 42. The ecosystem is part of Brightlands, a community which combines the ecosystems Chemelot, Campus Greenport, Maastricht Health Campus, and Smart Services Campus.

Table 5: Dichotomous data table for firm growth

	Conditions						Outcome
	Manifest						
Ecosystem	**Company**	**University**	**Institute**	**High quality environment**	**Investor**	**Incubator or accelerator**	**Growth**
Amsterdam Science Park	⊗	●	●	●	●	●	●
Chemelot	●	⊗	⊗	●	●	●	●
Grow Campus[a]	⊗	●	●	⊗	●	●	⊗
Green Chemistry Campus	●	⊗	⊗	⊗	⊗	⊗	●
Healthy Aging Campus	⊗	⊗	●	⊗	●	⊗	●
High Tech Automotive Campus	●	⊗	●	●	⊗	⊗	●
High Tech Campus Eindhoven	●	⊗	●	●	●	●	●
Leiden Bio Science Park	●	●	●	●	●	●	⊗
Maastricht Health Campus	⊗	●	●	●	●	●	⊗
Mercator Science Park	⊗	●	⊗	⊗	⊗	●	⊗
Novel-T[b]	⊗	●	⊗	●	●	●	●
Novio Tech Campus	●	⊗	⊗	⊗	⊗	●	●
Pivot Park	●	⊗	⊗	●	●	●	●
Polymer Science Park	●	⊗	⊗	●	●	⊗	●
Space Business Park	⊗	⊗	●	⊗	●	●	●
Science Park Technopolis	⊗	●	●	●	●	●	●
TU/e Science Park	⊗	●	●	●	●	●	●
Utrecht Science Park	●	●	●	●	●	●	●
Wetsus/Water Campus	⊗	●	●	⊗	●	⊗	●
WUR Campus	⊗	●	●	●	●	●	●
Zernike Science Park	⊗	●	⊗	●	●	●	●

Note: Black circles denote the presence of a condition or high performance, and circles with a cross indicate its absence or low sperformance. [a] Formerly known as Food & Health Campus. [b] Formerly known as Kennispark Twente.

Table 6: Necessary condition consistency and coverage for firm growth

	High Performance		Low Performance	
Condition	**Consistency**	**Coverage**	**Consistency**	**Coverage**
Manifest company	0.47	0.89	0.25	0.11
~Manifest company	0.53	0.75	0.75	0.25
Manifest university	0.47	0.67	1.00	0.33
~Manifest university	0.53	1.00	0.00	0.00
Manifest institute	0.59	0.77	0.75	0.23
~ Manifest institute	0.41	0.88	0.25	0.13
High quality environment	0.71	0.86	0.50	0.14
~High quality environment	0.29	0.71	0.50	0.29
Investor	0.82	0.82	0.75	0.18
~Investor	0.18	0.75	0.25	0.25
Incubator or accelerator	0.71	0.75	1.00	0.25
~Incubator or accelerator	0.29	1.00	0.00	0.00

Note: a ~ indicates the absence of the condition.

Table 7: Truth table for firm growth

	Manifest						
Row	**Company**	**University**	**Institute**	**High quality environment**	**Investor**	**Incubator or accelerator**	**Growth**
1	⊗	⊗	●	⊗	●	⊗	●
2	⊗	⊗	●	⊗	●	●	●
3	⊗	●	⊗	⊗	⊗	●	⊗
4	⊗	●	⊗	●	●	●	●
5	⊗	●	●	⊗	●	⊗	●
6	⊗	●	●	⊗	●	●	⊗
7	⊗	●	●	●	●	●	● [a]
8	●	⊗	⊗	⊗	⊗	⊗	●
9	●	⊗	⊗	⊗	⊗	●	●
10	●	⊗	⊗	●	●	⊗	●
11	●	⊗	⊗	●	●	●	●
12	●	⊗	●	●	⊗	⊗	●
13	●	⊗	●	●	●	●	●
14	●	●	●	●	●	●	⊗ [b]

Note: Black circles denote the presence of a condition or positive outcome, and circles with a cross indicate its absence or a negative outcome. [a] consistency of 0.80. [b] consistency of 0.50.

The campus was founded as the Life & Science Campus Maastricht in 2009 by the municipality of Maastricht, the province of Limburg, Maastricht UMC+, the University of Maastricht, and LIOF (Jacbos et al., 2009). Their cooperation agreement was to be evaluated after three years in 2012 in terms of finance and content. Over the years following 2013 Maastricht Health Campus BV was founded to create 1100 new jobs in the ecosystem by 2023 by acquiring start-ups and attracting large firms. Furthermore, several projects to enhance the quality of Maastricht Health Campus were started, such as Brain Unlimited, a neuro-imaging research centre, and Mosae Vita, an environment for people, companies and researchers to interact. As Maastricht Health Campus was still fairly new and developing its strategy and environment during the time BCI (2014) did their research, this could have affected the loss firms in the ecosystem. The current number of the amount of firms in Maastricht Health Campus is 73 companies, a growth of 73.8% compared to the total number of firms in 2014 (Brightlands, 2017) and this would indicate high performance over the last year. Still, this gives only little justification to adapt the performance level of Maastricht Health Campus to high during that period. However, another method suggested by Rihoux and Ragin (2009) is to use frequency criteria (i.e. consistency) to "orientate" the outcome, meaning that one looks at the ratio of positive and negative cases for each configuration and change the outcome of the configuration to match with the majority of the cases. This configuration has four out of five cases leading to high performance and therefore, this configuration is set to lead to high performance.

4.1.4 Solutions

The next step is to minimize using Boolean Minimization to produce more parsimonious solutions. The software used produces three solutions with each their own level of complexity. As mentioned before, the intermediate solution was used as it offers a balance between complexity and parsimony. Furthermore, the minimization process will be applied to the high and low performance cases separately, as one cannot assume causal symmetry (Rihoux & Ragin, 2009). The combined output can be found in table 8. Solutions are grouped by their similarity in terms of which manifest organizations are present.

Table 8: Configurations for firm growth

	High performance						**Low performance**
Conditions	**1a**	**1b**	**1c**	**2**	**3a**	**3b**	**4**
Manifest company	●	●	●				⊗
Manifest university	⊗			●	⊗		●
Manifest institute			●		●	●	
High quality environment		●	●	●			⊗
Investor		●		●	●	●	
Incubator or accelerator				●		⊗	●
Raw coverage	0.39	0.33	0.22	0.44	0.17	0.11	0.67
Unique coverage	0.11	0.00	0.00	0.33	0.06	0.06	0.67
Consistency	1.00	1.00	1.00	0.89	1.00	1.00	1.00
Solution coverage	**1.00**						**0.67**
Solution consistency	**0.94**						**1.00**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

A total of seven solutions were found, six for high performance and one for low performance. The table shows only those solutions of which the consistency is high enough (≥ 0.80). When examining the high performance solutions in general, there seems to be much variation in the solutions and no condition is deemed necessary. However, the conditions manifest company, manifest institute, high quality environment, and investor are never required to be absent in order to achieve a positive outcome. Furthermore, the presence of a manifest university or an incubator or accelerator in an ecosystem is only required once. In general, it appears that for each individual manifest organization there is a configuration possible where they are (one of the) ecosystem leader(s) and achieve high ecosystem performance, although there is some variation in which other conditions should be present.

Looking at solutions 1a, 1b, and 1c, they indicate that for an ecosystem to grow in terms of total amount of firms, a manifest company as ecosystem leader should be present. As only solution 1c also requires a manifest institute and none require a manifest university as ecosystem leader, the ecosystems in these solutions can be characterized as business ecosystems. After further inspection of the data it appears five out of nine ecosystems only have a manifest company as a manifest organization present in the ecosystem, making this distinction only partially true. 1a suggests that the only other requirement is for a manifest university to be absent, suggesting some counterproductive cooperation between the two as ecosystem leaders. Furthermore, this indicates that a manifest company as ecosystem leader does not require any assistance from other roles to achieve firm growth in the ecosystem and is a sufficient condition. However, 1b and 1c propose that a manifest company as ecosystem leader does needs support from sponsors (high quality environment and investor), or from another ecosystem leader and expert, and sponsor (manifest institute and investor). These solutions however, have no unique coverage, indicating they do not add to the total coverage of the solutions combined. As for further commonalities among the ecosystem in the solutions, each solution contains ecosystems with different foci (e.g. life sciences, chemistry, and automotive) and development phases.

Solution 2 proposes that high performance can also be achieved through the presence of a manifest university as ecosystem leader, combined with a high quality environment, investor, and incubator or accelerator acting as sponsors, experts and champions. Surprisingly, the presence or absence of a manifest company as a second ecosystem leader does not affect the performance in this configuration. As only two of the eight ecosystems do have a manifest company present, this solution predominantly contains knowledge ecosystems. Moreover, a manifest university and company can be ecosystem leaders together in a high performance ecosystem as long as another condition is present, as suggested by solutions 1b and 1c. However, unlike the manifest company a

manifest university as ecosystem leader relies on assistance from other roles to achieve high performance in the ecosystem. Further inspection of the ecosystem that comply with this configuration reveals that this solution predominantly contains ecosystems which either have a focus on life sciences or high-tech. As for development phase, five out of eight are in the mature phase, the remaining three are in the growth phase.

Solutions 3a and 3b are grouped as they both require an institute as ecosystem leader and investor as sponsor to be present. They differ in what condition should be missing, an incubator or accelerator fulfilling the role of export, sponsor and champion, or a manifest university as a second ecosystem leader. This suggests that in such an ecosystem a university and an incubator or accelerator are substitutes, but the presence of both in an ecosystem has a nullifying effect on growth. Interestingly, the roles these two conditions represent only slightly overlap (i.e. both have expert activities), which indicates that they are not substitutes according to their activities. Furthermore, no solution exist in which the manifest institute as ecosystem leader without other roles present can achieve high performance, similar to the manifest university. In both solutions only one ecosystem also has a manifest company present, making the ecosystems predominantly knowledge ecosystems. Moreover, in solution 3a the manifest university needs to absent, indicating a leadership conflict similar to solution 1a. These solutions together contain equal numbers of ecosystems in the growth and mature phase of development. Regarding their focus, it appears that there is no distinctive common focus.

As for low performance, solution 4 is the sole solution and proposed that the absence of a manifest company as ecosystem leader and high quality environment as sponsor combined with a manifest university as ecosystem leader and incubator or accelerator as expert, sponsor and champion leads to low performance. Due to the absence of a manifest company these ecosystems can be considered knowledge ecosystems. This further acknowledges the beneficial effect of a high quality environment functioning as sponsor and manifest company as ecosystem leader for high performance. This is further confirmed when this solution is compared to high performance solution 2; it is similar to solution 4, except for that the ecosystem does have a high quality environment as sponsor and has high performance. With the exclusion of Leiden Bio Science Park as a low performance ecosystem, the ecosystems that do have low performance are either in the growth or start-up phase of development and are all focused on life sciences. It is worth noting that there are also many ecosystems with a life sciences focus which do have high performance, as shown by the previous solutions.

The coverages indicate the percentage of cases that are explained by each solution and can also be found in table 8, and are calculated for each individual solution as well as for the solutions as a whole. Coverage is divided into "raw" and "unique" coverage. Raw coverage is the degree of observations covered by the solution, and unique coverage covers the cases that can only be explained by that solution (Ragin, 2008). Based on unique coverage, solutions 1b and 1c add nothing to the explanatory power of the solutions which cannot be explained by the other solutions. Solution 2 has most empirical importance, although it has a smaller but still high consistency. Thus, the configuration with a manifest university as ecosystem leader, supported by a high quality environment and investor as sponsors, and an incubator or accelerator functioning as sponsor, expert and champion is the most important solution. Second most important is an ecosystem with a manifest company as ecosystem leader, without a manifest university interfering this leadership, and third comes the presence of a manifest institute as ecosystem leader with an investor as sponsor, without either a manifest university function as second ecosystem leader or an incubator or accelerator playing the role of expert, sponsor and champion. In total the high performance solutions can explain all observations with almost no loss in consistency. The low performance solution can explain two-thirds of the observations with no conflicting cases.

4.1.5 Analysis without Non-varying Conditions

However, the non-varying conditions could influence these results. Therefore, table 9 shows the same analysis without the conditions investor and incubator or accelerator to assess the influence of their limited variety. By removing these conditions another contradiction was created regarding Grow Campus and Wetsus/Water Campus, which configuration is characterized by the presence of a manifest university and institute as ecosystem leaders, and the absence of a manifest company as ecosystem leader and a high quality environment as sponsor. After further examination of the data, Grow Campus' growth rate was 0% (from 15 in 2012 to 15 in 2014), while Wetsus/Water Campus experienced 30% growth (from 20 in 2012 to 26 in 2014). As for ecosystem focus, Grow Campus is centred on agriculture and food, while Wetsus/Water Campus revolves around water technology. Furthermore, the development phase of Grow Campus is 'start-up' as opposed to 'growth' for Wetsus/Water Campus. Lastly, the manifest institute in Grow Campus is a local hospital, while there is no hospital associated with the Wetsus/Water Campus. These differences could be the cause for the different performance, but no further explanations for their different performance could be found. As it is unclear as to what performance this configuration should lead to and the ratio is one high performance versus one low performance, the performance

is set to low (Rihoux & Ragin, 2009). The contradiction regarding Maastricht Health Campus is resolved similar to the previous analysis.

In general, solutions 5, 6, and 7 are all focused on one of the manifest organizations function as ecosystem leader. Furthermore, without the inclusion of investor and incubator or accelerator, solution 5 appears to be a copy of solution 1a, while solution 6 is similar to 2, ands solution 7 is a match with 3a. Again, these results suggests that a manifest university as ecosystem leader requires support to achieve ecosystem growth, while the manifest company in the same role does not. Furthermore, a manifest institute functioning as ecosystem leader still does not require are high quality environment as a sponsor to be present. Moreover, the combination of a manifest company or institute with a manifest university as dual ecosystem leaders once more requires the presence of another condition, which is now a high quality environment in the role of sponsor. With regard to the low performance solution, solution 8 is similar to solution 4, albeit the presence of a manifest university doesn't matter anymore and an institute must be absent in terms of ecosystem leaders. This further underlines the need for assistance for a university as ecosystem leader to achieve ecosystem growth. It would seem that the change in conditions only has an effect on the solution for low performance. Comparing solution 8 to solution 6, again it appears that a high quality environment as sponsor is crucial to achieve high performance. Similarly, when solutions 8 is compared with solution 7 the same is true for the manifest institute functioning as ecosystem leader.

As for the coverage, the high performance solutions have a similar importance distribution as before and can explain almost all of the cases, while the low performance solution has only limited explanatory power.

Table 9: Configurations for firm growth without non-varying conditions

	High Performance			Low Performance
Condition	**5**	**6**	**7**	**8**
Manifest company	●			⊗
Manifest university	⊗	●	⊗	
Manifest institute			●	⊗
High quality environment		●		⊗
Raw coverage	0.39	0.44	0.22	0.33
Unique coverage	0.28	0.44	0.11	0.33
Consistency	1.00	0.89	1.00	1.00
Solution coverage	**0.94**			**0.25**
Solution consistency	**0.94**			**1.00**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

4.2 Growth of the Total Amount of Spin-offs

In essence this analysis is similar to the previous analysis, except performance is now based on the growth of the total amount of spin-offs in the ecosystem. Again, cases with growth are considered to have high performance, those without growth or with decline are labelled with having low performance. Two ecosystems (Polymer Science Park and Novio Tech Campus) are not considered in this analysis due to incomplete or missing data about this measure. As a result, this analysis contains only nineteen ecosystems.

4.2.1 Dichotomous Data Table

Starting with the dichotomous data table, found in table 10, it appears that the number of cases with low performance has increased comparted to the total amount of firm growth performance measure, even though the total number of cases has decreased. Furthermore, ecosystems Zernike Science, Grow Campus and Mercator Science Park have low performance, which is the second time for the last two ecosystem. Counterintuitively, Grow Campus and Zernike Science both have four out of six conditions present, but still have low performance. Similarly, Healthy Aging Campus only has two conditions present whilst having high performance.

4.2.2 Condition Consistency

The next step is to assess the necessity of the conditions based on their consistency, which is presented in table 11. Again, when a condition has a consistency of 0.80 or higher it can be considered necessary for the outcome.

Table 10: Dichotomous data table for spin-off growth

	Conditions						Outcome
	Manifest						
Ecosystem	**Company**	**University**	**Institute**	**High quality environment**	**Investor**	**Incubator or accelerator**	**Growth**
Amsterdam Science Park	⊗	●	●	●	●	●	●
Chemelot	●	⊗	⊗	●	●	●	●
Grow Campus[a]	⊗	●	●	⊗	●	●	⊗
Green Chemistry Campus	●	⊗	⊗	⊗	⊗	⊗	⊗
Healthy Aging Campus	⊗	⊗	●	⊗	●	⊗	●
High Tech Automotive Campus	●	⊗	●	●	⊗	⊗	⊗
High Tech Campus Eindhoven	●	⊗	●	●	●	●	●
Leiden Bio Science Park	●	●	●	●	●	●	●
Maastricht Health Campus	⊗	●	●	●	●	●	●
Mercator Science Park	⊗	●	⊗	⊗	⊗	●	⊗
Novel-T[b]	⊗	●	⊗	●	●	●	●
Pivot Park	●	⊗	⊗	●	●	●	●
Space Business Park	⊗	⊗	●	⊗	●	●	●
Science Park Technopolis	⊗	●	●	●	●	●	●
TU/e Science Park	⊗	●	●	●	●	●	●
Utrecht Science Park	●	●	●	●	●	●	●
Wetsus/Water Campus	⊗	●	●	⊗	●	⊗	●
WUR Campus	⊗	●	●	●	●	●	●
Zernike Science Park	⊗	●	⊗	●	●	●	⊗

Note: Black circles denote the presence of a condition or high performance, and circles with a cross indicate its absence or low performance. [a] Formerly known as Food & Health Campus. [b] Formerly known as Kennispark Twente.

Only the presence of an investor and incubator or accelerator in cases with high performance score higher than the threshold for necessity, while also having a high coverage. Thus, both the presence of an investor as sponsor and incubator or accelerator as sponsor, expert and champion can be considered as necessary, as would be expected from theory.

Table 11: Necessary condition consistency and coverage for spin-off growth

	High performance		Low performance	
Condition	**Consistency**	**Coverage**	**Consistency**	**Coverage**
Manifest company	0.36	0.71	0.40	0.29
~Manifest company	0.64	0.75	0.06	0.25
Manifest university	0.64	0.75	0.06	0.25
~Manifest university	0.36	0.71	0.40	0.29
Manifest institute	0.79	0.85	0.40	0.15
~ Manifest institute	0.21	0.50	0.60	0.55
High quality environment	0.79	0.85	0.40	0.15
~High quality environment	0.21	0.50	0.60	0.50
Investor	1.00	0.86	0.40	0.13
~Investor	0.00	0.00	0.60	1.00
Incubator or accelerator	0.86	0.80	0.60	0.20
~Incubator or accelerator	0.14	0.50	0.10	0.50

This necessity also shows signs of asymmetrical causality, as there are cases with low performance which also had an investor and/or incubator or accelerator. Therefore, this condition is not sufficient for high performance and more conditions are required to be present. Moreover, the presence of a manifest institute as ecosystem leader is marginally below the threshold for necessity (0.79) and has high coverage, suggesting that it is also a necessary condition.

4.2.3 Truth Table and Conflicting Observations

The following step is to create and analyse the truth table, see table 12. There are twelve configurations accounted for in the data, which means that the remaining 52 are logical remainders. This suggests that there is limited diversity. Furthermore, there is one configuration (row 4) that contains contractionary cases, namely Novel-T and Zernike Science Park. Both these ecosystems have a manifest university as ecosystem leader, together with a high quality environment and investor as sponsor, and incubator or accelerator fulfilling the role of sponsor, expert and champion. After further analysis of the data Novel-T grew from 150 to 175 spin-offs, a growth of 16.67%, while Zernike Science Park remained at 25, a growth of 0%. After reaching out to Zernike Science Park, they could not explain for this lack of growth, as they only started monitoring the number of spin-offs in 2015. However, there are differences; Novel-T was in the 'mature' development phase and is focused on high tech and entrepreneurship ("Founders", n.d.), while Zernike Science Park was in the growth phase and the university in this ecosystem is focused on energy, healthy aging, and sustainable society ("Onderzoek", n.d.). However, the Healthy Aging Campus, which is also in Groningen, also covers the healthy aging research and had a growth of 25 to 32 spin-offs (28%), which could have gone at the expense of Zernike Science Park. Furthermore, the Healthy Ageing Campus' manifest institute is the UMCG, a research hospital, while Zernike Science Park is not directly associated with this hospital. However, since the start of 2017 Zernike Science Park and Healthy Aging Campus are cooperating and started Campus Groningen ("Campus Groningen", n.d.). As it is unclear as to what performance this configuration should lead to and the ratio is one high performance versus one low performance, the performance is set to low.

4.2.4 Solutions

The solutions based on the truth table with a consistency equal or greater than 0.80 can be found in table 13 and are grouped based on their similarity. A total of six solutions were found, four for high performance and two for low performance. In general, it is noticeable that in none of the high performance configurations a manifest university as (one of the) ecosystem leader(s) is required. Moreover, they all require an investor functioning as expert, sponsor and champion to be present, making it a necessary condition as predicted by the consistency table.

Continuing with the high performance solutions 1a, 1b, and 1c, all three require a manifest institute to be ecosystem leader, while in solution 2 this condition does not matter. As no manifest company is required to function as ecosystem leader in these solutions, the ecosystems in these solutions can be considered knowledge ecosystems.

Table 12: Truth table for spin-off growth

Row	Manifest			High quality environment	Investor	Incubator or accelerator	Growth
	Company	University	Institute				
1	⊗	⊗	●	⊗	●	⊗	●
2	⊗	⊗	●	⊗	●	●	●
3	⊗	●	⊗	⊗	⊗	●	⊗
4	⊗	●	⊗	●	●	●	⊗ [a]
5	⊗	●	●	⊗	●	⊗	●
6	⊗	●	●	⊗	●	●	⊗
7	⊗	●	●	●	●	●	●
8	●	⊗	⊗	⊗	⊗	⊗	⊗
9	●	⊗	⊗	●	●	●	●
10	●	⊗	●	●	⊗	⊗	⊗
11	●	⊗	●	●	●	●	●
12	●	●	●	●	●	●	●

Note: Black circles denote the presence of a condition or positive outcome, and circles with a cross indicate its absence or a negative outcome. [a] consistency of 0.50.

Table 13 Configurations for spin-off growth

	High performance				Low performance	
Condition	**1a**	**1b**	**1c**	**2**	**3**	**4**
Manifest company				●	●	⊗
Manifest university	⊗			⊗	⊗	●
Manifest institute	●	●	●			
High quality environment		⊗	●	●		⊗
Investor	●	●	●	●	⊗	
Incubator or accelerator		⊗	●	●	⊗	●
Raw coverage	0.21	0.14	0.57	0.21	0.40	0.40
Unique coverage	0.07	0.07	0.50	0.14	0.40	0.40
Consistency	1.00	1.00	1.00	1.00	1.00	1.00
Solution coverage	**0.93**				**0.80**	
Solution consistency	**1.00**				**1.00**	

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

Indeed, after further examination of the data only three of the eleven ecosystems in these solutions has a manifest company present. As for focus, it appears there is no dominant common focus in these solutions. Solution 1a and 1b suggest that the combination of a manifest institute as ecosystem leader and investor fulfilling the role of expert, sponsor and champion should go without either a manifest university as a second ecosystem leader or a high quality environment function as sponsor and an incubator or accelerator playing the roles of expert, sponsor and champion in order to achieve high performance. This indicates that a manifest university and the combination of a high quality environment and incubator or accelerator are substitutes in the sense that they have the same effect on an ecosystem with a manifest institute and investor. They have no overlap in terms of the associated activities belonging to their roles. Furthermore, with these two solution there is no configuration possible that permits both a manifest university as one of the ecosystem leaders, a high quality environment as sponsor and an incubator or accelerator as sponsor, expert and champion at the same time while still having high performance. This suggests that the combination of those conditions will have a limiting effect on the performance of an ecosystem with a manifest institute as ecosystem leader and investor as sponsor. However, solution 1c does allow such a combination to exist and thus, is contradictory to solutions 1a and 1b. Based on the coverages of solutions 1a, 1b, and 1c, the solution with the most empirical importance is solution 1c. Therefore, it is assumed that to achieve high performance in an ecosystem with a manifest institute as ecosystem leader, the presence of a high quality environment and investor as sponsor, and incubator or accelerator as expert, sponsor and champion is required. This proposes that a manifest institute as ecosystem leader needs assistance from other roles in order to create

more spin-offs in the ecosystem. Interestingly, this solution predominantly contains ecosystems in the mature development phase.

Continuing with solution 2, the presence of a manifest institute as a second ecosystem leader is not required when a manifest company is already the ecosystem leader, when a high quality environment and investor functioning as sponsors, and an incubator or accelerator is present to fulfil the roles of expert, sponsor and champion, as long as there is no manifest university present. Again, this shows signs of conflict between a manifest company and university as dual ecosystem leaders. Furthermore, this type of configuration can be characterized as a business ecosystem, as further examination of the data also reveals that only one out of three ecosystems also has a manifest institute. Moreover, while a manifest company as an ecosystem leader could achieve growth of firms in the ecosystem on its own, in terms of spin-offs this is not the case. As the firm growth performance measure also includes spin-offs, this would lead to suggest that a manifest company is only capable of generating more firms in an ecosystem which are not spin-offs. Additionally, as both the manifest company and institute require the assistance of a high quality environment, investor, and incubator or accelerator for the roles of sponsor, expert and champion, this proposes that increasing the number of spin-off in an ecosystem is a task that requires the combination of multiple different activities. However, the coverage of this solution is limited, giving it only some degree of empirical importance. In totality the solutions for high performance can explain almost all observed cases. As for commonalities between the ecosystems adhering to this solution, two of the three ecosystems in solution 2 are in the mature phase of development and each has a different focus.

As for the low performance solutions, solution 3 indicates that an ecosystem with a manifest company as ecosystem leader lacking a university for the role of second ecosystem leader, an investor as sponsor, and an incubator or accelerator as sponsor, expert and champion has low performance, whether or not an institute or a high quality environment is present. Furthermore, this solution contains both knowledge and business ecosystems. Comparing this solution to solution 2, it appears that a manifest company as ecosystem leader with a sponsor through the presence of a high quality environment is missing certain activities that the others roles, but not the university, can provide. The second low performance solution 4 contains the only solution where a university must be present and suggests that even if an ecosystem has a university as a leader and an incubator or accelerator as sponsor, expert and champion, the absence of a manifest company as an ecosystem leader and a high quality environment as a sponsor leads to low performance. A manifest institute and an investor do not have any influence. As a manifest company must be absent, this solution contains only knowledge ecosystems. Both the solutions for low performance have high coverages, indicating they are both empirically important. Therefore, the results propose that it is never beneficial to have a university in an ecosystem to obtain growth in terms of spin-offs. A manifest institute and high quality environment have no influence on low performance.

4.2.5 Analysis without Non-varying Conditions

Again, the analysis is also performed without the conditions investor and incubator or accelerator, see table 14. Unlike the previous performance measure, this time the solutions are less similar to those with all conditions included. As a result there are three different conflicting configurations, of which two are resolved in sections 4.1.5 and 4.2.3. The third contradictory configuration is new and is concerned with High Tech Automotive Campus and High Tech Campus Eindhoven, which have a manifest company and institute as ecosystem leaders, and a high quality environment as sponsor. Further inspection of the data showed that High Tech Automotive Campus had a growth of 0%, remaining at 0 spin-offs in the ecosystem. High Tech Campus Eindhoven on the other hand had an increase of 15 (37.5 %), growing from 40 to 55. One possible explanation for the lack of growth and the fact that there were no spin-offs at all, could be that it is not the ecosystem's goal to attract spin-offs. However, in 2013 High Tech Automotive Campus had finished developing a 'spatial development plan' as a result of a search for a "simple, efficient, powerful, and sustainable spatial concept" to provide housing and space for starting, growing, and mature companies ("Locatieontwikkeling", n.d.). This confirms their ambition to attract spin-offs to the ecosystem. Furthermore, this suggests that before this concept was finalized, thus during the measurement of BCI (2014), there was no (adequate) strategy present to attract starting companies, which could indeed lead to low performance in terms of spin-off growth in the ecosystem. As it is unclear as to what performance this configuration should lead to and the ratio is one high performance versus one low performance, the performance is set to low.

Continuing with the solutions, solution 5 seems like a combination of 1a and 1b, indicating that a high quality environment as a sponsor and a manifest university as ecosystem leader must be absent for an ecosystem to have high performance, while the ecosystem leadership role must be filled by a manifest institute. As none of the ecosystems in this solution has a manifest company, they are considered to be knowledge ecosystems. However, solution 6 indicates that all conditions except the manifest company as an ecosystem leader are required. This suggests that a manifest university functioning as ecosystem leader and a high quality environment for the sponsor

role are also irrelevant for high performance; a manifest institute as ecosystem leader is a determining condition for ecosystem growth. However, the coverages of solution 6 are significantly higher than those of solution 5, proposing that the presence of a manifest university and a high quality environment are required in combination of a manifest institute for an ecosystem to have a high performance. Interestingly, this configuration also requires the presence of two ecosystem leaders, unlike the solutions obtained with all conditions used in the analysis. Further inspection of the data reveals that only two of the eight cases in this solution also has a manifest company present, making the ecosystems predominantly knowledge ecosystems. Solution 7 suggests that a manifest institute as ecosystem leader is not required when a manifest company fulfils this role in combination with a high quality environment as sponsor, indicating they are substitutes. Both ecosystems in solution 7 only have a company as a manifest organization present in the ecosystem and can therefore both be considered business ecosystems. Finally, the solutions for high performance can explain 79% of the cases.

Table 14: Configurations for spin-off growth without non-varying conditions

	High Performance			Low Performance	
Condition	**5**	**6**	**7**	**8**	**9**
Manifest company			●		⊗
Manifest university	⊗	●		⊗	
Manifest institute	●	●	⊗	⊗	⊗
High quality environment	⊗	●	●	⊗	⊗
Raw coverage	0.14	0.50	0.14	0.20	0.20
Unique coverage	0.14	0.50	0.14	0.20	0.20
Consistency	1.00	1.00	1.00	1.00	1.00
Solution coverage	**0.79**			**0.40**	
Solution consistency	**1.00**			**1.00**	

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

As for low performance, solutions 8 and 9 suggest that when all conditions are absent, except for either a manifest company or university as an ecosystem leader, the ecosystem will not experience growth in terms of the total amount of spin-offs. This indicates that a manifest company and a manifest university as an ecosystem leader alone is not capable of generating growth and the presence of multiple roles is required. Interestingly, solution 8 is the exact opposite of solution 6 and the ecosystem in this solution does contain a manifest company functioning as an ecosystem leader, making it a business ecosystem. Similarly, solution 9 only differs with solution 5 in terms of the condition manifest institute and doesn't have a manifest company present. As a manifest institute is present to act as ecosystem leader, it can be characterized as a knowledge ecosystem. Finally, the solution coverage for low performance is limited, explaining only 40% of the low performance cases.

4.3 Growth of the Total Amount of Employment

The final analysis is based on the performance measure of the total amount of employment in the ecosystem. Similar to the previous two performance measures, cases have high performance if the total amount of employment has grown and low performance if there is no growth or decline in the total amount of employment. The cases that were omitted in the previous analysis (Polymer Science Park and Novio Tech Campus) are added again, as the performance data is complete for all cases.

4.3.1 Dichotomous Data Table

The dichotomous data table is presented in table 15. This time ecosystems Amsterdam Science Park, Maastricht Health Campus, Mercator Science Park and Novel-T have low performance, making this Mercator Science Park's third low performance. The fact that Amsterdam Science Park, Maastricht Health Campus, and Novel-T all have low performance is counterintuitive as they all have most conditions present in their ecosystems. This is acknowledged by the fact they also produce contradictory configurations, which will be discussed in section 4.3.3. When examining the dichotomous data table it appears that all cases with low performance share the presence of a manifest university as (one of the) ecosystem leader(s) and an incubator or accelerator for the roles expert, sponsor and champion. Moreover, these cases do not have a manifest company performing the role of ecosystem leader. This suggests that these conditions are necessary for low performance.

Table 15: Dichotomous data table for employment growth

	Conditions						Outcome
	Manifest						
Ecosystem	**Company**	**University**	**Institute**	**High quality environment**	**Investor**	**Incubator or accelerator**	**Growth**
Amsterdam Science Park	⊗	●	●	●	●	●	⊗
Chemelot	●	⊗	⊗	●	●	●	●
Grow Campus[a]	⊗	●	●	⊗	●	●	●
Green Chemistry Campus	●	⊗	⊗	⊗	⊗	⊗	●
Healthy Aging Campus	⊗	⊗	●	⊗	●	⊗	●
High Tech Automotive Campus	●	⊗	●	●	⊗	⊗	●
High Tech Campus Eindhoven	●	⊗	●	●	●	●	●
Leiden Bio Science Park	●	●	●	●	●	●	●
Maastricht Health Campus	⊗	●	●	●	●	●	⊗
Mercator Science Park	⊗	●	⊗	⊗	⊗	●	⊗
Novel-T[b]	⊗	●	⊗	●	●	●	⊗
Novio Tech Campus	●	⊗	⊗	⊗	⊗	●	●
Pivot Park	●	⊗	⊗	●	●	●	●
Polymer Science Park	●	⊗	⊗	●	●	⊗	●
Space Business Park	⊗	⊗	●	⊗	●	●	●
Science Park Technopolis	⊗	●	●	●	●	●	●
TU/e Science Park	⊗	●	●	●	●	●	●
Utrecht Science Park	●	●	●	●	●	●	●
Wetsus/Water Campus	⊗	●	●	⊗	●	⊗	●
WUR Campus	⊗	●	●	●	●	●	●
Zernike Science Park	⊗	●	⊗	●	●	●	●

Note: Black circles denote the presence of a condition or high performance, and circles with a cross indicate its absence or low performance. [a] Formerly known as Food & Health Campus. [b] Formerly known as Kennispark Twente.

4.3.2 Condition Consistency

Additional evidence for the necessary conditions is found in the condition consistency table (table 16); it suggests that indeed a manifest company and incubator or accelerator are necessary with a consistency of at least 0.80, although their coverage is low. As for the high performance ecosystems, it appears that an investor as sponsor is necessary, as both its consistency and coverage are higher than 0.80.

Table 16: Necessary condition consistency and coverage for employment growth

	High performance		Low performance	
Condition	**Consistency**	**Coverage**	**Consistency**	**Coverage**
Manifest company	0.53	1.00	0.00	0.00
~Manifest company	0.47	0.67	1.00	0.33
Manifest university	0.47	0.67	1.00	0.33
~Manifest university	0.53	1.00	0.00	0.00
Manifest institute	0.65	0.85	0.50	0.15
~ Manifest institute	0.35	0.75	0.50	0.25
High quality environment	0.65	0.79	0.75	0.21
~High quality environment	0.35	0.86	0.25	0.14
Investor	0.82	0.82	0.75	0.18
~Investor	0.18	0.75	0.25	0.25
Incubator or accelerator	0.71	0.75	1.00	0.25
~Incubator or accelerator	0.29	1.00	0.00	0.00

4.3.3 Truth Table and Conflicting Observations

The next step was to create and analyse the truth table, which can be found at table 17. There are fourteen observed configurations, leaving fifty logical remainders. There were multiple contradictory configurations found during this analysis; row 4 and 7 both have a consistency lower than 1.00, indicating contradictory cases.

Starting with row 7, the configuration where only the manifest company was missing had two cases with low performance and three with high performance. Theory would suggest that such a configuration would lead to high performance, as many roles are fulfilled. However, Amsterdam Science Park and Maastricht Health Campus had low performance.

Firstly, the values in BCI (2014) where the employment growth in Amsterdam Science Park are based on already added some ambiguity to the calculation: a change from 800-900 to 850 could be interpreted in different ways, how much is 800-900 exactly? In the analysis the average was taken and as a result the ecosystem went from 850 in 2012 to 850 in 2014, or 0% growth. However, if a different interpretation is taken for 800-900 the growth could also be positive (i.e. 800-900 < 850) or negative (800-900 > 850). The CEO of Amsterdam Science Park explained during a telephonic interview that the cause for the lack of growth of employment was that companies only want to have a "foothold" in Amsterdam Science Park to gain access to the generated knowledge. As a result, they mostly get "specialized teams" with a small number of employees, whereas in other ecosystems large companies establish themselves with "teams as large as 600 employees", significantly increasing the employment in the ecosystem. Furthermore, it was suggested that such large teams also tend to establish themselves in the 'Zuidas' in Amsterdam, an internationally renowned business district. Due to this difference Amsterdam Science Park seems to have low performance, while this could be caused by the motives of the participants that join the ecosystem.

The second ecosystem which caused the contradiction was Maastricht Health Campus as it has the same configuration as Amsterdam Science Park and also had low performance; employment did not grow over the period 2012-2014 and stayed stable at 900. As previously explained in section 4.1.3, Maastricht Health Campus was a fairly new ecosystem and was still developing plans to increase the amount of employment by 1100 in ten years. This indicates that before those plans were finalized and after the original agreement there was no longer a clear strategy in place to gain such growth, which could explain the low performance. However, whether or not this configuration leads to high performance is still inconclusive, and orienting the outcome based on the ratio of high (3) and low (2) performance ecosystems does not give a conclusive answer. Therefore, the outcome is set to lead to low performance.

A different configuration also had contradictory cases, namely Novel-T (previously known as Kennispark Twente) and Zernike Science Park in row 4. Their ecosystems has a manifest university as ecosystem leader with a high quality environment and investor as sponsor, and incubator or accelerator as expert, sponsor and champion. As this ecosystem has four out of six condition it was expected to have high performance. However, Novel-T experienced a significant loss of employment during 2012-2014 as it declined from 6300 to 5741 (-8.9%), while Zernike Science Park grew from 550 to 817 (48.55%) in that same period. Interestingly, during 2011 Novel-T grew from over 5800 to 6300 ("Opnieuw groei Kennispark Twente", 2012) and the ecosystem even won an award for best business area in the Netherlands in 2013 ("Kennispark in Enschede", 2013). Furthermore, in December 2012 Novel-T fused with Innovatieplatform Twente (Eijkel, Dillingh & Weekhout, n.d.), an initiative of the province of Overijssel to increase innovation, create employment opportunities and improve the social economical structure in the Twente area (Innovatieplatform Twente, 2007). Nevertheless, there was a significant decline in employment in the ecosystem. As it is still not clear what caused this difference, the configuration is set to low performance.

Table 17: Truth table for employment growth

	Manifest						
Row	**Company**	**University**	**Institute**	**High quality environment**	**Investor**	**Incubator or accelerator**	**Growth**
1	⊗	⊗	●	⊗	●	⊗	●
2	⊗	⊗	●	⊗	●	●	●
3	⊗	●	⊗	⊗	⊗	●	⊗
4	⊗	●	⊗	●	●	●	⊗ [a]
5	⊗	●	●	⊗	●	⊗	●
6	⊗	●	●	⊗	●	●	●
7	⊗	●	●	●	●	●	⊗ [b]
8	●	⊗	⊗	⊗	⊗	⊗	●
9	●	⊗	⊗	⊗	⊗	●	●
10	●	⊗	⊗	●	●	⊗	●
11	●	⊗	⊗	●	●	●	●
12	●	⊗	●	●	⊗	⊗	●
13	●	⊗	●	●	●	●	●
14	●	●	●	●	●	●	●

Note: Black circles denote the presence of a condition or positive outcome, and circles with a cross indicate its absence or a negative outcome. [a] consistency of 0.60. [b] consistency of 0.50.

To conclude, this configuration leads to both a significant loss of employment as well as to a significant increase of employment. This ambiguity in combination with one observation for each performance level results in this configuration being set as having a low performance.

4.3.4 Solutions

Based on the truth table the software generated solutions for both high and low performance, see table 18. In general, it would appear that it doesn't matter whether there is a manifest university fulfilling the role of ecosystem leader or an incubator or accelerator as expert, sponsor and champion in the ecosystem or not, as these conditions are not included into any of the solutions and are therefore not causally linked to the performance. This proposes that both conditions have no employment generating capabilities. Furthermore, when comparing solution 1 and 2 with solution 3 in terms of the conditions manifest company and manifest institute, it would appear that they are opposites, hinting towards causal symmetry for these conditions.

As for the high performance solutions, solution 1 indicates that in order for an ecosystem to have growth in terms of employment it only requires a manifest company that plays the role of ecosystem leader. This suggests that a manifest company by itself has the capability to increase the employment in an ecosystem, independent of the presence or absence of other participants. Further inspection of the data revealed that out of the nine ecosystems in this solution five can be considered pure business ecosystems, as they do not contain a manifest university or institute. Furthermore, this means that the manifest company condition is sufficient, but not necessary (i.e. it is capable of producing the positive outcome on its own, but it is not the sole explanation), as there is also a second solution. Solution 2 states that the presence of a manifest institute as an ecosystem leader and an investor as a sponsor with a high quality environment not present to act as a sponsor allows an ecosystem to grow in terms of employment. All ecosystems in this solution lack a manifest company and are therefore knowledge ecosystems. This solution proposes that the efforts made by the manifest institute as ecosystem leader and investor as sponsor

to increase the employment in the ecosystem only works when there is no high quality environment present to fulfil the role of sponsor, otherwise the efforts are compromised. This indicates a link between the activities of the manifest institute and investor to increase employment and a high quality environment. Although the high quality environment and investor both play the sponsor role, they do so only partially and with different activities: the high quality environment assists with developing the product or service of the firm, while the investor is mainly focused on providing financial assistance. As for commonalties in the ecosystems that belong to these solutions, it appears that in both solutions there is no predominant ecosystem focus or development phase.

Table 18: Configurations for employment growth

	High Performance		Low Performance
Condition	**1**	**2**	**3**
Manifest company	●		⊗
Manifest university			
Manifest institute		●	⊗
High quality environment		⊗	⊗
Investor		●	⊗
Incubator or accelerator			
Raw coverage	0.53	0.24	0.25
Unique coverage	0.53	0.24	0.25
Consistency	1.00	1.00	1.00
Solution coverage	**0.76**		**0.25**
Solution consistency	**1.00**		**1.00**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

To explain low performance solution 3 suggests that when a manifest company, a manifest institute, a high quality environment, and an investor are all missing from the ecosystem, this would lead to low performance, whether or not a manifest university or incubator or accelerator are present. The combination of a manifest university as ecosystem leader with an incubator or accelerator functioning as expert, sponsor and champion does not lead to employment growth in the ecosystem. In other words, they are not able to create more jobs for the ecosystem. The coverages of the solutions indicate that while they all have reasonable empirical weight, solution 1 is most important. This further underlines the importance of a manifest company as an ecosystem leader for an ecosystem to achieve growth in the total amount of employment. As for the solution coverages, the high performance solution coverage is high and can explain 76% of the cases, while the low performance solution coverage can only do so for a quarter of the cases and has little empirical importance.

Table 19 Configurations for Employment Growth without Investor and Incubator or Accelerator

	High Performance		Low Performance
Condition	**4**	**5**	**6**
Manifest company	●		⊗
Manifest university			
Manifest institute		●	⊗
High quality environment		⊗	⊗
Raw coverage	0.53	0.24	0.25
Unique coverage	0.53	0.24	0.25
Consistency	1.00	1.00	1.00
Solution coverage	**0.76**		**0.25**
Solution consistency	**1.00**		**1.00**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

4.3.5 Analysis without Non-varying Conditions

As for the solutions without the investor and incubator or accelerator conditions, they are copies of solution 1, 2, and 3 minus those conditions, and can be found in table 19. Logically, solution 2 doesn't require an investor as sponsor anymore and the absence of an investor as sponsor is no longer needed for solution 3. As it was determined previously that the condition incubator or accelerator had no effect on the outcome, the fact that removing this condition doesn't cause any changes further acknowledges its irrelevance for employment in the ecosystem. As for the coverages, they are identical to the previous analysis.

4.4 Sensitivity Analysis

In this section the analyses are repeated with different thresholds defining the outcome of a case to see how sensitive the previous results are. Rihoux and Ragin (2009) suggested that thresholds for determining the membership of a case to a certain outcome may be adapted as long as the changes are justifiable. Furthermore, Rihoux and Ragin (2009) suggested the use of mvQCA or fsQCA in case of contradictory configurations, as it allows for varying degrees of membership. Based on the available data in BCI (2014) fsQCA is chosen as the growth rates can also be expressed as a percentage of growth relative to the ecosystem's size. The new thresholds are based on data of the Central Bureau of Statistics [CBS] (2017a,b) in the Netherlands, which allows for the calculation of the national growth rates for firm and employment growth in the Netherlands. As they do not provide data on spin-off growth in the Netherlands, it is assumed that this growth is to some degree comparable to firm growth and therefore the same rate is chosen. The national growth rate is used as a crossover point for average performance for an ecosystem. Six-value fuzzy set with the thresholds shown in table 20 was chosen to ensure each case was assigned to the most logical group without cut-off values splitting similar ecosystems into different groups. Additionally, the amount of cases in each performance level are shown. Clearly, the new thresholds have a different effect on the performance level employment growth as for firm growth and spin-off growth; while employment growth now has almost all cases with above average performance, the latter two have a more evenly spread assignment of cases over the different performance levels. The following sections discuss the outcome of these analyses compared to the originals.

Table 20: fsQCA outcome thresholds

	Growth of total amount of					
	Firms		Spin-offs		Employment	
Outcome	Thresholds	Cases	Thresholds	Cases	Thresholds	Cases
1.00	growth > 50%	6	growth > 50%	4	growth > 50%	13
0.80	16 ≤ growth < 50%	5	16 ≤ growth < 50%	7	10 ≤ growth < 25%	3
0.60	8 ≤ growth < 16%	3	8 ≤ growth < 16%	2	-1 ≤ growth < 5%	3
0.40	4 ≤ growth < 8%	3	4 ≤ growth < 8%	1	-2 ≤ growth < -1 %	0
0.20	0 ≤ growth < 4%	2	0 ≤ growth < 4%	4	-4 ≤ growth < -2%	0
0.00	growth < 0%	2	growth < 0%	1	growth < -4%	2
National average	~ 8%		~ 8%[a]		~ -1%	

Note: [a] percentage is based on the average firm growth.

4.4.1 Firm Growth

Table 21 contains the solutions for the performance measure firm growth as a result of the fsQCA with the new thresholds. In general, the manifest university as an ecosystem leader is no longer required for high performance, while previously this was the solution with the highest empirical weight. Furthermore, it appears that the presence of an incubator or accelerator to fulfil the roles of expert, sponsor and champion is also no longer required in any of the high performance solutions. Continuing with the individual solutions, solution 1a proposes that a manifest company can still achieve high ecosystem performance on its own as an ecosystem leader, similar to the previous analysis. Interestingly, it now indicates that its leadership combined with a manifest university can lead to high performance, only requiring that a manifest institute is not part of the ecosystem leadership. Such a configuration was not found during the original analysis. However, further analysis of the data reveals that none of the ecosystems in this solution has a manifest university. Furthermore, this also makes all ecosystems that comply with this solution are business ecosystems. The combination of a manifest company as an ecosystem leader and a high quality environment as sponsor with the absence of an incubator or accelerator as sponsor, expert and champion in solution 1b bears resemblance to solution 1b found using csQCA, where the investor must be present to play the role of sponsor and the condition incubator or accelerator does not matter. Furthermore, this indicates that a manifest company as an ecosystem leader does need assistance with achieving high performance through a

high quality environment as a sponsor, as opposed to solution 1a. However, an incubator or accelerator to play the roles of expert, sponsor and champion must not be there. This indicates a negative effect when an incubator or accelerator is combined with a manifest company and high quality environment. However, this solution has limited coverage.

Table 21: Configurations for firm growth (fsQCA)

	High performance				Low performance
Conditions	**1a**	**1b**	**2a**	**2b**	**3**
Manifest company	●	●		⊗	⊗
Manifest university				⊗	●
Manifest institute	⊗		●	●	
High quality environment		●			⊗
Investor			●	●	
Incubator or accelerator		⊗	⊗		●
Raw coverage	0.34	0.13	0.13	0.15	0.24
Unique coverage	0.27	0.06	0.06	0.07	0.24
Consistency	0.92	0.90	0.90	1.00	0.90
Solution coverage	**0.61**				**0.24**
Solution consistency	**0.90**				**0.90**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

Solution 2a indicates that having a manifest institute as ecosystem leader can lead to high performance, as long as it is combined with the presence of an investor as sponsor and an incubator or accelerator is not there to act as sponsor, expert and champion. This suggests that such an ecosystem needs additional financial aid that a manifest institute alone cannot provide, similar to solution 3b using csQCA, but it should not come from an incubator or accelerator. The multiple roles this actor has could conflict with those of the ecosystem leader, while an investor is purely focused on financing. The ecosystems with this configuration all lack a manifest company in the ecosystem and as a result, they can all be considered knowledge ecosystems. Solution 2b suggests that the absence of an incubator or accelerator can be substituted by the absence of a manifest company and university as ecosystem leaders, indicating a conflict in leadership that would negatively impact the growth. This solution is similar to 3a in the original analysis. However, the absence of a manifest company as ecosystem leader is now also required, further acknowledging the conflict between a manifest institute and company in terms of leadership. Due to the required absence of a manifest company, this solution contains only knowledge ecosystems. A solution where the a manifest university is ecosystem leader with a high quality environment and investor as sponsor, and incubator or accelerator as sponsor, expert and champion were all required is no longer present. As for coverages, this analysis scores lower than the original and can therefore significantly explain less observations (61% versus 94%). The solution with most explanatory power is solution 1a, although it is conflicting with the outcome of the original analysis. As for low performance, both analyses provided a similar configuration as explanation, only the coverages are lower (24% versus 50%) and a slightly lower consistency (0.90 versus 1.00), indicating that not all observations follow this explanation.

Again, this analysis is also performed without the non-varying conditions of investor and incubator or accelerator and its results can be found in table 22. Solution 4 resembles solution 1a and solution 5 matches solution 2b, while solutions 1b and 2a have no original counterpart. A manifest university as ecosystem leader and a high quality environment as sponsor are not required in any of the solutions, similar to the original analysis. Moreover, the combination of a manifest company and institute as ecosystem leaders will not lead to high performance. The configuration of only a manifest institute as ecosystem leader however does lead to high performance, with or without a high quality environment present to act as sponsor. Similarly, a manifest company as ecosystem leader without a manifest institute leads to high performance, although this time the presence of a manifest university doesn't matter. Again, these results propose that a manifest company and institute should not both be present in an ecosystem. Furthermore, a manifest university can be ecosystem leader, as long as this leadership is shared with a manifest company and not with a manifest institute. This proposes that a manifest company and university conflict with a manifest institute on certain areas of leadership, while a manifest company and university do not. As for coverages, solutions 4 has the highest and is empirically more important, although both solutions do not have a high coverage. The solution coverage is therefore also limited and together the high performance solutions can

only explain 49% of the cases, indicating a high degree of randomness. As for the low performance solution, the results are similar to the previous analyses.

Table 22: Configurations for firm growth without non-varying conditions (fsQCA)

	High performance		Low performance
Condition	**4**	**5**	**6**
Manifest company	●	⊗	⊗
Manifest university		⊗	
Manifest institute	⊗	●	⊗
High quality environment			⊗
Raw coverage	0.34	0.15	0.13
Unique coverage	0.34	0.15	0.13
Consistency	0.92	1.00	1.00
Solution coverage	**0.49**		**0.13**
Solution consistency	**0.94**		**1.00**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

4.4.2 Spin-off Growth

In table 23 the results of the fsQCA analysis for spin-off growth are presented. Whereas the csQCA had four solutions for high performance, with some degree of similarity and contradictions, this analysis provides more distinct solutions. As an investor as sponsor is present in both solutions it is a necessary condition, similar to the original analysis. Solution 1 indicates that a manifest institute as ecosystem leader and an investor as sponsor, combined with the absence of a manifest university leads to high performance. This is similar to solution 1a found using csQCA. Further inspection of the data reveals that this solution contains both knowledge and business ecosystems. As for solution 2, a manifest company as ecosystem leader with support from a high quality environment and investor as sponsor, and incubator or accelerator fulfilling the roles of sponsor, expert and champion causes an ecosystem to have high performance. This solution is similar to solution 2 using csQCA, only this time a manifest university has no influence on the outcome, instead of being required to be absent. This solution also contains both knowledge and business ecosystems. Comparing solution 1 and 2 it appears that a manifest institute as ecosystem leader requires less support than a manifest company as ecosystem leader to achieve spin-off growth in the ecosystem, indicating that an institute has such capabilities by itself. This is similar to what was found using csQCA. Solution 2 has a higher coverage than solution 1, and together they can explain 52% of the cases, while the original analysis could do so for 93%.

Table 23: Configurations for spin-off growth (fsQCA)

	High Performance		Low Performance	
Conditions	**1**	**2**	**3**	**4**
Manifest company		●	●	⊗
Manifest university	⊗		⊗	●
Manifest institute	●			
High quality environment		●		⊗
Investor	●	●	⊗	
Incubator or accelerator		●	⊗	●
Raw coverage	0.22	0.37	0.23	0.26
Unique coverage	0.15	0.30	0.23	0.26
Consistency	0.57	0.88	0.80	0.90
Solution coverage	**0.52**		**0.49**	
Solution consistency	**0.89**		**0.85**	

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

As for the low performance solutions, these are again similar to the original analysis, except for lower coverage values. Solution 3 and 4 also have a lower consistency than its original counterpart. Solution 3 contains a mix of knowledge and business ecosystems, while solution 4 contains only knowledge ecosystems. Overall, the low performance solutions can only explain 49% of the observations, less than the analysis using csQCA and indicates the presence of other factors that were not accounted for in the analysis. Moreover, it suggests randomness in the observations with low performance.

Similarly to the previous analyses, the analysis was also performed without the conditions investor and incubator or accelerator. The results of this analysis can be found in table 24. Surprisingly, this analysis has more solutions than the analysis with all conditions. Similarly to what happened during the csQCA, solution 5 is slightly different from solution 1, a high quality environment as sponsor is now required to be absent in the configuration to lead to high performance. Furthermore, solution 7 bears some resemblance of solution 2, although now a manifest university is required to be present and act as ecosystem leader. The leadership was previously together with a manifest institute, while in this analysis it is with a manifest company. Solution 6 is exactly like the original solution. Solutions 5 and 6 both indicate that a manifest institute as ecosystem can be replaced by the combination of a manifest company as ecosystem leader and a high quality environment as a sponsor, and are mutually exclusive for obtaining high performance. However, as solution 7 proposes, high performance can also be achieved by joint ecosystem leadership of a manifest company and university, and high quality environment as a sponsor. In this situation a manifest institute is of no relevance. All three solutions have low coverages, indicating they can only explain a small portion of the cases, and together they can only explain 45% of the observations. To compare, the solutions gathered during the csQCA could 79% of the observation with high performance. As for low performance, these results are similar to the results from the csQCA, albeit the coverages are lower.

Table 24: Configurations for spin-off growth without non-varying conditions (fsQCA)

	High Performance			**Low Performance**	
Condition	**5**	**6**	**7**	**8**	9
Manifest company		●	●		⊗
Manifest university	⊗		●	⊗	
Manifest institute	●	⊗		⊗	⊗
High quality environment	⊗	●	●	⊗	⊗
Raw coverage	0.15	0.17	0.13	0.11	0.14
Unique coverage	0.15	0.17	0.13	0.11	0.14
Consistency	0.90	1.00	0.80	0.80	1.00
Solution coverage	**0.45**			**0.26**	
Solution consistency	**0.90**			**0.90**	

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

4.4.3 Employment Growth

Table 25 contains the results of the sensitivity analysis with employment growth as performance measure. There are some similarities with csQCA analysis, there are two solutions for high performance and one for low performance. Furthermore, the positive solutions again contain one with a manifest company as ecosystem leader, solution 1, and one with a manifest institute as ecosystem leader, solution 2. A manifest university is once more irrelevant for the performance. However, solution 1 now contains the absence of a manifest institute, while the other conditions still remain unconnected to performance. Thus, a manifest company as ecosystem leader on its own has the capabilities to achieve employment growth in the ecosystem, but when a manifest institute joins the manifest company in leading the ecosystem it compromises those capabilities. Solution 2 states that high performance can be achieved through the presence of a manifest institute as ecosystem leader with an investor as sponsor, indicating that a manifest institute as ecosystem leader is lacking financial resources that the investor can complement. Furthermore, this suggests that a manifest company as ecosystem leader and the combination of a manifest institute as ecosystem leader and an investor as sponsor are substitutes. Moreover, a manifest institute and company can be joint ecosystem leaders when there is an investor present in the ecosystem functioning as sponsor. Interestingly, these solutions both have higher coverages than their csQCA counterparts, although this could originate from the fact that most cases are now considered to have high performance. Solution 2 has the highest coverage and is therefore the one with the most empirical weight. Furthermore, the high performance solutions combined can explain 91% of the observations, while the original solutions could only explain 76%. As

for the low performance solution, it is a copy of the original low performance solution, with a minor increase in coverage. Again, the increased coverage could be a result of the polarization of the cases.

Continuing with the analysis without the conditions investor and incubator or accelerator, the results can be found in table 26. Again the results are similar to the original analysis using csQCA. However, a high quality environment as sponsor is no longer required to be absent in combination with a manifest institute as ecosystem leader to gain high performance in the ecosystem. Solutions 4 and 5 indicate that both a manifest company and a manifest institute individually have the capabilities as ecosystem leader to achieve high ecosystem performance without the requirement of another organization or role, making them sufficient but not necessary conditions. And again, both these solutions have higher coverage than their originals, albeit their consistency is lower. In comparison, the fsQCA high performance solutions achieve a coverage of 0.94 with a consistency of 0.90, while the csQCA leads to a coverage of 0.76 with a consistency of 1.00. In other words, in this case the sensitivity analysis provides solutions which has more empirical weight, but at the same time is less precise as it covers some observations that do not have high performance. As for solution 6, explaining low performance, this solution is identical to its original counterpart, with a minor increase in coverage.

Table 25: Configurations for employment growth (fsQCA)

	High performance		**Low performance**
Condition	**1**	**2**	**3**
Manifest company	●		⊗
Manifest university			
Manifest institute	⊗	●	⊗
High quality environment			⊗
Investor		●	⊗
Incubator or accelerator			
Raw coverage	0.28	0.63	0.26
Unique coverage	0.28	0.63	0.26
Consistency	0.96	0.90	1.00
Solution coverage	**0.91**		**0.26**
Solution consistency	**0.92**		**1.00**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

Table 26: Configurations for employment growth without non-varying conditions (fsQCA)

	High performance		**Low performance**
Condition	**4**	**5**	**6**
Manifest company	●		⊗
Manifest university			
Manifest institute		●	⊗
High quality environment			⊗
Raw coverage	0.48	0.66	0.26
Unique coverage	0.28	0.47	0.26
Consistency	0.91	0.88	1.00
Solution coverage	**0.94**		**0.26**
Solution consistency	**0.90**		**1.00**

Note: Black circles denote the presence of a condition, and circles with a cross indicate its absence. A white space indicates that the condition has no effect on the outcome.

4.4.4 Conclusion

In general, the sensitivity analysis provides similar insights into which conditions affect the different performance measures, although the total solution coverage has significantly decreased with firm growth and spin-off growth. In contrast, the solution coverage of the solutions for employment growth have significantly increased, with only

a minor sacrifice in consistency. This is most likely a result of the different diffusion of the cases over the different performance levels. As a result, the revised analysis gives more parsimonious solutions than the original analysis in the case of employment growth, for the other two measures the original analysis provided more distinct solutions.

5. DISCUSSION

This study set out to assess the influence of ecosystem participants and ecosystem participant diversity on the performance of the ecosystem they operate in. More specifically, how three different types of ecosystem leaders (i.e. a company, university, or institute) and the roles of investor, expert, sponsor and champion affect the growth of firms, spin-offs and employment in knowledge and business ecosystems. The presence of these roles in an ecosystem were not measured directly, but through the presence of several proxies: a high quality environment, investor, and incubator or accelerator. By using a configurational approach, the different combinations of these actors and their associated roles have been compared. Firstly, the general results are discussed, followed by the three different performance measures in each their own section.

5.1 General Results

5.1.1 Participant Diversity

Diversity in the sense of the diverse roles by Dedehayir et al. (2016) or as the presence of large companies, universities and institutes in an ecosystem is not always required; some solutions for high performance only require the presence of two or three conditions. However, the solutions with most explanatory power for firm growth and spin-off growth have all roles present in the ecosystem. This is in line with theory that attributes higher ecosystem performance to participant diversity (Cohen, 2013; Dedehayir et al., 2016; Tötterman & Sten, 2005). Similarly, the low performance solutions are characterized by the required absence of conditions, in line with the associated lower performance of limited diversity. Of all three performance measures, spin-off growth seems to be the 'most demanding' measure, with an investor as sponsor as a necessary condition and also requiring a manifest institute or company as ecosystem leader and often requiring the presence of a high quality environment as sponsor and incubator or accelerator as sponsor, expert and champion. The other performance measures often have solutions that only entail two or three conditions.

5.1.2 Ecosystem Leaders

Remarkably, it seems that each performance measure has a distinct ecosystem leader that is most associated with high performance: the total amount of firms in an ecosystem is mostly determined by a manifest university as ecosystem leader, while for spin-off growth this is true for a manifest institute as ecosystem leader and employment growth has a manifest company most associated as ecosystem leader. Ultimately, an ecosystem would want to have high performance on all three of the measures. There is one solution that can achieve this: a manifest company as ecosystem leader with a high quality environment and investor as sponsor and an incubator or accelerator fulfilling the roles of expert, sponsor and champion. Interestingly, the absence of a manifest university is required to achieve high performance on all three performance measures. This indicates a certain conflict that arises between the university and the other conditions, most likely between the manifest company and university in terms of leadership, as Clarysse et al. (2014) made clear that they have different goals and activities.

As for the question posed by Dedehayir et al. (2016) on the effect of multiple leaders in an ecosystem, it appears that almost all results indicate that multiple leaders are not required to be present in an ecosystem to have high performance. More specifically, out of the 35 high performance solutions (including those from the analysis without non-varying conditions and the sensitivity analysis) only 2 solutions required the presence of two manifest organizations, both in the analysis with spin-off growth as performance measurement and excluding the conditions investor and incubator or accelerator. Furthermore, some solutions even suggest that the combination of multiple manifest organizations should be avoided in order to achieve high performance.

However, there is a substantial body of knowledge that focuses on the Triple Helix, the relationships between industry, university and government. It argues that it is the combination of these three elements, with a larger role for the university, which has "the potential for innovation and economic development" in ecosystems (Etzkowitz, 2003, p.238). This suggests that an ecosystem would benefit from the combination of a manifest company and a manifest institute or university as collaborative ecosystem leaders. Indeed, Etzkowitz (2003) talks of "collaborative leadership" to connect people and different views, and the leadership has a regulating role to ensure consensus and balance conflicts of interests. Although in this study the role of regulator and thus government was omitted, the results show little advantageous effect of the combination of a university or institute and company as ecosystem leaders. Moreover, the results even show that this joint leadership would occasionally even lead to low performance. Furthermore, it was possible to characterize most solutions as either knowledge of business

ecosystems, and only a few were both. However, there are two important conditions for the Triple Helix to function: gaining enough critical mass in terms of actors and resources, and the support of entrepreneurship via funding and networking. Still, even with the roles of sponsor, expert and champion that could assists with achieving these conditions it appears that a Triple Helix configuration has a negative impact on performance, while high performance can often be achieved without it.

5.1.3 Sensitivity Analysis

The sensitivity analysis provided similar results as the original analysis, although it produces solutions with significant lower coverage for the performance measures firm growth and spin-off growth. However, for employment growth it produced higher coverage. A possible cause for this difference is the different threshold values that have been applied. Both firm and spin-off growth saw a decrease in the average membership due to increased threshold values and as a result had less power to explain high performance. The opposite happened with employment growth as its threshold values were lowered and there was a slight increase in average membership, allowing for more coverage on the high performance solutions.

The following sections will go further into the results of each of the performance measures. The first performance measure discussed is firm growth, followed by spin-off growth and finally, employment growth.

5.2 Firm Growth

5.2.1 Difference in Ecosystem Leaders' Capabilities

Starting with firm growth, the results have shown that with each manifest organization high performance (i.e. growth of the total number of firms in the ecosystem) can be achieved. However, there is a difference in the assistance required for each manifest ecosystem leader; a company can achieve this on its own when there is no university present, while an institute or university as ecosystem leader do require other organizations and roles to be present. More specifically, an institute requires the presence of an investor as sponsor and a university requires an investor and a high quality environment as sponsor, and an incubator or accelerator to function as sponsor, expert and champion. Theses varying degrees of assistance required indicate a difference in capabilities to attract and acquire firms. Such a difference between companies and universities or public research organisations was predicted by Clarysse et al. (2014), as they have a different focus of activities (i.e. knowledge generation versus customer value). The non-commercial focus could deter firms into establishing themselves into the ecosystem. It would seems that the presence of a high quality environment, investors, and incubators or accelerators might bring the required commercial perspective that the firms find lacking in institutes and universities.

5.2.2 Private Funding

Furthermore, Clarysse et al. (2014) and Koh (2010) indicated that ecosystems led by universities or public research organisations benefit from more private funding and global relationships, while companies often already have such funding and relationships. This is confirmed by the results as the need for an investor as sponsor for both the manifest university and manifest institute to provide private funding and networking abilities. As a manifest company is a private organization it can provide such funding itself and is likely to already have global relationships. Therefore, it does not require a sponsor to be present. In essence, it would appear that the manifest company plays multiple roles suggested by Dedehayir et al. (2016), and not just ecosystem leader. However, this does not explain the difference between manifest institutes and universities, as a high quality environment and incubator or accelerator are not deemed necessary for the manifest institute to attract new firms.

5.2.3 Conflict between Ecosystem Leaders

Moreover, the results suggest that in order to achieve high performance the manifest university cannot always be present when a manifest company or manifest institute is already ecosystem leader. This indicates there is a certain conflict between on the one side the manifest university and on the other side the manifest company or manifest institute, most likely in terms of leadership as mentioned before. The suggested critical success factors by Hoffmann (2001) do not provide insights into why collaboration specifically with a university is more difficult and how come this conflict can be resolved with the introduction of another condition. However, disagreement on ecosystem strategy and architecture (Autio & Thomas, 2014) or the different foci of activities (Clarysse et al., 2014) could play a part in this. Indeed, Bruneel, d'Este and Salter (2010) did a study on the factors that diminish the barriers that are present with university-industry collaborations. They divided the barriers into two categories, orientation-related barriers and transaction-related barriers. As for the orientation-related barriers, the long-term orientation of university research was the largest obstacle, while the substantial transaction-related barriers were related to intellectual property and administrative procedures and are harder to overcome (Bruneel et al., 2010). Furthermore, they found that the strongest mechanism to lower the barriers is trust and requires long-term investment in interactions, mutual understanding of goals, and a focus on face-to-face contacts between industry

and academia. This would also explain why such a conflict vanishes when there are one or more conditions present in the ecosystem, depending on whether or not the collaboration is with a manifest institute or manifest company. Moreover, Greitzer, Pertuze, Calder, and Lucas (2010) have found critical success factors for industry-university collaboration and developed seven best practices. Several of these best practices are concerned with boundary-spanning activities and communication linkages between the organizations. These are activities of the ecosystem leader, sponsor, champion and entrepreneur roles (Dedehayir et al, 2016) and functions of third parties as anchors as previously discussed. It could be argued that through the introduction of certain actors (e.g. an investor) the two organizations increase their linkage with each other and have a common project and interest. Furthermore, it requires employees and managers who are aware of both sides and thus creates a bridge between the organizations. Moreover, the gap between the different foci (Clarysse et al., 2014) and ecosystem strategy and architecture (Autio & Thomas, 2014) would be reduced. However, each high performance solution has at least one of these roles to cover these best practices. Moreover, all but one ecosystem has active open innovation which also covers these activities. Still, the Triple Helix is not required for achieving high performance and is even detrimental to ecosystem performance in certain configurations.

5.2.4 Future Research

Future research could further investigate the conflict between a manifest university and institute. Although the two are often considered to be similar (e.g. Clarysse et al., 2014), it appears there is some level of difference between the two that would prevent them to effectively collaborate and achieve firm growth in their ecosystem (e.g. level of educational activities, organizational goal, or degree of commercialism). New insights could be gained that would allow the two organizations to more successfully cooperate. Secondly, future research could delve into the activities that the ecosystem leaders undertake to increase the amount of firms in the ecosystem. This could give insights into why the manifest company can achieve high performance on this measure while the manifest institute and university do not. This would clarify if manifest companies are playing multiple roles suggested by Dedehayir et al. (2016) or if this could be caused by their commercial attitude. Additionally, looking into the reasons why firms join a particular ecosystem (e.g. the offered support and facilities, its network, or proximity to large players) could provide insights into this matter.

5.3 Spin-off Growth

Secondly, the performance was measured in the growth of spin-offs present in the ecosystem. Firm growth included both regular firms and spin-offs and gives no insights into which type of organization accounted for the growth. Meaning, there could have been a decrease of one type while the other grew. If the growth was larger than the loss the ecosystem would have had high performance, even though there was a decrease in one type of the firms. The spin-off growth performance measure gives more insights into this ratio, as it is only concerned with the number of spin-off in the ecosystem.

5.3.1 Difference in Ecosystem Leaders' Capabilities

Again, high performance is obtainable with all three manifest organizations. However, the manifest university is only once required to be an ecosystem leader and has surprisingly only limited beneficial effect on spin-off growth in the ecosystem. The presence of a university is only required when the non-varying conditions are omitted, and only in combination with a manifest institute or company as joint ecosystem leader. This goes against what Baptista (1998), Dedehayir et al. (2016) and Phelps et al. (2012) suggest; the presence of a university creates knowledge spill-over, increases innovation and helps with valorisation of knowledge, which should fuel spin-offs. However, results from Zhang (2009) indicate that spin-offs from universities tend to be similar to regular start-ups in terms of venture capital raised, the probability of making profit and size of employment and therefore, also hints towards the limited influence that universities have on creating spin-off growth in an ecosystem. Moreover, it could be that the manifest university has outsourced these activities to other actors in the ecosystem on its behalf and does little to attract spin-offs itself. Consequentially, the university could be considered obsolete through the operationalization of this study as high performance is accredited to the other actors acting in the name of the university. Furthermore, the results indicate that a manifest university does not function well as anchor role in an ecosystem to create a platform and attract and acquire spin-offs, although this was suggested by Agrawal and Cockburn (2002, 2003) and Iansiti and Levien (2004a). A manifest company and manifest institute are able to perform the role of ecosystem leader, but do require the presence of a high quality environment and investor for the sponsor role, and an incubator or accelerator as a sponsor, expert and champion.

5.3.2 Conflict between Ecosystem Leaders

Moreover, there is evidence that the collaboration with a manifest university is troublesome for the manifest institute and manifest company, similar to what was found based on firm growth. However, this conflict now mostly affects the combination of a manifest company and university and can be explained by the barriers between

industry-university collaboration by Bruneel et al. (2010) and the importance of the best practices by Greitzer et al. (2010).

5.3.3 Attracting Firms versus Attracting Spin-offs

When comparing the high performance solutions for spin-off growth to firm growth it turns out that attracting firms in general has different requirements than spin-offs specifically. It can be concluded that while a manifest company has no trouble to attract regular firms by itself, the same cannot be said when considering spin-offs as it requires the presence of a high quality environment and investor as sponsors, and an incubator or accelerator to fulfil the roles of sponsor, expert and champion. Moreover, the manifest institute also requires these actors to be present to attract spin-offs compared to regular firms, where only the presence of an investor was required. This is further evidence that spin-offs require aid with developing their organization (Aarikka-Stenroos & Halinen, 2007; Barringer & Harrison, 2000; Clarysse et al., 2014; Cohen, 2013; Holmen & Pedersen, 2003; Oukes & Raesfeld, 2014;Yin et al., 2012), while regular firms require less assistance of the ecosystem to function and therefore, less roles are necessary for ecosystems to achieve high performance for firm growth.

5.3.4 Private Funding

Moreover, the investor is deemed a necessary condition for high performance as it is present in all the high performance solutions of both the original and the sensitivity analyses. The necessity of an investor for spin-offs has been identified by Dedehayir et al. (2014) as the sponsor role that provides funding for starting companies. This role is also partially played by the incubator or accelerator as it also assists with funding. However, it seems that incubators or accelerators only have a positive effect on the growth of spin-offs in the ecosystem in two of the four solutions when they are combined with an investor and high quality acting as sponsor and either a manifest company or institute functioning as ecosystem leader. This is remarkable as their activities are specifically designed to support new ventures (Cohen, 2013; Milanov & Shepherd, 2013; Tötterman & Sten, 2005). This suggests that spin-offs' primary concern is with funding, and only to a lesser degree require knowledge and expertise regarding business development.

5.3.5 Future Research

Future research should further explore the results that a manifest university does not support spin-off growth, which goes against current knowledge. Insights into which activities the universities undertake themselves to attract and acquire spin-offs and which are 'outsourced' should provide some answers to this. Furthermore, additional research could focus on what type of support (i.e. funding or mentorship) spin-offs deem to be most important. This could validate the findings that an investor is considered a necessary condition for spin-off growth, while an incubator or accelerator is not.

5.4 Employment Growth

Finally, the third analysis used the growth of employment in the ecosystem as a performance measure.

5.4.1 No Growth through Universities and Incubators or Accelerators

The presence of a university or incubator or accelerator seem to have no effect on the employment in the ecosystem. Employment growth rates of universities themselves seem to be limited with only 14% in 16 years ("Veel wetenschappers", 2017), and do not contribute much to the employment growth themselves. However, a manifest university is associated with firm growth in an ecosystem when there is a high environment, investor and incubator or accelerator present. An increase in firms is most likely accompanied with an increase in employment, however this is not always the case; ecosystems Amsterdam Science Park and Novel-T are good examples of this. Furthermore, QCA is concerned with combinations of conditions and configurations; it is not possible to argue that as a condition is present in a configuration, it alone should also have a (smaller) positive effect. As for incubators and accelerators, it could be argued that the minimal mentorship incubators offer and the limited duration, selective admission and cyclical nature of accelerators (Cohen, 2013) causes their workforce to require limited to no growth over time. However, the spin-offs that they attract do have growth potential; however, they can chose to leave the ecosystem when successful or dissolve when they are not. It would appear that at the bottom-line these opposing effects nullify each other and the condition has no effect on performance in end.

5.4.2 Manifest Companies and Institutes

Furthermore, a manifest company is deemed a sufficient condition for high performance and can achieve employment growth on its own, similar to firm growth. And similarly, a manifest institute in combination with an investor also leads to high performance, again a similar combination as with firm growth. It could be argued that if the manifest company self is successful, it could expand its own workforce and therefore, increase the employment in the ecosystem by itself. However, is the ecosystem in such a scenario also successful? Moreover,

there are some indications that a manifest company needs a manifest institute to be absent to lead to a high performance ecosystem, whereas with firm growth it was the manifest university that couldn't be combined with the manifest company. This could be another exhibit of conflict between two leading organizations.

5.4.3 Future Research

Future research could further investigate incubators and accelerators specifically and focus on the employment growth they create in the ecosystem. This would give insights into their causality with employment growth and could clarify the suspicions raised in this study. Furthermore, more precise insights into where employment growth originates from should provide answer as to the sufficiency of a manifest company for employment growth.

6. IMPLICATIONS FOR PRACTICE AND THEORY

This section will highlight the main implications found for practice and theory.

6.1 Implications for Practice

Basically, understanding the impact different actors and roles have on the performance of ecosystems helps policy makers to better understand which participant are complementary towards the ecosystem's goal. This allows them to design strategies that align more closely with the ambition of the ecosystem.

6.1.1 Optimal Ecosystem Performance Configuration

Ultimately, policy makers would want their ecosystems to achieve high performance for each of the three measures in this study. In order to do so, the results suggest that they should include a manifest company as ecosystem leader, supported by a high quality environment and investor as sponsors and an incubator or accelerator fulfilling the roles of expert, sponsor and champion. Additionally, a university should not be present in the ecosystem. This configuration leads to growth in terms of total number of firms, spin-offs and employment in the ecosystem.

6.1.2 Required Conditions for Growth and Diversity

However, not every ecosystem has the desire or possibility to implement the optimal ecosystem performance configuration; for example, the ecosystem could be built around a university. Furthermore, an ecosystem could be uninterested in achieving growth in all three performance measure in the ecosystem. For instance, an ecosystem wants employment growth and firm growth, but it does not matter whether these firms are spin-offs or not. In these cases, the policy makers of ecosystems can still obtain insights from this study as the results provide multiple solutions for each performance measure. By clearly defining the ambitions of the ecosystems a matching configuration can be selected and complementary participants can be approached to fulfil the required roles. Furthermore, relevant practitioners should not blindly focus on increasing participant diversity, as it is not required for high performance and can even lead to counterproductive combinations and lower performance.

6.2 Implications for Theory

The results of this study contribute to the academic world researching business and knowledge ecosystems by showing that such network are complex and what has been accepted as true simply cannot be generalized and applied to each real life situation. The results indicate limited support for the associated beneficial effects of the Triple Helix and diversity. Furthermore, it is interesting to see that a university has no positive effect on spin-off growth in ecosystems. The following section will go further into detail in each of these findings.

6.2.1 Triple Helix

Starting with the Triple Helix (Etzkowitz, 2003), the results imply that industry-university configurations are not beneficial for ecosystem performance, even when the required conditions are met. Moreover, the results propose that it is a cause for conflicts and suggest that an ecosystem should go with either a business ecosystem configuration or a knowledge ecosystem configuration, and not a combination. Moreover, there is only limited added value of a university in an ecosystem, while the Triple Helix theory implies that a university has a large role towards high performance. These results imply that a university plays a smaller role towards achieving a high performance ecosystem than the theory would suggest, while the industry's role has significantly increased. Additionally, this could imply that there are more conditions required to be met in order for the Triple Helix to function.

6.2.2 Diversity and Performance

As for participant diversity, theory has gained insights into which actors and roles attribute to the performance measures. Furthermore, while it is confirmed that participant diversity is indeed beneficial (Baptista, 1998; Powell et al., 2010), it is shown that simply increasing diversity does not neccesaliry increase performance. Similar to

Iansiti and Levien, the results suggests that the participants must be complementary to the other participants and the goal of the ecosystem to increase performance. Moreover, it adds to the body of knowledge on the topic of ecosystem participant roles, as the roles as described by Dedehayir et al. (2016) are not all required for an ecosystem to achieve high performance and a link has been created as to which roles contribute to diverse performance measures

6.2.3 Universities and Spin-Off Growth

Lastly, this study contributes to research concerning knowledge ecosystems and innovation by showing that in this study universities are not causally related to spin-off growth in ecosystems. Interestingly, current research attributes several advantages for innovative spin-offs to be located near universities, such as the flow of knowledge and personnel (Baptista 1998; Clark et al., 2000; Phelps et al., 2012). The positive effect attributed to having a university in an ecosystem on spin-off development seems misplaced and could be the result of other organizations in the ecosystem surrounding the university.

7. LIMITATIONS

This section will address the limitations of this study, which are in turn additional recommendation for future research.

Firstly, in this study the boundaries of the ecosystem were ultimately geographical boundaries and as a result, the core of the ecosystem has been investigated. However, one could go further than such boundaries as any organization or individual that affects the ecosystem can be considered to be part of it to some degree (e.g. Iansiti & Levien, 2004b; Moore, 1993; Teece, 2007). For example, Maastricht Health Campus is part of the Brightlands community, which also entails Chemelot, Smart Services Campus and Greenport (Brightlands, 2017). One could argue that this is essentially one ecosystem. Furthermore, the universities in the ecosystems Science Park Technopolis, Novel-T and TU/e Eindhoven have been cooperating since 2007 ("Results of cooperation", n.d.) and recently the university established in WUR Campus was added to this collaboration (4TU.Federation, 2017). This raises the question to what degree this entails one ecosystem. Furthermore, the relative small size of the Netherlands all ecosystems could be considered as being geographically 'close' to each other and as one big ecosystem. However, there are distinct differences between the individual ecosystems which would have been lost when they are grouped and as such, this is more a general remark than an actual limitation of this study.

Secondly, several roles proposed by Ddedehayir et al. (2016), and in particular the regulator role, were not included in this study. As they do affect the performance of the ecosystem, their inclusion should provide a more accurate explanation of the causality of the roles on the different performance measures. Moreover, by assessing the degree to which a particular role carries out its associated activities fsQCA can be used to more precisely determine the presence of a role in an ecosystem. This allows for fine-grained data on membership compared to csQCA. Additionally, there could also be other forces at play that affect the performance of an ecosystem that are not covered by the roles of Dedehayir et al. (2016). Even though, this is partially covered by the interpretation aspect of QCA, where one returns to the observations and the researcher uses his or hers in-depth knowledge of the cases to gain further insights into the causes; however, integrating all factors that affect the performance level of an ecosystem into QCA would most likely not produce parsimonious solutions, as there are most likely to many conditions.

Thirdly, there is no consensus on what exactly entails ecosystem success. In this study several measures of growth were taken to indicate performance; however, others have used innovation output (e.g. Clarysse et al. 2014) or firm survival (e.g. Iansiti & Levien, 2004a). For each different performance measure taken the results would vary. Furthermore, different ecosystems could have different goals meaning that they could perform well according to their own measure, but poor on measures devised by the ignorant researcher. This would lead to certain observations being marked as having low performance, skewing the results. However, this does not pose a direct problem for practitioners, if they focus on the results obtained using the performance measure they deem most important, its insights should still be useful.

Lastly, although the data contained a large sample of ecosystems in the Netherlands, there were several limitations concerning the sample and data. As the data was gathered by another party some of the richness of the data and in-depth insights into the observations were lost. Furthermore, how exactly the data was codified and what choices were made regarding this process were also unknown. The time-period of two years is also limited; by extending this period the long-term effects of the conditions could be further investigated and the influence of external events and other incidents would be reduced. Moreover, the sample was limited to ecosystems in the Netherlands and does not allow for further generalisation. It would be interesting to see whether or not comparable countries (e.g. in terms of culture and government) exhibit the same results, and if dissimilar countries have other results.

8. CONCLUSION

To conclude, adopting a configurational approach to examine ecosystem participant roles and characteristics with a focus on economic performance measures has allowed for new insights into the complex systems of knowledge and business ecosystems. With regard to the research question, the causality of the ecosystem participant roles to ecosystem performance has been established through several proxies. It appears that achieving high performance for each individual performance measure can be achieved through diverse knowledge ecosystem, business ecosystem, and mixed ecosystem configurations. Furthermore, a single optimal configuration has been found that leads to high performance on all three performance measures. Moreover, high participant role diversity is not required to achieve high performance. Additionally, the required need for assistance by spin-offs to develop their firm has been confirmed. Lastly, the results indicate a conflict between different ecosystem leaders. With this knowledge practitioners can adapt their ecosystem strategy accordingly.

Additional research on the dynamics between the types of ecosystem leaders used in this study should help to better understand the conflict between them and could clarify its cause. Moreover, further research into the activities these ecosystem leaders undertake to gain high ecosystem performance could explain the differences in required assistance between ecosystem leaders for each of the performance measures, and specifically, help explain the lack of causality of the university with spin-off growth. Lastly, new insights into what spin-offs deem most important for their development (i.e. mentorship, funding or proximity to large players) could validate findings of this study.

9. APPENDICES

Appendix A – Theoretical Overview

Table A-1: Overview of ecosystem theory

Subject	Author(s)	Summary of findings
Ecosystem participant diversity	Baptista (1998)	The diversity of organizational forms will result in an increased adaptive ability of the ecosystem. Both linkages among firms and with universities and public research organizations as well as intense labour mobility across different players facilitate collective learning and increase the speed of innovation diffusion.
	Phelps et al. (2012)	Physical proximity to knowledge generators such as public research organizations (PROs), universities and large firms with established R&D departments typically have a positive influence on the focal firm's innovative output.
	Iansiti & Levien (2004b)	Business ecosystems are characterized by a large number of loosely interconnected participants dependent on each other for their mutual performance. Each participant is specialized in a specific activity and it is the collective efforts of many participants that constitute value, while efforts individually have no value outside the collective effort. Rich networks sharing elements of both cooperation and competition emerge that link companies across products, services, and technologies.
	Powell et al. (2010)	Diversity of organizational forms is fundamental for knowledge ecosystem development.
Keystone/anchor/ industrial leader	Iansiti & Levien (2004a)	A "keystone" company whose role is to ensure that each member of the ecosystem remains in good health. Keystone companies also create "platforms" such as services, tools, or technologies, which are open for other players in the ecosystems to enhance their own performance. Consequently, keystone players are involved with the creation of value within the ecosystems as well as sharing the value with the other participants.
	Agrawal & Cockburn (2002)	The anchor tenant does not directly compete with the other types of organizations that inhabit the community. Local universities or public research organisations can fulfil the role of anchor organizations in the knowledge generation process.
	Agrawal & Cockburn (2003)	Anchors assist in providing access to subsequent connections and field formation and hence actively spur economic growth.
	Clarysse et al. (2014)	An industrial leader should act as an anchor stone to develop a business ecosystem around them. If the innovation output of the knowledge ecosystem can be commercialized by a global business ecosystem, a regional business ecosystem is not required and the region should develop links to global business players, but the region will lose local employment associated with the business ecosystem. This can be combatted by attracting global firms to settle in the region.
	Owen-Smith, & Powell (2004)	An anchor can partially be replaced by a global research network without the need for physical proximity.
Financial systems	Clarysse et al. (2014)	Private financial agents and not public sector organisations should take the lead in the financial support network to facilitate the transition from knowledge to business ecosystem. Third parties like incubators, accelerators and business angels can help.

Table A-1: Overview of ecosystem theory (cont.)

Subject	Author(s)	Summary of findings
Financial systems	Koh et al. (2005)	More involvement of the private sector in terms of financing and the building of global relations to increase the performance of the ecosystem.
Ecosystem roles	Dedehayir et al. (2016)	Four categories of roles during innovation ecosystem genesis: • Leadership roles (ecosystem leader and dominator) • Direct value creation roles (supplier, assembler, complementor, and user) • Value creation support roles (expert and champion) • Entrepreneurial ecosystem roles (entrepreneur, sponsor, and regulator) Certain activities are likely to be enacted ahead of others as the ecosystem unfolds, changing the activities of each role over time.
Ecosystem strategy levels	Autio & Thomas (2014)	Due to the complex nature of innovation ecosystems there are four strategic levels required: technology strategy, economic strategy, behavioural strategy, and institutional strategy
Control mechanisms	Autio & Thomas (2014)	Control mechanism that enables firms to influence ecosystem evaluation and to use for levers for value appropriation, the value creation dynamics, and the control migration, which concerns the control mechanisms that migrate elsewhere as an ecosystem evolves.
Ecosystem architecture	Autio & Thomas (2014)	There are three architectures that are important to consider during the creation of the innovation ecosystem: technology, activity, and value.
Alliance success factors	Hoffman et al. (2001)	Five most important critical success factors: precise definition of rights and duties; contributing specific strengths; establishing required resources; deriving alliance objectives from business strategy; and speedy implementation and fast results.

Table A-2: Overview of third party theory

Subject	Author(s)	Description of findings
Third party type	Simmel & Wolff (1950)	Two main types of third parties: tertius gaudens and tertius iungens.
Third party function	Holmen & Pedersen (2003)	Three mediating functions of third actors: joining, relating, and insulating.
	Oukes & Raesfeld (2014) Yin et al. (2012)	Third parties can help with the development of the network and the network embeddedness of start-ups by initiating relationships for the start-up.
	Cohen (2013) Holmen & Pedersen (2003)	Third parties can expand the network horizon of the start-ups by offering access to their own network.
	Clarysse et al. (2014)	Third parties can attract the necessary financial attention in an ecosystem to develop a financial support network to bridge the business-knowledge ecosystem gap.
	Aarikka-Stenroos & Halinen (2007)	Twelve roles that third parties can play in relationship initiation, and categorized them in four key processes: awareness, access, matching and specifying the deal.
	Barringer & Harrison (2000)	Third parties provide competitive advantage for the whole network.
Accelerators and incubators	Cohen (2013)	Accelerators and incubators differ in duration, cohorts, business model, selection frequency venture stage, education offered, venture location, and mentorship.
	Tötterman & Sten (2005)	Incubators can adapt their mix of start-ups and connected third parties to improve synergies, which improves the bonds between parties.
	Milanov & Shepherd (2013)	The reputation of newcomers' first partners exerts a positive influence on their future status, over and above intermediate network conditions.

Appendix B – Ecosystem Characteristics and Performance Data

Table B-1: Analysed ecosystems and their characteristics

Ecosystem	Development phase	R&D focus	High quality environment	Manifest knowledge carrier(s)	Active open innovation
Amsterdam Science Park	Mature	Yes	Yes, comprehensive	UvA, CWI, NIKHEF, AMOLF	Yes
Chemelot	Mature	Yes	Yes, comprehensive	DSM, Sabic	Yes
Grow Campus[a]	Start-up	Yes	Yes, limited	JB hospital, HAS, Avans	Yes
Green Chemistry Campus	Start-up	Yes, partially	Yes, limited	Sabic	In development
Healthy Aging Campus	Growth	Yes	Yes, limited	UMCG	Yes
High Tech Automotive Campus	Growth	Yes	Yes, comprehensive	PDE, TUV, TNO	Yes
High Tech Campus Eindhoven	Mature	Yes	Yes, comprehensive	Philips, Holst	Yes
Leiden Bio Science Park	Mature	Yes	Yes, comprehensive	LMC, LEI, Crucell	Yes
Maastricht Health Campus	Growth	Yes	Yes, comprehensive	UM, UMC	Yes
Mercator Science Park	Growth	Yes	Yes, limited	RUN, HAN	Yes
Novel-T[b]	Mature	Yes	Yes, comprehensive	UT	Yes
Novio Tech Campus	Growth	Yes	Yes, limited	NXP	Yes
Pivot Park	Growth	Yes	Yes, comprehensive	MSD	Yes
Polymer Science Park	Start-up	Yes	Yes, comprehensive	DSM, Wavin	Yes
Space Business Park	Growth	Yes	Yes, limited	ESA	Yes
Science Park Technopolis	Mature	Yes	Yes, comprehensive	TU, TNO, Deltares	Yes
TU/e Science Park	Growth	Yes	Yes, comprehensive	TU, TNO	Yes
Utrecht Science Park	Mature	Yes	Yes, comprehensive	UU, Danone, UMC + institutes	Yes
Wetsus/Water Campus	Growth	Yes	Yes, limited	TTI Wetsus, VHLarenstein	Yes
WUR Campus	Mature	Yes	Yes, comprehensive	WUR, DLO	Yes
Zernike Science Park	Growth	Yes	Yes, comprehensive	RUG, Hanze Hogeschool	Yes

Note: Adapted from BCI (2014). [a] formerly known as Food & Health Campus. [b] formerly known as Kennispark Twente.

Table B-2: Additional ecosystem characteristics

Ecosystem	Incubator	Accelerator	Investor
Amsterdam Science Park	Yes	No	Yes
Chemelot	Yes	Yes	Yes
Grow Campus[a]	Yes	No	Yes
Green Chemistry Campus	No	No	No
Healthy Aging Campus	No	No	Yes
High Tech Automotive Campus	No	No	No
High Tech Campus Eindhoven	Yes	No	Yes
Leiden Bio Science Park	Yes	No	Yes
Maastricht Health Campus	Yes	No	Yes
Mercator Science Park	Yes	No	No
Novel-T[b]	Yes	No	Yes
Novio Tech Campus	Yes	Yes	Yes
Pivot Park	Yes	No	Yes
Polymer Science Park	No	No	Yes
Space Business Park	Yes	Yes	Yes
Science Park Technopolis	Yes	No	Yes
TU/e Science Park	Yes	No	Yes
Utrecht Science Park	Yes	No	Yes
Wetsus/Water Campus	No	No	Yes
WUR Campus	Yes	No	Yes
Zernike Science Park	Yes	No	Yes

[a] formerly known as Food & Health Campus. [b] formerly known as Kennispark Twente.

Table B-3: Ecosystem performance

	Total amount of firms		Total amount of spin-offs		Total amount of employment	
Ecosystem	2012	2014	2012	2014	2012	2014
Amsterdam Science Park	100	120	10	40	800-900[c]	850
Chemelot	46	51	8	14	1185	1410
Grow Campus[a]	10-15	10-15	10-15	10-15	75	135
Green Chemistry Campus	5	12	0	0	15	20
Healthy Aging Campus	26	40	25	32	420	1200
High Tech Automotive Campus	27	33	0	0	470	491
High Tech Campus Eindhoven	115	130	40	55	8000	10000
Leiden Bio Science Park	122	122	22	27	5400	6583
Maastricht Health Campus	53	42	28	31	900	900
Mercator Science Park	75	65	50	45	1100	1040
Novel-T[b]	384	400	150	175	6300	5741
Novio Tech Campus	1	21	-	2	3	500
Pivot Park	11	38	12	20	111	350
Polymer Science Park	1	2	-	5	3	25
Space Business Park	12	35	6	12	500	750
Science Park Technopolis	206	219	145	192	4750	5574
TU/e Science Park	108	123	42	45	1000	1575
Utrecht Science Park	60	80	30	42	900	1675
Wetsus/Water Campus	20	26	13	15	85	192
WUR Campus	70	90	40	55	1300	1800
Zernike Science Park	70	74	25	25	550	817

Note: Adapted from BCI (2014). [a] formerly known as Food & Health Campus. [b] formerly known as Kennispark Twente. [c] interpreted as 850.

Appendix C – Prime Implicant Ties

The following are the prime implicants ties that have been found for each of the minimizations. On the left side is the complex formula, on the right is the chosen minimization. In certain cases no justification was found to keep only one minimization and multiple minimizations where chosen. Not all minimizations had ties and therefore, not all minimizations are listed. The conditions have been abbreviated to limit the required space, see table C-1. A ~ in front of the conditions indicates its absence, a * or nothing in front of the condition indicates its presence. Furthermore, 6 conditions refers to the analyses with all conditions while 4 conditions refers to the analyses without the non-varying conditions.

Table C-1: Condition abbreviations

Condition	Abbreviation
Manifest company	comp
Manifest university	uni
Manifest institute	insti
High quality environment	hq
Investor	inv
Incubator or accelerator	incu

Original Analysis

Firm growth

4 conditions – low performance

~comp*uni~insti~hq	➔	~comp~insti~hq

Spin-off growth

6 conditions – high performance

~incu*inv*~hq*insti*uni~comp	➔	~incu~hq*inv
incu*inv*hq*insti* uni*comp	➔	incu*hq*insti
incu*inv*hq*insti* uni~comp	➔	inv*hq*insti

6 conditions – low performance

~incu~inv~hq~inst~uni*comp	➔	~incu*comp
~incu~inv*hq*inst~uni*comp	➔	~incu*comp

4 conditions – high performance

~comp~uni*insti~hq	➔	~uni*insti~hq
comp~uni~insti*hq	➔	comp~insti*hq

Employment growth

6 conditions – low performance

~comp*Uni~ìnsti~hq~inv*incu	➔	comp~insti~hq

4 conditions – low performance

~comp*uni*insti~hq	➔	~comp~insti~hq

Sensitivity Analysis

Firm Growth

6 conditions – high performance

~comp~uni*insti~hq*inv*incu	➔	~comp~uni
comp~uni~insti*hq*inv*incu	➔	comp~insti

4 conditions – low performance

~comp*uni~insti~hq	➔	uni~insti~hq

Spin-off growth

6 conditions – high performance

comp*uni*insti*hq*inv*incu ➔ incu*comp & investor*comp

6 conditions – low performance

~incu~inv~hq~insti~uni*comp ➔ ~incu*comp

4 conditions – high performance

~comp~uni*insti~hq ➔ ~uni*insti~hq

comp~uni~insti*hq ➔ comp~insti*hq

Employment growth

6 conditions – high performance

~incu~inv~hq~ìnsti~uni*comp ➔ ~insti*comp

incu~inv~hq~ìnsti~uni*comp ➔ ~insti*comp

~incu*inv*hq~ìnsti~uni*comp ➔ ~insti*comp

incu*inv*hq~ìnsti~uni*comp ➔ ~insti*comp

6 conditions – low performance

Incu~inv~hq~ìnsti*uni~comp ➔ ~hq~insti~comp

4 conditions – high performance

comp~uni~insti~hq ➔ comp

4 conditions – low performance

~comp*uni~insti~hq ➔ ~comp*uni~insti~hq

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