1 Weak network problems, startup performance and spillovers: The role of incubators in entrepreneurial ecosystems

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Abstract

‘To promote economic growth, policy makers try to create an environment that facilitates technological entrepreneurship. This environment increasingly often referred to as the entrepreneurial ecosystem. Especially, the continued existence of a network between startups and other stakeholders is seen as a key ingredient for startup success, and for a successful entrepreneurial ecosystem. However, in many European regions, these networks are still underdeveloped. The innovation systems literature refers to this lack of connectivity as a ‘weak network problem’. Incubators can be used as a tool to develop networks, overcome weak network problems, and strengthen the entrepreneurial ecosystem. However, this process is poorly understood. Hence, this research poses the following research question: what is the effect of ecosystem conditions and support mechanisms by incubators on the occurrence of weak network problems and the performance of their startups? We argue that ecosystem conditions and support mechanisms theoretically influence two important factors in network formation: meeting and mating. We apply these insights in an agent based model. By using an experimental design we can precisely estimate how much each ecosystem condition and support mechanism contributes to overcoming weak network problems and the performance of startups. Our simulation shows that incubators that introduce startups to investors can greatly alleviate weak network problems. However, this leads to an ecosystem with a moderate amount of well-performing startups. For a high number of well-performing startups, it is important to change institutions in the entrepreneurial ecosystem. Finally, offering a shared infrastructure is the most advantageous support mechanism.'
Weak network problems, startup performance and spillovers: The role of incubators in entrepreneurial ecosystems

1. Introduction

Technological entrepreneurship is seen as an important means to contribute to economic growth (Ahmad and Ingle, 2013; Wong et al., 2005) and to engage in transformative change to overcome societal challenges (Geels and Schot, 2007). Hence, policy makers try to create an environment that facilitates technological entrepreneurship. This environment increasingly often referred to as the entrepreneurial ecosystem, and consists of all factors that affect the founding, growth and survival of startups (Spigel, 2017; Stam, 2015). Especially, the continued existence of a network between startups and other stakeholders is seen as a key ingredient for startup success (Davidsson and Honig, 2003; Eveleens et al., 2017; Ter Wal et al., 2016), and for a successful entrepreneurial ecosystem (Feld, 2012; Spigel, 2017; Van Weele et al., 2017a). In the entrepreneurial ecosystem, networks are conduits for resource exchange, like funds or information, knowledge or know-how. However, in many European regions, these networks are still underdeveloped (Van Weele et al., n.d.). The innovation systems literature refers to this lack of connectivity as a ‘weak network problem’ (Klein Wollothuis et al., 2005; Wieczorek and Hekkert, 2012). Incubators can be used as a tool to develop networks (Hansen et al., 2000), overcome weak network problems (Van Weele et al., n.d.), and strengthen the entrepreneurial ecosystem (Fernández Fernández et al., 2015). The term incubator refers to a wide array of programs and organizations that support new technology based startups to boast the performance of these businesses (Bergek and Norrman, 2008; Bruneel et al., 2012; Hackett and Dilts, 2004). There are four important gaps that warrant more attention in the field of incubator research in the context of entrepreneurial ecosystems.

First, to understand how incubators can help overcome weak network problems, one must understand how networks form in entrepreneurial ecosystems. Although the entrepreneurship literature has considered the role that networks play for individual startups (Davidsson and Honig, 2003; Ter Wal et al., 2016; Witt, 2007), “the EE (entrepreneurial ecosystems) literature has not yet

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1 There is a great variety among incubators and their practices (Aernoudt, 2004). Moreover, many other initiatives draw in part on the same support mechanisms as incubators, examples are co-working spaces focused at startups (Butcher, 2012; Spinuzzi, 2012), accelerators (NESTA et al., 2011; Pauwels et al., 2015) venture builders (Diallo, 2015). Yet, many of these can be seen as a manifestation of the pluriform incubation phenomenon (Bosma and Stam, 2012). For clarity, we refer to all these initiatives as incubators.
produced a comprehensive network approach that could shed light, for instance, on the crucial question why some EE are able to make vital connections while other EE fail to do so (Alvedalen and Boschma, 2017, p. 894).” The literature on entrepreneurial networks suggests that institutions play a key role in network formation (Johannisson et al., 2002), as these facilitate interactions between agents (Huggins et al., 2012). Yet, it is currently unknown how such ecosystem conditions influence network formation.

Second, incubators might be able to help overcome weak network problems in various ways (Van Weele et al., n.d.). For example, they can unburden startups from other tasks, giving them time to search for network partners (Amezcua et al., 2013; Bergek and Norrman, 2008; Patton, 2013). Incubators can also speed-up the process of network formation by introducing potential network partners to each other. Yet, the effects of these mechanisms on overcoming weak network problems are unknown. Understanding if and when incubators can help overcome weak network problems gives policy makers a potentially useful tool to promote entrepreneurial ecosystems (Van Weele et al., n.d.).

Third, the success of tenants is a key performance indicator for incubators (Amezcua and Grimes, 2013; Eveleens et al., 2017; Fernández Fernández et al., 2015). To justify their use, the support mechanisms should in some way contribute to startup performance. It is currently unclear if this is actually the case. Empirical studies found positive (Aernoudt, 2004; Stokan et al., 2015; Van Rijnsoever et al., 2017), negative (Schwartz, 2013), mixed (Amezcua et al., 2013), or no (Pena, 2004; Tamásy, 2007; Westhead and Storey, 1994) effects of incubation on startup performance. These contradictory findings partially result from the fact that the theoretical mechanisms that drive network formation are underdeveloped in incubation research (Eveleens et al., 2017; Theodorakopoulos et al., 2014), and that support practices are often employed simultaneously (Bergek and Norrman, 2008; Bruneel et al., 2012; Schwartz and Hornyh, 2008), which makes it difficult to disentangle separate effects.

Fourth, viewing the incubator as a part of an entrepreneurial ecosystem adds an extra complication to testing the effect of incubators on startup performance that has not been considered before. If startups interact in a network, then it becomes possible that some of the benefits of incubation, such as knowledge or contacts, ‘spill over’ from incubated to non-incubated startups. Hence, it is unknown when incubators should pursue what mechanism to enhance the performance of their startups.
To address these gaps, this research poses the following research question: *what is the effect of ecosystem conditions and support mechanisms by incubators on the occurrence of weak network problems and the performance of their startups?*

To answer this question, we combine insights from the literatures on entrepreneurial ecosystems, innovation systems and incubators. We argue that ecosystem conditions and support mechanisms theoretically influence two important factors in network formation: meeting and mating. We apply these insights in an agent based model. By using an experimental design we can precisely estimate how much each ecosystem condition and support mechanism contributes to overcoming weak network problems and the performance of startups.

Our simulation shows that incubators that introduce startups to investors can greatly alleviate weak network problems. However, this leads to an ecosystem with a moderate amount of well-performing startups. For a high number of well-performing startups, it is important to change institutions in the entrepreneurial ecosystem. Finally, we show that offering a shared infrastructure is the most advantageous support mechanism for incubators, as this gives most benefits to incubated startups, and has the least amount of spillover benefits to non-incubated startups.

Theoretically, this paper is the first to systematically consider the joint effects of separate support mechanisms on performance of the entrepreneurial ecosystems and incubators from a network perspective. Based on our results we make recommendations to policymakers and incubator managers about how incubators can strengthen entrepreneurial ecosystems.

2. Theory

We first provide a short background on entrepreneurial ecosystems and the role of incubators therein. Then we proceed with explaining the outcome variables to measure ecosystem and startup performance, the processes that lead to these variables, and the independent variables that influence these processes.

2.1. Entrepreneurial ecosystems and innovation systems

The idea of entrepreneurial ecosystems is relatively new, and underconceptualized (Alvedalen and Boschma, 2017; Stam, 2015). However, it is related to the more developed literature on innovation systems (Ács et al., 2014; Alvedalen and Boschma, 2017; Stam, 2015). The main difference
between the innovation systems and entrepreneurial ecosystems is that the latter explains how system conditions influence the entrepreneurial agency of actors to create value (Ács et al., 2014; Stam, 2015), while the former looks at the development of innovations. The close relationship between the two allows us to borrow concepts and ideas from innovation systems and apply these to entrepreneurial ecosystems.

Following the literature on innovation systems (Carlsson and Stankiewicz, 1991; Van Rijnsoever et al., 2015; Wieczorek and Hekkert, 2012), we conceptualize the entrepreneurial ecosystem as a set of actors that interact and exchange resources in a network under an institutional regime and an infrastructure. Analogues to regional innovation systems, an entrepreneurial ecosystem works on a regional level (Feld, 2012; Spigel, 2017; Stam, 2015) that is embedded in a national context (Ács et al., 2014). The prime actors in entrepreneurial ecosystems are entrepreneurs, which can be found in startup firms, but also as intrapreneurial agents in mature firms (Stam, 2015). Given the focus on support mechanisms by incubators, this paper focusses on entrepreneurs in startup firms. Startup firms differ from larger, more mature firms in two fundamental ways (Chandy and Tellis, 2000). First, they are relatively unburdened by history, routines and vested interests, which gives them the degrees of freedom to explore technological paths and markets that larger firms cannot. Second, they are poor on resources. This curtails the possibility to explore new technologies and markets, and leads to a high risk of going out of business. Hence, startup firms need to seek and interact with other actors that can supply them with resources (Feld, 2012; Neck et al., 2004; Stam, 2015; Van Weele et al., n.d.), and for that, they need a network. Universities and schools can supply talent, knowledge or specialized equipment. Venture capitalists, banks and angel investors are sources of financial capital. Users or clients are a source of market information, and eventually sales. Being affiliated with certain actors further provides startups legitimacy and social capital (Eveleens et al., 2017). The institutional regime in the entrepreneurial ecosystem consists of the combined set of ‘rules of the game’ (North, 1990) that influence the behavior of the actors the system. Examples are networking or the probability of exchanging resources. Institutions can be hard, like formal rules or regulations, but also soft, like shared norms, routines or habits (DiMaggio and Powell, 1983; Roxas et al., 2007; Scott, 1995). Last, the infrastructure consists of the physical backbone that makes these exchanges possible, like roads, trains, and internet access.

The literature on innovation systems also argues that failures can occur in each part of the innovation system (Klein Woolthuis et al., 2005; Wieczorek and Hekkert, 2012). This paper focusses specifically on the concept of weak network problems, which means that the network between actors is insufficiently developed (idib).
2.2. Incubators in the entrepreneurial ecosystem

The prime goal of incubators is to support startups and to deal with challenges in the entrepreneurial ecosystem (Amezcua et al., 2013). Incubators became widespread to support new organizations in the 1980s, but have been around since the 1950’s. This first generation of incubators primarily offered a shared infrastructure including, office space, facilities, parking, and possibly specialized equipment like laboratories (Barrow 2001; Bruneel et al. 2012). In the 1980s, incubators shifted their focus to technology-based startups (Bruneel et al. 2012; Schwartz and Hornych 2010). Having sufficient business knowledge and experience was deemed critical to make these startups successful. Hence, incubators promoted learning through professional consulting services, coaching, and mentoring, in addition to basic services (Bruneel et al. 2012), leading to better business proposals. The rise of the Internet in the 1990s, accompanied by a fast growing IT sector coincided with the creation of incubators that emphasized network services (Bruneel et al. 2012; Hansen et al. 2000; Lalkaka 2002). Support services like incubators helped connect startups to resource providers, such as investors (Bruneel et al., 2012; Eveleens et al., 2017). Finally, the rise of the entrepreneurial ecosystem literature, places the incubator in a larger context. This raised questions about the role of incubators as system builders (Stam, 2015; Van Weele et al., 2017a, n.d.). They partly fulfill the role that intermediaries play in innovation systems, by connecting startups to other actors and facilitating resource exchanges (Howells, 2006). Moreover, incubators increasingly act as representatives for startups that lobby for institutional change at governmental organizations like municipalities, and they articulate help the needs of startups in the ecosystem.

2.3. Outcome variables

A successful entrepreneurial ecosystem facilitates the founding and growth of value creating startup firms. Startups need to interact with other actors to gain access to resources (Eveleens et al., 2017; Witt, 2007), which means that a network must be present at the system level to keep these exchanges going over time (Hekkert et al., 2007). In the remainder of this paper, we focus on the network that consists of the relationships between startups and investors as an example for our discussion. Early-stage technology based startups require substantial amounts of funding for research and product development prior to making sales (Westhead and Storey 1997). Moreover, investors do not only transfer funds to the startup. Both partners engage in a long-term relationship that also often involves the transfer of valuable market and business knowledge, and relevant network contacts from the investor to the startup. These intangible resources are seen to contribute most to a comparative advantage of the startup (Eveleens et al., 2017). In return, the investor receives shares or influence in the startup, which solidifies the relationship further. Finally, raising
funds from external stakeholders like angels or venture capitalists (Rothaermel and Thursby, 2005; Van Rijnsoever et al., 2017) is a signal of viability of the startup (De Clercq et al. 2006; Rothaermel and Thursby 2005; Vohora et al. 2004). Based on this, we identify two outcome variables that describe two dimensions of system performance. We are aware that the network of startups is broader than only investors, but this relationship is well-documented. However, as the processes we describe are based on network formation in general, our model can theoretically be generalized to other actors that provide crucial resources.

2.3.1. Weak network problems

A weak network problem means that this network is underdeveloped (Klein Woolthuis et al., 2005; Wieczorek and Hekkert, 2012). In our context this means that no investment deals are made between startups and investors. The lack of crucial funds severely hampers the survival changes and growth perspective of startups. As startups are the key actors in the entrepreneurial ecosystem, preventing weak network problems between startups and investors is crucial for a well-functioning entrepreneurial ecosystem (Van Weele et al., 2016). Overcoming or preventing this weak network problem in an entrepreneurial ecosystem is our first outcome variable.

2.3.2. Number of investment deals

As investments are an important indicator for startup performance (Batjargal, 2007; Shane and Stuart, 2002; Ter Wal et al., 2016), the number of investment deals between startups and investors in an ecosystem is our second outcome variable. Incubators are primarily held accountable for the successful performance of their tenant startups (Amezcua and Grimes, 2013; Eveleens et al., 2017). This incentivizes incubators to target their support efforts at their own tenants, rather than at all startups in the ecosystem.

It is possible that some benefits of incubation spillover to non-incubated startups. An example is that network ties between incubated startups and investors that were brokered by the incubator are shared with non-incubated startups. From a systemic perspective, this is a desirable thing as it strengthens the network, and it is not necessarily harmful to the incubator. However, when a support measure in which the incubator invests time and effort disproportionally favors non-incubated startups, then this might damage the competitive position of the incubator. To capture the effects of spillover benefits, we make a distinction between the number of investment deals for all startups and incubated startups only.

2.4. Processes
For a network between investors and startups to emerge, both actor types must partner with each other. For this to take place, two processes must take place: meeting and mating (Kalmijn and Flap, 2001; Snijders et al., 2010; Van Duijn et al., 2003; Verbrugge, 1977). Successful partnering ultimately depends on both (Flap and Völker, 2004; Verbrugge, 1977). If these processes take place insufficiently, no network will emerge, and existing networks will collapse, leading to a weak network problem. As a consequence, no investment deals can be closed. Institutions and incubators can influence the conditions for meeting and mating.

2.4.1. Meeting

Meeting refers to the chance that potential partners find each other. Especially, in case of startup-investor relationships, the literature suggests that meeting does not take place by chance, but via introductions by other agents (Engel et al., 2017; Fritsch and Schilder, 2008; Shane and Cable, 2002), which requires an existing network. Actors that are connected to both investors and startups introduce both parties to each other. Examples are other startups that are already connected to parties, but also intermediaries like incubators (Bøllingtoft and Ulhøi, 2005; Dutt et al., 2016). For meeting to take place there must be sufficient actors in the system that are searching for potential partners, or that are at least findable. In emerging entrepreneurial ecosystems the meeting chances between startups and other actors are hampered by three factors. First, startups have a relatively short lifespan; they have less time to develop search routines, to actually meet other actors, or to arrange introductions. Second, during their short life span startups are pre-occupied with survival, and building their organization. This further limits time and resources to seek potential partners, or to arrange meetings between others. Third, startups are often small, and lack the connections or reputation to be noted, which makes it more difficult for others to find them.

2.4.2. Mating

Mating refers to the chances that after meeting, actors actually form a relationship, in this case an investment deal. For mating to occur both potential partners must see the benefits to form a relationship (see section 2.3), and trust each other to hold their end of the bargain (Roos and Klabunde, 2014).

2.5. Independent variables: ecosystem conditions

The chances of meeting and mating depend on the conditions in the entrepreneurial ecosystem. Given that introductions are the dominant process through which investors and startups find each other (Fritsch and Schilder, 2008; Shane and Cable, 2002), there are two factors in the ecosystem...
that influence the chances of meeting: availability (e.g. being there) of startups in the ecosystem after receiving investments and cooperation (e.g. willingness to share) between startups. These factors are primarily associated with soft institutional conditions (Johannisson et al., 2002). In the current context, mating depends on the investment chance (e.g. the propensity to pair), which is influenced by a combination of institutional and actor conditions. We discuss each condition and the influence on our outcome variables below.

2.5.1. Availability

Availability is about being there in the ecosystem. It refers to the time that after being invested the startup remains available in the ecosystem to introduce other agents to each other. The longer the invested startup remains available, the larger the chances are that it can help broker relationships between other startups and investors. After securing sufficient investments to further develop the startup, entrepreneurs can disconnect themselves from the network of startups and focus solely on the development of their business. However, this would also disconnect investors from other startups that are worth investing in. Hence, successful entrepreneurial ecosystems often develop norms that expect the startup to remain available after being invested, this is often called a ‘culture of paying it forward’ (Ready, 2012; van Stijn et al., 2017) or ‘intelligent altruism’ (Engel et al., 2017); the startup shares parts of the benefits of an investment deal with other startups, usually in the form of simple advice, or introductions between other startups and the investor. This helps to prevent weak network problems and increases the number of investment deals.

2.5.2. Cooperation

Cooperation is the willingness to share contact. It refers to the extent that startups are willing to connect to each other, even in the absence of investor relations. If one of the startups in the network becomes connected to an investor, then this startup can introduce this actor to its peers, diffusing the network contact through the network of startups. Thereby, cooperation increases meeting chances. Successful entrepreneurial ecosystems often have strong communities of startups (Feld, 2012; Van Weele et al., 2017a). Startups in a community have a shared purpose (Zhang and Watts 2008), identity (Akkerman et al., 2008), and repertoire (Garavan et al., 2007; Wenger, 1998). Further, there is a high degree of trust and there are strong norms against violation of this trust (Van Weele et al., 2017a). This often leads to a dense network of startups, in which introductions to relevant actors are commonly made (ibid).

From a network perspective, there is no need for a dense network for introductions to occur. The average path length in a network decreases logarithmically with the number of ties (Albert and
Barabási, 2002; Watts and Strogatz, 1998). There is only a marginal increase in meeting chances when the number of ties becomes larger. Hence, we expect that overcoming weak network problems thus requires overcoming a threshold to gain a sufficiently dense network; it does not mean that more ties among startups are better.

2.5.3. Investment chance

Investment chance is the propensity to pair. It refers to the likelihood that investors will invest in a startup after meeting. Most startups will fail, which makes investing in them a high-risk endeavor. In general, many European countries are said to suffer from a shortage investment capital (Bottazzi and Da Rin, 2002; Philippon and Véron, 2008). Overall, the chances of a startups getting funding from an investor are typically around 3% (Becker, 2014; Kerr et al., 2014), but these chances are affected by many institutional, infrastructural and macro-economic conditions (Batra et al., 2003). Van Weele et al. (n.d.) identify three factors that influence the startup investment climate. The first is the fragmented European market, which hampers the opportunity for fast growth (Bravo-Biosca, 2011). Second, the investment might be too risky. These risks can stem from uncertainties in the environment, like unknown market demand, competing technologies, fluctuating regulations (Meeus and Oerlemans, 2000), or the likelihood that a partner will hold his or her end of a bargain (Bergh et al., 2009; Nieto and González-Álvarez, 2016). Third, the capacities of the startups matter. Actors require capabilities to engage and manage relationships (Niesten and Jolink, 2015; Schilke and Goerzen, 2010), and to absorb (Cohen and Levinthal, 1990), and combine the knowledge and resources that can be acquired (Kogut and Zander, 1992). However, startups generally lack these types of skills (Van Weele et al., n.d.). This adds to the risk of investing in startups.

2.6. Independent variables: support mechanisms

Incubators can use various support mechanisms to facilitate the creation of investments deals or the emergence of the network. Bruneel et al. (2012) describe how the support mechanisms evolved historically over three generations: creating economies of scale, learning, and networking (see section 2.2). Others look at the practices observed in incubators and categorize these as direct support, networking (Bergek and Norrman, 2008; Patton, 2013), community building (Bøllingtoft and Ulhøi, 2005; Hughes et al., 2007) or sometimes field building (Amezcua et al., 2013). We combine these conceptualizations to five generic support mechanisms that incubators use. These mechanisms can contribute to overcoming weak network problems, by tackling the meeting or mating criterion and some can directly influence the number of investment deals. However, in contrast to the generic
ecosystem conditions, we can expect that the support mechanisms are primarily beneficial to incubated startups, with possible spillover benefits.

2.6.1. Infrastructure support

The first mechanism is *infrastructure support*, which entails the sharing of tangible resources such as subsidized (office) space, facilities, and parking (Barrow, 2001; Bruneel et al., 2012; Patton, 2013), as well as supplying a limited amount of funds. Creating economies of scale (Bruneel et al., 2012) is part of this mechanism. Theoretically, sharing resources reduces costs, and allows incubated startups to focus their time and effort on developing or searching for resources crucial to the business (Barrow 2001; Bruneel et al. 2012). Similarly, supplying a limited amount of funds also buys the startup time. Startups can use the time gained by efficient resource sharing and extra funding to seek useful connections. This increases the chances that startups and investors, or startups amongst themselves, meet each other. The prime beneficiaries of this mechanism are incubated startups. However, non-incubated startups can also benefit from this mechanism, as more potential partners become available. Infrastructure support does not enhance the chances of mating. This is because the resources shared are often not valuable, rare, inimitable or non-substitutable (Barney, 2001), and hence do not contribute directly to the development of the business or its performance (Eveleens et al., 2017).

2.6.2. Networking

The second mechanism is *networking*, which refers to the activities of incubators that help startups connect to actors that can provide them with valuable resources (Davidsson and Honig, 2003; Eveleens et al., 2017), such as investors, universities or potential clients. This can be done through encouragement, introductions or referrals made by the incubator management, coaches or mentors to reach out to specific external parties (Eveleens et al., 2017; Patton et al., 2009; Rice, 2002). The networking mechanism is widely acknowledged by the incubation literature. By bringing startup and investors together, networking increases the chances of meeting. Given equal chances of mating, more meetings mean that more long-term relationships are created between startups and investors. Moreover, there are spillover benefits. Connected startups can function as intermediaries between investors and other startups, which allows further growth of the network. This makes the networking mechanism a way to directly overcome weak network problems for all startups in the ecosystem. Empirical evidence further suggests that the networking mechanism is an effective manner to boast the performance of incubated startups (Amezcu et al., 2013; Van Rijnsoever et al., 2017).
2.6.3. Community building

The third mechanism is *community building*, which is that the incubator deliberately connects incubated startups to each other. Activities associated with community building include social events, a critical selection of new members, the active introduction of tenants to each other by the incubator (ibid), and co-working (Van Weele et al., 2017a). These activities lead to the building of a community within the incubator (Bøllingtoft and Ulhøi, 2005; Hansen et al., 2000; Tötterman and Sten, 2005), and primarily increase the meeting chances for incubated startups, and to a lesser extent for non-incubated startups, who happen to be connected with incubated startups. To our knowledge, there is no direct empirical evidence for that community building mechanism enhances the performance of incubated startups. Its advantage seems to lie more in learning from peers, and gaining a sense of belonging as a startup (Van Weele et al., 2017a).

2.6.4. Field building

The fourth mechanism is *field building*, is closely related to community building. Field building is that the incubator deliberately connects startups to peers outside the incubator that are active in the same field. It is only explicitly coined by Amezcua et al (2013, p. 1634) who state that “*that sponsors increase new organizations’ alignment and engagement with critical stakeholders is by connecting those organizations to other similar and new organizations within a field, to improve the opportunity for collaboration, knowledge sharing, and ultimately legitimacy for these emerging organizational communities.*” Activities associated with field building include social events with actors outside the ecosystem, network meetings, or active introductions. These activities also increase the meeting chances for incubated startups, and non-incubated startups. Empirically, the field building mechanism has been shown to enhance the performance of incubated startups, especially when there are little startups in the ecosystem (Amezcua et al., 2013).

2.6.5. Business learning

Finally, there is *business learning*, which entails the acquiring, distributing, interpreting and structuring of business related knowledge by the startup (Dodgson, 1993; Huber, 1991). Bruneel et al. (2012) coined this the learning mechanism in their historical approach. Having sufficient business knowledge and experience is deemed critical to make these technology-based startups successful (Bruneel et al. 2012; Schwartz and Hornych 2010). Hence, incubators promote learning though professional consulting services, coaching, and mentoring. This lead to a better use of resources, the gaining of capabilities that facilitate networking, improved business models, and a further developed organization (Bergek and Norrm an, 2008; Rotger et al., 2012; Van Weele et al., 2017b). From a
theoretical perspective, business learning makes the startup a more attractive partner for actors that can provide them with resources. The business learning mechanism thereby increases the chances of *mating*. These benefits extend theoretically only to incubated startups. Empirical studies report mixed effects of this mechanism on various startup performance measures. Chrisman (2005) reports a positive effect on growth, but with diminishing returns to the amount of effort invested. Rotger et al. (2012) do not find this effect of business learning on growth, but they do find positive effects on size and survival. Van Rijnsoever et al. (Van Rijnsoever et al., 2017) find no effect of business learning on the amount of investments raised. Overall, there is not enough evidence to determine the effectiveness of this mechanism on startup performance.

3. Methods

We simulated the effects of the ecosystem conditions and support mechanisms on the outcome variables using an agent based model (Bonabeau, 2002). This gives insights in the effect of separate independent variables. We tested a full factorial design with 972 experimental combinations. Each combination was run 100 times.

3.1. Model setup

We ran our agent based simulations with the NETLOGO-program. Each run starts with a grid of 32 by 32 patches (Figure 3) on which 100 startup agents (depicted by an orange person) are randomly distributed. At the center of the grid is an investor depicted by a dollar coin. Around the investor are four incubators, depicted by little houses that are connected to the investor. Moreover, the investor is also connected to four startups that already received investments, which is indicated by their larger size. The sole purpose of these invested startups is to serve as initial introducing agents between the other startups and the investor. At the start, each startup has enough resources to explore the grid for 50 steps. This fits with the idea that entrepreneurial networking is a highly uncertain process (Engel et al., 2017). Given that startups have different positions on the grid, they have different chances of meeting other actors. The closer a startup is to an incubator or an invested startup, the better its position in the search space, and the larger the chances of meeting. Hence, the starting position on the grid can be seen as a measure for the quality of the startup.
3.2. Model procedure

Each model run consists of 4000 time steps, giving the model time to reach a dynamic equilibrium. During each time step each startup moves to an adjacent patch in a random direction on the grid, and loses one resource point. This step represents the search process of the startup while developing their business. The search can take place across various theoretical dimensions, like cognitive space, geographical space or market space (Katila and Ahuja, 2002; Nelson and Winter, 1982). During the search process, a number of events can occur.

3.2.1. Connecting to another startup

When a startup arrives on the same patch as another startup, they can become connected depending on the level of cooperation.

3.2.2. Connecting to the incubator

When a startup arrives on an incubator patch, it automatically becomes connected to an incubator. This means that the startup joins the incubation program, and can benefit from the support mechanisms.

3.2.3. Connecting to the investor

There is no way for a startup to become directly connected to the investor. At each step incubators and invested startups can introduce a connected startup without investments to the investor. The chance of establishing a connection between the startup and the investor is equal to the mating chance.
3.2.4. Exiting the market

When the startup runs out of resources, it exits the market. For the model it is not relevant if this is through bankruptcy, voluntary termination, mergers or acquisition. It is then replaced by a new startup at a new random patch on the grid. In this manner, the number of startups on the grid is always 100. Because each model run takes 4000 steps, startups are replaced up to 200 times.

3.3. Operationalization of outcome variables

3.3.1. Weak network problems

This is a binary variable. There is a weak network problem when there are no startups with a connection to the investor at the end of a model run.

3.3.2. Number of investment deals

The number of investment deals was measured as the number of startups with a connection to the investor at the end of a model run. The number of investment deals by incubated startups was measured as the number of incubated startups with connections to the investor at the end of a model run.

3.4. Operationalization of ecosystem conditions

These variables are fixed during a model run, but vary across model runs.

3.4.1. Availability

Availability varies the number of time steps that startups search the grid after they received an investment. This allows them to share their relationship with investors with other startups. The variable has three levels: (1) ‘Low’ is the reference category and gives no extra time steps, (2) ‘Medium’ gives 50 extra time steps, and (3) ‘High’ gives 100 extra time steps.

3.4.2. Cooperation

Cooperation determines the chance that two startups that meet each other on the grid form a relationship with each other. The variable has three levels: (1) ‘Low’ is the reference category and sets the chance of forming a relationship to zero, (2) ‘Medium’ sets the chance of forming a relationship to 50%, and (3) ‘High’ sets the chance of forming a relationship to 100%.

3.4.3. Investment chance
Investment chance was measured by adjusting the mating chance between startups and investors. The variable has three levels: (1) ‘Low’ is the reference category and sets the mating chance unchanged at 3%, which is in line with empirical data (Becker, 2014; Kerr et al., 2014). (2) ‘Medium’ sets the mating chance to 6%, and (3) ‘High’ sets the mating chance to 9%.

3.5. Operationalization of support mechanisms

These variables are fixed during a model run, but vary across model runs.

3.5.1. Shared infrastructure

As argued above, a shared infrastructure buys the incubated startup time to search for resources to develop its business further. Hence, this variable gives startups additional time steps to search the grid upon joining the incubator. The variable has three levels: (1) ‘Low’ is the reference category and gives no extra time steps, (2) ‘Medium’ gives 50 extra time steps, and (3) ‘High’ gives 100 extra time steps.

3.5.2. Networking

Networking means that the incubator brings the incubated startup in contact with an investor. In the model, at each time step the incubator introduces the investor to one of incubated startups that has no investments yet. This increases the chances of meeting. The variable has two levels: (1) ‘No’ is the reference category, and (2) ‘Yes’ implements networking mechanism.

3.5.3. Community building

Community building means that the incubator brings the incubated startup in contact with other incubated startups. In the model, at each time step the incubator successfully brokers a relationship between two incubated startups. The variable has two levels: (1) ‘No’ is the reference category, (2) ‘Yes’ implements the field building mechanism.

3.5.4. Field building

Field building means that the incubator brings the incubated startup in contact with other non-incubated startups. In the model, at each time step the incubator successfully brokers a relationship between an incubated and a non-incubated startup. The variable has two levels: (1) ‘No’ is the reference category, (2) ‘Yes’ implements the field building mechanism.

3.5.5. Business learning
Business learning increases the mating chances between that startup and investors. In the model, this variable adjusts the mating chance between incubated startups and investors. The variable has three levels: (1) ‘Low’ is the reference category and leaves the mating chance unchanged, (2) ‘Medium’ doubles the mating chance, (3) ‘High’ triples the mating chance.

3.6. Data and analysis

After each run, the model records output values for all variables. As we run each experimental combination one 100 times, our final dataset consisted of 194400 observations. A histogram of the data revealed that the outcome variables are distributed in a peculiar way (Figure 4). There are 55166 model runs that yielded zero investments. The remaining 139234 models yielded between one and 97 investments, which are distributed according to a bimodal distribution (e.g. it has two peaks). This could indicate that there are specific factors that substantially increase the number of investment deals. In a similar fashion, there are 55689 model runs that yielded no investments for incubated startups. This distribution varies between 1 and 48 investments for incubated startups.

The data was analyzed in two manners. First, we plotted histograms of the outcome variables for each level of the independent variables. This shows exactly how each variable causes what changes in the distribution of the outcome variables. Further, for both outcome variables we fitted a
zero inflated negative binomial regression model, which formalizes the results from the histograms. The zero inflated negative binomial regression model consists of two parts. The first part is a binary logit model that predicts the likelihood of a weak network problem occurring. The second part is a negative binomial model that predicts the number of investment deals. It is conditional on the first part. As predictors, the models contained the levels of the independent variables. We also explored possible two-way and three-way interactions, but these did not contribute substantially to model performance.

To understand the spillover benefits, we also plotted similar histograms for the number of investment deals by incubated startups, and also fitted a zero inflated negative binomial regression model that predicts the number of investments deals by incubated startups. To separate effects of our independent variables on the number of investments deals by incubated startups, the model that predicts this variable controls for the number of investments deals\(^2\) and the share of incubated startups.

As indicator for model accuracy we report Efrons \(R^2\), which is the squared correlation coefficient between the values predicted by the model and the dependent variable. We do not report the p-values, as the simulations are not empirical and thus not generalizable to a population. Moreover, with 194400 observations, most estimators will be significant. Instead, we focus on the effect sizes.

4. Results

Figure 5a-5h show distributions of the outcome variables and how they vary for different levels of the independent variables. The third and fourth of Table 1 present the results of the accompanying zero-inflated negative binomial regression model. The overall model has an Efron's \(R^2\) of 0.76, which is very accurate. Figure 6a-6h the distributions in the number of investment deals for incubated startups and how these differ for the levels of the independent variables. The last two columns of Table 1 present the results of the accompanying zero inflated negative binomial model. This model has an excellent fit with an Efron's \(R^2\) of 0.89. Due to the addition of the control variables, the coefficients in the negative binomial model part signify the ratio to which the independent variables increase the number of investment deals by incubated startups. This can be interpreted as the extent to which incubated startups benefit more from the independent variables than non-

\(^2\) We used the log of this variable, as the linear term led to perfect separation of the data, which can lead to biased estimators.
incubated startups. If the coefficient is larger than one, the incubated startups benefit more from the support measure than non-incubated startups.

4.1. Weak network problems

The binary logit part of the model shows that medium and high levels of availability and cooperation are important ecosystem conditions that help prevent weak network problems. The zero counts in Figures 5a and 5b show that these conditions reduce the occurrence of weak network problems with between 55% and 61%. The result indicates that medium levels of these ecosystem variables are effective for reducing weak network problems, but that the difference between a medium and high level of both ecosystem conditions does not have much added value.

The networking support mechanism also has a strong effect to prevent weak network problems. Figure 5e shows that networking shifts over 98% of the observations with zero investment deals to the left peak of the distribution. This means that by acting as intermediaries between startups and inventors, incubators can play a strong role in preventing weak network problems, but that it does not lead to highly successful ecosystems. The combination of these ecosystem conditions and the networking support mechanism almost guarantees the prevention of weak network problems. The main effects of all other variables are very small compared to availability, cooperation, and networking, meaning that they are ineffective to prevent network problems.

The binary logit part of the model predicting the number of incubated investment deals shows that the log of number of investment deals gives a near perfect prediction. Adding the independent variables resulted in a model that could not be identified, due to strong correlations between the control variables and the independent variables. The independent variables thus have no additional explanatory power over the control variables. In other words, weak network failure for incubated and non-incubated startups is determined by the same conditions.

<table>
<thead>
<tr>
<th>Weak network problems (Logit model)</th>
<th>Number of investment deals (Negative binomial model)</th>
<th>Weak network problems incubated startups (Logit model)</th>
<th>Number of incubated investment deals (Negative binomial model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4266.50</td>
<td>5.77</td>
<td>18415439.98</td>
</tr>
<tr>
<td>Ecosystem conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability: Medium</td>
<td>0.02</td>
<td>2.79</td>
<td>1.15</td>
</tr>
<tr>
<td>Availability: High</td>
<td>0.01</td>
<td>3.57</td>
<td>1.53</td>
</tr>
</tbody>
</table>
Cooperation: *Medium* 0.03 1.90 0.83  
Cooperation: *High* 0.02 2.05 0.83  
Investment chance: *Medium* 0.37 1.22 1.04  
Investment chance: *High* 0.25 1.32 1.06  

<table>
<thead>
<tr>
<th>Support mechanisms</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared infrastructure:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Medium</em></td>
<td>0.41</td>
<td>1.28</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>Shared infrastructure: <em>High</em></td>
<td>0.21</td>
<td>1.52</td>
<td>2.39</td>
<td></td>
</tr>
<tr>
<td>Networking: <em>Yes</em></td>
<td>0.00</td>
<td>0.99</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Community building: <em>Yes</em></td>
<td>0.56</td>
<td>1.03</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>Field building: <em>Yes</em></td>
<td>0.71</td>
<td>1.17</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>Business learning: <em>Medium</em></td>
<td>0.65</td>
<td>1.22</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>Business learning: <em>High</em></td>
<td>0.57</td>
<td>1.31</td>
<td>1.02</td>
<td></td>
</tr>
</tbody>
</table>

| Control variables                   |        |        |        |        |
| Investment count                    | 0.00   | 1.01   |        |        |
| Share incubated startups            | 0.40   | 0.91   |        |        |

| Log(\(\theta\))                     | 2.73   | 8.36   |        |        |

| Efron’s \(R^2\)                      | 0.76   | 0.89   |        |        |
4.2. Number of investment deals

The negative binomial part of the model shows that the number of investment deals strongly depends on availability and cooperation. The main effects show that a high availability leads to 3.57 times more investment deals, while a high level of cooperation leads to 2.05 times more investment deals. Figure 5a and 5b show that higher levels of availability and cooperation mainly cause a shift in observations from left peak of the distribution to a right peak. Investment chance increases the number of investment deals with 22% to 32%. This is substantial, but not nearly as much as the other two ecosystem conditions. Figure 5c shows that this is mainly due to a positive shift in observations within the right peak of the distribution. This result implies that mating is not as important as a bottleneck as meeting.

Some support mechanisms also contribute to the total number of investment deals. First, a shared infrastructure gives startups the time to find new partners, which increases the number of investment deals between 28% and 52%. Figure 5d shows that this is mainly due to a shift of observations within the left peak of the distribution (e.g. ecosystems with a medium level of investment deals), and less for ecosystems with a high number of investment deals. Field building increases the number of investments deals by 17%, shifting observations from the left to the right peak of the distribution (Figure 5g). Business learning leads to an increase of between 22% and 31% in investment deals. This is primarily due to a shift in within the right peak of the distribution (Figure 5h). Business learning thus becomes more effective in ecosystems that already have a high number of investment deals. For business learning to be effective, there needs to be a network that gives startups the opportunity to meet investors. Finally, community building and networking have a negligible effect on the number of investment deals.

The last column of Table 1 shows that there are two variables that strongly influence the number of incubated investment deals. First, higher levels of cooperation lower the number of incubated investment deals with 17% compared to total number of investment deals. This effect is most likely due to the fact that a higher level of cooperation facilitates investment in non-incubated startups, which leads to a relative decline in share of investments in incubated startups.

The largest beneficial effect on the number of investment deals for incubated star-ups comes from a shared infrastructure. Pooling resources, gives the incubated startups more time to search for investment deals compared to their non-incubated peers. These higher chances for meeting lead to an increase in incubated investments between 83% and 139%. The other incubation support mechanisms hardly have any effect on the number of investment deals for incubated startups. The
lack of effects is especially notable for field building and business learning, which moderately positively affected the number of investment deals for all startups. From this result one can infer that incubated startups that are subject to two mechanisms serve disproportionally often as introducing agent for all startups. The spillover benefits to the system from field building and business learning thus seem to be larger than the benefits for the incubator and its startups. For field building this result is expected, as it involves actively connecting to non-incubated startups. The spillover effect from business learning is surprising. Figures 5h and 6h show that extra investment deals in the right peak of the distribution are with non-incubated startups, rather than with incubated startups. As the right peak of the distribution in the number investment deals is by caused medium and high levels of availability and cooperation (Figure 5a and 5b), we estimated an additional model in which we interacted these variables with business learning (for reasons of space we do not show the full model). This model show that business learning does increase the number of incubated investments deals by about 8 to 9% compared to non-incubated investment deals in ecosystems with low levels of availability and cooperation. However, when the levels of availability and cooperation increase, the beneficial effect of business learning for incubated startups disappears. This is due to the fact that in these well-connected ecosystems, the chances of meeting become so large that the chances of mating, in the range that we explored (which is based on empirical data), become less important for making an investment deal. For the lowest level of business learning (3%) it takes about 23 times to meet to have a 50% chance of becoming invested, for the highest level (9%) this is about 8 times. Both numbers of meeting are plausible in the life span of startups that we used in the Incubated startups subject to business learning will get their investments earlier than non-incubated startups, but in well-connected ecosystems the latter also stand a very good chance of receiving investments. Moreover, in well-connected ecosystems, the startups that received investments earlier (such as the incubated startups that were subject to business learning) also serve as broker to investors for startups that have not received investments yet. The group that most likely benefits from this brokering is that of non-incubated startups. This explains why business learning, in well-connected ecosystems, is relatively more beneficial to non-incubated startups than incubated startups.

5. Conclusions and implications

We posed the following research question: what is the effect of ecosystem conditions and support mechanisms by incubators on the occurrence of weak network problems and the performance of startups? To this end we derived several ecosystem conditions and incubator support mechanisms, and argued how they influence the changes of meeting and mating between startups and investors.
Our model showed that ecosystem conditions and support mechanisms that influence
meeting chances are more important than those that influence mating chances. The most effective
variable to prevent weak network problems was networking as support mechanism. However,
networking leads to ecosystems with only a moderate amount of investment deals. To obtain a well-
connected ecosystem with a high number of investment deals (e.g. the right peak of the
distribution), it is important to have medium or high levels of availability and cooperation. Incubators
can boast the number of investment deals a bit further through a shared infrastructure, and business
learning, but a truly well-connected ecosystem cannot be created by incubators alone.

A second conclusion is that incubators theoretically can increase the performance of their
tenants. The most beneficial support mechanism for incubated startups is a shared infrastructure.
However, incubated startups lose some of their advantage in an ecosystem that has medium to high
levels of cooperation. The absolute number of incubated investment deals is still higher when there
is a medium to high level of cooperation, but the share in number of investment deals by incubated
startups is larger than when there are low levels of cooperation.

Third, there are three support mechanisms that have spillover benefits to non-incubated
startups. Networking helped incubated and non-incubated alike when overcoming weak network
problems. Field building is more beneficial to non-incubated startups than incubated startups. The
most surprising finding was that, in well-connected ecosystems business learning is more beneficial
to non-incubated than to incubated startups. Willing or not, employing these support mechanisms
let’s incubators play a strong role as system builders.

5.1. Theoretical implications

By linking institutional conditions and support mechanisms to process of network formation,
we contribute to the much needed comprehensive network approach to explain why certain
entrepreneurial ecosystems develop crucial connections, while others do not (Alvedalen and
Boschma, 2017). We observed that institutional conditions that lead to higher chances of meeting led
to a higher increase in investment deals than the one the leads to a higher mating chance. We note
that our institutional conditions are, by definition, archetypical in our model. Hence, we illustrated
them with practical examples in the context of entrepreneurial ecosystem. Future empirical research
should test whether these institutions indeed have the expected effect on network formation.
Further, given the similarities to entrepreneurial ecosystems, it is plausible that much of the
theoretical effects found also apply to innovation systems. This is especially true, if these systems are
dominated by small or medium sized enterprises that are available for a limited amount of time to
connect to other actors. Applying our model can thus also enrich future research on innovation systems.

Second, our model shows incubators can contribute to building networks in entrepreneurial ecosystems, but not build a well-connected system. This confirms earlier claims from qualitative research that incubators can only provide symptomatic solutions to systemic problems that are caused by institutions (Van Weele et al., n.d.). We advise future empirical research to quantitatively test what the effects of incubators are on network formation in entrepreneurial ecosystems, taking into account institutional conditions.

Third, we showed how various support mechanisms separately aid startups with getting investments. Thereby, we theoretically enrich the debate about the effectiveness of incubation, showing that positive effects are to be expected. A novel insight is that the benefits some support mechanisms spillover to non-incubated startups, benefitting the entrepreneurial ecosystem as a whole. This is advantageous to advocates of system building, but also warrants empirical validation. Moreover, the spillover effects further complicate the assessment of the effects of incubation on startup performance, as incubated and non-incubated startups are interdependent. Future research that assesses the effectiveness of incubators needs to take spillover benefits into account. This can be done by comparing the performance of incubated startups with the performance of non-incubated startups that are nested in the same ecosystem, and with the performance of startups from ecosystems without any incubators.

5.2. Limitations

This paper has a number of limitations. First, although some parameters are based on empirical data, the model we used is a theoretical abstraction of reality. This allows us to fundamentally understand the effects of separate ecosystem conditions and support mechanisms. As we aimed to keep the model parsimonious (Bonabeau, 2002; Lave and March, 1993), we did not included factors that were not required to answer our research question. For example, we only focused on the relationship between startup and investors, and the brokering role incubators played therein. The reason for this is that we there is no reason to expect other effects from other actor types the startup can connect with. We also did not take into account that non-incubated startups can learn from other sources or experience, which can increase the chance of mating over time. Given that mating was relatively unimportant to our outcomes, this omission likely only had a limited effect on our results. Finally, we only allowed for connecting to investors via brokering, but not for meetings by chance. We also ran simulations in which did allow for meetings by chance, but this only led to negligible number of additional investment deals.
5.3. Policy implications

This paper has three important policy implications. First, through networking incubators play an important role in overcoming weak network failure. These spillover benefits give a rationale for policy makers to support incubators that employ these support measures, even if these incubators are of a private nature.

Second, our model confirmed earlier claims that incubators can partially remedy the symptoms of poorly performing ecosystems (Van Weele et al., n.d.). Incubators alone are not enough. To obtain a high number of investment deals, it is important to address two ecosystem conditions that of an institutional nature. Startups must remain available to serve as intermediary after they have received investments. Therefore it is important to create a culture of paying it forward (Ready, 2012; van Stijn et al., 2017). Incubators can play a role here, but especially investors can make remaining available a condition for receiving funds. This is also in the interest of investors, as it gives them access to future business opportunities. In a similar fashion, it is important to have a culture or even a community in which startups cooperate, rather than only compete. This asks for the development of trust, and shared norms between startups. The development of such a community is largely a bottom-up initiative by startups themselves (Feld, 2012; Van Weele et al., 2017a).

Third, a shared infrastructure is the most effective support mechanisms to give an advantage to incubated startups. However, it is also the most expensive support mechanism, as it requires the substantial investments in tangible resources, like money and office space. For incubators that aim at high performing startups, a shared infrastructure is definitely an attractive option. However, for policy makers that wish to build high performing startup ecosystem, addressing institutional conditions is probably more attractive.

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