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Intermediaries for the greater good: How entrepreneurial support organizations can embed constrained sustainable development startups in entrepreneurial ecosystems

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A R T I C L E I N F O

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A B S T R A C T

Sustainable development startups (SDSs) are important to help overcome societal challenges. However, starting an SDS or investing in them is a high-risk endeavor. Hence, policymakers are trying to make entrepreneurial ecosystems (EEs) more favorable for SDSs. A critical component of any EE is a financial support network, through which startups receive investments and business knowledge most importantly from private venture capitalists (VCs), among other finance providers. To be successful, SDSs thus need to become embedded in the financial support network. This embeddedness also allows SDSs to serve as network brokers between VCs and other startups, which is beneficial for the entire EE. Entrepreneurial support organizations (ESOs) can help build a sufficiently dense financial support network by introducing startups to other actors. However, there are often not enough promising SDSs in an EE to meaningfully influence the financial support network. This places ESOs that promote SDSs in the dilemma of which startups to admit: they can either focus their efforts exclusively on SDSs or give their unfilled spots to non-SDSs, with the latter facilitating network brokering among startups. Therefore, this paper answers the following research question: What is the effect from ESOs' support mechanisms and admission regimes on the number of investments in SDSs? Using an agent-based model, I demonstrate that ESOs are a necessity for EEs with many constrained SDSs, particularly when the constraints are technology-based. Without ESOs, the presence of such SDSs negatively influences the entire EE due to a loss of brokering in the financial support network. ESOs can help repair this damage by having the right admission regimes and helping tenant SDSs overcome some of their constraints. Ultimately, the most effective way to do this is to have an admission regime under which only SDSs are accepted and receive twice as much support from the ESO.

1. Introduction

Entrepreneurship for sustainable development can be defined as the "discovery, creation, and exploitation of opportunities for (future) goods and services that simultaneously sustain the natural and social environment, and provide economic and non-economic gain for others" (Johnson, 2020). I refer to new ventures that engage in entrepreneurship for sustainable development as sustainable development startups (SDSs) .

Scholars argue that such SDSs are an important source of innovations that help overcome the challenges described in the United Nations' Sustainable Development Goals (Apostolopoulos et al., 2018; Horne et al., 2020; Tiba et al., 2020), such as mitigating climate change and promoting good health and well-being.

However, making SDSs successful is easier said than done. Many SDSs suffer from market or institutional constraints, making them less profitable (Hoogendoorn et al., 2019). Other SDSs, such as those in cleantech or the life sciences, require large capital investments to finance a strong technology base (Bjornali and Ellingsen, 2014; Leendertse et al., 2020; Marra et al., 2015; Zhang et al., 2013). Both constraints make investing in SDSs a high-risk endeavor (De Lange, 2017; Leendertse et al., 2020). Consequently, only an average of 8.4% of startups that received investments in the top 17 global startup regions contribute to Sustainable Development Goals (Tiba et al., 2021).

To increase this number, policymakers are trying to steer the entrepreneurial ecosystem (EE)—comprised of all the factors that affect the founding, growth, and survival of startups in a given region (Spigel, 2017; Stam, 2015)—toward favoring SDSs (Cohen, 2006; Neumeyer and

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Santos, 2018; Theodoraki et al., 2018; Volkmann et al., 2019). A critical component of an EE is its financial support network (Clarysse et al., 2014; van Rijnsoever, 2020). The financial support network gives startups access to private venture capitalists (VCs) who supply much-needed funds, business knowledge, and market connections. Startups meet VCs predominantly via the brokering activities of other startups and intermediaries in the financial support network (Engel et al., 2017; Fritsch and Schilder, 2008). Thus, to gain access to VCs, SDSs need to become embedded in this network. Moreover, if SDSs are not embedded in the financial support network, fewer startups are available to serve as network brokers for other startups, which can lead to fewer VC investments in SDSs and non-SDSs alike. However, we do not know how the constraints SDSs face influence their embeddedness in the financial support network and, thus, the number of VC investments in startups.

One way to embed SDSs in the financial support network is through entrepreneurial support organizations (ESOs), which are organizations "explicitly founded for the purposes of catalyzing entrepreneurial activity and providing entrepreneurs with support" (Bergman and McMullen, 2021). The most prominent example of these are business incubators, other examples include accelerators or venture builders. Simulations have demonstrated that if sufficient startups (about 20%) are supported sufficiently by an ESO as an intermediary organization, they can overcome deficiencies in the financial support network in insufficiently developed EEs van Rijnsoever (2020). ESOs can do this through various support mechanisms, such as introducing startups to VCs or helping to improve a business's quality. ESO, in particular incubators, commonly select their tenants by examining the business team's quality and its ideas (Bergek and Norrman, 2008). However, if ESOs wish to promote SDSs, they need to add the startup's (sustainable development) purpose as an additional selection criterion. These ESOs face a tough choice: They can choose to focus their support efforts only on SDSs, but given the low share of SDSs in various EEs (Marra et al., 2015; Tiba et al., 2021), such an exclusive admission regime means that valuable support capacity in an EE is not utilized. This can lead to a loss of brokering among startups in the financial support network. The alternative is ESOs giving unfilled spots to non-SDSs. This allots more critical mass to the much-desired brokering among startups, but it also dilutes the ESO's resources available to non-SDSs.

To solve these issues, paper answers the following research question:

What is the effect of ESOs' support mechanisms and admission regimes on the number of investments in SDSs?

I answer this question by extending the empirically validated agent-based model by Van Rijnsoever (2020), which disentangles the effects from different ESO-support mechanisms on the number of startup investments in an EE[1]. I extend the model by adding SDSs with different constraints and ESO admission regimes. Agent-based models are suitable for simulating complex interactions between entrepreneurs and other agents and their outcomes at a system level (McMullen and Dimov, 2013). The model demonstrates the plausible effects from support mechanisms and admission regimes on the number of investments in SDSs in an EE.

This paper demonstrates how ESOs can embed SDSs or other constrained startups in regional networks. I provide much needed insights on network formation in EEs (see Alvedalen and Boschma, 2017), by focusing on how the various constraints of startups influence the formation of networks in the EE, and how ESOs can help develop networks in EEs to support SDSs (Steinz et al., 2015; Theodoraki et al., 2018; Volkmann et al., 2019).

Furthermore, I contribute to literatures related to EEs, such as literature on clusters (Lechner and Leyronas, 2012; Owen-Smith and Powell, 2004; Saxenian, 1990) and on regional innovation systems (Cooke, 2002; Culkin, 2016). The results demonstrate how ESOs can help constrained startups become part of critical networks in a region. I finally contribute to other (eco)system literature in which sustainable entrepreneurship plays a role, such as technological innovation systems (Hekkert et al., 2007; Planko et al., 2016) and mission-oriented policies (Hekkert et al., 2020; Mazzucato, 2016), by demonstrating how ESOs can serve as network intermediaries to promote sustainable development (see Kivimaa et al., 2019). Practically, this study helps regional policymakers, ESOs choose their support strategies for SDSs and startups with similar constraints.

2. Literature review

I first discuss this paper's most important concepts—entrepreneurial ecosystems (EEs), sustainable development startups (SDSs), different types of entrepreneurial support organizations (ESOs)—and how they admit and support startups. These concepts are applied in the agent-based model.

2.1. Entrepreneurial Ecosystems and the Financial Support Network

The origins of EEs can be traced back to the literature on regional development, such as clusters, industrial districts, and (regional) innovation systems and strategy (specifically the concept of business ecosystems) (ACS et al., 2017a; Cavallo et al., 2018). However, whereas the focus of previous literature was on innovation, employment, and economic growth, EEs explain how system conditions influence actors' entrepreneurial agency to create value (Ács et al., 2014; Stam, 2015). Similar to clusters Porter (2000), startups in a well-developed EE benefit from the availability of common resources, such as knowledge, human capital, infrastructure, a supply chain, supportive organizations, access to finance, and having peers with whom to compare performances. The success of an EE in fostering certain types of firms, such as SDSs, can lead to the establishment of a specialized regional cluster Pitelis (2012) that provides innovation, employment opportunities, and economic growth. Such possible economic benefits are an extra reason for regional policy makers to foster EEs.

Conceptually, the EE can be viewed as a set of actors that interact and exchange resources in a network under an institutional regime and an infrastructure van Rijnsoever (2020). Similar to regional innovation systems Cooke (2002), the EE can be divided into a science subsystem and a business subsystem, with an financial support network bridging them. This final element is critical to a well-functioning EE (Clarysse et al., 2014). The financial support network comprises startups and investors—such as business angels, public investors, banks, and private VCs—and the relationships between them. More than any other type of funder, VCs give startups access to the financial capital and business advice required to translate innovative (scientific) business ideas into marketable solutions, thereby helping startups transform from science-based organizations to scalable commercial enterprises (Bocken, 2015; Clarysse and Bruneel, 2007; Ter Wal et al., 2016). VCs have the advantage of being experienced in business, strongly connected to both subsystems and well-involved with their startups, as well as serving as stable presences within EEs (De Clercq et al., 2006; Powell et al., 2005; Ter Wal et al., 2016). Thus, VCs and startups are the focal actors in the financial support network (Clarysse et al., 2014).

Forming an financial support network involves two primary processes: meeting and mating (Kalmijn and Flap, 2001; van Rijnsoever, 2020; Verbrugge, 1977). *Meeting*, which refers to two potential partners encountering each other, can take place randomly or through brokerage (Jackson and Rogers, 2007). Meeting randomly can take place anywhere, e.g., on a street, in a bus, or online. In an financial support network, meeting randomly is applicable mostly to startups meeting other startups, but they also can meet with each other via brokering. Meeting VCs takes place almost exclusively through brokerage (Engel et al., 2017; Fritsch and Schilder, 2008), including introductions by other startups, and EE intermediaries, such as ESOs (Bøllingtoft and

[1] Van Rijnsoever (2020) refers to ESOs as incubators.

Ulhøi, 2005a; Dutt et al., 2016). Therefore, a well-functioning financial support network needs to include a sufficient number of network ties among startups to allow brokering to happen van Rijnsoever (2020).

Meanwhile, *mating* refers to actors forming a relationship after meeting. The relationships among startups often are low-risk and informal, and primarily revolve around referrals, exchanging advice, and friendship (van Weele et al., 2018a). Accordingly, such ties are forged easily, but relationships between VCs and startups involve transactions involving valuable resources and often are managed through formal mechanisms, such as contracts (De Clercq et al., 2006). Startups that mate with VCs receive investments that prolong their lifespans, allowing them to serve as network brokers for longer periods of time.

2.2. Sustainable development startups and their constraints

The concept of sustainable development entrepreneurship comprises various lines of research that study various related, but are slightly different types of entrepreneurship (Johnson and Schaltegger, 2020; Tiba et al., 2018; Vedula et al., 2021), including social entrepreneurship (Mair and Marti, 2006; Saebi et al., 2019; Santos, 2012), environmental entrepreneurship (Leendertse et al., 2020; Piwowar-Sulej et al., 2021; Schaltegger and Wagner, 2011), entrepreneurship for the public good (Vedula et al., 2021), and sustainable entrepreneurship (Dean and McMullen, 2007; Johnson and Schaltegger, 2020; Schaltegger and Wagner, 2011; Tiba et al., 2021). Based on the concept of sustainable development entrepreneurship, I define SDSs as novel ventures that engage in the "discovery, creation, and exploitation of opportunities for (future) goods and services that simultaneously sustain the natural and social environment, and provide economic and non-economic gain for others" (Johnson and Schaltegger, 2020, p. 1141). SDSs are small, flexible, and have relatively few vested interests, allowing them to come up with radical solutions to grand societal challenges (Dean and McMullen, 2007), either via technological innovation, new business models, or organizational or institutional change (Johnson and Schaltegger, 2020; Zahra et al., 2009).

The definition of SDSs encompasses the creation of social value environmental and economic value, making them compatible with the triple bottom line of people, planet, and profit commonly used in research on corporate social responsibility (CSR; Saebi et al., 2019; Tiba et al., 2018). In line with the triple bottom line, I also assumed that SDSs are for-profit entities that wish to be active in the business ecosystem and, therefore, are dependent on VCs and the financial support network. However, whereas with corporate social responsibility, the intent is to avoid the loss of social or environmental value (i.e., doing no harm; Campbell, 2007), SDSs emphasize the creation of additional value in the social or environmental dimension without losing value in the other dimension (Muñoz et al., 2018).

Based on characteristics such as their goals, strategies, and organizational forms, a large heterogeneity exists among SDSs (Bergset and Fichter, 2015; Ebrahim and Rangan, 2014; Schaltegger and Wagner, 2011). However, SDSs face two common and major constraints that inhibit their chances of receiving sufficient funding from VCs and joining the financial support network (Hoogendoorn et al., 2019), and given the heterogeneity among SDSs, they might suffer from these constraints to various degrees.

First, market constraints make SDSs less attractive to invest in, lowering their mating chances with VCs (De Lange, 2017; Juravle and Lewis, 2009; Wüstenhagen and Teppo, 2006). SDSs commonly operate in imperfect or failing markets (Hoogendoorn et al., 2019; Pinkse and Groot, 2015), in which public value is often insufficiently accounted for in prices of goods or services. Therefore, SDSs are at a disadvantage against competing non-SDSs. Moreover, certain prospective users, such as those in developing countries, often do not have the means to buy the goods or services that SDSs offer (Mair and Marti, 2006; Tiba et al., 2020). Furthermore, SDSs frequently are constrained institutionally (Hoogendoorn et al., 2019), as their products or services do often not adhere to the market's regulations, standards, norms, habits, or cognitive frames (Smink et al., 2015; Steinz et al., 2015).

Second, many technology-based SDSs are constrained because they require more investment capital than other types of startups (Evans, 2018; Leendertse et al., 2020; Martin and Moser, 2016). "Hardware" SDSs, such as in cleantech or life sciences, often face higher costs due to the need to conduct large-scale R&D, clinical trials, or demonstration projects, as well as set up production lines. This leads to a high "burn rate" of funds and the need for extra investments (Bjornali and Ellingsen, 2014; Marra et al., 2015; Zhang et al., 2013).

These constraints inhibit SDSs from partaking in the financial support network, i.e., fewer startups are available to serve as brokers. This can lead to fewer VC investments in SDSs and non-SDSs alike. Furthermore, these constraints are not applicable exclusively to SDSs, e.g., startups in the sharing economy (Uzunca et al., 2018), gig economy (Frenken et al., 2020), and fintech (Lee and Shin, 2018) sectors often face regulatory difficulties, creating market constraints. Many technology-based spinoffs from universities also suffer from the need for greater investments. This study's results also apply to other startups with these constraints. Thus, SDSs serve as an exemplary case.

2.3. Types of entrepreneurial support organizations

Historically, the literature on ESOs consists of studying different types organizations that perform similar tasks (Bergman and McMullen, 2021). A very prominent strand of literature developed around incubators, which are organizations or programs that support startups (Bergek and Norrman, 2008; Bruneel et al., 2012). However, the best way to do this has been the subject of long-running academic debate (Amezcua et al., 2013; Bruneel et al., 2012; Eveleens et al., 2017). Over the years, incubators and other support programs have experimented with different forms and levels of support, leading to the emergence of several incubator types (Galbraith et al., 2019; Grimaldi and Grandi, 2005). Incubators have developed over three generations (Aerts et al., 2007; Bruneel et al., 2012). The first became widespread in the 1980s and focused on creating economies of scale by providing shared office space and facilities (Bruneel et al., 2012). Although this remains important for modern incubators' value proposition, incubators later shifted their focus toward providing intangible resources. In the 1990s, incubators noted that the founders of technology-based start-ups lacked entrepreneurial experience, so incubators expanded their services to include coaching and training for entrepreneurs to enhance business learning (Bruneel et al., 2012). This second generation also started to provide funding in exchange for equity. In the late 1990s, the third generation focused on giving start-ups access to networks, facilitating the acquisition of external resources, and providing legitimacy to start-ups (Bøllingtoft and Ulhøi, 2005b; Bruneel et al., 2012; Hansen et al., 2000). Thus, this third generation serves as intermediaries in the regional EE to promote the network between startups and VCs, or among startups van Rijnsoever (2020). Intermediaries as network brokers have been argued to be important in the formation of regional economic clusters Smedlund (2006), the development of innovations Howells (2006), entrepreneurial ecosystems (Goswami et al., 2018; Stam, 2015), and the acceleration of sustainability transitions (Kivimaa et al., 2019).

In addition to incubators, other types of ESOs exist that (partially) perform activities similar to those of incubators in an EE, but are named differently (Aernoudt, 2004; Clayton et al., 2018). The most prominent example is accelerator programs (Pauwels et al., 2015), which generally focus on supporting "early-stage, growth-driven companies through education, mentorship, and financing in a fixed-period, cohort-based setting" Hathaway (2017). The acceleration period often is three to six months, while incubators can offer support for a longer period of time Cohen (2013). However, a wide variety of accelerator designs exist with regard to sponsorship, purpose, and their support programs (Cohen et al., 2019). Another type of organization that can perform tasks of

ESOs are technology transfer offices (TTOs), which are responsible for the commercialization of technologies at universities or other knowledge institutes. TTOs do this in part by helping secure intellectual property rights (Backs et al., 2019), as well as assisting with the creation of academic spin-off firms and preliminary investments, then connecting these firms with other actors in the EE, such as VCs (Algieri et al., 2013; Gubitta et al., 2015). TTOs' activities mainly apply to technology-based startups, but these activities are similar to what other ESOs offer. A third example of ESOs are co-working spaces, which are organizations that allow people to people-share an office space Spinuzzi (2012). For starting entrepreneurs, this is often more convenient and flexible than renting private office space. Co-working spaces often offer limited support to startups, but they allow entrepreneurs to build relationships with other tenants in the co-working space, as well as facilitate the creation of communities (Clayton et al., 2018; van Weele et al., 2018a), similar to some functions that other ESOs perform in an EE.

These entities can be thought of as manifestations of the pluriform ESO phenomenon (Bergman and McMullen, 2021). Thus, I refer to all such initiatives as *entrepreneurial support organizations* as umbrella term to which the field converges. This study's results apply to these organizations to the extent that they perform similar activities in the EE.[2]

2.4. ESO Admission Regimes

ESOs can help startups gain access to the financial support network (van Rijnsoever, 2020), but before doing so, they must select which startups will receive their support (Bergek and Norrman, 2008; Hackett and Dilts, 2004). Generally, ESOs select tenants based on the entrepreneur or team's qualities (Aerts et al., 2007; Bergek and Norrman, 2008) and the startup's business idea. When it comes to the distinction between SDSs and non-SDSs, a startup's sustainable development purpose can become an additional explicit selection criterion. Applying this criterion can lead to three different admission regimes.

First, ESOs may not use sustainable development as a selection criterion. They can admit SDSs and non-SDSs alike as long as they meet the other selection criteria in place. I refer to this as an *open admission regime*. Second, ESOs can have an *exclusive admission regime*, in which they only admit SDSs that reach a minimum level when promoting sustainable development. Thus, they can focus their efforts only on this target group (Schwartz and Hornych, 2008). However, due to their low prevalence (see Marra et al., 2015; Tiba et al., 2021), it is often difficult to attract a sufficient number of SDSs to the ESO. Thus, it is likely that not enough critical mass exists for brokering between startups in the financial support network to take place. If they have the resources, ESOs also can give their tenant SDSs more intensive support in terms of time and effort to counter this loss. Third, ESOs can have a *preferred admission regime*, in which they prioritize admitting SDSs, but fill unutilized ESO capacity with non-SDSs to build enough critical mass for brokering to take place. Thus, all tenants receive about the same level of support, but ESO resources to non-SDSs are diluted in the name of system building.

The choice of admission regime partially depends on the ESO's operating model (Grimaldi and Grandi, 2005) and the conditions that external (public) sponsors set. For example, some ESOs are dependent on tenant startups for income, such as from office rent or service fees. In this case, it makes (financial) sense to fill the ESO to maximum capacity. Still, some public sponsors demand that the ESO only support SDSs.

2.5. ESO support mechanisms

After admission, ESOs commonly aid startups through various support mechanisms (Amezcua et al., 2013; Bruneel et al., 2012; Cohen et al., 2019; van Weele et al., 2017). Van Rijnsoever (2020) identified three support mechanisms that lead to systemic EE benefits, and I applied these mechanisms in the model.[3]

The first is field building, i.e., the ESO deliberately introduces tenant startups to peers outside of the ESO (Amezcua et al., 2013). Such introductions increase meeting chances between supported and non-supported startups. Field-building activities include active introductions or network meetings with startups outside the ESO. The SDSs that become part of the network of startups in this manner, in turn, can be introduced to VCs by their peers.

The second is VC networking, in which ESOs serve as network brokers between startups and VCs, thereby increasing meeting chances between the two groups. VC networking typically entails organizing events, introductions, or referrals (Patton et al., 2009; Van Rijnsoever et al., 2017). For SDSs, facilitating extra meetings with VCs can be beneficial, as they likely need more meetings with different VCs to strike a deal.

The third is business learning, which allows the startup to improve its ideas and management qualities. Business learning lets startup entrepreneurs acquire new knowledge, reflect on their business ideas and practices (Bruneel et al., 2012; van Weele and Van Rijnsoever, 2017), and develop new capabilities (van Rijnsoever and Eveleens, 2021). Overall, they prevent startups from being content too early with many businesses' decisions (Cohen et al., 2018). Incubators promote learning through professional consulting services, coaching, and mentoring (Cohen et al., 2019; Rotger et al., 2012; van Weele et al., 2017). Business learning makes startups more attractive partners, thereby increasing mating chances between startups and VCs. Moreover, in the context of SDSs, business learning also entails how they should manage their dual mission of creating social/environmental value while making a profit.

3. Methods

I tested each support mechanism for different types of SDSs under different admission regimes by extending the agent-based model from Van Rijnsoever (2020). This model was originally developed to test the effects of ESO support mechanisms on the development of an financial support network in different types of EEs. The model was created using the methodology described by Rand and Rust (2011), where the input values, output values, and internal mechanisms are all empirically validated and correspond with reality. The details of the model and its validation are described in van Rijnsoever (2020). I first summarize this original model, after which I describe the adaptations I made to answer the research question.

3.1. Original model

3.1.1. Agents, properties, and environment

The agents in the model were 100 startups based on empirical EE estimates (Casper, 2007; Clarysse et al., 2014; Cooke, 2002). The model simulated a period of 40 years, which corresponds to the time it can take

[2] A fourth and novel startup support form comprises venture builders, also known as tech studios, startup factories, or venture production studios. At the moment, scant scientific research has been conducted on what this form exactly entails, but it comprises companies that build startups by gathering business ideas and hiring professional teams to transform the most promising ideas into successful businesses (Diallo, 2015; KarSin, 2019). As the team comprises professionals, venture builders likely rely less on ESO-support mechanisms, such as network support, or business learning. Given the low number of extant empirical studies on venture builders, and the fact that they share limited features with ESOs, I cannot assert that this study's results apply to venture builders.

[3] Van Rijnsoever also tested other support mechanisms' effects, such as community building, a shared infrastructure, deal-making, and peer-coupling. However, these mechanisms were relatively ineffective when it came to building an financial support network, which the initial tests also confirmed. Thus, I did not test these mechanisms in detail.

to build a thriving EE, such as Silicon Valley. The model iterated at 2,000 time steps, with each time step representing about one week. In most instances, the model reached dynamic equilibrium in fewer than 1,000 time steps. Following the empirical estimate of 8.4% (Tiba et al., 2021), I set the share of SDSs to 10%.

Each startup had the following properties.

- **Funds** (between 0 and infinite time steps): Indicates the number of time steps that the startup can survive. Funds effectively determine cumulative meeting chances over time.
- **Ties to other startups:** Records the other startups to which a focal startup is tied.
- **Tie to VC** (true/false): Indicates if the startup is tied to a VC and if that startup received an investment.
- **Dating period** (0–10 time steps): Indicates the remaining time steps of the dating period with a VC; the length of the dating period is based on the typical duration of negotiating an investment deal with a VC, or 2–3 months (De Clercq et al., 2006).
- **Deal period** (0–100 time steps): Indicates the remaining time steps during which the startup is tied to the VC. Having an investment deal with a VC typically allows a startup to survive for about 2 extra years (De Clercq et al., 2006; Suster, 2018), which served as the basis for the length of the deal period in this work.
- **Honeymoon period** (0–75 time steps): Indicates the remaining time steps during which a startup cannot meet a VC. The length of the honeymoon period is based on the notion that after three-quarters of a VC deal period, startups need to seek new funds again (De Clercq et al., 2006; Quintero, 2017).
- **Supported** (true/false): Indicates if a startup is supported by an ESO.

3.1.2. Initialization and startup behaviors

The initialization phase of each model run started with the creation of 100 startup agents. All startup properties were set to false, zero, or default. The model then allocated funds to the startups according to a Poisson distribution with a mean of 200 time steps. This corresponds to startups' survival time (Boyer and Blazy, 2014; Eurostat, 2017; Hyytinen et al., 2015). Finally, as initial agents to broker ties, the "tie to VC" was set to true for 4 randomly selected startups.

The startups could display the following behaviors during each time step:

- **Update:** One time step is subtracted from each startup's funds, dating period, deal period, and honeymoon period if that property has a value larger than 0. If the burn rate is 2, then two time steps are subtracted.
- **Meeting another startup at random:** Each startup is randomly assigned to another startup as a potential partner. Each startup then receives a random number between 0 and 1. If this number is smaller than the chances of meeting at random among startups, then the two potential partners meet.
- **Meeting another startup through brokerage:** For each startup that is tied to more than one other startup, two of the startups it has a tie to are randomly selected; these two startups then meet.
- **Mating with other startups:** For each pair of startups that meet, the model generates a random number between 0 and 1. If this number is smaller than the mating chances between startups, then the startups in that pair form a tie.[4]
- **Meeting with a VC:** Startups with both a dating period and honeymoon period = 0 and that are tied to a startup that is tied to a VC will meet the VC. The dating period is set to 10 time steps.
- **Mating with a VC:** If the dating period of a startup becomes 0, then the model generates a random number between 0 and 1. If this number is smaller than the mating chances with a VC, then the startup's "tie to VC" is set to true. The startup's funds are also increased by 100 time steps, the honeymoon period set to 75 time steps, and the deal period set to 100 time steps. The chance of mating with VCs defaults to 3% (Becker, 2014; Kerr et al., 2014).
- **Admit startups:** If the number of startups with supported = true is smaller than the support capacity of the ESO, then the model randomly selects one startup with supported = false. This startup then changes to supported = true. Up to 20% of all startups can be admitted to the ESO.
- **Exit and entry:** Startups with funds = 0 die; a new startup is then created with the same properties and values as the startups upon model initialization. New startups have a 10% chance of being SDSs.

3.2. Adapted model

3.2.1. Additional properties

I added the following startup properties to model the different SDS types.

- **SDS** (true/false): Indicates if a startup is an SDS.
- **Investment penalty** (0.5 or 1 (default)): Multiplied by the chances of mating with VCs.
- **Burn rate** (1 (default) or 2): Multiplied by the funds that are used at each time step.

3.2.2. Input variables

The input variables were the types of SDSs, admission regimes, and separate support mechanisms. In separate runs, I added four archetypical SDSs to the model that were characterized by their investment penalties and burn rates. I thereby captured a substantial part of the heterogeneity among startups. I simulated the effect of different values for these parameters in a model without any ESO support mechanisms (see Appendix A). Based on this and scarce empirical evidence, I used multiples of two as constraint values for the following SDSs:

- **Generic SDSs:** There are no constraints, and the investment penalty and burn rate are set to default 1; generic SDSs serve as the reference category and are not expected to be abundant in real life.
- **Market-constrained SDSs:** Despite the evidence that market constraints lower SDSs' chances of mating with VCs (Juravle and Lewis, 2009; Wüstenhagen and Teppo, 2006), there is little data to quantify these mating chances. Accordingly, I chose an investment penalty of 0.5.
- **Technology-based SDSs:** These SDSs use more funds, so the burn rate is 2. Burn rates vary greatly among startups Suster (2014), and there are few reliable comparisons between technology-based and non-technology-based startups. The scarce evidence that is available (Bowden, 2014; CBinsights, 2017; Špetič, 2014) indicates that setting the burn rate to 2 is plausible.
- **Double-constrained SDSs:** These SDSs combine the former two categories. The investment penalty is 0.5 and the burn rate 2.

I also added the following ESO admission regimes to the model[5]:

- **Open regime:** SDSs and non-SDSs have the same chance to be admitted to the ESO; this is the reference category.

[4] I assumed that SDSs and non-SDSs have an equal chance of meeting and mating with each other. This assumption is based on the idea of shared norms and values among startups for open informal collaboration (Feld, 2012; van Weele et al., 2018a).

[5] Another theoretically possible admission regime is that ESOs do not admit any SDSs upon deeming them unprofitable. However, as I studied how ESOs can promote investments in SDSs, I did not consider this scenario here.

- **Preferred:** SDSs are always admitted before other startups. When all SDSs are supported, other startups are admitted. All startups receive the same level of support.
- **Exclusive normal effort:** The ESO only admits SDSs. All startups receive the same level of support.
- **Exclusive double effort:** The ESO only admits SDSs. However, because the ESO is not completely filled, it has excess time and resources. Therefore, I let the supported startups receive double the level of support.

During each time step, the model implemented the support mechanisms; in case of the exclusive double effort regime, it implemented each mechanism twice. The implementation worked as follows[6]:

- **None:** No support mechanisms are implemented; this is the reference model.
- **Field building:** A randomly selected supported startup meets a randomly selected non-supported startup.
- **VC networking:** A randomly selected supported startup with dating period and honeymoon period = 0 meets a VC; the dating period is set to 10 time steps.
- **Business learning:** Doubles the mating chances of supported startups with VCs after meeting them.

Further, the model controls for starting conditions, which is the state of development of the network among startups at the beginning of the simulation. Using starting conditions accounts for empirically observed differences in EE development (Acs et al., 2017b; Autio et al., 2014; Global Entrepreneurship Monitor, 2017; Startup Genome Project, 2017), which influence the various support mechanisms' effectiveness (Amezcua et al., 2013; Hallen et al., 2020). The starting conditions varied by the mating chances among startups and effectively determined to what extent the startups would meet VCs through brokerage:

- **Undeveloped:** In the undeveloped condition, the mating chances between startups are set to 10%, which gives little opportunity to meet VCs through brokerage.
- **Emerging:** In the emerging condition, the mating chances between startups are set to 20%, but meeting VCs through brokerage remains problematic.
- **Maturing:** In the maturing condition, the mating chances between startups are set to 40%. This provides opportunities to meet VCs through brokerage.
- **Developed:** In the developed condition, the mating chances between startups are set to 80%. Much brokerage takes place.

3.2.3. Output variables

After each model run, I recorded the following output variables:

- **VC–startup investments:** The average number of startups (SDSs and non-SDSs) that were tied to VCs over the last 500 time steps.
- **VC–SDS investments:** The average number of SDSs that were tied to VCs over the last 500 time steps.

In contrast to van Rijnsoever (2020), I measured the output variables over the last 500 time steps rather than at the end of the model. This measure gave more precise results and was less sensitive to model variations. Both output variables indicated the number of VC investments over a period of 10 years. I ran the model 1,000 times for each combination of input variables and starting conditions and reported the average value. In total, this yielded 384,000 observations. Appendix B provides the model's full results.

4. Results

4.1. Differences between types of sustainable development startups

Table 1 shows how much the output variables differ between the reference model with generic SDSs (column 1) and the model runs with the three types of constrained SDSs in each starting condition (columns 2–4). Appendix A provides the results under other investment penalties and burn rates.

The results consistently indicate that technology-based SDSs receive less VC investments than market-constrained SDSs. As can be expected, double-constrained SDSs are worst off. In addition, due to the presence of either type of constrained SDS in the EE, non-SDSs also receive less VC investments.

Compared to generic SDSs, in emerging conditions the presence of market-constrained SDSs reduces the number of VC startup investments by more than half. Their lower mating chances with VCs mean that there are less brokers between VCs and other startups in the EE. The presence of technology-based SDSs and double constrained SDSs leads to an almost complete disappearance of VC startup investments. This is because the high burn rate of these startups inhibits them from staying long enough in the EE to function as network brokers. Accordingly, the financial support network cannot develop. In maturing conditions, the presence of either constrained SDS also leads to reduced VC investments, but the mating chances between startups are sufficiently high and partially compensate for the loss of brokering by either type of constrained SDS. In the maturing condition, the effect of both of the double-constrained SDSs' handicaps becomes evident. Their shorter presence in the EE and lower mating chances with VC lead to the largest loss of VC startup investments. This effect is not visible in emerging conditions because the technology-based constraint sufficiently inhibits the financial support network from developing.

Even in developed starting conditions, the presence of the constrained SDSs is evident, but the constraints play out differently. The presence of market constraints leads to a loss of 18.5 VC startup investments, while the presence of technology-based startups leads to a loss of only 12.7. This is because in the developed condition, the network among startups that facilitates meetings with VCs is sufficiently developed. Rather, the mating chances between VCs and startups largely determine the number of VC startup investments van Rijnsoever (2020), and these mating chances are lower for market-constrained SDSs than technology-based SDSs. Hence, for market-constrained SDSs, the loss of brokering is mainly present in the maturing and developed conditions; for technology-based SDSs, this loss is primarily in the emerging and maturing conditions. Overall, given the dependence of the financial support network on the presence of SDSs as network brokers, we see that in all conditions, the presence of only 10% of SDSs with constraints leads to a reduction of more than 10% in VC startup investments.

Given the assumed investment penalties and burn rates, ESO support mechanisms can partially mend this damage to the EE. Appendix B shows how much VC investments' different support mechanisms add to the EE and thus if they compensate for the presence of SDSs. In the model runs with undeveloped or emerging starting conditions and with one of the three constrained SDSs types, field building and VC networking (albeit to a lesser extent) can bring the values of both output variables above those in the reference scenario in which generic SDSs do not receive any support mechanisms. This is because these support mechanisms actively promote the meeting between startups and VCs, either directly or via brokering. In the maturing and developed starting conditions, ESOs can almost fully overcome the loss of investments due to the presence of technology-based SDSs through field building and business learning. Despite applying different support mechanisms, the presence of market-constrained SDSs almost always leads to less VC startup investments compared to model runs with unsupported generic SDSs in maturing and developed conditions. This is because none of the combinations of single support mechanisms and admission regimes fully

[6] I simulated the effect of other support mechanisms as well, but these were hardly effective.

Table 1
Results of each type of SDS when there are no support mechanisms and how the other types of SDSs differ from generic SDSs. The values represent the average number of startups after 500 model runs. The number of VC-SDS investments is included in the number of VC startup investments.

Starting condition	Output variable	Output values	Difference with generic SDSs		
		(1) Generic SDSs	(2) Market-constrained SDSs	(3) Technology-based SDSs	(4) Double constrained SDSs
Undeveloped	VC startup investments	0	0	0	0
	VC-SDS investments	0	0	0	0
Emerging	VC startup investments	23.8	-12.2	-21.8	-22
	VC-SDS investments	2.7	-1.7	-2.6	-2.6
Maturing	VC startup investments	78.1	-16.7	-23.1	-32.9
	VC-SDS investments	8.6	-3.1	-5.2	-6.3
Developed	VC startup investments	94.5	-18.5	-12.7	-27.3
	VC-SDS investments	10.2	-3.5	-4.2	-6.2

compensate for the lower mating chances that these SDSs have with VCs. In the model runs with double-constrained SDSs, no single support mechanism offsets the damage to the EE in the maturing and developed starting conditions. This is because the constraints of these SDSs are of a different nature and require a combination of compensating support mechanisms, rather than a single mechanism.

4.2. Differences between admission regimes

The effect of all admission regimes is largely the same for all SDS types under all starting conditions (Appendix B). Therefore, I discuss the results for generic SDSs only (Table 2). The columns 1 to 4 in Table 2 indicate the extra number of VC investments caused by the ESO support mechanisms compared to the reference model in Table 1 column 1.

Compared to an open regime, the other three admission regimes allow ESOs to boost VC–SDS investments to varying degrees. Under these three admission regimes, field building and VC networking are the most effective ways to increase VC–SDS investments in the underdeveloped and emerging starting conditions. This is because in those conditions, the meeting chances between startups and VCs are low, and the support mechanisms increase those meeting chances. In the maturing and developed starting conditions, meanwhile, business learning is the most effective mechanism. This finding is in line with earlier empirical evidence (Amezcua et al., 2013; Hallen et al., 2020) and can be explained by the fact that under these conditions, the mating chances between VCs and startups need to increase.

Overall, field building increases VC–startup investments more under the open, preferred, and exclusive double effort regimes than under the exclusive normal effort regime. When it comes to VC–SDS investments, field building leads to about the same increase under all admission regimes except undeveloped starting conditions, where the exclusive normal effort regime lags behind. Both results stem from the fact that under the latter admission regime, the ESO capacity in an EE is effectively cut in half without compensation, which means that the network among startups is stimulated the least of all regimes.

VC networking increases VC startup investments in all starting conditions and under all admission regimes to about the same extent. This is because the ties between VCs and startups that are forged in this manner have little effect on the development of the network among startups that is necessary for further brokering to happen. Regarding VC–SDS investments, VC networking is less effective in the preferred regime than in either exclusive admission regime, especially with underdeveloped starting conditions. This is because in the preferred regime, the chances are lower for an SDS to be selected to meet a VC than in both exclusive admission regimes.

Business learning increases VC startup investments under the preferred and double effort exclusive regimes about the same, while the normal effort exclusive regime is less effective in this regard. This is

Table 2
Results for generic SDSs under different admission regimes and starting conditions. The values represent the average number of startups after 500 model runs. Table 1 column 1 serves as reference model.

Support mechanism	Starting condition	Output variable	Admission regime			
			(1) Open regime	(2) Preferred	(3) Exclusive normal effort	(4) Exclusive double effort
Field-building	Undeveloped	VC startup investments	+58.0	+58.5	+27.9	+50.1
		VC-SDS investments	+6.3	+9	+5.7	+9
	Emerging	VC startup investments	+63.9	+64.6	+53.7	+63.1
		VC-SDS investments	+6.9	+8.6	+9.1	+9.6
	Maturing	VC startup investments	+21.1	+22.2	+16.7	+20.3
		VC-SDS investments	+2.3	+2.8	+3.6	+3.4
	Developed	VC startup investments	+10.3	+11.0	+7.8	+10.2
		VC-SDS investments	+1.4	+1.7	+1.9	+1.8
			Open regime	Preferred	Exclusive normal effort	Exclusive double effort
VC-networking	Undeveloped	VC startup investments	+23.0	+22.8	+21.1	+23.9
		VC-SDS investments	+2.5	+9.4	+14.1	+16.1
	Emerging	VC startup investments	+33.9	+35	+33.9	+34.9
		VC-SDS investments	+3.8	+9.8	+12.3	+12.8
	Maturing	VC startup investments	+4.9	+6.4	+6.5	+6.5
		VC-SDS investments	+0.7	+4.1	+5.5	+5.5
	Developed	VC startup investments	+1.7	+3.3	+3.3	+3.3
		VC-SDS investments	+0.5	+2.3	+3.1	+3.5
			Open regime	Preferred	Exclusive normal effort	Exclusive double effort
Business-learning	Undeveloped	VC startup investments	0	0	0	0
		VC-SDS investments	0	0	0	0
	Emerging	VC startup investments	+19.7	+20.4	+9.5	+21.5
		VC-SDS investments	+1.9	+5.5	+4.3	+10.7
	Maturing	VC startup investments	+17.5	+16.8	+10.1	+20.4
		VC-SDS investments	+1.9	+9.7	+9.8	+21.0
	Developed	VC startup investments	+16.7	+16.2	+11.1	+21.0
		VC-SDS investments	+2.1	+11	+12.2	+24.1

because fewer startups benefit from business learning under the latter regime. When it comes to VC–SDS investments, business learning in the double effort exclusive regime works better than the other two admission regimes in all starting conditions since here, SDSs exclusively benefit from the ESO's extra efforts.

Table 3 summarizes which of combinations support mechanisms and admission strategies lead to the largest increase in both types of VC investments. The exclusive double effort admission regime is generally the most effective to promote both types of VC investments, in combination with business learning and VC networking. Only in undeveloped starting conditions using field building does the preferred admission regime lead to more VC startup investments than the exclusive admission regimes. However, when it comes to VC–SDS investments, the exclusive double effort admission regime is always equally or more effective than the preferred admission regime.

5. Conclusions

This study indicates that ESOs are a necessity for EEs with many constrained SDSs, especially when this constraint stems from being technology-based. Without ESOs, the presence of such SDSs negatively influences the entire EE due to a loss of brokering in the financial support network. ESOs can help repair this damage by having the right admission regimes and aiding tenant SDSs in overcoming some of their constraints. Technology-based SDSs have less VC investments than market-constrained SDSs, but ESOs can also help the former more easily surmount their constraints. In undeveloped or emerging starting conditions, ESOs can best promote SDSs via field building and VC networking, while business learning is the most effective support mechanism in maturing and developed starting conditions.

In general, concentrating resources on a few SDSs in the exclusive double effort regime is the most effective admission regime in terms of startups and VC–SDS investments. However, ESOs with either an exclusive double effort or preferred admission regime are able to largely offset the loss of the brokering function in the financial support network through field building. This is not the case for the exclusive normal effort regime, which only works well in combination with VC networking.

6. Discussion

6.1. Theoretical implications and limitations

Theoretically, the results on how the presence of constrained startups, such as SDSs, affect the development of EEs contribute to the literature on sustainable EEs (Cohen, 2006; Steinz et al., 2015; Theodoraki et al., 2018; Volkmann et al., 2019). I provide further insights into the question of why certain EEs can develop vital connections while others do not (Alvedalen and Boschma, 2017). These insights are particularly critical to scholars who aim to develop EEs that promote SDSs (Cohen, 2006; Steinz et al., 2015; Theodoraki et al., 2018; Volkmann et al., 2019).

I further contribute to the emerging literature about the relationship between ESOs and their systemic effects (Bergman and McMullen, 2021). I demonstrate that ESOs, effectively can help remedy the financial support network by using a double effort regime and the right support mechanisms. This result supports the claimed importance of the presence of support services in an EE (Stam, 2015; van Weele et al., 2018b), when the network among startups is underdeveloped, or when a substantial number of constrained startups exists. This is also an important on network intermediaries in innovation Howells (2006), technology transfer (Algieri et al., 2013; Gubitta et al., 2015), and sustainability transitions (Kivimaa et al., 2019), as it indicates where these intermediaries, from a systems perspective, can best focus their resources to incorporate these constrained startups in a network.

Table 3
Best scoring admission regimes on both output variables for different support mechanisms.

	Field-building	VC-networking	Business-learning
VC startup investments	Preferred, exclusive double effort	All three admission regimes	Preferred, exclusive double effort
VC SDS investments	All three admission regimes	Exclusive normal effort, exclusive double effort	Exclusive double effort

The insights also apply to the literature streams on regional economic development. A successful EE eventually can grow into a regional cluster Pitelis (2012), but when this cluster comprises firms that suffer from market constraints or are highly technology-based, the results suggest the presence of network intermediaries that can accelerate their success. This insight also applies to systemic literature in which sustainable entrepreneurship and intermediaries play a role in promoting sustainable development (see Kivimaa et al., 2019), such as technological innovation systems (Hekkert et al., 2007; Planko et al., 2016) and mission-oriented policies (Hekkert et al., 2020; Mazzucato, 2016).

Furthermore, I framed the model in the context of SDSs and ESOs, but the resulting insights also apply to other sectors with startups that suffer from similar constraints. Applicable examples of sectors with many market-constrained startups include the sharing economy (Uzunca et al., 2018), gig economy (Frenken et al., 2020), and fintech (Lee and Shin, 2018). Innovations by these startups often do not fit with their prospective markets' regulations, standards, norms, habits, or cognitive frames. The most prominent example of startups that suffer from constraints due to a strong technological base is high-tech spin-off firms from universities (Storey and Tether, 1998; Vincett, 2010). These startups need to transform themselves from research-based organizations into market-oriented firms, and embedding in financial support networks is critical to enabling these startups to do so (Clarysse et al., 2014).

This study's main limitation is that it is based on a simulation model, which is a simplification of a complex reality. However, the model's earlier validated empirical basis in terms of input values, mechanisms, and output variables van Rijnsoever (2020) allows for a plausible simulation of the effects from different archetypical SDSs and admission regimes. In fact, a plausible simulation of hypothetical measures is one of this model's strengths. Still, future research should test whether these findings hold empirically for EEs facilitating SDSs, as well as for the broader contexts to which the model is applicable theoretically.

A second limitation is that I only examined the relationships between startups, ESOs, and VCs. However, it is possible for SDSs to discover alternative routes to bridge the chasm between the science and business subsystems, such as via impact investors, philanthropy, universities, or government contracts. However, these alternative routes are less likely to lead to long-term success for SDSs, as they rely on actors that are not as well-established and connected as VCs. Nevertheless, future studies still should examine these routes' impact as well. Further, the model did not consider other outcomes at the system level, such as on unemployment or patent activity (Cohen et al., 2019). This is a direction for further research. Finally, I examined ESOs as driving policy instruments that build EEs for SDSs. I recommend that future researchers also assess the effects from changing the institutional arrangements in an EE that inhibit SDSs from joining financial support networks, such as measures to reduce risks to VCs or public co-financing with VCs.

A final limitation is that I considered ESOs in the model as a static entity. However, ESOs learn over time from their environment and their tenants (Bergman and McMullen, 2021). This might result on a change of strategy by the ESO. Future research could model the implications of adaption on the development of the EE.

6.2. Practical implications

From a practical perspective, I recommend that regional policy-makers who wish to promote SDSs ensure that ESOs are present in an EE. The more developed the EE is, the better it can support ESOs that focus only on SDSs. The model further confirms earlier claims that such ESOs need to be a continuous presence in an EE (van Weele et al., 2018b); thus, they need long-term support. The network among startups is likely to collapse after ESOs stop their brokering activities, as long as the conditions that promote or inhibit the development of the network are insufficient (van Weele et al., 2018b). In the case of SDSs, this means that the root causes of constraints need to be addressed. This can be done for example by creating market conditions that favor the business models of market-constrained SDSs.

For ESOs I recommend applying support mechanisms that fit with the level of development of the EE. Theoretically, exclusive double effort is the most effective admission regime, but not all ESOs implement this regime because it leaves valuable support capacity unutilized. In these cases, the preferred regime is often an acceptable alternative. ESOs with strong connections to VCs also can use the VC networking mechanism effectively. I note that in this paper, I only examined support mechanisms that strengthened the financial support network.

I recommend that entrepreneurs who are considering starting an SDS ensure that their business suffers from a maximum of one constraint; either market or technological, but not both. Given their constraint, SDSs likely will benefit from joining an ESO. When doing so, these entrepreneurs need to consider to what extent the ESO's admission regime and support mechanisms are compatible with the level of development. EE. The more developed the EE is, the more important an emphasis on business learning becomes. Furthermore, research has shown that startups are often attracted to an ESO finance or free office space (van Weele et al., 2020, 2017). However, SDSs need to realize that field building, VC networking, and business learning are more important for the long-term success of their businesses.

Credit author statement

Frank van Rijnsoever is the sole authors of this paper. He conceived the research question and design, programmed the agent based model, analyzed the data, and wrote all versions of the paper.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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