Utrecht University

School of Economics

Entrepreneurial Ecosystems

A Systems Perspective

Erik Stam
Andrew van de Ven

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U.S.E. Research Institute
Kriekenpitplein 21-22, 3584 EC Utrecht, The
Netherlands Tel: +31 30 253 9800, e-mail: use.ri@uu.nl
www.uu.nl/use/research

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Entrepreneurial Ecosystems: A Systems Perspective

Erik Stam
Utrecht School of Economics
Utrecht University

Andrew van de Ven
Carlson School of Management
University of Minnesota

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Abstract
There is growing interest in ecosystems as an approach for understanding the context of entrepreneurship at the macro level of an organizational community. It consists of all the interdependent actors and factors that enable and constrain entrepreneurship within a particular territory (Stam, 2015; Adner, 2017; Stam & Spigel, 2018). Although growing in popularity, the entrepreneurial ecosystem concept remains loosely defined and measured. This paper shows the value of taking a systems view of the context of entrepreneurship. We develop a systems framework for studying entrepreneurial ecosystems, develop a measurement instrument of its elements, and use it to examine the quality of entrepreneurial ecosystems in 12 regions of the Netherlands. We measure the quality of entrepreneurial ecosystems with an index value comprising 10 ecosystem elements and measure entrepreneurial outputs with the prevalence of high-growth firms. We find that the quality of entrepreneurial ecosystems is strongly related to entrepreneurial outputs. Strong interrelationships among the ecosystem elements also reveals their interdependence and need for a systems perspective.

Keywords: entrepreneurial ecosystems, entrepreneurship, high-growth firms

JEL classification: D2, E02, L26, M13, O43, P00, R1, R58

Comments welcomed to: E.Stam@uu.nl

Entrepreneurial Ecosystems: A Systems Perspective

1. Introduction

Scholars and practitioners alike are concerned with the quantity and quality of entrepreneurial activity in a society. For example, scholars involved in the Global Entrepreneurship Monitor (GEM) have documented the prevalence of various forms of entrepreneurial activity across countries and regions (Reynolds et al., 2005; Stam et al., 2011). In addition, policymakers concerned with economic development have sought to identify policy “levers” with which to encourage higher levels of entrepreneurial activity resulting in economic growth and job creation (Audretsch & Link, 2012). Borrowing from biology, the metaphor of an entrepreneurial ‘ecosystem’ is increasingly used by scholars (Stam, 2015; Spigel, 2017) and practitioners (Feld, 2012; Isenberg, 2010) for understanding the context for entrepreneurship in particular territories (countries, regions, cities). The entrepreneurial ecosystem comprises a set of interdependent actors and factors that are governed in such a way that they enable productive entrepreneurship (Stam 2015).

Current work on ecosystems is underdeveloped, and is focusing more on superficial generalizations based on successful case studies such as Silicon Valley or Boulder, Colorado. As applied to entrepreneurship in a region, the metaphor is loosely defined, highly undertheorized, and not adequately measured (Stam, 2015). The purpose of this paper is to critically review the emerging literature on entrepreneurial ecosystems, and extend it by proposing an integrated model that connects the functional attributes of entrepreneurial ecosystems with entrepreneurial outputs and welfare outcomes. Using this conceptual framework, we introduce a methodology for measuring entrepreneurial ecosystems and present empirical findings from a study of entrepreneurship in 12 regions of the Netherlands. The paper concludes by discussing the implications of this entrepreneurial framework for advancing theory and policy practice, and how the measurement instrument can be applied in other territories.

2. The emerging literature on entrepreneurial ecosystems

The fundamental ideas behind entrepreneurial ecosystems emerged in the 1980s and 1990s as part of a shift in entrepreneurship studies away from individualistic, personality-based research towards a broader community perspective that incorporates the role of social, cultural, and economic forces in the entrepreneurship process (Nijkamp, 2003; Steyaert & Katz, 2004). Van de Ven (1993), for example, argued that individual entrepreneurs cannot command all the resources, institutions, markets, and business functions that are required to develop and commercialize their entrepreneurial ventures. Popular folklore notwithstanding entrepreneurship is a collective achievement that resides not only in the behaviours of individual entrepreneurs, but requires key roles from numerous entrepreneurs in both the public and private sectors to develop an industrial infrastructure that facilitates and constrains innovation.

Works by Pennings (1982), Dubini (1989), Van de Ven (1993), and Bahrami and Evans (1995) developed the concept of an ‘entrepreneurial infrastructure’ in order to explain the influence regional economic and social factors have over the entrepreneurship process. Building on previous movements that decentred the individual entrepreneur as the sole locus of value creation, the new contextual turn emphasizes the importance of situating the entrepreneurial phenomenon in a broader context that incorporates temporal, spatial, social, organizational, and market dimensions of context (Zahra, 2007; Zahra et al., 2014; Autio, Kenny, Mustar, Siegel & Wright, 2014).

While work on entrepreneurial ecosystems is still in its infancy, there are already several empirical studies showing how a rich entrepreneurial ecosystem enables entrepreneurship and subsequent value creation at the regional level (Fritsch, 2013; Tsvetkova, 2015; Autio, et al 2014). For example, Mack and Mayer (2016) explore how early entrepreneurial successes in Phoenix, Arizona has contributed to a persistently strong entrepreneurial ecosystem based on visible success stories, a strong entrepreneurial culture and supportive public policies. Similarly, Spigel's (2017) study of entrepreneurial ecosystems in Waterloo and Calgary, Canada suggests that while ecosystems can have different structures and origins, their success lies in their ability to create a cohesive social and economic system that supports the creation and growth of new ventures. Other work on regions such as Silicon Valley (Saxenian, 1994; Patton & Kenney, 2005), Washington DC (Feldman, 2001) and Kyoto (Aoyama, 2009) – even if not using the precise term 'entrepreneurial ecosystem' – described how contexts influence entrepreneurial success. Works such as Acs et al. (2014) have employed large-scale quantitative methods, rather than qualitative case studies, to identify strong entrepreneurial ecosystems at the national level.

While seductive, the entrepreneurial ecosystem concept is problematic, and the rush to employ it has run ahead of answering several fundamental conceptual, theoretical, and empirical questions. The phenomenon at first appears rather tautological: entrepreneurial ecosystems are systems that produce successful entrepreneurship, and where there is a lot of successful entrepreneurship there is apparently a good entrepreneurial ecosystem. Such tautological reasoning ultimately offers little insight for research or public policy.

Secondly, the approach as yet provides only long laundry lists of relevant factors without clear reasoning of their cause and effect nor how they are tied to specific place-based histories. While these factors provide some focus, they offer no consistent explanation of their interdependent effects on entrepreneurship – and, ultimately, on aggregate welfare. The World Economic Forum (2013) study, for example, concludes that access to markets, human capital and finance are most important for the growth of entrepreneurial companies. But these can best be seen as superficial perquisites, not as the fundamental causes for the success of ecosystems (Acemoglu, Johnson & Robinson, 2005). An adequate explanation should distinguish between the necessary and contingent conditions of an ecosystem and clearly define the role of the government and other institutions. This has not yet been accomplished.

And third, it is not clear what is the appropriate level of analysis of an entrepreneurial ecosystem. Geographically, it could be a city, a region or a country. It can also be other systems less strictly defined in space, such as sectors or technologies, which create opportunities for firm creation and growth. For most system elements it seems possible to demarcate them at a regional (sub-national) level (e.g. regional labour markets), while the conditions can be designed on both regional and national level (e.g. national laws and regulations) (cf. Stam & Bosma, 2015). In addition, entrepreneurs of high-growth firms and especially entrepreneurial employees in large established firms could act as ecosystem connectors on a global scale, connecting distinct regional entrepreneurial ecosystems in their role as knowledge integrators (Sternberg, 2007; Malecki, 2011).

3. The entrepreneurial ecosystem defined

There is not yet a widely shared definition of entrepreneurial ecosystems amongst researchers or practitioners. The first component of the term is *entrepreneurial*: a process in which opportunities for creating new goods and services are explored, evaluated, and exploited (Schumpeter, 1934; Shane & Venkataraman, 2000). The entrepreneurial ecosystem approach often narrows this entrepreneurship down to 'high-growth start-ups' or 'scale-ups', claiming that this type of entrepreneurship is an important source of innovation, productivity growth and employment (World Economic Forum, 2013; Mason & Brown, 2014). Empirically, this claim seems too exclusive: networks of innovative start-ups or entrepreneurial employees can also be forms of productive entrepreneurship (Baumol, 1993). However, innovative and growth-oriented entrepreneurship appears to be increasingly emphasized in the entrepreneurship literature (Shane, 2009; Stam et al., 2012; Mason & Brown, 2013; Henrekson & Sanandaji, 2014).

The second component of the term *ecosystem* borrows from biology, where ecosystem ('ecological system') has been defined as "a biotic community, its physical environment, and all the interactions possible in the complex of living and nonliving components" (Tansley 1935). When applying the metaphor to an organizational community ecology, Hawley (1950; 1968) adopted three core features of ecosystems: *co-evolution* and *mutualistic interdependence* among a *complex nested system* of diverse organizations and actors. As in biological ecology, a community ecology perspective focuses on the co-evolutionary rise and fall of many diverse organizations and institutions that are mutualistically related and perform differentiated but complementary roles that enable emergence, growth and survival as elements of a broader system of community evolution (Astley & Van de Ven, 1983; Astley, 1985; Freeman & Audia 2006). This mutualistic interdependence includes both cooperative and competitive (or coopetition) relationships among partisan, distributed, and embedded actors pursuing their own interests in the ecosystem, all of which contribute to the complexity of the system. For organizational ecologists, a recognizable community emerges only when the population in a region develops an identifiable cohesion that derives from the mutualistic interdependence among symbiotically-related actors with complementary differences (Astley & Van de Ven, 1983: 258). This necessitates a methodology for studying entrepreneurial ecosystems as a branch of a broader set of complex systems; notably artificial as distinguished natural systems (Simon 1962). Being human artificial constructions, entrepreneurial ecosystems emphasize the distinct role of foresight and institutions.

The evolutionary process in which actors become engaged in the development of an entrepreneurial ecosystem can begin any number of ways. It varies with the business and technology being developed. For example, it can begin with purposeful intentions and inventive ideas of entrepreneurs, who undertake a stream of activities to gain the resources, competence, and endorsements necessary to develop an economically viable enterprise. As they undertake these activities, the paths of independent entrepreneurs, acting out their own diverse intentions and ideas, intersect. These intersections provide occasions for interaction and recognizing areas for establishing cooperative and competitive relationships (Garud, 1994). Sometimes these interactions may be triggered by an ecosystem leader (Nambisan & Baron, 2013), and sometimes they emerge through a process of partisan mutual adjustment among partisan and distributed actors who become embedded in the ecosystem as it develops over time (Van de Ven & Garud 1993).

Cooperative relationships emerge among the actors who can achieve complementary benefits by integrating their functional specializations. Competitive relationships emerge as alternative business paths become evident and different entrepreneurs "place their bets on" and pursue alternative paths. We must emphasize that during the initial period of industry emergence, applied research and development is highly uncertain and often dependent on basic science and technology. Depending on the technological alternative chosen by an entrepreneurial individual or firm, it becomes highly dependent on different clusters of basic research institutes, such as universities, laboratories, disciplines, that have been producing and directing the accumulation of basic knowledge, techniques, and experience associated with a given technological alternative.

By engaging in cooperative and competitive relationships and by interacting in the same networks, groups of entrepreneurs in the public and private sectors increasingly isolate themselves from traditional industries by virtue of their interdependencies and growing commitments to and unique knowledge of a new technology. Isolation frees an emerging system from institutional constraints of existing technologies and industries (Astley, 1985) and permits it to develop its own distinctive structural form (Rappa, 1987). Coordination among actors takes place not so much by a central plan, organizational hierarchy or price mechanism but mostly through interactions (Mattsson, 1987) and partisan mutual adjustments among actors (Astley and Van de Ven, 1983).

As the number of organizational units and actors gains a critical mass, a complex network of cooperative and competitive relationships begins to accumulate. This network itself becomes recognized as a new field, and takes the form of a hierarchical, loosely coupled system. Of course, hierarchy in an ecosystem is a matter of degree, and some ecosystem components may be only minimally, if at all, hierarchical. Hierarchy is often a consequence of institutional constraints imposed by political and governmental regulatory bodies. Hierarchy also emerges in relationships with key linking-pin organizations who either become dominant industry leaders or control access to critical resources (money, competence, technology) needed by other firms in the ecosystem.

Loose coupling promotes both flexibility and stability to the ecosystem. Links between component subsystems are only as rich or tight as is necessary to ensure the survival of the system (Aldrich & Fiol, 1994). In his architecture of complexity Simon (1962) discussed how a loosely joined system provides short-run independence of subsystems and long-run aggregate dependence. The overall system can be fairly stable, due to the absence of strong ties or links between elements and subsystems, but individual subsystems can be free to adapt quickly to local environmental conditions. Thus, in a complex, heterogeneous, and changing environment, a loosely joined ecosystem is highly adaptive.

We view this emerging ecosystem as consisting of the key entrepreneurs and firms that govern, integrate, and perform all of the functions required for entrepreneurship to flourish in a territory. The structure of this system, when fully developed, consists of the key elements, outputs and outcomes of the entrepreneurial ecosystem shown in Figure 1.

As Figure 1 illustrates, we view the *output* of entrepreneurial ecosystems as the process by which individuals create opportunities for innovation. This innovation eventually leads to new value in society and this is therefore the ultimate *outcome* of an entrepreneurial ecosystem while entrepreneurial activity is a more intermediary *output* of the system. This entrepreneurial activity can have many manifestations, such as innovative start-ups, high-growth firms and entrepreneurial employees.

4. The elements of an entrepreneurial ecosystem

As just discussed, an entrepreneurial ecosystem consists of all the infrastructure elements that are required to sustain entrepreneurship in a geographical region. Van de Ven (1993) was one of the first to propose four broad components of an ecosystem (or what he terms an ‘infrastructure”) for entrepreneurship, including: (1) institutional arrangements that legitimate, regulate, and incentivise entrepreneurship, (2) public resource endowments of basic scientific knowledge, financing mechanisms, and pools of competent labor, (3) market demand of informed consumers for the products and services offered by entrepreneurs, and of course, (3) proprietary business activities that private entrepreneurs provide through R&D, manufacturing, marketing, and distribution functions (Van de Ven, 1993).

Since then, practitioners have elaborated and expanded on these elements of an entrepreneurial ecosystem. Feld (2012) for example, emphasized the interaction between the players in the ecosystem (with high network density, many connecting events, and large companies collaborating with local start-ups) and access to all kinds of relevant resources (talent, services, capital), with an enabling role of government in the background. Isenberg (2010) formulated six distinct domains of an ecosystem: policy, finance, culture, support, human capital and markets. This largely elaborates Van de Ven's (1993) ecosystem categories, as well as eight pillars proposed by the World Economic Forum (2013, p. 6–7) for a successful ecosystem. These pillars focus on the presence of key factors (resources) like human capital, finance and services; the actors involved in this (talent, investors, mentors/advisors, entrepreneurial peers); the formal ('government and regulatory framework') and informal institutions ('cultural support') enabling entrepreneurship; and finally, access to customers in domestic and foreign markets.

Drawing on these studies, Spigel (2017, p. 50) defines entrepreneurial ecosystems as 'combinations of social, political, economic, and cultural elements within a region that support the development and growth of innovative startups and encourage nascent entrepreneurs and other actors to take the risks of starting, funding, and otherwise assisting high-risk ventures.' He groups these attributes into three categories – cultural, social, and material – that explain the level of entrepreneurial activity as the output of entrepreneurial ecosystems: cultural attributes (supportive culture and histories of entrepreneurship), social attributes (worker talent, investment capital, networks, mentors and role models), and material attributes (policy and governance, universities, support services, physical infrastructure, open markets). Importantly, these categories of attributes are not isolated from one another but are created and reproduced through their interrelationships. For example, networking programmes sponsored by a regional government depends on the pre-existence of knowledge-sharing networks within the region to build on, which in turn requires the effort of business networking and knowledge sharing to be legitimized within the local culture.

5. Entrepreneurial ecosystem model

Building on these studies, we propose an integrative model of entrepreneurial ecosystems, as shown in Figure 1. The proposed model extends insights from the previous literature by providing more causal depth with three ontological layers (framework conditions, systemic conditions, and outputs), including upward and downward causation, and co-evolutionary processes among ecosystem elements. Specifically, the entrepreneurial ecosystem model is based on three propositions.

Upward causation proposition 1. The ten entrepreneurial ecosystem elements explain the levels of entrepreneurial activity in a territory.

Downward causation proposition 2. Prior entrepreneurial activities feedback to increase entrepreneurial ecosystem elements in a territory.

Evolutionary proposition 3. The entrepreneurial ecosystem elements are mutually interdependent and co-evolve to enable and constrain entrepreneurial outputs in a territory over time.

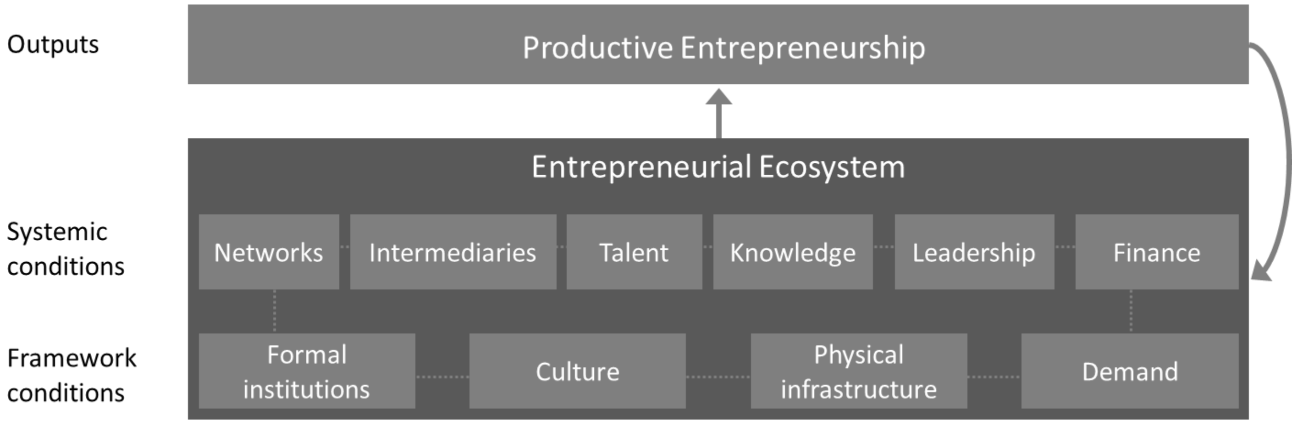

Figure 1. Key elements and outputs of the entrepreneurial ecosystem (based on: Stam 2015)

The elements of the entrepreneurial ecosystem can be distinguished as framework conditions and systemic conditions. The framework conditions include the social (informal and formal institutions) and physical conditions enabling or constraining human interaction. In addition, access to a more or less exogenous demand for new goods and services is also of great importance. This access to buyers of goods and services, however, is likely to be more related to the relative position of the ecosystem than its internal conditions. These conditions might be regarded as the fundamental causes of value creation in the entrepreneurial ecosystem. However, in order to fully understand how these fundamental causes lead to this outcome, we first need to gain insight into how systemic conditions lead to entrepreneurial activity.

Systemic conditions among interdependent elements are the heart of the ecosystem: networks of entrepreneurs, leadership, finance, talent, knowledge and support services. The presence of these elements and the interaction between them are crucial for the success of the ecosystem. Networks of entrepreneurs provide an information flow, enabling an effective distribution of knowledge, labour and capital (Malecki, 1997). Leadership provides direction and role models for the entrepreneurial ecosystem. This leadership is critical in building and maintaining a healthy ecosystem (Feldman, 2014). This involves a set of 'visible' entrepreneurial leaders who are committed to the region (Feldman & Zoller, 2012). Access to financing – preferably provided by investors with entrepreneurial knowledge – is crucial for investments in uncertain entrepreneurial projects with a long-term horizon (see e.g. Kerr & Nanda, 2009). But perhaps the most important element of an effective entrepreneurial ecosystem is the presence of a diverse and skilled group of workers ('talent': see e.g. Acs & Armington, 2004; Lee, Florida & Acs, 2004; Qian, Acs & Stough, 2013). An important source of opportunities for entrepreneurship can be found in knowledge, from both public and private organizations (see e.g. Audretsch & Lehmann, 2005). Finally, the supply of support services by a variety of intermediaries can substantially lower entry barriers for new entrepreneurial projects, and reduce the time to market of innovations (see e.g. Howells, 2006; Zhang & Li, 2010).

6. Measuring entrepreneurial ecosystems

We turn now to developing operational measures of an entrepreneurial ecosystem. These measures, of course, are inevitably influenced by the local context being examined, which can be characterized as a North-Western European, advanced capitalist economy. More in particular, our research context consists of entrepreneurial ecosystems in 12 regions (provinces) of the Netherlands. We have taken the province as the unit of analysis for measuring entrepreneurial ecosystems. It may be debated whether the provincial border provides the most adequate boundary of entrepreneurial ecosystems. The boundaries are almost always arbitrary, most likely somewhere in between the municipality and the national level. Is the province the best unit of analysis, or should entrepreneurial ecosystems perhaps be analysed in a more nested or polycentric (Ostrom, 2010) way, further problematizing the territorial view 'borrowed' from the ecological analogy? If we take the openness of the system serious this also opens 'explanatory power' of events and elements outside the current regional boundary, affecting the prevalence of entrepreneurship beyond regional boundaries. We developed the following measures for each of the following ecosystem elements.

6.1 Formal institutions

Formal and informal institutions (culture) reflect the rules of the game in society (North 1990). For entrepreneurship, the quality and efficiency of institutions matter: the level of perceived corruption and the general regulatory framework within countries. We use data from the Quality of Governance 2012 survey. It consists of data acquired for a large, European Commission-funded project on measuring quality of governance within the EU (Charron, Lapuente, and Dijkstra 2012). The survey is the largest one ever undertaken to measure quality of governance at the sub-national level so far. It includes approximately 34,000 EU citizens for a total of 172 regions, either at the NUTS1 or NUTS2 level, within the EU member states. Survey questions are focused on four aspects related to three public services (education, healthcare and law enforcement): corruption, rule of law, government effectiveness, and voice and accountability. Four standardized indicators are provided with and used in the "formal institutions" element of the entrepreneurial ecosystem (for additional details refer to Charron, Lapuente, and Dijkstra 2012).

6.2 Culture

Entrepreneurship culture (as an informal institution) reflects the degree to which entrepreneurship is valued in society. We measure entrepreneurship culture indirectly with the prevalence of new firms, which indicates how 'common' starting up a business is in a particular region.

Entrepreneurship culture could also be measured with the degree to which self-employment is seen as a viable career choice and the degree to which successful entrepreneurs are valued (both derived from the Global Entrepreneurship Monitor). However, this measure is not readily available for regions within the Netherlands.

6.3 Physical infrastructure

Physical infrastructure is a composite measure including indicators of motorway and railway potential accessibility and the number of passenger flights (see Annoni & Dijkstra, 2013). Motorway accessibility includes the population living in surrounding regions weighted by travel time along motorways, while railway accessibility includes the population living in surrounding regions weighted by travel time along railways. Motorway and railway potential accessibility indicators take into account ferry networks allowing for correcting islands penalization. Potential accessibility is a construct of two functions, the activity function representing the activities or opportunities to be reached and the impedance function representing the effort, time, distance or cost needed to reach them (Spiekermann, Wegener, and Copus, 2002). For potential accessibility the two functions are combined multiplicatively, i.e. they are weights to each other and both are necessary elements of accessibility. The interpretation is that the greater the number of attractive destinations in areas j and the more accessible areas j are from area i, the greater the accessibility of area i. The accessibility model used is based on the work of Spiekermann and Wegener (1996) and uses centroids of

NUTS 2 regions as origins and destinations. The accessibility model calculates the minimum paths for the road network, i.e. minimum travel times between the centroids of the NUTS 2 regions. For each region the value of the potential accessibility indicator is calculated by summing up the population in all other regions weighted by the travel time to go there. For access to the region to itself, the time to the centroid of the region is used, while for access to other regions: (i) travel time over the network between the two centroids plus the (ii) access from the destination centroid to the destination region are used. The potential accessibility indicators use population and give the highest weight to the population that can be reached within four hours (Annoni & Dijkstra, 2013).

The indicator on passenger flights is from Eurostat/EuroGeographics/National Statistical Institutes and corresponds to the daily number of passenger flights accessible within a 90 minutes’ drive from the region’s centre.

6.4 Demand

Demand is measured as a composite consisting of disposable income per capital and two measures of potential market demand. Disposable income is included as income per capita. The two indicators on potential market demand provide an estimate of the GDP and population available within a pre-defined neighbourhood. They are expressed respectively in purchasing power standards and population size (EU average set to 100). See Annoni and Kozovska (2010) for details on the computation of potential market demand indicators.

6.5 Networks

Networks indicate the connectedness of businesses for new value creation, which is measured as the percentage of businesses (with at least 10 employees) in a region that collaborate for innovation, based on data of the Community Innovation Survey 2010 (CIS; see Arundel & Smith, 2013).

6.6 Leadership

Leadership provides guidance for and direction of collective action. Leadership is measured with the prevalence of innovation project leaders. We have constructed a database with information on all the innovation projects in the Netherlands that received (Dutch or European) public subsidies in the period 2010-2013 (see Stam et al., 2016). We selected projects with at least two participating organizations (2231 projects). The geographical origin of these projects is established by taking the province of the main applicant or principal firm. This allowed us to measure the prevalence of innovation project leaders per 1000 businesses in each region.

6.7 Talent

Talent can be indicated by the prevalence of individuals with high levels of human capital. This is measured with the share of the population aged 15-65 years with a higher education degree.

Talent could also be measured with the share of the labour force with at least secondary education, but we have chosen for the more general, population based indicator.

6.8 Finance

The supply and accessibility of finance for new and small firms is an important condition for their growth and survival. We use the amount of venture capital (startup and growth) invested in the region as an indicator for the finance element. This measure is based on data of the National Association for Private Equity, which registers all private equity deals in the Netherlands. We only use the data on the startup and growth segments (and not on buyouts, and management buy-ins), because these are most closely related to the envisaged output of the ecosystem: high-growth firms. Because the annual data on venture capital investments is highly volatile and for some regions based on a very small number of deals, we take a 3 year lagged average per year.

Finance can be traced in many other ways: for example with the ease of access to loans (see Stam, 2018), the prevalence of informal investors (Global Entrepreneurship Monitor), and crowdfunding. Data for these measures is available at the national, but not at the regional level, or just for a few years.

6.9 Knowledge

Investments in new knowledge are an important source of entrepreneurial opportunities, and if they lead to (better) solutions, they are also a source of prosperity. New knowledge is created in many ways, but probably the best measured activity is investments in (public and private) research and development. Our indicator for the knowledge element is the percentage of gross domestic product invested in R&D (by public and private organizations).

6.10 Intermediate services

The supply and accessibility of intermediate business services can substantially lower the barriers and increase the speed of new value creation. Our indicator for intermediate services is the percentage of business service firms in the business population.

Table 1 Empirical measures of the Entrepreneurial Ecosystem Elements

Elements	**Description**	**Variable name**	**Empirical indicators**	**Data sources**
Formal institutions	The rules of the game in society, in particular the quality of government.	QUALGOV	Four components: corruption, rule of law, government effectiveness and voice & accountability.	Quality of Government Survey
Entrepreneurship culture	The degree to which entrepreneurship is valued in a region.	NEWFIRM	New firms registered per 1000 inhabitants	CBS (Netherlands Census Bureau)
Physical infrastructure	Physical infrastructure and the position of a region	ACCESS	Three components: accessibility via road, accessibility via railroad, accessibility via airports (number of passenger flights within 90 minutes' drive); relative to EU average	EU Regional Competitiveness Index
Demand	Potential market demand	DEMAND	Three components: purchasing power per capita, regional product, total human population; relative to EU average	EU Regional Competitiveness Index
Networks	The connectedness of businesses for new value creation	INNOCOL	Percentage of firms in the business population that collaborate for innovation	EU Community Innovation Survey
Leadership	Leadership that provides guidance for and direction of collective action	PROLEAD	Leadership is measured with the prevalence of innovation project leaders per 1000 businesses, derived from a database with information on all the innovation projects in the Netherlands that received (Dutch or European) public subsidies in the period 2010-2013. The geographical origin of these project leaders is established by taking the province of the main applicant or principal firm.	Birch Consultants (see Stam et al. 2016)
Talent	The prevalence of individuals with high levels of human capital	EDU	Percentage of higher-educated in the adult population	CBS (Netherlands Census Bureau)
Finance	The amount of venture capital (startup and growth) invested in the region	VC	Amount of venture capital per 1000 establishments (3 year lagged average)	National Association of Private Equity
New knowledge	Investments in new knowledge	R&D	Percentage of gross domestic product invested in R&D (by public and private organizations)	CBS (Netherlands Census Bureau)
Intermediate services	The supply and accessibility of intermediate business services	BUSSERV	Percentage of business service firms in the business population	CBS (Netherlands Census Bureau)

6.11 Entrepreneurship outputs

A ‘healthy’ entrepreneurial ecosystem is said to produce entrepreneurship as an output and ultimately aggregate value as outcome. There are no perfect measures of either entrepreneurship or aggregate value creation. To capture both output and outcome we use the concept of productive entrepreneurship (see Stam, 2015; Stam & Spigel, 2018). Productive entrepreneurship refers to “any entrepreneurial activity that contributes directly or indirectly to net output of the economy or to the capacity to produce additional output” (Baumol 1993, p. 30). We interpret this as entrepreneurial activity that creates aggregate welfare.

Prior research has shown that ambitious entrepreneurship has stronger effects on economic growth than other types of entrepreneurship (Stam et al., 2011; Wong, Ho, and Autio, 2005), and that young firms are a driver of job creation (Haltiwanger, Jarmin, and Miranda, 2013; Criscuolo, Gal, and Menon, 2014), and that young high-growth firms accelerate the reallocation of jobs from old to new industries (Bos & Stam, 2014). These empirical measures of entrepreneurship can be seen as proxies for productive entrepreneurship. In this paper we have proxied productive entrepreneurship with the prevalence of high-growth firms (Henrekson & Johansson, 2010; OECD 2011; Stam & Bosma, 2015). These high-growth firms are rare, but not so rare as “unicorns” (start-ups valued over $1 billion). Taking “unicorns” as entrepreneurial output, would leave many regions with zero output. We could also start at the other side of the ‘entrepreneurship funnel’, and count the share of the population that has the intention to start a business, or has just started a business. But we regard this to be an indicator of entrepreneurial culture in a region, not as entrepreneurial output. However, one might take a more process view of entrepreneurial outputs, and differentiate the entrepreneurial ecosystem contexts per phase of the entrepreneurial process (see Stam & Bosma, 2015). This is probably most relevant for the finance element, with nascent entrepreneurs, start-ups, moderately growing, high-growth and unicorn firms having substantially different finance needs.

The Dutch Financial Times (Financieele Dagblad), in collaboration with the Chambers of Commerce, has developed a somewhat more selective measure of high-growth firms in the Netherlands: the number of independent firms with a profitable growth in turnover of at least 20% per year over three years (i.e. at least 72.8 % over the full three-year period). The selection logic for the 2013 sample is as follows (FD Gazellen 2013):

1. There are about 2 million registered firms in the Netherlands
2. 825,000 of these firms are obliged to publish their annual financial details
3. 11,400 of these firms have published annual financial reports
4. Only 1750 of these firms had an average turnover growth of at least 20 % over the last three years
5. 784 of these also fulfilled the following requirements: profitable, financial position, payment behaviour.
6. After a quality check, 394 gazelles remained (in 2014: 331).

There are huge differences across regions, even within a small country like the Netherlands: in 2014 the absolute number of high-growth firms ranges from 1 to 75, but even in relative terms there is a 15-fold difference between the lowest ranked region 0.003% and the highest ranked region 0.045%.

In the next section, we will analyse the effects of the individual elements on the shares of high-growth firms.

7. Results

7.1 Descriptive Statistics

Basic descriptive statistics of the data collected on the entrepreneurial ecosystems in the 12 Netherlands regions for the three years (2009, 2012, and 2015) are presented in Tables 2 and 3.

Table 2 Mean, minima, maxima, and S.D. (normalized values)

	Minimum	Maximum	Mean	Std. Deviation
QUALGOV2009	.7970	1.2750	.999917	.1762263
NEWFIRM2009	.7750	1.2950	.951583	.1502861
ACCESS2009	.5470	1.3730	.999667	.2844888
DEMAND2009	.2740	1.1910	.651167	.3416790
INNOCOL2009	.8858	1.0864	1.000000	.0604002
PROLEAD2009	.1900	1.4340	.779583	.4364244
VC2009	.1019	2.1916	.829715	.6351865
EDU2009	.7470	1.3140	.943917	.1615687
RD2009	.2200	1.3200	.850833	.3397180
BUSSERV2009	.5600	1.3490	.891250	.2312594
EEINDEX2009	5.99	12.42	8.8985	2.11997
HGFIRMS2009	.000313742	.000849968	.00054353350	.000160467163
QUALGOV2012	.80	1.28	.9999	.17623
NEWFIRM2012	.74	1.31	.9400	.18742
ACCESS2012	.23	1.95	1.0001	.60954
DEMAND2012	.33	1.78	1.0002	.48622
INNOCOL2012	.86	1.09	.9999	.06954
PROLEAD2012	.19	1.43	.7796	.43642
VC2012	.01	2.33	.6678	.64806
EDU2012	.73	1.31	.9461	.16056
RD2012	.28	1.32	.8458	.32332
BUSSERV2012	.57	1.30	.8834	.22500
EEINDEX2012	5.67	12.67	9.0628	2.40051
HGFIRMS2012	.000074757	.000488885	.00023600192	.000107054815
QUALGOV2015	.94	1.15	1.0000	.06112
NEWFIRM2015	.72	1.37	.9274	.19820
ACCESS2015	.29	2.02	1.0000	.52935
DEMAND2015	.39	1.79	1.0002	.45831
INNOCOL2015	.96	1.07	.9999	.03257
PROLEAD2015	.19	1.43	.7796	.43642
VC2015	.10	1.87	.7489	.62425
EDU2015	.75	1.32	.9417	.16239
RD2015	.29	1.36	.8450	.32798
BUSSERV2015	.57	1.25	.8914	.20267
EEINDEX2015	5.86	13.06	9.1334	2.23085
HGFIRMS2015	.000075339	.000474515	.00028787025	.000135948113

Table 3 Correlation table

	QUALGOV2009	NEWFIRM2009	ACCESS2009	DEMAND2009	INNOCOL2009	PROLEAD2009	VC2009	EDU2009	RD2009	BUSSERV2009	EEINDEX2009	HGFIRMS2009	QUALGOV2012	NEWFIRM2012	ACCESS2012	DEMAND2012	INNOCOL2012	PROLEAD2012	VC2012	EDU2012	RD2012	BUSSERV2012	EEINDEX2012	HGFIRMS2012	QUALGOV2015	NEWFIRM2015	ACCESS2015	DEMAND2015	INNOCOL2015	PROLEAD2015	VC2015	EDU2015	RD2015	BUSSERV2015	EEINDEX2015	HGFIRMS2015
QUALGOV2009	1																																			
NEWFIRM2009	-.147	1																																		
ACCESS2009	-.713**	.352	1																																	
DEMAND2009	-.606*	.513	.877**	1																																
INNOCOL2009	-.111	.560	.348	.421	1																															
PROLEAD2009	-.393	.285	.562	.729**	.671*	1																														
VC2009	-.180	.753**	.419	.514	.835**	.564	1																													
EDU2009	-.233	.724**	.630*	.691*	.768**	.623*	.931**	1																												
RD2009	-.617*	.406	.592*	.736**	.695*	.830**	.581*	.619*	1																											
BUSSERV2009	-.289	.743**	.723**	.809**	.624*	.635*	.790**	.913**	.607*	1																										
EEINDEX2009	-.406	.690*	.714**	.840**	.800**	.824**	.867**	.932**	.814**	.917**	1																									
HGFIRMS2009	-.457	.265	.601*	.605*	.386	.634*	.554	.564	.465	.685*	.659*	1																								
QUALGOV2012	1.000**	-.147	-.713**	-.606*	-.111	-.393	-.180	-.233	-.617*	-.289	-.406	-.457	1																							
NEWFIRM2012	-.290	.973**	.415	.547	.582*	.341	.800**	.750**	.475	.767**	.732**	.417	-.290	1																						
ACCESS2012	-.837**	.072	.801**	.724**	.178	.471	.184	.370	.713**	.458	.509	.453	-.837**	.179	1																					
DEMAND2012	-.774**	.313	.852**	.792**	.282	.468	.404	.566	.653*	.663*	.645*	.647*	-.774**	.445	.905**	1																				
INNOCOL2012	-.057	.524	.260	.341	.893**	.576	.690*	.589*	.588*	.471	.664*	.209	-.057	.483	.034	.037	1																			
PROLEAD2012	-.393	.285	.562	.729**	.671*	1.000**	.564	.623*	.830**	.635*	.824**	.634*	-.393	.341	.471	.468	.576	1																		
VC2012	-.449	.355	.732**	.826**	.412	.763**	.411	.519	.563	.717**	.719**	.780**	-.449	.405	.482	.572	.391	.763**	1																	
EDU2012	-.185	.728**	.580*	.666*	.812**	.616*	.945**	.987**	.637*	.902**	.930**	.549	-.185	.744**	.340	.523	.663*	.616*	.509	1																
RD2012	-.673*	.385	.644*	.751**	.571	.792**	.505	.596*	.967**	.619*	.777**	.444	-.673*	.447	.779**	.682*	.479	.792**	.560	.592*	1															
BUSSERV2012	-.328	.733**	.742**	.836**	.649*	.685*	.799**	.905**	.650*	.989**	.939**	.703*	-.328	.756**	.468	.649*	.540	.685*	.753**	.905**	.653*	1														
EEINDEX2012	-.646*	.479	.858**	.932**	.591*	.828**	.617*	.751**	.859**	.848**	.905**	.739**	-.646*	.558	.778**	.838**	.448	.828**	.836**	.737**	.866**	.871**	1													
HGFIRMS2012	-.376	.447	.632*	.648*	.782**	.702*	.861**	.856**	.694*	.785**	.877**	.776**	-.376	.544	.486	.634*	.613*	.702*	.605*	.880**	.614*	.816**	.793**	1												
QUALGOV2015	.031	-.216	.102	-.067	.331	.297	.189	.097	.084	.067	.146	.370	.031	-.196	-.065	-.152	.495	.297	.265	.160	.049	.152	.111	.407	1											
NEWFIRM2015	-.237	.990**	.442	.580*	.557	.330	.778**	.763**	.435	.787**	.734**	.361	-.237	.987**	.152	.410	.490	.330	.426	.753**	.419	.775**	.550	.507	-.215	1										
DEMAND2015	-.706*	.440	.833**	.810**	.347	.498	.504	.645*	.640*	.755**	.712**	.715**	-.706*	.572	.817**	.981**	.083	.498	.623*	.602*	.654*	.734**	.857**	.679*	-.167	.536	.853**	1								
INNOCOL2015	.662*	-.437	-.521	-.407	-.243	-.163	-.144	-.153	-.384	-.244	-.294	-.161	.662*	-.505	-.422	-.498	-.224	-.163	-.322	-.116	-.370	-.259	-.403	-.131	.198	-.476	-.220	-.507	1							
PROLEAD2015	-.393	.285	.562	.729**	.671*	1.000**	.564	.623*	.830**	.635*	.824**	.634*	-.393	.341	.471	.468	.576	1.000**	.763**	.616*	.792**	.685*	.828**	.702*	.297	.330	.494	.498	-.163	1						
VC2015	-.049	.532	.416	.532	.051	.186	.463	.555	-.010	.605*	.460	.411	-.049	.505	.033	.254	.046	.186	.491	.509	.042	.587*	.358	.329	-.131	.583*	.277	.345	.082	.186	1					
EDU2015	-.218	.678*	.633*	.705*	.717**	.613*	.906**	.992**	.589*	.903**	.915**	.566	-.218	.702*	.380	.571	.534	.613*	.526	.976**	.571	.891**	.745**	.848**	.073	.723**	.635*	.644*	-.079	.613*	.614*	1				
RD2015	-.530	.297	.557	.731**	.637*	.869**	.554	.609*	.965**	.611*	.800**	.521	-.530	.358	.693*	.605*	.544	.869**	.598*	.636*	.946**	.659*	.855**	.718**	.184	.326	.697*	.587*	-.159	.869**	.053	.601*	1			
BUSSERV2015	-.285	.724**	.692*	.824**	.675*	.729**	.814**	.910**	.670*	.981**	.950**	.692*	-.285	.739**	.431	.595*	.572	.729**	.760**	.913**	.671*	.992**	.865**	.813**	.163	.761**	.663*	.683*	-.187	.729**	.598*	.902**	.695*	1		
EEINDEX2015	-.531	.589*	.814**	.907**	.551	.741**	.747**	.870**	.730**	.925**	.929**	.762**	-.531	.656*	.654*	.786**	.399	.741**	.777**	.846**	.752**	.934**	.939**	.831**	.072	.662*	.825**	.833**	-.234	.741**	.610*	.883**	.756**	.935**	1	
HGFIRMS2015	-.334	.457	.585*	.653*	.663*	.658*	.731**	.706*	.612*	.658*	.785**	.570	-.334	.468	.340	.371	.755**	.658*	.624*	.759**	.552	.749**	.679*	.826**	.552	.482	.518	.398	-.106	.658*	.414	.700*	.659*	.756**	.721**	1

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

Table 2 shows the means, minimum and maximum values, and standard deviations of the entrepreneurial ecosystem elements and outputs in 2009, 2012, and 2016. There is substantial variation in the values of the different entrepreneurial ecosystem elements, even within a small country like the Netherlands. Very often the highest ranked region has an absolute value that is more than double the absolute value of the lowest ranked region. There is also a 15-fold difference in the rate of high-growth firms between regions within the Netherlands. This regional heterogeneity in the prevalence of high-growth firms is much more substantial than the heterogeneity in the prevalence of start-ups, as captured with the entrepreneurship culture element (cf. Stam 2005).

Table 3 shows the correlations among the entrepreneurial ecosystem elements and outputs within and across 2009, 2012, and 2015. Several entrepreneurial ecosystem elements are highly correlated in this Dutch dataset, as might be expected. There are three clusters of interdependent sets of elements. First, EDU, NEWFIRM and BUSSERV are strongly correlated to each other. Second, RD and PROJLEAD are strongly correlated. These two clusters reflect key dimensions of the knowledge economy. Third, ACCESS and DEMAND are strongly positively correlated, reflecting a population prosperity and movement dimension. Remarkably, QUALGOV is consistently (but not statistically significant) negatively correlated with the other elements. Another remarkable finding is that there is only one of the elements consistently (positively) statistically related to HGFIRMS, namely BUSSERV.

We proposed that the ten entrepreneurial ecosystem elements explain entrepreneurial activity and aggregate value creation outcomes in a region. The 'standard' methodological procedure in social science for tracing the effects of individual independent variables, controlling for the effects of the other independent variables, is a multivariate regression model. We executed a multivariate linear regression model with ten independent variables reflecting the ten elements of the entrepreneurial ecosystem, with the share of high-growth firms per province as dependent variable (see Table 4). Despite of the very high R2 (0.964-0.992) of the models, none of the independent variables has a statistically significant effect on the dependent variable, and several even have negative coefficients. The lack of statistical significant relations of 'predictor' variables with entrepreneurial output does not mean that the elements are unimportant. They may all be important, but are perhaps already at a value that is beyond a necessary threshold value (such as institutions and infrastructure, which are all at the top levels within Europe; see Annoni and Dijkstra 2013). The diagnostics question is whether a weakest link analysis (cf. Szerb & Acs 2011) is appropriate in this context, because a relatively low value of an element that is beyond the necessary minimum level (e.g. formal institutions) is not a substantial constraint.

Table 4 Multivariate linear regressions

Dependent Variable: HGFIRMS2009

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	.002	.001		1.950	.302
QUALGOV2009	-.001	.001	-1.123	-1.978	.298
NEWFIRM2009	-.001	.000	-1.032	-4.020	.155
ACCESS2009	-.001	.000	-1.020	-1.267	.425
DEMAND2009	.000	.000	.493	.980	.506
INNOCOL2009	.001	.001	.541	1.006	.498
PROLEAD2009	9.240E-5	.000	.251	1.027	.491
VC2009	.000	.000	.901	1.134	.460
EDU2009	-.001	.001	-1.313	-1.687	.341
RD2009	-.001	.000	-1.185	-2.126	.280
BUSSERV2009	.002	.000	2.176	5.352	.118

R2: .992

Dependent Variable: HGFIRMS2012

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	.000	.001		.244	.847
QUALGOV2012	-.001	.000	-.830	-1.296	.418
NEWFIRM2012	-.001	.001	-1.869	-1.355	.405
ACCESS2012	-.001	.001	-3.790	-1.205	.441
DEMAND2012	.001	.000	2.730	1.350	.406
INNOCOL2012	.001	.001	.390	.961	.513
PROLEAD2012	.000	.000	-.986	-.775	.580
VC2012	2.283E-5	.000	.138	.216	.864
EDU2012	.001	.001	.856	1.041	.487
RD2012	.001	.001	1.716	.876	.542
BUSSERV2012	.000	.000	.427	.421	.746

R2: .971

Dependent Variable: HGFIRMS2015

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	.000	.002		-.097	.939
QUALGOV2015	.002	.001	.813	2.382	.253
NEWFIRM2015	.000	.001	-.392	-.460	.725
ACCESS2015	.000	.000	-1.011	-1.196	.443
DEMAND2015	.000	.000	.383	.527	.691
INNOCOL2015	-.002	.002	-.417	-.857	.549
PROLEAD2015	.000	.000	-1.130	-1.322	.412
VC2015	.000	.000	.731	1.850	.315
EDU2015	.000	.000	.506	.919	.527
RD2015	.001	.000	1.677	1.978	.298
BUSSERV2015	1.172E-5	.001	.017	.018	.989

R2: .964

The high correlations between predictor variables (see Table 3) pose the statistics problem of ‘multicollinearity’. One predictor variable (e.g. ACCESS) can be linearly predicted from the others (e.g. DEMAND) with a substantial degree of accuracy. In a situation of multicollinearity, the coefficient estimates of the multiple regressions may change erratically in response to small changes in the model or the data. Multicollinearity does not reduce the predictive power or reliability of the overall model, it only affects calculations regarding individual predictors. A multiple regression model with correlated predictors can indicate how well the entire bundle of predictors forecasts the outcome variable (i.e. a high R2), but it may not give valid results about any individual predictor, or about which predictors are redundant with respect to others. This multicollinearity is also a reason why an index value might better represent the ‘quality’ of the entrepreneurial ecosystem than a set of independent variables.

Decomposing the entrepreneurial ecosystem into a set of elements and then regressing these on the output of the entrepreneurial ecosystem, does not seem to be adequate both for substantive and statistical reasons. The substantive reason is that the entrepreneurial ecosystem should be treated as one system, not as set of independent elements. In an ecosystem there are no direct, one-to-one relationships. The statistical reason is that the individual elements do not reveal to be statistically significantly related to the prevalence of gazelles, despite the large explained variance of the model.

The established empirical literature on the geography of entrepreneurship and economic development has revealed several factors to be of relevance in explaining the spatial heterogeneity in entrepreneurship. This suggests that there is a limited set of factors, or elements that affects the prevalence of entrepreneurship in a region. However, because of its inherent connectivity, nonlinearity and openness, a complex system affords limited functional decomposability (Martin and Sunley 2007), which suggests that the overall functioning of the entrepreneurial ecosystem cannot be deduced from knowledge of the function of its elements. We have seen this in the non-significance of the individual elements in explaining the rate of gazelles (see the regression analysis in table 4). By constructing an index value, also by multiplying the composing elements (see figure 4), we do more justice to the systemic nature of the ecosystem than can be done with traditional multivariate regressions.

In the next section we will take a systems analytical strategy, and analyse how the prevalence of high-growth firms relates to the entrepreneurial ecosystem index.

7.2 Entrepreneurial Ecosystem Index

On the basis of existing geography of entrepreneurship studies (see Stam, 2010; 2015; Stam & Spigel, 2018), an entrepreneurial ecosystem index is constructed based on ten elements. The elements that are foundational to the entrepreneurial ecosystem index are listed in Table 1. The index compresses a large amount of data: the Dutch entrepreneurial ecosystem index, with 12 regions (units), is based on ten thousands of data points (for example the value of the leadership element is based on 2231 innovation projects). For mapping the quality of entrepreneurial ecosystems we have constructed an entrepreneurial ecosystem index. The index is created to compare different units (regions, countries) and a rank in terms of multiple features (elements). The unit may be regions or countries, depending on the (policy) audience to which it is targeted and/or which spatial unit of analysis most adequately covers the relevant mechanisms in the context of entrepreneurship. Since one unit is stronger in one particular feature and the other in another feature, it is necessary to find a universal way to compare and summarize them in one index.

The ten elements of the entrepreneurial ecosystem can be quantified, and be given a comparable value. This is done by normalizing the average value of each element to 1 and then let all deviations be relative to one: with elements in regions performing less than the average having a value below 1, and elements in regions performing better than the average having a value above 1. The advantage is that this allows us to compose an index value, and compare the quality of different entrepreneurial ecosystems. This index value is computed in an additive way (E1+E2+…En). The elements of the index all get the same weight. In a later research phase other weighting techniques than the equal weighting methodology may be applied, based on either the opinion of experts or based on statistical properties of the data. The elements are here summed into one index value, which moves around 10, with regions performing on the average for all elements scoring an index value of 10, while regions performing above the average for all elements scoring an index value higher than 10. This is shown in Figure 2 for provinces in the Netherlands (2009 data), revealing variation from 5.99 (Drenthe) to 12.42 (Utrecht).

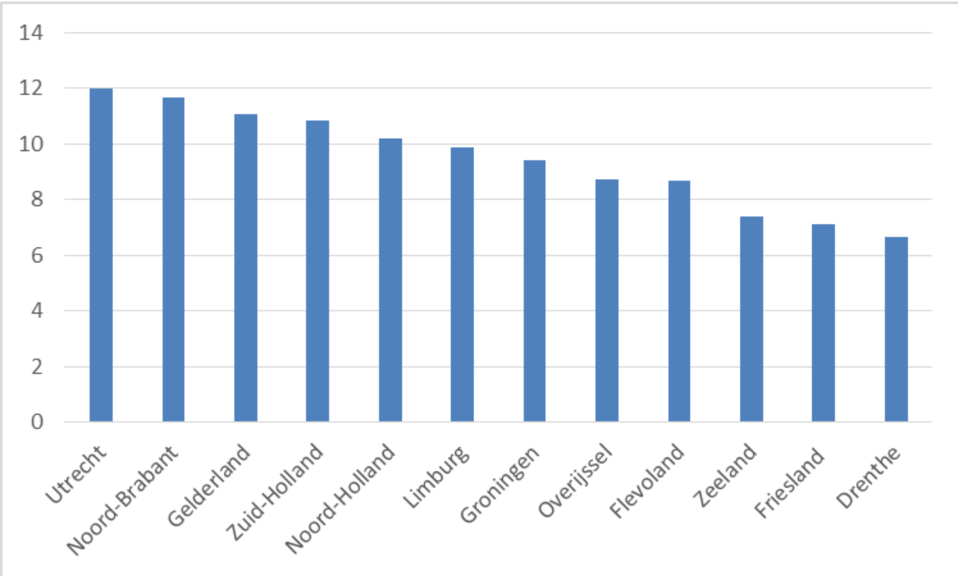

Fig. 2 Entrepreneurial ecosystem index Netherlands provinces (additive, 2009)

The disadvantage of this index construction is that elements with above average value (ranging from 1 to infinity) can have a stronger effect on the index than elements with below average value (ranging from 0 to 1). To solve this, we take the natural logarithm of the elements, so that these symmetrically oscillate around 0, with negative values for regions below average, and positive values for regions above average. This also means that the total index value oscillates around 0 and not around 10 (see Figure 3). The index values now vary between -2.52 (Drenthe) and 0.67 (Utrecht).

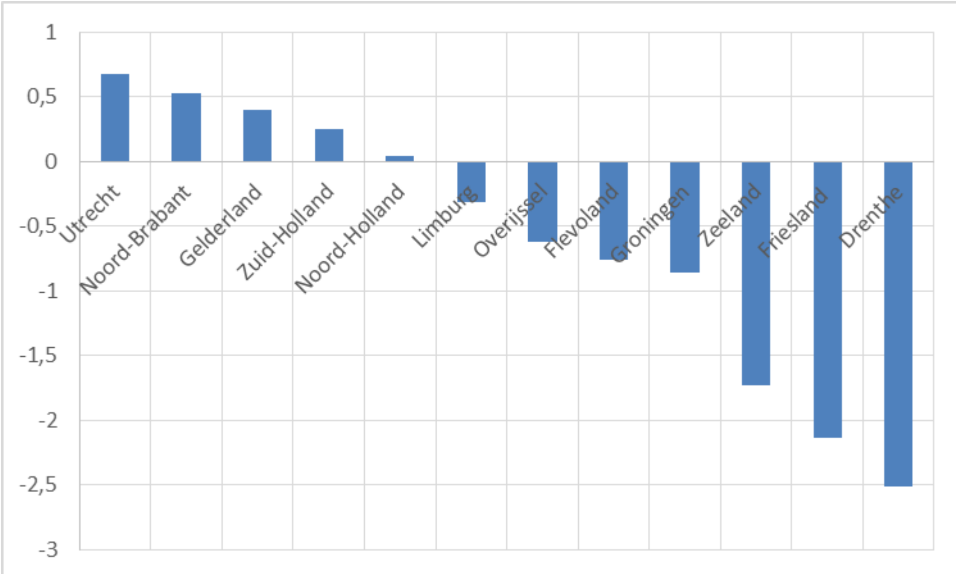

Fig. 3 Entrepreneurial ecosystem index Netherlands provinces (natural logarithm values, 2009)

The essence of ecosystems is the interaction among its elements. This interaction is not adequately covered when an index is constructed as a sum of its elements. If we take the interactive nature of the system seriously, and the resulting non-linear relations, the index should be constructed differently. For this we compute an index that is not additive (E1+E2+…En) but multiplicative (E1*E2*…En). This leads to index values with much larger variation, as the effect of deviations of the average is now much more substantial. The index values now vary between 0.003 (Drenthe) and 4.727 (Utrecht) (see Figure 4). This leads to substantially more variation in the index value: the bottom region Drenthe has an index value that is 0.06% of the value of the top performing region Utrecht. This variation is hugely larger than the 15-fold difference in the prevalence of gazelles in the lowest ranked region 0.003% and the highest ranked region 0.045%. Even though the multiplicative index better captures the interactive nature of the system, its external validity seems to be insufficient.

Table 5 Entrepreneurial ecosystem quality rankings with different index measures (2009)

Province	Additive	Natural logarithm	Multiplicative
Groningen	7	9	9
Friesland	11	11	11
Drenthe	12	12	12
Overijssel	8	7	7
Gelderland	3	3	3
Flevoland	9	8	8
Utrecht	1	1	1
Noord-Holland	5	5	5
Zuid-Holland	4	4	4
Zeeland	10	10	10
Noord-Brabant	2	2	2
Limburg	6	6	6

However, whatever index measure one uses, the rank order of provinces remains largely the same (see table 5). We also performed the same analysis with the 2012 and 2015 data revealing qualitatively similar outcomes. In addition, we executed several robustness checks on the composition of the index: we repeated index calculations with 9 elements, to see whether this affected the quality rankings of the entrepreneurial ecosystems. This also did not substantially change the rank orders of the regions.

To what extent is the prevalence of high-growth firms a function of the quality of the entrepreneurial ecosystem? The first test of this is to see whether there are statistically significant positive correlations between EEINDEX and HGFIRM. Table 3 shows that HGFIRM is always strongly positively correlated to EEINDEX, suggesting upward causation. The second test, is to create a linear model with EEINDEX as the independent variable and HGFIRM as the dependent variable. Figure 5 shows the scatterplot and the linear relation between these two variables (based on 2009 data). This linear model has an R2 ranging from 0.434 (in 2009) to 0.692 (in 2012), also suggesting upward causation.

8. Discussion

The aim of our entrepreneurial ecosystem model is not only to predict, but also to better understand how (entrepreneurial) economies function (Thurik et al., 2013) and in particular how they ‘produce’ entrepreneurship as an emerging property of the system (Arthur, 2013). Our study of entrepreneurial ecosystems in 12 Netherlands regions explored how elements of entrepreneurial ecosystems can be measured and related to their outputs. Although limited to three data collection waves, we also examined temporal developments in ecosystems over time. In doing so, we moved from the ecosystem metaphor to a complex system model of the entrepreneurial economy, at least from an epistemological point of view (Martin and Sunley, 2007). Our analysis is based on a relatively small set of Dutch regions. To arrive at more robust findings, this analysis should be repeated in other regions and multiple periods. This would also allow for feedback effects of the entrepreneurial output on the entrepreneurial ecosystem. The analyses should also be repeated in other contexts, potentially revealing different relations between the entrepreneurial ecosystem and its output.

8.1 Propositions

Our analyses reveal evidence for the upward causation as spelled out in proposition 1: The ten entrepreneurial ecosystem elements explain the levels of entrepreneurial activity in a territory. However, the ecosystem should be treated as a whole system: its overall quality is positively related to entrepreneurial output; it should not be decomposed in ten elements for tracing upward causation.

Our analyses reveal evidence for downward causation as formulated in proposition 2: Prior entrepreneurial activities feedback to increase entrepreneurial ecosystem elements in a territory. We find positive feedback effects of the prevalence of high-growth firms on most of the subsequent values of the ecosystem elements, although not consistently in all the periods. We also find strong positive correlations between the rate of high-growth firms at T0 and the rate at T3. The lack of consistent evidence for downward causation might be related to our crude, relatively short term (3 year lagged) analysis of the presumed feedback effects. More refined in-depth qualitative research might reveal that founders of high-growth firms, later in life become active as leader or venture capitalist in their region, which is not captured in our data.

Finally, we find substantial evidence for our evolutionary proposition 3: The entrepreneurial ecosystem elements are mutually interdependent and co-evolve to enable and constrain entrepreneurial outputs in a territory over time. There is strong interdependence in three clusters of elements. Talent, entrepreneurial culture and support services are strongly correlated to each other, both simultaneously and over time. The same counts for knowledge and leadership (in innovation projects), also reflecting interdependencies in the knowledge economy. We also find strong interdependencies, both simultaneous and over time, between physical infrastructure and demand. In general, we find very strong positive intertemporal correlations of the values of the individual elements, showing strong path dependence in the evolution of entrepreneurial ecosystems. We summarize our propositions in Figure 4.

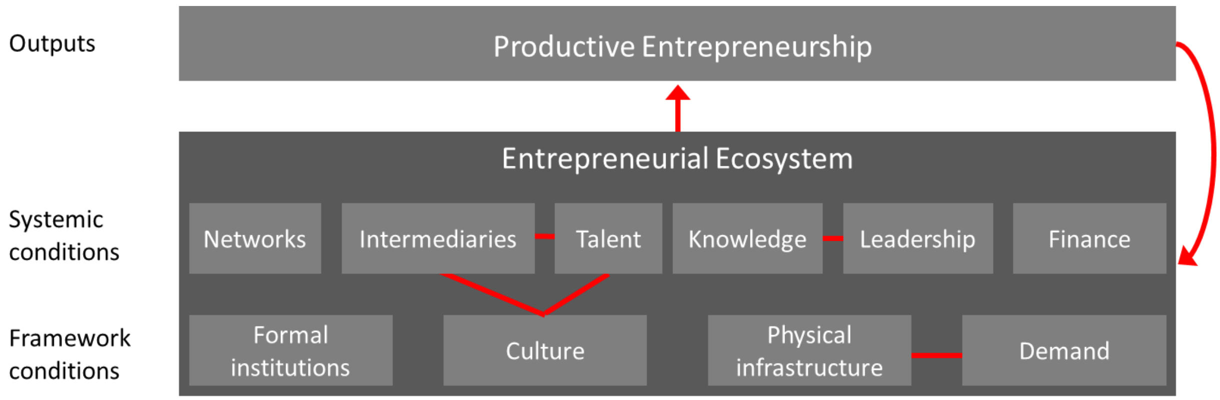

Fig. 4 Empirical evidence for propositions

8.2 A systems perspective

Traditionally, studies on the context of entrepreneurship have taken an interaction approach, analysing the interactions between individual elements, especially the effects of a limited number of independent (input) variables on dependent (output) variables. These interaction-based studies are "reductionist" (Drazin & Van de Ven, 1985) in the sense that apart from what can be captured by a few control variables, they pay limited attention to contextual conditions that may influence the relationships among the variables investigated. At the same time, this focus allows studies taking the interaction approach to provide a relatively high degree of granularity and detail. The main statistical method applied consists of regression analysis. We have shown the limits of such an approach in this study. We have built a bridge towards a systems approach. Such a systems approach goes back to Simon (1962) who described complex organizational systems as (nearly) decomposable into subsystems in which a limited number of elements interact more directly with one another than they do with other elements of the system beyond the boundaries of the subsystem concerned. A systems approach focuses on the emergence of effects at the level of the entire system, looking at the relative performance outcomes of entire sets of multiple elements (Drazin & Van de Ven, 1985). The focus is on the working of the entire system of factors. With the construction of an entrepreneurial ecosystem index we have quantitatively captured the quality of entrepreneurial ecosystems. This quantitative approach provides a complement to qualitative approaches that identify and describe entrepreneurial ecosystems as sets of multiple characteristics (Mack & Mayer 2016; Spigel 2017). In the future, studies could identify whether a particular number, proportion, or combination of factors is in place, and use Boolean comparative analysis to trace causal relations in the evolution of entrepreneurial ecosystems.

The systems model of an entrepreneurial ecosystem developed in this paper has important implications for entrepreneurship theory and practice. First, it requires scholars and policy makers to become more sensitive to the macro context of entrepreneurship; too often context has been treated as 'exogenous' where it is not included in the conceptual framework, but 'taken for granted, its influence underappreciated or … controlled away' (Welter, 2011, p. 173–4). As a result, previous work in entrepreneurship has tended to overlook the role of context in order to produce generalizable models of entrepreneurial activity when instead context should be the specific focus of investigation. A context such as location should not be treated as a simple control variable or proxy; a deeper examination is required of how the cultural, social, political, and economic structures and processes associated with a place influence all aspects of the entrepreneurial journey. A context like location is not a *cause* of particular entrepreneurial practices but rather reflects a much more complex influence on entrepreneurship (Johannisson, 2011).

Second, the ecosystem concept emphasizes that entrepreneurship is not limited to the for-profit sector; numerous entrepreneurial actors in the public and not-for-profit sectors play crucial roles in facilitating or constraining elements of an ecosystem. By studying the roles and how they interact to develop and commercialize a business ventures, we can understand how the risk, time, and cost to an individual entrepreneur are significantly influenced by developments in the ecosystem.

Third, the systems framework emphasizes that any given entrepreneurial firm is but one actor, able to perform only a limited set of roles, and dependent on many other actors to accomplish all the functions or elements for an ecosystem to thrive. As a consequence, an individual entrepreneur must make strategic choices concerning the kinds of proprietary resource endowments and institutional functions in which it will participate and what other actors it will engage to achieve self-interest and collective objectives. These strategic choices make clear that the ways entrepreneurial firms choose to allocate their efforts are variables and that the lines separating the firm from its entrepreneurial community are not sharply drawn but are fluid and change frequently over time. These choices and transactions evolve over time, not only as a result of individual firm behavior but just as importantly by the interdependencies that accumulate among firms engaged in numerous components of the emerging ecosystem.

Pragmatically, therefore, entrepreneurs should be concerned not only with their own immediate proprietary business tasks, but also with those of other firms in their resource distribution channel and with the overall ecosystem. Switching involvements among different system elements and proprietary distribution channels is expensive. Influencing one's own existing channel may be more efficient than switching channels or creating new ones. Also, there is an ongoing tension for each ecosystem participant to organize its own proprietary business functions as opposed to contributing to the creation of the ecosystem's marketing, resources and institutional arrangements. Although the former may advance the entrepreneur's position as a first-mover in the short run, the latter provides the infrastructure that ultimately will influence all the actors in the entrepreneurial ecosystem.

Fourth, longitudinal study of an entrepreneurial ecosystem will call attention to the accretion of numerous institutional, resource, market and proprietary events that influence each other over an extended period, as Van de Ven & Garud (1993) observed in the development of the cochlear implants ecosystem. These components of an ecosystem are highly interdependent, and need to be viewed as a complex system that seldom emerges evenly over time. As a result uneven temporal developments of ecosystem elements act as bottle-necks inhibiting entrepreneurship in a region. Moreover, the very ecosystem elements that are created to facilitate the emergence of entrepreneurship in one area can hinder subsequent development in other areas. This generative process has a dynamic history of creative destruction (Schumpeter, 1934) that is important to study if we are to understand entrepreneurship and economic development.

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