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Framing Open Innovation
in Start-ups' incubators:
A Complexity Theory perspective

Battistella C. (University of Udine)

De Toni A. F. (University of Udine)

Pessot E. (University of Udine)

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Framing Open Innovation in start-ups' incubators: A Complexity Theory perspective

Cinzia Battistella

Associate Professor, University of Siena, Italy

Email: cinzia.battistella@unisi.it

Alberto F. De Toni

Full Professor, University of Udine, Italy

Email: alberto.detoni@uniud.it

Giovanni Martinazzo

Research Fellow, University of Udine, Italy

Email: martinazzo.giovanni@spes.uniud.it

Elena Pessot (Corr.)

Post-doc Research Fellow, University of Udine, Italy

Email: elena.pessot@uniud.it

Abstract

Recently, concepts and principles from the Complexity Theory (or, generally speaking, the complexity sciences) have been applied as a perspective for capturing the influence of the context, interaction and adaption in the innovation processes, such as the ones enabled in the business incubators. The purpose of this paper is to implement a frame of reference for understanding the start-ups' incubator as a complex system where innovation, learning and self-organisation take place.

We build on the interfaces between the Complexity Theory (i.e. complexity sciences) and Open Innovation literature to identify principles, patterns and conditions that frame the incubation practices as simple rules aimed to sustain the innovation process towards the creation of new ventures. Results from the multiple case studies conducted in five incubators show that the features of variety, non-linear interaction, interdependence, autonomy, emergence of the incubation process framed as a complex system are enabled in different ways by the combination of the open innovation practices and services provided by the start-ups' incubators, including the provision of physical infrastructure, access to funding streams, experts/entrepreneurs networking, education / workshops, mentorship and advice.

Keywords: Open Innovation, Business incubator, Complexity sciences, Practices, Case study

Introduction

Concepts and principles from the Complexity Theory (or, generally speaking, the complexity sciences) have been widely adopted to understand the interactions and dynamics that characterise organisations and business networks. Recent studies applied the complexity lens as a perspective for exploring and capturing the conditions enabling the emergence of innovation processes in firms. For example, complexity science has been adopted as a new approach for studying innovation processes in industrial districts (Albino et al., 2006), representing the emergence of social innovation and its many differences (Goldstein et al., 2010), analysing the creativity emergent process (De Toni et al., 2012). Indeed, "innovation, by its very nature, involves the *unprecedented*, the *unpredictable*, and the *non-deducible* with respect to current circumstances" (Goldstein et al., 2010).

A diffuse topic of investigation through complexity lens is the mechanisms and approaches adopted in open innovation networks (e.g. Jarvenpaa and Wernick, 2011), ecosystems (e.g. Dougherty, 2017) and in general in opening up the innovation process with one or more relationships with external actors. Among the several practices identified, the incubation and venturing process has a key role in offering supportive environments for sustaining the growth of new ventures such as the incubators and bring innovations to the market (Chesbrough and Brunswicker, 2014; van de Vrande et al., 2009). In their recent literature review, Hausberg and Korreck (2018) argue that a promising research direction is the adoption of open innovation as a theoretical lens to understand the incubators. Previous contributions have mainly focused on the study of the practices and services offered by the incubators from the perspective of their value offer (e.g. Bruneel et al., 2012) or their model in running their business (e.g. Grimaldi and Grandi, 2005).

This paper aims to analyse the context of business incubators as a process of innovation emerging from the interdependence of autonomous agents which interact in different, non-linear ways with other sources of knowledge to stimulate the growth of new ventures. We build on the interfaces between the Complexity Theory (i.e. complexity sciences) and Open Innovation literature to identify principles, patterns and conditions that frame the incubation practices as simple rules aimed to sustain the innovation process carried out by the tenant start-ups. Aiming to a deeper understanding of the micro-level foundations of the innovation processes that leverage on both internal and external sources of knowledge across the boundaries of a start-ups' incubator, we formulated the research question as follows:

RQ: How can business incubators related practices enable an emergent open innovation environment from a complexity theory perspective?

Theoretical background

Open Innovation and Complexity Theory

Nowadays, companies need to select the mechanisms and behaviours to be most beneficial in engendering a continuous innovation process while dealing with the increasing complexity on a day-by-day basis (Chapman and Hyland, 2004; Jarvenpaa and Wernick, 2011). Businesses are

required to innovate and evolve in an ecosystem that is increasingly complex (Dougherty, 2017; Sun et al., 2018), with new, comprehensive approaches.

In this sense, complexity thinking represents a key perspective for a deeper understanding of innovation (Johannessen and Aasen, 2007), especially after the introduction of the 'network' as a key unit for analysing the innovation process beyond an organisation's boundaries (Andriani, 2011). The innovation network of a company embraces heterogeneous and autonomous agents such as competitors, suppliers, customers, research centres, and other public institutions that interact pursuing the common goal of developing, exploiting or commercializing an innovation (Albino et al., 2006; Jarvenpaa and Wernick, 2011). For example, the properties of complex adaptive systems are adopted as perspective to study the features of the innovation ecosystems (Russell and Smorodinskaya, 2018) and the industrial districts (Albino et al., 2006), characterised by a complex network of inter-organizational relations. In their literature review, Poutanen et al. (2016) identify the complexity themes addressed in the innovation literature, and specifically in the publications focusing on the Open Innovation paradigm. They argue that the micro-level foundations of the innovation process include the interactions, the relationship formation and the knowledge creation among multiple different players. These interactions are non-linear as to favour dynamics deriving from communication and feedback flows (Sun et al., 2018). Indeed, open innovation is characterised by the involvement of different innovation actors, the formation of multifaceted inter-organisational relationships between them, the paths inside and outside an organisation's boundaries to access the distributed knowledge (Jarvenpaa and Wernick, 2011). Moreover, innovation results in the emergence of networks of innovation that are distributed, self-organised and integrating internal flexibility with a high variety of resources and diversity of capabilities (Andriani, 2011). In this sense, an ecosystemic view of innovation as system of actors requires to consider it as an initiative that may not have been planned, but emerging from the interactions among actors within the broader system (Sun et al., 2018).

The structures and dynamics deriving from leveraging on different actors as sources of innovation can be framed as emergent phenomena resulting from the local choices of the different actors (Albino et al., 2006). The interaction with external sources of innovation is characterised by a high degree of diversity, as there are different players, in different interactions, within different institutional contexts and operating according to different norms (Goldstein et al., 2010). The level of variety is also reflected in the highly skilled personnel required in the innovation process. Moreover, the environment in which innovation is developed is characterised by a growth or variety and diversity (Andriani, 2011). With the aim of fostering spontaneous forms of coordination for innovation and meeting the shared goals, organisations are required to enable greater autonomy and creativity (De Toni et al., 2012; Sun et al., 2018) among these different actors. A key capability is then taking advantage of the emergence of these dynamics through an active, deliberate management of them (Dougherty, 2017). Indeed, the innovation capability of an organisation – and a network of organisations – is strictly linked to its knowledge management and organisational learning (Chapman and Hyland, 2004), which derives from the interaction of autonomous agents

characterised by their own norms, beliefs, values, and assumptions (Albino et al., 2006).

Basing on this analysis of the literature, we summarised the key features of innovation at the interface between the complexity science and the open innovation perspective as: emergence, non-linear interaction, interdependence, variety, autonomy.

The start-ups' incubator as an Open Innovation environment

The Open Innovation paradigm (Chesbrough, 2003) has been demonstrated being valuable for firms willing to leverage both internal and external sources of knowledge in order to innovate and widen their potential to realize new business opportunities (Chesbrough et al., 2003). Among main mechanisms to enact the opening up of the innovation process, the role of business incubation and venturing has received increasing attention in literature (Chesbrough and Brunswicker, 2014; van de Vrande et al., 2009). Indeed, business incubators – and in general the organisations supporting the formation and development of early stage ventures – have a key role as innovation intermediaries in respect to the tenant start-ups (Battistella et al., 2017; Macchi et al., 2014).

Hausberg and Korreck (2018) argue that Open Innovation represents a promising theoretical lens in understanding the determinants and implications of business incubators. This kind of infrastructure sustains the creation and growth of new entrepreneurial teams by offering them access to purposive flows of knowledge and a supportive environment for experimentation, interdependence and therefore learning from the integration of this knowledge into the development of their business (Blok et al., 2017; Bøllingtoft, 2012; Gupta et al., 2016). Indeed, an early involvement within the market dynamics can provide an important value to start-up teams for learning, creating partnerships and better developing the potential business, with the final aim of reducing the market and technical uncertainty (Chesbrough et al., 2006) and accessing to knowledge networks and inter-organisational networks (Gupta et al., 2016). In this sense, they are a key enabler in enabling the opening up of the innovation pathway to external sources of knowledge by the new ventures (Battistella et al., 2017). Moreover, the incubators stimulate innovation and entrepreneurship processes in the regions where they are located (Clausen and Rasmussen, 2011).

Beyond the provision of basic services and facilities, the business support services and the networking activities (i.e. the intangible aspects) are gaining relevance in the business models of incubators (Hausberg and Korreck, 2018; Macchi et al., 2014). Connections and knowledge-intensive services opportunities are identified and built both inside and outside the incubator's boundaries (Cooke, 2017; Macchi et al., 2014). Business incubators provide an environment where tenant start-up teams can leverage on linkages with experienced entrepreneurs, other start-up teams, professionals specialised in intellectual property, strategic and managerial issues, business angels and other players offering external financing (Blok et al., 2017). They allow the new ventures to develop their own innovation strategies by leveraging on external sources when their liabilities associated with being new and small don't allow tangible business opportunities (Macchi et al., 2014; Soetanto and Jack, 2013). Tenant start-ups are able to be established to a bigger scale than without the industry incubator programme (Clausen and Rasmussen, 2011). Moreover, factors such

as the proximity and the specialisation of the business incubator facilitate the exchange of knowledge, experiences, contacts and resources (Cooke, 2017). Firstly, the close presence of different people willing to innovate within the same facility enables face-to-face meetings and the creation of multiple connections (Grimaldi and Grandi, 2005). The co-location of networked agents and the collaboration between them are demonstrated having a crucial role in facilitating knowledge transfer, generating new ideas and transforming them into marketable innovative assets (Russell and Smorodinskaya, 2018). The business incubators show a commitment in open innovation activities and at the same time the tenant start-ups demonstrate an explicit attitude in the co-creation of new ideas with other actors (Macchi et al., 2014). Secondly, business incubators are usually specialised in the type of services offered and the selection is restricted to start-ups satisfying requirements such as the type of industry and the entrepreneurial team composition. Therefore, common aims and technical background are a further base for stimulating purposive inflows and outflows of knowledge (Chesbrough et al., 2006) across the incubator system boundaries.

Basing on these considerations, the strategies of the business incubators which are focused on open innovation and partly bottom-up based (Macchi et al., 2014), and involve different, specialised networks of actors, offer a valuable context to investigate the conditions and the added value of adopting the complexity perspective in the open innovation research field.

Methodology

With the aim of gaining deeper insights and explore the micro-foundations of the innovation paths enabled by a business incubator towards tangible business opportunities for its tenant start-ups, we performed a multiple case study research (Voss et al., 2002; Yin, 2013). We selected five incubators on the basis of their expertise (all operating from more than fifteen years), their infrastructure and the characteristics of the incubation process (e.g. main objectives and length). They all show a clear involvement in start-up teams' growth by offering not only advice and access to networks, but also long incubation programmes (between 1 and 3 years) and in some cases also till the post-incubation phase. Table 1 shows the main characteristics of the five business incubators selected as case studies.

Table 1 – The five start-ups' incubators

CHARACTERISTICS	Incubator A	Incubator B	Incubator C	Incubator D	Incubator E
Year of foundation	2008	2005	2005	1999	2000
Number of employees	15	8	400	20	20
Number of tenant start-ups	190	30	64	161	113
Property (private / public)	Public	Public	Private	Public	Public
Location / infrastructure	Inside technological	Inside technological	Affiliated with a university (Ca'	Inside university	Inside university

	park	park	Foscari Venice)		
Main objectives	Mentoring	Mentoring, networking for financing	Venturing	Networking, Researching	Networking, Researching
Period of incubation	3 years	5 years	3 months	3 years	3 years
Scope (pre / post-incubation)	Pre- and post-incubation	No	No	Post-incubation	Post-incubation

The data collection phase included semi-structured interviews and information gathered from archival and publicly available documentation of each incubator. Throughout the research, we focused on the practices and services of the selected incubators that are addressed to the start-ups' growth, supporting the expansion of their innovation process up to an initial maturity. We bounded the scope of the study to the incubation process, i.e. the phases between the so-called pre-incubation period, when start-ups are created and recruited, and the post-incubation or graduation phase, when start-ups reach a level of maturity that allows them to exit the programme and usually develop their business in an independent and self-sustained way. We classified and distinguished the practices and tools of each incubator following the categories of services identified in previous studies (i.e. Battistella et al., 2017; Bøllingtoft, 2012; Blok et al., 2017) as: physical infrastructure, access to funding streams, experts/entrepreneurs networking, education / workshops, mentorship and advice.

Subsequently, we analysed the practices at the light of the main concepts and principles of complexity theory at the interface with the open innovation perspective. From the cross-case analysis, we derive a theoretically and empirically grounded framework through which categorise the practices and activities of business incubators as simple rules to support the innovation processes (and their management) of the tenant start-ups.

Results

The first empirical analyses of the five case studies revealed recurring features in the practices and services for supporting the innovation process of start-ups toward the maturity phase. Table 2 shows the open innovation services and practices of the five business incubators. All the incubation programmes are targeted to provide access to dedicated networks. They all show practices aimed to provide to the tenant start-ups the basic tools to self-organise in an environment where the inclusion into several types of networks allows frequent contacts and in-depth meetings with experts and innovative people (such as the other entrepreneurial teams).

Some incubators aim to provide less structured environments with the provision of focused resources and expertise while accessing to networks with a wider scope. For example, they facilitate meetings with experts to improve the entrepreneurial ideas both from a technical point of view (e.g. software development) and on economic and business issues.

Table 2 – Open Innovation services and practices in the five business incubators

SERVICES	Incubator A	Incubator B	Incubator C	Incubator D	Incubator E
Physical infrastructure	<ul style="list-style-type: none"> Offices Possibility to use shared tools and spaces (common spaces for eating and meetings, repository, security, Internet and phone, photocopies, post and pallet receiving) 	<ul style="list-style-type: none"> Offices ICT infrastructures (use of ICT tools) 	<ul style="list-style-type: none"> Provision of co-working spaces Offices located also in foreign countries Mobility (e.g. car sharing) 	<ul style="list-style-type: none"> Offices Labs ICT infrastructures (use of ICT tools) 	<ul style="list-style-type: none"> Offices Shared facilities (co-working spaces, flexible and scalable spaces, meeting rooms, relax spaces)
Access to funding streams	<ul style="list-style-type: none"> Direct investment of public dedicated funds Dedicated agreements with banks Tax and legal advice Financial advice: mentorship and meetings with experts to define sources for funding 	<ul style="list-style-type: none"> Public funding presentations Provision of financial support Financial advice: meetings with experts to define sources for funding Assistance for funds rising 	<ul style="list-style-type: none"> Direct investment Investment seed Contacts with potential investors, i.e. business angels and venture capitalists Provision of seed investments, dedicated to the idea definition, the product validation and the market tests 	<ul style="list-style-type: none"> Collection of seed funds Dedicated agreements with banks Dedicated agreements with business angels and venture capitals Public funding presentations Financial advice: mentorship about the financing strategy 	<ul style="list-style-type: none"> Corporate venturing Corporate spin offs Specific challenges for digitalization by companies (e.g. Vodafone) Financial advice: mentorship about the financing strategy
Experts/ Entrepreneurs networking	<ul style="list-style-type: none"> Presence in a scientific and technological park Technical advice Technical analysis to validate the innovative features of the entrepreneurial idea 	<ul style="list-style-type: none"> Presence in a scientific and technological park Erasmus for Entrepreneurs: programme of exchange of entrepreneurs in Europe to favour learning by doing Assistance for partner search 	<ul style="list-style-type: none"> Affiliation with the local university and its spin-offs Frequent networking with entrepreneurs Informal exchange of knowledge (storming pizza) Demo day, demo night Group training 	<ul style="list-style-type: none"> Mentors network Investor network Provider network Strategic partners network Demo day Presentations Challenges Informal exchange of knowledge Advisory board 	<ul style="list-style-type: none"> Observatory about start-ups (Start-up Intelligence) Challenges around technology (Hackathon) Start up scouting & Innovation Consultancy Call for Ideas Tailored Start up Erasmus for young entrepreneurs

		<ul style="list-style-type: none"> ▪ Technical advice: meetings with experts to improve the idea from a technical point of view ▪ Economic and business advice: Meetings with experts to improve the entrepreneurial idea in three areas: (1) business administration (2) innovation management, technological transfer and IPR (3) project management 	<ul style="list-style-type: none"> ▪ International networking (e.g. GAN network) 	<ul style="list-style-type: none"> ▪ Collaboration with other companies (Club Italia Investimenti, Microsoft for start-up, HubSopt for start-up) 	<ul style="list-style-type: none"> ▪ Platform for business matching (d!economy) ▪ Platform for future technology matching (d!tech) ▪ Platform for workshops and conferences on digital business (d!talks) ▪ Platform for events and networking (d!campus)
Education / workshops	<ul style="list-style-type: none"> ▪ Business planning courses and seminars ▪ Participation to public and private events and seminars organised by the scientific park ▪ Dedicated workshops 	<ul style="list-style-type: none"> ▪ Business planning courses and seminars, advice on how to develop a business plan 	<ul style="list-style-type: none"> ▪ Courses on strategic issues, economic and financial planning, logistics ▪ Campus related to schools (design school, professional school, h-international school) ▪ Path for students "H-frame u" (students in digital management with internships in companies) ▪ Laboratories for young people and students ▪ Summer programs for digitalization of students ▪ Masters in digitalization 	Na	<ul style="list-style-type: none"> ▪ Business training ▪ Access to university/business schools courses ▪ Management team identification ▪ Group training, workshop, focus group ▪ Brand definition training ▪ Business culture development ▪ E-learning ▪ Knowledge database access

<p>Mentorship and advice</p>	<ul style="list-style-type: none"> ▪ Business mentorship: face-to-face meetings with internal tutors to constantly collect feedback and advice for economic and strategic issues ▪ Budget and management control ▪ Economic and business advice ▪ Market analysis and desk analysis ▪ Patent analysis and search ▪ Specific consultancy 	<ul style="list-style-type: none"> ▪ Business mentorship: face-to-face meetings with internal tutors (who can eventually ask for help from an external consultant) to constantly collect feedback and advice for economic and strategic issues ▪ Technical mentorship: face-to-face meetings with internal tutors (who can eventually ask for help from an external consultant) in order to constantly collect feedback and advice for technical issues related to idea ▪ Presence of a technical scientific committee to evaluate the business plan from a technical and business point of view 	<ul style="list-style-type: none"> ▪ Industry partner ▪ Accelerator team ▪ Tech Partner ▪ GAN (Global Accelerator Network) service ▪ Mentorship & workshop 	<ul style="list-style-type: none"> ▪ Mentorship ▪ Specialised tutor dedicated to every single company 	<ul style="list-style-type: none"> ▪ Scouting ▪ Tutorship ▪ Mentorship ▪ Consultancy ▪ Specific scouting on customer experience (e.g. AVIVA Customer Innovation Award) ▪ Challenges with companies (e.g. Unlock Your ability with Energy industry companies) ▪ Legal advice ▪ Marketing assistance ▪ Research of customers and partners assistance ▪ Promotion with PRs ▪ Technological assistance ▪ Customer relations management ▪ Business planning
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Moreover, some incubators rely on the internal networks of start-ups, in distinct stages of growth and also involved in different programmes, to share knowledge and favour co-located networks. Others try to extend the internal networks to a global dimension, by enabling collaborations with the foreign offices.

Discussion

All the start-ups' incubators selected for the study show that the provision of tools and services to sustain the innovation paths of tenant start-ups' results in an organic development of self-organising dynamics and emergent properties (Andriani, 2011). They all act as knowledge hubs by providing connections to internal and external networks of different types of sources, such as universities and research institutes, funding sources (e.g. business angels and venture capitalists) and incubators in other regions (Clausen and Rasmussen, 2011).

The incubators provide to their tenant start-ups several share assets, both tangible and intangible, in various configurations and in a complementary way. Along with this line, incubators should provide all the types of practices to create awareness on the possible paths to be undertaken when start-ups are looking for reducing uncertainty, increasing diversity or number of linkages in the future market. This is in line with the results by Bruneel et al. (2012), which show that start-ups located in the more recent incubation programmes make full use of the service portfolio.

Business incubators create an institutional environment for a continuous improvement, with the goal of eliminating possible barriers and provide the incentives to access to business networks, more collaboration opportunities and intensive – and even unintended – knowledge spillovers (Russell and Smorodinskaya, 2018) across and along the incubation process.

Table 3 shows the relationship of open innovation practices with complexity principles in the context of the selected start-ups' incubators. We can argue that some categories of open innovation services and practices stimulated more some principles, in particular:

- Physical infrastructure: principles of emergence, autonomy and interdependence
- Access to funding streams: principles of autonomy and interdependence
- Experts/ Entrepreneurs networking: all complexity principles identified
- Education / workshops: principles of variety and autonomy
- Mentorship and advice: principles of autonomy and non-linear interaction

Table 3 – Complexity principles reinforced by open innovation services and practices in the business incubators

COMPLEXITY PRINCIPLES					
SERVICES AND PRACTICES	Emergence	Non-linear interaction	Interdependence	Variety	Autonomy
Provision of office and co-working space	<ul style="list-style-type: none"> Shared facilities 		<ul style="list-style-type: none"> Provision of co-working spaces Offices located also in foreign countries Shared facilities Labs 		<ul style="list-style-type: none"> Possibility to use tools and spaces Offices Labs ICT infrastructures Mobility (e.g. car sharing)
Access to funding streams			<ul style="list-style-type: none"> Contacts with potential investors, i.e. business angels and venture capitalists Corporate venturing Corporate spin offs Dedicated agreements with banks Financial advice: mentorship and meetings with experts to define sources for funding Financial advice: meetings with experts to define sources for funding 		<ul style="list-style-type: none"> Direct investment Seed investments Tax and legal advice Public funding presentations Provision of financial support Assistance for funds raising Financial advice

<p>Experts/ Entrepreneurs networking</p>	<ul style="list-style-type: none"> ▪ Presence in a scientific and technological park ▪ Technical analysis to validate the innovative features of the entrepreneurial idea ▪ Demo day ▪ Presentations ▪ Challenges ▪ Call for Ideas 	<ul style="list-style-type: none"> ▪ Frequent networking with entrepreneurs ▪ Affiliation with the local university and its spin-offs ▪ Erasmus for Entrepreneurs ▪ Informal exchange of knowledge ▪ Challenges ▪ Collaboration with other companies ▪ Call for Ideas 	<ul style="list-style-type: none"> ▪ Presence in a scientific and technological park ▪ Frequent networking with entrepreneurs ▪ Affiliation with the local university and its spin-offs ▪ Erasmus for Entrepreneurs ▪ Technical advice ▪ Economic and business advice ▪ Mentors network ▪ Investor network ▪ Provider network ▪ Strategic partners network ▪ Group training ▪ International networking (e.g. GAN network) ▪ Platform for business matching (d!economy) ▪ Platform for future technology matching (d!tech) ▪ Platform for workshops and conferences on digital business (d!talks) ▪ Platform for events and networking (d!campus) 	<ul style="list-style-type: none"> ▪ Frequent networking with entrepreneurs ▪ Affiliation with the local university and its spin-offs ▪ Erasmus for Entrepreneurs ▪ Informal exchange of knowledge ▪ Group training ▪ International networking (e.g. GAN network) ▪ Collaboration with other companies ▪ Observatory about start-ups (Start-up Intelligence) ▪ Start up scouting & Innovation Consultancy ▪ Tailored Start up ▪ Erasmus for young entrepreneurs 	<ul style="list-style-type: none"> ▪ Presence in a scientific and technological park ▪ Assistance for partner search ▪ Technical advice ▪ Advisory board
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Business support / mentoring		<ul style="list-style-type: none"> ▪ Business mentorship ▪ Technical mentorship ▪ Economic and business advice ▪ Presence of a technical scientific committee ▪ Accelerator team ▪ GAN (Global Accelerator Network) service ▪ Challenges with companies ▪ Promotion with PRs 			<ul style="list-style-type: none"> ▪ Business mentorship ▪ Technical mentorship ▪ Economic and business advice ▪ Market analysis and desk analysis ▪ Patent analysis and search ▪ Specific consultancy ▪ Accelerator team ▪ GAN (Global Accelerator Network) service ▪ Research of customers and partners assistance
Education / workshops				<ul style="list-style-type: none"> ▪ Business planning courses and seminars ▪ Participation to public and private events and seminars organised by the scientific park ▪ Dedicated workshops ▪ Campus related to schools ▪ Path for students "H-frame u" (students in digital management with internships in companies) ▪ Laboratories for young people and students ▪ Summer programs for digitalization of students ▪ Masters in digitalization 	<ul style="list-style-type: none"> ▪ Business planning courses and seminars ▪ Advice on how to develop a business plan ▪ Dedicated workshops ▪ Masters in digitalization ▪ Access to university/business schools courses ▪ Group training, workshop, focus group ▪ Brand definition training ▪ business culture development ▪ E-learning ▪ Knowledge database access

Overall, the results allow conceptualising the incubation programme as a networked process embedded in a complex system whose boundaries are determined by the interactions between multiple different stakeholders. They offer evidence that the practices of the incubators do have an impact on the pathways of the tenant start-ups to the initial maturity as they are framed to enable both the network connections and the entrepreneurial skills. The business incubators create the conditions for innovative and collaborative networks as simple rules in order to stimulate their systematisation at a higher scale, once the start-ups end the incubation programme and are enabled to look for the creation and diffusion of innovation in higher level networks. Therefore, start-ups' incubators can be framed as environments "where a rich texture of entrepreneurship and technological constraints allows the conversion of energy (in the form of intellectual creativity and funding)" (Andriani, 2011: 462) into innovative products and services.

Specifically, the networking seems to support the overall principles at the base of the incubation process as a complex adaptive system. Indeed, the more recent generation of business incubators is mainly focusing on the provision of the access to technological, professional, and financial networks and in general the sources of assets and knowledge beyond their boundaries (Bruneel et al., 2012), and this can be explained at the light of the growing complexity of the business and social world of nowadays. Moreover, they foster the principle of variety by providing focused education and training, also reflecting the differences in the way they run their services (Grimaldi and Grandi, 2005).

As regards the access to funding streams, also the provision of financial resources represents a key foundation for the innovation process as also financial capital contributes as a systemic resource (Sun et al., 2018).

The practices of the incubators should then be framed as simple, micro rules in order to foster the needed knowledge and innovation process of new ventures to emerge, evolve 'more fully' and persist over the long term (Dougherty, 2017). In this way, this kind of infrastructure need to re-examine its practices and the mechanisms they foster in tenant start-ups from a complexity theory perspective in order to manage and capitalize (De Toni et al., 2012) on the emergent innovation processes.

Conclusions

This paper presents a novel perspective on roles and paths in open innovation as it adopts the complexity concepts in the particular contest of business incubators, conceptualised as a complex system where start-ups benefit from the access to multiple dedicated networks for advice and access to resources and knowledge sources. It contributes to the debate on the application of complexity principles to the open innovation research field by studying the conditions – in this case, the practices of the business incubators – that enable a network-based innovation development for the creation of new value (Gupta et al., 2016; Dougherty, 2017). From the practitioners' point of view,

this study provides some guidelines for business incubators, and in general institutions and programmes supporting new ventures growth, to address their activities and services in an effective way. These should be maintained in a simple, focused manner to make the tenant start-ups improving their entrepreneurial skills, increasing the linkages with several knowledge sources and taking advantage of the emergence of processes for a sustainable growth (Dougherty, 2017) beyond the incubation programme. The start-up teams as well should leverage on the created micro-mechanisms and adapt them to the market conditions to better sustain their growth and possible survival. Synergies and innovation patterns among start-ups and supporting institutions are indeed a valuable mean to promote entrepreneurship and economic growth (Blok et al., 2017; Dougherty, 2017).

Despite the case study methodology has been proved adequate when considering the complexity perspective within the innovation research (Poutanen et al., 2016), the obtained results could be integrated by a quantitative research and further analysed along different viewpoints. The latter ones include for example the contextual conditions not considered in the analysis (e.g. location and objectives of the start-ups' incubator), the types of entrepreneurial teams accepted in the incubation programmes, and the temporal dynamics throughout the innovation pathways, e.g. recurring patterns during the development of specific activities that involve the overall system. These factors can be then operationalised in moderating variables influencing the prosecution of the start-up growth from the incubation programme to their maturity within the market.

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