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Economics and Ethics

Ernesto Tavoletti, Corrado Cerruti

Business Incubation: The Case of the European Space Agency

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Business Incubation: The Case of the European Space Agency

Ernesto Tavoletti, Corrado Cerruti[1]

Abstract

We test a theoretical framework, based on four principles, that has been developed through a previous systematic literature review. The 'laboratories' that have been chosen in order to test the theoretical framework are the business incubators at the European Space Agency (ESA). The methodology is a multiple case study research of ESA's business incubators. The reason why we have chosen them is that the same ESA's successful business incubation programme is applied in different business incubators across different nations. That provides a unique empirical setting in which to test the internal and construction validity of our principles, neutralizing the influence of the hosting country. The final result is not a 'statistical generalization' regarding a population of business incubators, but an empirically, multiple case study based, 'analytical generalization' of the proposed theoretical framework. Such theoretical framework appears effective in explaining the success of ESA's business incubation programme. The collected evidences also have practical implications as we expect the framework can be applied by policy makers approaching the business incubation tool and extended to non-profit, publicly funded business incubators – the overwhelming majority of operating business incubators – that might take advantage from aligning their development strategy to our proposed framework.

JEL Classifications: L26 – Entrepreneurship; M13 - New Firms, Startups.

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Editorial notes

The paper builds upon a previous literature review and theoretical framework:

- TAVOLETTI, E. (2012), "Business Incubators: Effective Infrastructures or Waste of Public Money? Looking for a Theoretical Framework, Guidelines and Criteria", *Journal of the Knowledge Economy*, DOI: 10.1007/s13132-012-0090-y.

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1. Introduction

Business incubation has been a very popular practice for years. The first business incubator in history is thought to be the Batavia Industrial Center, opened in Batavia, N.Y., in 1959 (Adkins, 2002), but the concept of providing business assistance services to early-stage companies in shared facilities did not catch on until at least the late 1970s.

Starting from the beginning of the 1980s, the number of business incubators in the world has been growing rapidly and according to the National Business Incubation Association – a USA based organization – there are 7,000 incubators in operation across the world (NBIA, 2011). It is estimated that more than 1,400 incubators are in North America but their growth in the developing world has been impressive: China had over 500 incubators by 2006 (Chandra and Chao, 2011), Brazil had over 400 in 2007 (Chandra et al., 2007) and India has about 43 Technology Business Incubators registered under the Department of Science and Technology (Manimala and Vijay, 2011).

An updated count of business incubators in the European Union is not available: according to a 2006 project sponsored by the European Commission and conducted by Paris Dauphine University – 'Economics of Business Incubation (Incunomics) Project' – the number is 936 (Goddard and Chouk, 2006).

There is a widespread belief that business incubators, especially if focused on technology, can give a boost to economic development, because of their potential for high-tech job creation and wealth-generation through business growth. Business incubation merits are widely described in practitioner publications (Tornatzky et al., 2003). The NBIA claims that in 2005 alone, North American incubators assisted more than 27,000 start-up companies that provided full-time employment for more than 100,000 workers and generated annual revenue of more than $17 billion (Knopp, 2007).

There is also evidence that for every $1 of estimated public operating subsidy provided, the incubator, clients and graduates of NBIA member incubators generate approximately $30 in local tax revenue alone (University of Michigan et al., 1997).

Many academics question the methodological soundness of these positive claims because they just measure intended effects and do not compare them with unintended ones (Bearse, 1998): they do not consider that some firmswould have grown and been funded even outside the incubator; some others moved into the incubator at a later stage of their growth, attracted by cheap office space, facilities or public funding.

As it has been very well clarified, suitable methods for analyzing the effectiveness of business incubators are the before-and-after comparison and the 'control-group' concept (Tamásy, 2007): effectiveness is understood as differences in regional and business performance after the use of business incubation (longitudinal analysis); the 'control-group' concept compares characteristics from a group of firms or regions taking advantage of business incubators and a control group not utilizing business incubator facilities (cross-sectional analysis), with both groups selected randomly or according to a set of criteria. Moreover 'using the logic of the NBIA, creating on average 20,000 jobs per year in a nation with a labour force of 147.4 million and an unemployed rate of 5.5% (in 2004) is not really a big push' (Tamásy, 2007: 469).

Some comprehensive and methodologically sound evaluations of business incubators cast serious doubts about their effectiveness in several countries – such as Germany (Sternberg et al., 1997), USA (Luger and Goldstein, 1991), UK (Monck et al., 1988) – and according to several different criteria, such as employment and wealth (Phan et al., 2005; Siegel et al., 2003), level of innovation (Colombo and Delmastro, 2002; Westhead, 1997), incidence of technology transfer (Phillips, 2002), performance (Peña, 2004; Westhead and Storey, 1994) and university-industry interaction (Rothaermel and Thursby, 2005a, 2005b).

As most of the business incubators across the world are non-profit organizations focused on economic development and supported by public money, they are demanded to be effective and deserving of taxpayers' money. Even in North America about 94% of operating business incubators are non-profit organizations focused on economic development and only 6% of North American incubators are for-profit entities, usually set up to obtain returns on shareholders investments (Knopp, 2007). About 31% of North American business incubators are sponsored by economic development organizations; 21% are

sponsored by government entities; 20% are sponsored by academic institutions; 8% are sponsored by other types of organizations; 8% of business incubators are 'hybrids' with more than one sponsor; 4% are sponsored by for-profit entities; 8% of incubators have no sponsor or host organization (Knopp, 2007).

Considering the relevance of the issue, and the amount public support and public funding, there is a need for a theoretical framework to decide when a business incubator should be established and how it should be managed. Our objective is limited to that large majority of publicly funded business incubators with a public goal.

The paper proceeds as follows. The next section presents the theoretical background as a conceptual framework. The conceptual framework we adopt has been developed through a previous systematic literature review (Tavoletti, 2012). The following section describes the methods used: the multiple-case research design, data collection and data analysis. Each of the following four paragraphs addresses empirically one of the four principles on which our conceptual framework is based. Then the results are presented and the final section discusses the results and draws conclusions.

2. Theoretical background

A systematic literature review has been carried out recently (Tavoletti, 2012) in order to systematize the available theoretical knowledge on business incubators focused on economic development and so improve their effectiveness. It builds specifically on a previous literature review (Hackett and Dilts, 2004a) and one attempt to draw a theoretical framework (Maital et al., 2008). Based on that systematic literature review, four main principles have been drafted, that should regulate the establishment and management of business incubators.

The first principle recommends to *Protect weak-but-promising ventures from the market and do not emulate the market in the incubator*. It deals with the issue of how to select and manage incubated ventures in order to reach the long run public goals of business incubation. It suggests that a business incubator must be a 'space protected from market forces' intended to promote the growth of

'weak-but promising' ventures, so that introducing market criteria inside the incubator (such as selecting the strongest ventures or the one that would pay higher rents) increases the static efficiency of the incubator but decreases its dynamic efficiency and moves it away from its goals: 'A system—any system, economic or other—that at every point of time fully utilizes its possibilities to the best advantage may yet in the long run be inferior to a system that does so at no given point of time, because the latter's failure to do so may be a condition for the level or speed of long run performance' (Schumpeter, 1942: 83). So that keeping market forces out of the incubator is not to the detriment of efficiency in general (it is to the detriment of static efficiency in the short run) but a precondition for innovation and dynamic efficiency: 'this ability to hold off market forces (at least temporarily) enables organizations to pursue innovative activities' (Ghoshal and Moran, 1996: 34).

The second principle states that *In business incubation it is critical to take the region into account: a) when choosing the incubator location; b) when selecting ventures; c) when coaching and supporting the incubated ventures*. It highlights that business incubation depends on the regional economy and must take regional opportunities and limits into account, starting from the location of a business incubator. A region needs to have a sufficiently large population and advanced economy in order to reach agglomeration economies and host a business incubator (Bee, 2004). It must also possess a strong university or other research-oriented organisation in the region (Rothaermel and Thursby, 2005a). Incubators should select ventures, whose solutions, technologies and services are relevant to the regional economy or can have an impact on it. These will allow firms within the incubator to develop a base of local clients which will help develop the regional economy. Coaching and supporting should help ventures dealing with the specific regional constraints.

The third principle states that *Business incubation is a process, option-driven and based on interdependent co-production relationships among incubatees, incubator management and external networked actors*. It deals with the nature of business incubation itself: what it is, how it works and how it should be organized. The concept of business incubation as an 'option driven process' (Hackett and Dilts, 2004b), based on 'interdependent co-production relationships' (Rice, 2002) among 'networked actors' (Bøllingtoft and Ulhøi, 2005) is the most suitable to catch the

intangibility, uncertainty and relational nature of the phenomenon. It is also the most suited to avoid the 'real estate drift' that characterizes many business incubators (Tamàsy, 2007). The most relevant implication of the principle is that real estate investments and tangible infrastructures are not an essential ingredient of business incubation. Business incubation performance is considered as a function of the incubator's ability to create options through selection, monitoring, counseling, allocation of resources and containment of terminal option failure (Hackett and Dilts, 2004b).

The fourth principle recommend to *Take advantage of a virtual incubation approach to bring publicly supported business incubation into regions that cannot support a business incubator*. It suggests a new approach in order to combine the importance of public funds in business incubation and avoid the waste of public money that has characterized 'real estate business incubation'. At one extreme, in fact, it may be suggested 'technology-oriented business incubators should be run as private organisations without public funding' (Tamàsy, 2007: 469), in order to avoid any possible waste of public money but it seems unlikely that a 'weak-but-promising' new venture will survive in a poorly endowed region if incubator protection and assistance is not provided in its infancy (Carayannis and von Zedtwitz, 2005). The 'virtual incubator' approach can combine public support for 'weak-but-promising' ventures in less endowed regions and avoid expensive real estate investments in regions that lack the resources to support a business incubator.

The definition of these four principles has two main limits.

The first one is linked to the typical technicalities of the systematic literature review from which they have been derived. The review has been limited to: (1) scholarly peer reviewed journals that can be retrieved in database; (2) and a limited set of keywords (Tavoletti, 2012). The choice is justified by the rigor that both systematic literature review and scholarly peer reviewed journals provide.

The second limit of the four principles is related to how they were conceived and drafted. They significantly extend, integrate and modify principles that have already been identified (Maital et al., 2008) or, at least, they use those principles as a starting point, so that they are not a jump into the unknown but

a leap forward. Nonetheless, the link between systematic literature review results and identification and drafting of principles is still very subjective.

Given the limitations here above, the present contribution aims at testing the four general principles above presented by looking at the case of the European Space Agency (ESA) business incubators (ESA BICs from now on).

3. Methods

3.1. Research design and setting

We used an empirical, multiple-case research design (Eisenhardt, 1989) to test our principles, where each business incubator in ESA is an observation unit or 'a case'.

We chose ESA because it represents one of the most respected scientific institutions in Europe hosting several business incubators in different European countries: in that sense it is a unique opportunity to compare the effectiveness of the same incubating institution across different national contexts and partially neutralize the influence of the general environment (Manimala and Vijay, 2011).

ESA BICs are one of the three main lines of action pursued by ESA's Technology Transfer Programme Office (TTPO): 1) Technology transfer services and applications; 2) Support to business generation through incubation; 3) investment/financing. TTPO was created in 1990 to support the European space industry in transferring space technologies to other commercial applications in order to strengthen the European space industry and European (non-space) industries which may benefit from using space technologies. So that the ultimate goal is economic development in Europe in order to benefit European citizens, TTPO is funded by ESA, whose activities are funded by all Member States on a scale based on their Gross Domestic Product.

ESA's business incubators are a success story among publicly funded incubators with an economic development purpose. According to the latest reports, ESA BICs have a documented positive impact on incubatees, for example accelerating the 'time to market' and 'organisational development' or in-

creasing survival rate: it is reported that 81% of incubatees are still operating, 6% have been absorbed (acquired by another company), and 13% have closed their operations (Euroconsult, 2010). There is a high increase in the number of companies which consider themselves to be competitive on entering the incubator (13%) and on leaving it (55%). Overall, the incubator programme has had a positive effect on the business model of incubatees, with 81% of incubatees reporting that their business model benefited and improved as a result of the programme.

ESA BICs and their technology transfer programme have been benchmarked recently with other incubators, such as GRACE (UK), MsET (USA), IPF Ottawa (Canada) and UMIC (UK) and other transfer programmes, such as NASA (USA), CSA (Canada), CERN (France), with positive results (Euroconsult, 2010), so that ESA BICs represent a best practice for other incubators that are public funded and have an economic development objective. For these reasons we expect that ESA's business incubators are exceptional 'laboratories' (Yin, 2009) for the objectives of our research.

The objective of our empirical test is to reach an 'analytical generalization' (Yin, 2009) of our four principles – it is not to reach a 'statistical generalization' (Yin, 2009). In that sense the single ESA's business incubators cases are not intended as a sample out of a population but as especially endowed 'laboratories'. Their main quality and the reason why we have chosen them is that the same ESA's successful business incubation framework is applied across different national and regional environments. That provides a unique opportunity to test the internal validity and construction validity of our principles, neutralizing the influence of the hosting country. Reaching a 'statistical generalization' of our principles, regarding any larger population, is not an objective of a case study research approach.

There are six ESA business incubation centres. They are located in Noordwijk (the Netherlands), Darmstadt (Germany, Frankfurt), Rome (Italy), Oberpfaffenhofen (Germany, Munich), Harwell (UK, Oxford), and Redu (Belgium), the last two having opened in 2011.

We began with an in-depth analysis of each case through the lens of our four principles. We analyzed each case independently to form our own view of each case. The goal was to verify the four principles in each case. We then

turned to cross-case analysis, in which the insights that emerged from each case were compared with those from other cases to identify consistent regularity. Comparisons were initially made between varied pairs of cases. Discrepancies and agreements between principles and data were noted and investigated further by revisiting the data. We followed an iterative process of cycling among drafted principles, data, and literature to refine our findings, refine those principles, and clarify our contributions.

3.2. Data collection sources

We used several data sources. Data were collected from: (a) business incubators' websites, corporate material and archives; (b) direct semi-structured interviews based on a questionnaire for each ESA BIC manager; (c) field visits to incubators and observations; (d) secondary sources, such as business publications; (e) informal follow-ups with e-mails and phone calls.

Data collected from the different sources were triangulated in order to assure reliability. We want to emphasize that each incubator has a rich website (ESA, 2011) with detailed information about the incubatees and graduated firms and, most important of all, being all the websites coordinated by ESINET (European Space Incubators Network), they were comparable. In fact, in July 2002, ESINET was launched by four partners (ESA, EBN, WSL and D'Appolonia), as an experimental platform for the transfer of knowledge and technologies, and today it has become the leading network of incubators focusing on space-related technologies. Since 2009, EBN (European Business and Innovation Centre Network) has managed ESINET. EBN is the leading pan-European non-governmental network, created 25 years ago by the European Commission and industry leaders, incorporating several hundreds of business and innovation centers and innovation-based incubators.

A main source of information was an unpublished final report of Euroconsult and the Conference Board of Canada (2010) for the European Space Agency, which assessed the economic impact of the Technology Transfer Programme. The report compares four ESA incubators: the one at the European Space Research and Technology Centre (ESTEC) in Noordwijk, The Netherlands, the one at the European Space Operations Centre (ESOC) in

Darmstadt, Germany, the one at the European Centre for Earth Observation (ESRIN) in Frascati, Italy, and the one in Oberpfaffenhofen, Germany, managed by Anwendungszentrum GmbH Oberfpaffenhofen (AZO). The report is very rich as it collects and analyses data about internal management, incubation processes, efficiency and efficacy of the four incubators, and compares them with four selected external incubators, in order to assess and benchmark their overall performance.

3.3. Data analysis

The incubators are very different from one another: those in Redu and Harwell started their operations in 2011 and are still looking for entrepreneurs and start-up companies. The others have already reported results about staff and funding (Table 1).

ESA's incubatees have a broad spectrum of backgrounds, ranging from numerous economic sectors and attracting different levels of financing. Most of them have a business to business market positioning, have been financed by personal resources, such as time and cash, or a parent company, and after one year of incubation on average, they are still in operation. Variation depends on the starting point of the companies, whether they are start-ups or pre-existing companies. Their starting point determines the financing profile.

ESA BICs are effective in increasing ventures' competitiveness as incubatees are more competitive after graduating from the incubator: 60% of entering companies are considered non-competitive in their targets markets at inception (the percentage is closely aligned to those companies which are considered start-ups or spin-offs). However, on leaving the incubator, 55% consider themselves to be competitive at the time (Euroconsult, 2010).

We began by writing descriptive cases for each business incubator. The cases included data regarding both the four drafted principles and the main issues regarding the management of each incubator. We then began the cross-case analysis, looking for similarities and differences regarding both the four principles and the main issues, based on the data that it was possible to identify and collect in each incubator.

We then engaged in repeated iterations among data, literature and theory until we had a strong match between theory and data (Yin, 2009). The result presented in the following sections describe the "pattern matching" (Yin, 2009) between the four principles on business incubators (Tavoletti, 2012) and the ESA BIC case evidences.

4. Advocating purpose in business incubation as opposed to market

The first principle we want to verify in ESA BICs is related to the dilemma of relying on market mechanisms or 'purpose' in selecting ventures and managing the incubator. It states what follows.

Principle 1- *Protect weak-but-promising ventures from the market and do not emulate the market in the incubator.*

According to transaction cost economics (TCE), markets and firms are important because both play important roles in the development of capitalist economies: transactional circumstances make one more effective than the other but firms are just another type of 'contractual instrument, a continuation of market relations, by other means' (Williamson, 1991: 162).

According to TCE, markets and firms apply the same logic and each kind of transaction, depending on the circumstances, is best performed in markets or organizations. On the other hand, it might be argued that markets and organizations are not a continuum but operate with entirely different logics (Goshal and Moran, 1996).

Markets follow a logic of 'autonomous adaptation' in the short term with indifference to any possible outcome: the availability of prices and the focus on static efficiency are its main distinctive features. On the other hand, organizations base their logic on 'purpose adaptation', based on cooperation and coordination.

The main advantage of 'purpose adaptation', over the undirected 'autonomous adaptation' of markets, is that it works when prices are not available, is

able to pursue dynamic efficiency, and influences the preferences and behaviours of actors as part of a community with a purpose.

If a transactional approach is adopted, where no distinction is made between the logic of markets and organizations, it might be suggested that office space, meeting rooms, facilities or use of laboratories inside incubators are best allocated through a price-based market mechanism, whenever circumstances allow doing so. It might be suggested that the selection of incubatees should be based on their ability to pay the higher rents.

The problem with such an approach, in business incubation and innovation management in general, is that a highly efficient state that is preceded by the occurrence of relatively inefficient states may not be reached, regardless of how efficient the future state is: applications of weak-but-promising new incubatees would be rejected to the benefit of profitable ventures in the short term, regardless of the potential of the first ones.

On that premise we have tried to verify our first principle in ESA's business incubators. ESA's business incubators stand apart in respect to other incubators (Corinne, Adkins, Wolfe and Lapan, 2010) as they provide direct funding to their incubatees and do not charge for most of their services.

ESA gives each incubatee €50,000 in funding (50% in some business incubators is provided by a local supporting institution), office space (for a small rent or free of charge depending from each ESA BIC), up to 80 hours of technical support from ESA staff and facilities, software and hardware support, and the ability to include mentioning the ESA BIC in their communication. In that sense ESA can be considered to be much more supportive than other incubators which do not provide initial financial support and do not provide additional free-of-charge consulting services.

As ESA does not charge for services and does not charge significantly for rents, no market mechanisms are in place either in the selection process or during the incubating process. The selection process is a very structured one and it aims to identify weak-but-promising ventures with no regard to their ability to pay for services or rents, or their general potential to support the incubator financially. The application form is available on the web and it is the first formal step to initiate the selection process. Sometimes applications are just enough to

cover the available positions as the number of ventures operating in innovative space technology is not numerous.

One incubator manager said that the main criterion in selecting ventures is 'team composition': at least one founder able to be the CEO, one expert in marketing and one with a technical background. In our interviews with business incubators' managers, being 'commercially promising' ranks second, 'scientific credentials' ranks third, while 'ability to attract sponsors' is not significant and the 'ability to pay the rent' is irrelevant.

ESA BICs' evaluation forms for applicants assign a 0-100 score to the following five criteria: *1) Background and experience (weight 30):* a) team composition and ownership structure; b) support entities; c) vision; *2) Business case (weight 20):* a) business idea; b) market; c) business model and finance; *3) Technology/service (weight 20):* a) technical feasibility of the technology/service to be developed; b) non-space benefit; c) research and development strategy; d) intellectual property strategy; *4) Activity proposal (weight 20):* a) milestones/cost planning; b) work breakdown; c) management; d) ESA's investment opportunity; *5) Formal aspects (weight 10):* a) compliance with ESA general and specific requirements; b) acceptance of tender conditions.

The importance of protecting 'weak-but-promising' ventures is especially significant in the space industry, as space applications are developed for a very limited number of clients in order to meet the unique requirements of the space environment, so that ventures are very small in size and, despite having cutting edge technology that could provide huge benefits to European citizens, they do not have the resources to dedicate significant marketing efforts to expand their business outside the space sector. Some of these ventures could not have come into existence without ESA BICs.

One significant example is 'Mathcomp Medical Systems' that was hosted by the ESA BIC at ESTEC from August 2003 to December 2006. The ventures developed a new non-invasive treatment option for cancer that is more patient-friendly and without the negative side effects associated with chemotherapy and radiation. Benefits for the patient include less discomfort and little risk of disfigurement, and it is a cost saving for the public health care system because hospitalization is not required.

The technology combines a magnetic resonance imaging technique, used to locate and diagnose cancerous tissue, and a high-intensity focused ultrasound, used to 'burn' malignant cells. Combining the two technologies, through miniaturization and integration of microelectronic and mechanical elements, requires high competences that are typical of space missions and it was possible to develop the new technology thanks to ESTEC's laboratories. The ESA BIC at ESTEC was decisive in allowing the weak-but-promising venture to bring the development from a theoretical concept to an initial design and to arrange workshops with ESA engineers and experts from the medical world. In addition, the incubator assisted in establishing business contacts with healthcare organizations and companies, hospitals and private clinics, and private and institutional investors for the further development of the technology.

In general, the support services recorded by ESA BICs to the incubatees are the following: €50,000 of seed money; office space and shared facilities; access to other sources of finance; access to engineering support from ESA experts; access to ESA resources such as test facilities, laboratories and workshops; "hands-on" assistance; business development support and advice; access to strategic partnerships and networking. The recent creation, in March 2010, of a dedicated venture capital fund towards space-based applications, the Open Sky Technologies Fund (OSTF), managed by Triangle Venture Capital Group on ESA's behalf, goes in the direction of increasing access to venture capital in a European market that is lagging behind in this area.

It is possible to conclude that no market mechanism is in place in ESA BICs either in the selection process or during the incubating process. On the other hand, a very well identified purpose is in place. For example, the main mission of the ESA Technology Transfer Programme (TTP), which includes the ESA BICs, is 'to facilitate the use of space technology and space systems for non-space applications and to further demonstrate the benefit of the European Space Programme to the European citizens' (ESA, 2011).

The Technology Transfer Programme Office (TTPO) is responsible for defining the overall approach and strategy for the transfer of space technologies and systems, including both the incubation of start-up companies and its funding. Based on these elements, we consider our first principle to be verified.

5. Advocating the regional dimension of business incubation

The second principle that we want to verify in ESA BICs is related to the regional dimension.

Principle 2 – *In business incubation it is critical to take the region into account: a) when choosing the incubator location; b) when selecting ventures; c) when coaching and supporting the incubated ventures.*

Regions play a very significant role. In ESA BIC Noordwijk (ESTEC) the original ESA incubator programme was create in collaboration with the Government. However, the new incubator programme launched in April 2010 has seen ESA expand the programme to include multiple partners in the region. As such, the new Dutch incubation model has been renamed 'ESA BIC Noordwijk' and in addition to ESA and the Dutch government (National Space Office and the Ministry of Economic Affairs), a regional bank has been added to the matrix which will complement the financial contribution awarded to start-ups upon entering the programme.

Specifically, the regional bank will provide loans in addition to ESA's funding. Furthermore, the management of the incubator will also change from a space-agency centric approach to a devolved approach in which the market and the local region will have a more significant role.

ESA BIC Oberpfaffenhofen (AZO) is a result of collaboration between ESA, the State of Bavaria, the German Aerospace Center (DLR), as well as the local regional bank of Kreissparkasse München Starnberg. As there is no immediate ESA centre in Bavaria, DLR is substituting ESA technical support. Created in August 2009, ESA BIC Oberpfaffenhofen is supported by the State of Bavaria and, as is the case with BIC Noordwijk, a local bank provides a loan programme for admitted incubatees.

ESA BIC Darmstadt (ESOC) is currently in discussions with the regional Hessen government to increase its share of co-funding the BIC. However, this lack of funding has impaired ESA BIC Darmstadt's ability to offer the same level and quality of incubation services offered in ESTEC and AZO.

In ESA BIC Italy (ESRIN), as is the case with BIC Darmstadt, there is a lack of co-funding from regional actors which impairs ESA BIC Italy's ability to offer services of an equal quality to ESTEC and AZO. However, there is a cooperation with the Business Innovation Center of Lazio Region (BIC Lazio) that hosts ESA BIC Italy.

Regional financial support to incubators is not always present but the best results are in BICs that are supported by regional actors. In any case, regional financial support to incubatees is always present: in addition to ESA's €50,000 contract on acceptance into the incubator programme, all of the incubatees received an additional investment from either public or private sources; the majority of companies have received in the region of €50,000 to €200,000 in additional investment; a few notable exceptions received over €500,000.

ESA takes the region into account when locating its incubators as all of them are located in very research-intensive areas with no exception: 1) ESA BIC Noordwijk is located at the European Space Research and Technology Centre (ESTEC), the largest ESA site and the scientific and technical heart of ESA, with more than 2,000 specialists; 2) ESA BIC Darmstadt is located close to the European Space Operations Centre, ESOC, ESA's navigation office and its main research site for Galileo-related navigation applications; 3) ESA BIC Rome is located at the European Space Research Institute (ESRIN), ESA's centre for Earth Observation (EO) activities, where EO satellites provide data which are used by scientists, institutions and industry to support the management of natural resources and the monitoring of the environment; 4) ESA BIC Oberpfaffenhofen is located at the new Aerospace Technology Park Oberpfaffenhofen (ASTO), close to the German Aerospace Center (DLR) site, with a strong research focus on robotics, mechatronics, communications, and navigation; 5) ESA BIC Harwell is located at Harwell, Oxford, the most vibrant research community for science, technology and innovation in Europe, with more than 4,500 specialist, focusing on a range of commercial applications including healthcare, medical devices, space, detector systems, computing, green enterprise and new materials; 6) ESA BIC Redu is located at the ESA Redu ground station at the Galaxia Business Park in Transinne-Libin, where, as a natural consequence of the variety of satellites operated by ESA from Redu, the incubator is aimed at companies specialized in telecommunica-

tions, Earth observation, navigation systems and integrated applications. All the locations of ESA BICs make leverage on local competences and a very research-intensive area and no attempt has been made to establish an ESA BIC without such circumstances.

ESA takes the region into account when selecting ventures as, through a very structured application procedure, they are allocated to its different incubators depending on the best possible matching between incubatees' need and BICs competences.

ESA BIC Rome, for example, based on ESRIN research competences on Earth Observation and related data collection, selects ventures that leverage on such competences: such as 'B-Open solutions', that operates on geospatial data management and related data standardization and interoperability, or 'NHAZCA', that monitors geological risks in constructions and infrastructures, or 'Raptech', that develops wireless sensors network for monitoring of photovoltaic systems, or 'Blu-Thread', that develops navigation solutions for the nautical sector based on navigation satellite technology.

ESA BIC Darmstadt, based on ESOC research competences in satellite navigation, selects ventures that most leverage on Galileo satellite navigation systems: such as 'SOCRATEC Telematic', that operates on precise positioning of airfreight; 'PosiTim', that operates on high precision positioning; 'IPAYMO', that develops secure mobile payment solutions based on establishing if the place of the transaction matches with the position of an electronic mobile device associated with the authorized person at the time of the transaction; or 'flinc', that works on clever ride sharing through a technology assisted smart route matching along a driver's route.

ESA BIC Oberpfaffenhofen based at the Aerospace Technology Park Oberpfaffenhofen (ASTO), close to the German Aerospace Center (DLR) site, selects ventures that focus on robotics, mechatronics, communications, and navigation: such as 'avionTeck' that develops a system to assist general aviation pilots in landing safely on small and poorly equipped fields under bad weather and low visibility conditions; 'TANKERING.com', that works on advanced flight performance optimization methods to reduce aircraft fuel consumption and cost; 'tiramizoo' that develops an online booking platform for local same-day couriers, with route planners for faster delivery; or 'ViaLight Communica-

tions', that develop laser data transmission between unmanned aerial vehicles, aircraft and high altitude platforms, and the ground.

ESA BIC Noordwijk is the scientific and technical heart of ESA and being the largest and main ESA BIC to be established in 2003, selects ventures with a broad spectrum, dividing them into the following groups: entertainment, environment, health, industry, life style, localization based services, software solutions, telecommunication and life science. The main space specializations of the centre and its more than 2,000 researchers are science missions, human spaceflight, exploration, telecommunications, satellite navigation and Earth observation, as well as technology development. Some of the most significant incubatees include: 'HISTAR Solutions', that developed a early-warning malaria system using Earth observation satellites and ground sensors; 'Mathcomp Medical Systems', that developed an ultrasound breast cancer treatment device; and 'Selene Baby Care Innovations', that developed a preventive monitor for Sudden Infant Death Syndrome, called 'BabyGuard'.

Other matchings are determined by personal competences and contacts in the area where the business incubator is located rather than any specific specialization in the area or the business incubator itself.

It is worth noting that the vast majority of incubatees concentrate on their local market, often related to the localisation of the ESA incubator (Euroconsult, 2010) so that, despite ESA being an international player, its incubatees are very regionally embedded.

The only relevant exception might be ESA BIC Harwell that considers itself as entirely focused on national economic development and makes no significant reference to regional development in its communication. That might be linked to the poor state of regional development policies in the UK. However, despite the business incubator's communications and statements, ESA BIC Harwell is very linked to and embedded in the local space cluster and it is no exception, in our view, to the regional dimension of business incubation. In fact, the incubator location has been selected because of the regional space cluster in Harwell, where ventures are selected based on the matching between their needs and local competences, coaching and incubation leverages on the local space cluster. Based on these elements, we consider our second principle to be verified.

6. Advocating business incubation as an option-driven and network-based process for the co-production of knowledge

The third principle that we want to verify in ESA BICs is related to the incubation process, its nature and main focus.

Principle 3 – *Business incubation is a process, option-driven and based on interdependent co-production relationships among incubatees, incubator management and external networked actors.*

Hackett and Dilts (2004b) advanced a real option-driven incubation process model in which 'business incubation performance' (measured in terms of incubatee growth and financial performance at the time of incubator exit) depends on three variables: 'selection performance' (refers to the degree to which the incubator behaves like an 'ideal type' venture capitalist when selecting emerging organizations for admission to the incubator); 'monitoring and business assistance intensity' (refers to the degree to which the incubator helps incubatees, time intensity of assistance provided and comprehensiveness); and 'resource munificence' (refers to the abundance of incubator resources: availability, quality and utilization).

A real options perspective (McGrath, 1999; Mitchell and Hamilton, 1988; Rosenberger, 2003) views incubatee selection as the creation of an option, and subsequent resource infusions, and monitoring and assistance, as option exercises.

The model suggests the following propositions/hypotheses: (1) The options lens is the most appropriate theoretical approach for developing a theory of business incubation that predicts and explains business incubation outcomes; (2) Business incubation performance is positively related to selection performance; (3) Business incubation performance is positively related to intensity of monitoring and business assistance efforts; and (4) Business incubation performance is positively related to resource munificence.

The theory considers business incubation as a 'process' and is 'option-driven' because business incubation performance is a function of the incubator's ability to 'create options through the selection of weak-but-promising in-

termediate potential firms for admission to the incubator, and to exercise those options through monitoring and counselling, and the infusion of resources while containing the cost of potential terminal option failure' (Hackett and Dilts, 2004b: 48).

A real option perspective is especially opposed to a resource-based view of business incubation that explains positive incubation outcomes on the basis of available resources, such as funds, space, experience of entrepreneurs and management, pool of high quality innovations and pool of industry contacts. A resource-based view of business incubation can be faulted for not taking into account issues of process (Foss, 1998) and other rivalry theories, such as dynamic capability theories, agency theories, institutional theory, structuration theory, scaffolding theories, behavioural theories and economics theories which have been shown to be less effective in explaining business incubation than a real option perspective (Hackett and Dilts, 2004b).

A process of co-production of knowledge occurs in business incubation, through counselling and networking in a 'dyadic relationship between incubator managers (and by extension the incubator's know-how network) and incubator company entrepreneurs' (Rice, 2002: 185)

Physical infrastructures, office space and laboratories pay a minimal role. On the other hand, ESA's clustering environment and branding component have valuable impacts on nurturing partnerships, and attracting new clients and investors. The ESA's brand in particular has helped to validate companies in the market place making them more attractive for business contacts. It is considered that the branding aspect of ESA plays a key role in backing the companies' business, particularly for clients and potential investors. In addition, prior to their incubation, companies (particularly start-ups) have limited access to potential clients and investors which explains why this is a key expectation of their incubation. In this regard, leveraging on the ESA brand and utilizing ESA to provide access to a greater number of companies and individuals across sectors is paramount. Indeed, a significant number of incubatees felt they would not otherwise have been able to reach these potential customers and investors (Euroconsult, 2010).

An incubator manager refers effectively to ESA BICs as the first 'franchising incubator' and, indeed, an international franchising, that makes leverage on

the ESA brand, centralized supra-national know-how and a great autonomy at both the business incubator level and national level.

The networking among incubatees is very significant and 91% consider their incubation to have accelerated their organisations' development and processes. The interaction is often reported to happen on a non-formal basis (e.g. from their proximity rather than through an established framework), in which incubatees could share lessons learned and business experiences. There is a social clustering effect, provided by ESA's campus-like environment while no particularly structured process is in place to stimulate networking among incubatees. The social clustering effect provided by ESA's campus-like environment benefitted the majority of incubatees, as 41% were greatly impacted, and 34% had 'some impact', while 25% reported 'limited impact' (Euroconsult, 2010). One incubator manager said that 'incubatees' days', conferences and fairs were organized regularly 'to favour interactions among incubatees and external networks'. Incubatees appreciate such efforts as they list 'promotional' and 'networking opportunities' as the most important services provided by the business incubator, after 'financial support' (Euroconsult, 2010). Companies benefit from their products being displayed at trade shows with ESA providing booths at technology trade fairs, feature articles in ESA brochures, and ESA website promotions. ESA's 'Investment Forum', 'Trade Fairs' and promotional services offered by the 'Technology Transfer Programme' are considered by incubatees as valuable business opportunities but several companies felt that a greater effort could be made in order to match companies with potential investors at the investment forum. While trade fairs were described as ideal venues for promotional networking purposes, they were also criticized as being difficult environments in which to close business deals (Euroconsult, 2010).

As with promotional support, 'networking support' is considered to be a main benefit with 90% either fully or somewhat satisfied with the support provided. Participants continued to collaborate with several ESA partners, and in some instances, formed alliances with outside firms or labs due to ESA's programme. Organised tours, lectures, presentations, group e-mails, invitations to conferences, and importantly the cluster effect brought about by the incubation process, are other processes by which companies and individuals disseminated ideas and built networks, as well as very informal networking practices in

informal environments such as ESTEC's cafeteria which contributed to a heightened sense of social and professional integration with other entities involved in the incubator programme (Euroconsult, 2010).

Mergers of incubatees and incubatees' teams were also reported as very significant in the co-creation of knowledge.

In addition ESA BICs help incubating ventures to find the appropriate competences inside ESA and favour interactions among ESA's specialists and incubatees, allowing them to receive free consulting from ESA whenever it is needed. ESA BICs' incubation programme provides 80 hours of free of charge technical assistance to each incubatee on a case by case and on an incubator by incubator basis.

A weak point of ESA BICs' incubation process is on financing as they are successful in providing a business environment but lack concrete processes and tools to support companies in implementing their financing. According to candidates' expectations, training sessions and better access to capital should be provided (Euroconsult, 2010). Nonetheless, ESA BICs provide some funding (€50,000) to new ventures and that makes them different from other incubators and less focused on fund raising. Indeed, the vast majority of companies express great satisfaction with the financial support provided by the grant offered at the start of the incubation; a small minority that was dissatisfied with the level of financial support was of the opinion that the amount of the grant was insufficient (Euroconsult, 2010). In some incubators the financial burden of the grant is shared between ESA and a local institution.

According to the options-driven theory of business incubation, performance may be considered as a function of the incubator's ability to "create options through the selection of weak-but-promising intermediate potential firms for admission to the incubator, and to exercise those options through monitoring and counseling, and the infusion of resources while containing the cost of potential terminal option failure" (Hackett and Dilts, 2004b: 48). Based on the analysis of ESA BIC's cases, we can conclude that business incubation in ESA is indeed a process, option-driven and based on interdependent co-production relationships among incubatees, incubator management and externally networked actors.

7. Advocating the need for using virtual incubation in order to reduce public spending

The fourth principle that we want to verify in ESA BICs is related to public support and possible ways to reduce its impact.

Principle 4 – *Take advantage of a virtual incubation approach to bring publicly supported business incubation into regions that cannot support a business incubator.*

As we have already highlighted, about 94% of operating business incubators in North America are non-profit organizations focused on economic development and only 6% of them are for-profit entities, usually set up to obtain returns on shareholders investments (Knopp, 2007). As far as the source of funding is concerned, 31% are sponsored by economic development organizations; 21% by government entities; 20% by academic institutions; 8% by other types of organizations; 8% of business incubators are 'hybrids' with more than one sponsor; 4% are sponsored by for-profit entities; 8% of incubators have no sponsor or host organization (Knopp, 2007).

The public nature of business incubation is no exception in Europe. According to a survey of European business incubators, 48% of BIs reported that they are sponsored entirely with public funds, 38% receive mixed sponsorship and 12% are financed from private sources. 'These figures highlight the widespread public support for BIs as an instrument of entrepreneurial policy' (Goddard and Chouk, 2006: 4) and 'almost all BIs in Europe are assisting start-ups to apply for government aid' (p. 7), so that public support has a central role in funding both business incubators and incubatees. It is worth noting that in Europe public financial support is needed to overcome financing shortages at the debt level more than at the equity level, as the percentage of tenant firms that confronted financing shortages, by source, are: 38% for micro-credits; 32% for revolving loans; 37% for debt capital; 33% for loan guarantees; 31% for venture capital; 27% for corporate finance; and 22% for public equity capital (Goddard and Chouk, 2006). The most widespread sources of public support in Europe, as a percentage of responding BIs' managers, are regional development agencies (59%) and national programmes for SMEs (64%) and in-

novative firms (58%), followed closely by support from local authorities (45%) and EU programmes for SMEs (41%). In addition, 25% of BIs report that EU programmes for innovative firms, tax credits and unemployment benefits are useful for their tenant firms (Goddard and Chouk, 2006).

We see a connection between the important role of public spending in business incubation, the increasing public financial constraints and the role of virtual incubation. Virtual incubation literature has been focusing on knowledge brokering and the market-space for ideas (Gans and Stern, 2003), on the role of immigrants as knowledge brokers (Greene and Butler, 1996), on the flows of knowledge in the global software industry (Nowak and Grantham, 2000), and on the potential of virtual incubation to bridge and leverage the diverse international divides (Carayannis and von Zedtwitz, 2005), but as far as we know, no attempt has been made to suggest that the tool could be used to review public spending on business incubation, re-focusing it on the processes more than on non-core real estate investments.

As we have already reported in the previous sections, ESA BICs are located in very research-intensive and economically dynamic areas and benefit from a very outstanding reputation. Nonetheless, public funding plays a central role. One incubator manager reported that 65% of revenues are 'public financial contributions' (regional and municipal government) and 30% are from ESA, while just 5% derives from services to external entities different from incubatees.

In all the ESA BICs for which we have data, funding from local and regional government and from ESA add up to at least 70% of all the revenues and in most of the cases they are around 80%. Sometimes a local bank is providing financial support but revenues from incubatees are basically non-existent (see table 1). On the other hand, incubatees receive €50,000 when admitted to the incubator. ESA BICs' experience confirms that, even in very strong institutions, business incubation with a regional development purpose requires substantial public funding. Incubatees list 'financial support' as the most important service provided by the business incubator, followed by 'promotional' and 'networking opportunities' (Euroconsult, 2010). It is to be noted that 'financial support' refers to the grant offered when entering the programme, and not to

the ability to attract third party financing which is often cited as a blockage by respondents, so that a public funding of the incubator is a precondition.

One incubator manager reported that 20% of incubatees were located outside the incubator facilities and that long distance coaching was in place. Nonetheless, the objective is to reduce the number of incubatees located outside the incubator in order to facilitate both networking and monitoring. ESA BICs are, in fact, neither located in less endowed regions nor are weak institutions, so there is no need to establish a virtual incubation but, on the other hand, it would be fruitful to locate willing incubatees in ESA facilities in order to improve monitoring and networking.

Nonetheless ESA BICs are able to carry on virtual business incubation with a number of incubatees. Virtual incubation is interesting for ESA BICs because they expand their reach through virtual incubation without opening ESA BICs in less endowed regions and far away from ESA's research centres, where incubators could be far less effective. This is the strategy they have been conducting until now, locating business incubators only in very research-intensive ESA centres, attracting incubatees in these centres or virtually incubating them if they were unwilling or unable to relocate themselves.

A very successful case of a virtual incubatee is 'Thruvision Systems Ltd' from the UK, which has not been physically incubated in an ESA BIC, but has been supported by ESA/ESTEC, both financially and technically, in a particular case of virtual incubation. Thruvision Systems works in security and defence imaging using terahertz and is one of the world's most advanced concealed object detection system companies. The company produces a portable people screening solution. With a detection distance of between 3m and 10m it can screen multiple people on the move, detecting metals, plastics, ceramics, liquids, gels and powders in real time. It is ideal for passenger screening (in airports, railway stations and undergrounds), visitor screening for high-profile sites and employee screening for loss prevention. It is a successful example of space technology transfer through a virtual incubation programme, to the general benefit of European citizens.

Actually, the ESA Technology Transfer Programme (TTP), which includes ESA BICs, has been a big 'virtual' business incubation process since its inception in 1990. Therefore, the ESA Technology Transfer Programme Office

(TTPO), which coordinates TTP, has put in place a new line of action with ESA BICs (ESTEC, in 2003; ESRIN, in 2005; ESOC in 2006; AZO in 2009; Harwell and Redu in 2011) just in order to progress beyond the 'virtual' incubation process and support the creation of physical business incubation centres. But both the TTPs still practice virtual business incubation and ESA BICs make use of virtual incubation.

Since its creation, the TTPO has successfully transferred 241 space technologies, (excluding BICs' technologies) under the auspices of ESA's Technology Transfer Programme (TTP), which has resulted in the creation of many virtually incubated new start-up companies. Between February 2009 and March 2010, the broker network successfully administered the transfer of 14 space technologies and 14 new space spin-off companies have been created in the same period with a total transfer value estimated to be €6.7m (Euroconsult, 2010). One among the many examples of such virtually incubated spin-off companies is 'Radiation Systems Ltd', established by a researcher in the Astronomy Group at Southampton University. It was set up to commercialize a patented high resolution gamma-ray spectroscopic detector invented by the researcher and his colleagues in the area of high-energy astrophysics. The technology had significant potential for application in cancer diagnosis, particularly in the detection of breast cancer and also the resulting spread of cancer cells throughout the lymphatic system. Radiation Systems has been supported by the ESA TTP and co-funding for a market research/feasibility study has been made available by ESA. Despite physical business incubation being the main specificity of ESA BICs inside the TTP, ESA BICs' managers stress the importance of locating ventures inside business incubators, in order to leverage the campus-like atmosphere. They are less in favour of long distance incubation and virtual incubation, and the tendency is to reduce the number of incubatees that are located outside the incubator. That confirms that long distance and virtual incubation should only be used when it is not possible to establish a traditional incubator, such as in poorly endowed regions. That would allow weak-but-promising ventures, located in less research-intensive areas and unable to move, to connect with coaching incubators located in the most research-intensive areas. Based on these elements, we consider our fourth principle to be verified.

8. Conclusions

In the end, we can claim that the first principle is extensively applied in ESA's business incubators and that no significant market mechanism is in place in its incubators. The cross-case analysis suggests that the more 'purpose-oriented' – as opposed to price-oriented (Ghoshal and Moran, 1996) – the incubator, the better its results.

The second principle is also applied as there is clear evidence that ESA's business incubators are established and operate taking the region and the local economy fully into account; looking at successful cases, such behaviour seems to support innovation in ESA's incubators. No clear 'control-group' was available as all ESA BICs are located in very endowed and research-intensive places but the ESA BICs that are less supported by local institutions are also those with inferior results.

The third principle is also supported by the experience in ESA as the real estate investment pays a very minor role, and business incubation as a process, option-driven, relational and network-based was tangible: ESA BICs leverage on the extensive ESA's international network and may well be depicted as an 'international franchising'.

The fourth principle is supported, as public funding has a central role in ESA and virtual incubation is used by ESA BICs in order to reach ventures that are unable or unwilling to relocate themselves in the incubators and the general strategy is to locate ESA BICs only in very research-intensive areas able to support the development of incubators and incubatees.

In addition, the cross-national comparison among ESA's incubators (and so incubators from the same institution in different nations) revealed what has already been observed in different contexts: as far as business incubation effectiveness is concerned, the conditions in the general environment (such as the support of local institutions or the competences in the region) are much more important than those in the task environment or in the incubator itself (Manimala and Vijay, 2011). The main recommendation for the policy maker is to focus on the general conditions in the environment that favour innovative entrepreneurship and not on an elusive successful recipe of business incubation management.

The four principles that have been tested in this paper are not intended as a recipe for business incubation management but as a general framework in order to avoid major mistakes when establishing and managing business incubators as a policy tool for economic development. In that sense they are the result of an exercise of 'theory building' from case study research (Eisenhardt, 1989).

The four principles are the result of a previous systematic literature review and conceptual framework on the theory of business incubation (Tavoletti, 2012) and have now been empirically tested through a multiple case study research in order to reach an 'analytical generalization' (Yin, 2009). In that sense the single ESA BICs cases are not intended to be a sample out of a population but seen as especially endowed 'laboratories' (basically the same ESA's successful business incubation framework across different national/regional environments) in which we had the opportunity to test the internal validity and construction validity of our principles.

Reaching a 'statistical generalization' of our principles, with regard to any larger population, is an entirely different objective and could be the oject purpose of future research efforts. Such efforts should identify a population of business incubators and a large enough representative sample from that population, in order to carry out an inferential test and reach a 'statistical generalization'. Such an attempt should be 'variable oriented', as opposed to our 'case oriented' one (Harrison, 2002). It would lose the richness of our approach but gain in measurability of single variables. As business incubation is a contemporary phenomenon within its real-life context, with no clearly evident boundaries between phenomenon and context, we doubt that a 'variable oriented' approach would be appropriate. A different and probably more fruitful way forward for research would be to carry out additional case studies, both successful and unsuccessful ones, with our same propositions and keeping a 'case oriented' approach.

The approach we used is not common in theory-building from case study research to date. In fact, we already had some propositions to test before conducting the case study and they were not developed in conducting the case, but are nonetheless coherent with that approach: '*a priori* specification of constructs can also help to shape the initial design of theory building research [..].

If these constructs prove important as the study progresses, then researchers have a firmer empirical grounding for the emergent theory' (Eisenhardt, 1989: 536). A good example in that sense is that of Bourgeois and Eisenhardt (1988) which identified several potential constructs from the literature before carrying out the case studies.

Our four principles are deeply rooted in the previous literature on business incubation and proved to be very effective in ESA's 'laboratories'. We hope that other researchers will carry on with both literal and theoretical replications (Yin, 2009) of our exercise. We are confident that our principles can already provide a simple and clear cut guideline and theoretical framework to policy makers, in order to review public spending in business incubation and avoid wasting public money on inappropriate business incubation projects.

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Tables

Table 1: – Breakdown of BICs staff and funding

ESA BIC	**ESTEC**	**ESOC**	**AZO**	**ESRIN**
Staff	2.05	0.4	0.35	0.85
Average Annual Funding	**€1.79M**	**€685K**	**€1.68M**	***€590***
ESA	30%	64%	30%	85%
Local Development Agency or Regional Government	49%	29%	40%	Na
Local Bank	14%	0%	15%	Na
Local Incubator (BVit, Vega, DLR, ?)	7% (in man-hours)	7%	15%	15% (80k)

Source: Euroconsult, 2010.