From boundary line to boundary space: The creation of hybrid organizations as a Triple Helix micro-foundation

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Abstract

In a Triple Helix framework, independent hybrid organizations can be created at the intersection of overlapping yet separate institutional spheres to address innovation blockages. However, the formation process of these organizations, which incorporate and combine elements from the Triple Helix spheres, has seldom been investigated. We address this gap by proposing a model that conceptualizes the creation process of these organizations. We argue that their creation opens up a "boundary space" that differs from a boundary line. By comparing empirical results of three cases, we identify a three-step creation process (recognizing a gap; bringing Triple Helix representatives together and creating a consensus; and designing an *ad hoc* contingent solution). We highlight the individual role of a boundary spanner in these dynamics. The results provide new insights on the micro-foundations of the Triple Helix. They also suggest an extension of the "boundary spanner" concept.

Keywords: Boundary Spanner, Triple Helix, New Venture, Entrepreneurship, Innovation Organizer, Venture Creation

1. Introduction

The Triple Helix of University-Industry-Government relations provides a framework for overcoming blockages to innovation in knowledge-based economies and regional innovation systems (Etzkowitz 2008). The intersection of these overlapping yet separate institutional spheres provides a location conducive to "innovation in innovation" (Etzkowitz, 2003), the formation of new independent hybrid organizations that integrate and combine elements from the various Triple Helix spheres in their design. Such organizations, which include venture capital firms, incubators and science parks, aim at enhancing innovation, especially in the form of new venture creation.

Many governments and universities throughout the world have dedicated considerable funds and other resources to forming such organizations, hoping to enhance innovation and technology venture creations (Avnimelech, Schwartz et al. 2007; Bergek and Norrman 2008; Champenois 2012; Wonglimpiyarat 2013; Croce, Grilli et al. 2014; Rubin, Aas et al. 2015). The performance of these organizations in terms of university-industry cooperation (Franco and Haase 2015), innovation and local entrepreneurship has been well researched and documented (Rothaermel and Thursby 2005; Mian, Fayolle et al. 2012; Barbero, Casillas et al. 2014; Fernandez-Alles, Camelo-Ordaz et al. 2015). Recent research advocates shifting the focus from strict performance to the internal practices of these organizations (Scillitoe and Chakrabarti 2010; Lundqvist 2014; Rubin, Aas et al. 2015; Shane, Dolmans et al. 2015; Weckowska 2015).

Nevertheless, while one aspect of these organizational practices pertains to their genesis, Triple Helix research has seldom investigated how these novel organizational models, operating at the intersection of overlapping spheres, are invented and implemented. The purpose of this paper is to address this gap by posing the following question: *How are hybrid independent organizations that support innovation and that exist between institutional spheres created?*

We propose a model that conceptualizes the creation of such organizations as resulting from the existence of an innovation gap and from collective action catalyzed by a specific type of individual. This individual catalyst is called a *boundary spanner* because he or she links separate institutional spheres and draws elements from Triple Helix spheres to contribute to the emergence of a new hybrid organization. We illustrate our model with three case studies

of organizations supporting new academic venture creations, from the USA and France. We thus identify three steps in the creation process of such organizations: recognizing a gap; bringing Triple Helix representatives together and creating consensus; and designing an *ad hoc* organizational solution. The three steps are catalyzed by the boundary spanner.

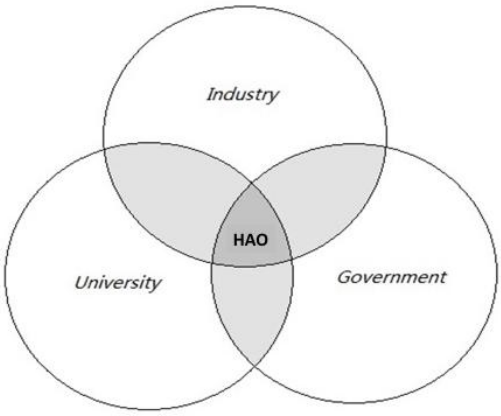
A major theoretical contribution of the paper is that it enriches the Triple Helix framework by providing a better understanding of one of its micro-foundations: namely, the creation process of "innovation in innovation" (Etzkowitz 2003). We propose a new boundary concept to conceptualize the intermediary position that hybrid organizations occupy, arguing that their creation takes place within a "boundary space" that, rather than separating the spheres, integrates elements from overlapping spheres.

The paper begins by discussing the Triple Helix framework and proposes the concept of "boundary space," a liminoid realm in which creative intercalation of elements from the Triple Helix spheres produces a novel organizational design. In the next section, we focus on the literature dedicated to boundary spanning/spanner. Both sections enable us to identify knowledge gaps and to derive two propositions as a model for the creation of independent hybrid organizations. After explaining the methodology, we illustrate and refine the theoretical model by presenting a comparison of empirical results of three cases. We conclude by discussing the implications of our findings for both theory and practice.

2. Triple Helix framework and boundary spaces

In the Triple Helix model, improvement in the conditions for innovation is conceived as resulting mainly from the increasing relations among university, industry, and government spheres, which partially overlap (cf. Figure 1) (Etzkowitz and Leydesdorff 2000).

Figure 1: Triple Helix Boundary Space



Collaboration between these institutional spheres, with each one playing its traditionally defined role, marks the first step in the formation of a Triple Helix (Etzkowitz 2008). This collaboration often starts with discussions between universities, firms and/or governments, and generally responds to a perceived gap in the regional innovation system. frequently triggered by an economic crisis or the development of a regional growth project (Svennson, Klofsten et al. 2012)

The next step in the development of a Triple Helix is the internal transformation of existing institutions that, on top of their traditional tasks, "take the role of the other" (Etzkowitz 2008) and perform new tasks. For example, industry firms pursue their core mission of producing goods and services while increasingly providing high level training, as evidenced by a number of leading companies' formation of their own "universities" in their area of expertise. Similarly, while governments are responsible for providing the regulatory regime, they also offer newly created ventures public venture capital (Etzkowitz, Gulbrandsen et al. 2001; Mazzucatto 2014).

Finally, the Triple Helix model posits a third stage in which "innovation in innovation" (Etzkowitz 2003) takes place, beyond the traditional and narrower sense of "innovation" as product innovation within firms. As relations among university-industry-government actors continue to increase, the conditions that produce innovation are enhanced (Fitjar, Gjelsvik et al. 2014).

Thus, the Triple Helix can be a platform for "institution formation" (Etzkowitz 2008) or creation of hybrid organizations that integrate and combine elements from the various Triple Helix spheres in their institutional design, to promote innovation. Organizational innovations such as venture capital firms, science parks and incubators, which synthesize elements of

several institutional spheres, exemplify such hybrid organizations (Etzkowitz 2008). These hybrid organizations are often autonomous in that they are not incorporated into one particular sphere, unlike other intermediate organizations that support Triple Helix collaborations and facilitate technology commercialization, such as government-supported organizations that act as sponsors of specific technological innovations, university incubators, or industry consortium associations (Johnson 2008). Hybrid organizations exist as entities independent from the spheres from which their elements were drawn. They are not controlled by any actor in particular but are accountable to several different stakeholders belonging to distinct spheres.

A prototypical example is American Research and Development (ARD), created in Boston in 1946 by the New England Council. MIT President Karl Compton played a key role therein (see Section 5.). At its inception, the first venture capital firm pursued a government-like mission of social good, was headed by a Harvard University professor, drew on mechanisms from the financial industry to design its own activities, and received industry funding as well as funding from technical universities other than MIT (Etzkowitz 2002; Etzkowitz 2008).

Another example is the Research Corporation, created in the early 20th century by a chemist at the University of California to organize technology transfer from the university to firms (Mowery and Sampat 2001; Etzkowitz 2002). Based on the government-sponsored patent system, the Research Corporation invented the technology transfer office as an independent organization. The organizational model worked as the primary means of commercializing academic research in the US for much of the 20th century, when most universities believed it was not appropriate or were unwilling to commit resources to establish their own technology transfer offices.

Such hybrid autonomous organizations (that we call "HAOs" in the remainder of the paper) are usually invented within a "consensus space" (Etzkowitz 2002; Etzkowitz 2008; Ranga and Etzkowitz 2013). A *consensus space* is defined as the "set of activities that bring together the Triple Helix system components to brainstorm, discuss and evaluate proposals for advancement towards a knowledge-based regime" (Ranga and Etzkowitz 2013). These activities generate social and relational capital and therefore facilitate coordination within and between different institutional spheres (Villarreal and Calvo 2015). The existence of a *consensus space* is a condition for the creation of HAOs that promote innovation in response to local conditions. This type of innovation takes advantage of resources at hand, in contrast to bureaucratically implemented solutions that may or may not consider local dynamics. By

cross-fertilizing diverse perspectives, ideas may be generated and results may be achieved that individual actors could not have accomplished alone. The concept of "consensus space" was introduced in an analysis of the creation of ARD (see Section 5.), and in particular the experience of the New England Council, created by six New England governors to develop a strategy for the renewal of a region that had been in economic decline since the early 20th century (Etzkowitz 2002).

Through their activities and skills, HAOs constitute an *innovation space* (Ranga and Etzkowitz 2013): a space in which a novel project is undertaken, drawing upon the resources aggregated within the consensus space, which enhances the development of local innovative firms. These projects typically harness the resources of existing "knowledge spaces" in universities, R&D units of firms, and government research organizations, and enhance these spaces, creating links among them and across the Triple Helix.

However, Triple Helix researchers have generally focused on Triple Helix structures and collaborations, as well as on intra-sphere dynamics. The outcome of overlapping Triple Helix spheres – or the creation of independent autonomous organizations supporting innovation – has received considerably less attention. The existence of such HAOs located between institutional spheres warrants further exploration and can provide new insights into the micro-foundations of the Triple Helix.

To support our arguments, we introduce the concept of "boundary space," which refers to (1) the creation process of HAOs and (2) the HAOs located between spheres (cf. Figure1). We add the term "space" to boundary, which typically refers to a "line." A boundary connotes a clear separation between non-overlapping spheres, whereas a boundary space refers to *a boundary that integrates elements from different overlapping spheres*. A "boundary space" is also a looser concept than the related notion of "field," which is an arena in which various actors engage in collaboration and competition (e.g. Bourdieu 1985; DiMaggio and Powell 1983; Fligstein and McAdam 2012). We do not attempt to analyze the structuring mechanisms of such fields around their actors' interests and behaviors, but rather we highlight the existence of organizations that carry out a set of activities between institutional spheres, where innovation is generated. Combining these contributions leads to the following proposition.

Proposition 1: *The existence of a gap ("problem") hindering the innovation process might lead to the creation of new hybrid autonomous organizations ("HAOs"). "Boundary space"*

refers to both the process of creation of these HAOs and to the HAOs themselves, which draw elements from overlapping spheres and are not incorporated into one sphere or another.

3. Boundary spanning and spanner

Boundary spanning plays a central role in innovation (Carlile 2004). It is generally acknowledged that knowledge sharing between separate professional and organizational areas is necessary for innovations such as new product development (Carlile 2004). Boundary spanning is depicted in the literature as a dual process of (i) information sharing and (ii) creation of cognitive closeness between distant parties (Comacchio, Bonesso et al. 2012). Information sharing corresponds to the research, access, and transfer of information useful for innovation across inter- or intra-organizational boundaries (Tushman 1977; Tushman and Scanlan 1981; Leendert Aalbers and Dolfsma 2015), whereas creation of cognitive closeness refers, in the case of science-industry cooperation, to the transformation of scientific knowledge into a language closer to the firms' communication codes (Carlile 2002; Carlile 2004).

Boundary spanning is typically performed by people who mediate flows of advice, information and trust between two distinct groups or actors (Friedman and Podolny 1992). These boundary spanners have been traditionally conceived as single individuals (Tushman and Scanlan 1981; Mangematin, O'Reilly et al. 2014), but also as a set of diverse individuals (Tushman 1977) or even as an organization (Guston 2001; Comacchio, Bonesso et al. 2012). From an intra-organizational perspective, boundary spanners participate in the sharing of expertise by linking groups of people separated by location, occupation, hierarchy or function (Cross and Parker 2004). They are also conceptualized as connecting an organization with its environment by performing the functions of information processing (selecting, transmitting and interpreting information originating in the environment) and external representation (resource acquisition and disposal, political legitimacy, social legitimacy and organizational image) (Aldrich and Herker 1977).

One common feature of individual and organizational boundary spanners is that they link two separate spheres, such as academia and markets (Baglieri and Lorenzoni 2014); SMEs and universities (Comacchio, Bonesso et al. 2012); a university lab and industry (Kidwell 2013); open source projects and firms (O'Mahony and Bechky 2008); science and policy communities (Guston 1999); and so on.

Recent research in science and innovation has proposed a broader vision of the boundary spanner's role. For example, Mangematin et al. concluded in a special issue dedicated to the topic that boundary spanners "are bridging different areas, academia, policy makers and firms. They have a role to articulate different objectives, time frames, logics and cultures. They also have a role within academia to create a dialogue between disciplines, and (...) combine different approaches and instruments to propose solutions" (Mangematin, O'Reilly et al. 2014, p.3). Boundaries may be spanned at different levels (physical, social or mental), with various degrees of success and following different configurations (Battard, Donnelly et al. 2013). Physical boundaries pertain to the infrastructure and role structure, social boundaries to the individuals' sense of belonging within a group, and mental boundaries to personal and professional identities (Hernes 2004; O'Kane, Mangematin et al. 2015).

In line with a Triple Helix perspective, and focusing on technology transfer as well as academia-based innovations, scholars have considered not only the inter-relationships between the scientific and policy communities, but also relationships with industry (Parker and Crona 2012). We build on these approaches by considering the boundary spanner's role as tripartite, linking university, industry and government spheres.

An interesting subset of contributions within the boundary spanning literature has emphasized the practices of boundary spanners (Carlile 2002; Carlile 2004; Levina and Vaast 2005) rather than the profiles of boundary spanners or the formal structures in which they operate. We focus on boundary spanning as "a competence in practice" (Levina and Vaast 2005), a stream of research that has identified three conditions for an individual ("nominated" as boundary spanner) to be able to effectively act as a boundary spanner: being peripheral and legitimate in both fields; having legitimacy as a negotiator; and developing the inclination to engage in boundary-spanning (Levina and Vaast 2005, p. 353).

Based on these contributions and on the key role played by MIT President Compton in the creation process of the prototypal hybrid organization ARD aimed at bridging science and industry through new technology venture creations (Etzkowitz 2002), we hypothesize that specific individuals may play a crucial role in the creation of HAOs. By linking separate institutional spheres and drawing elements from the different spheres that the hybrid organizations can integrate, they consequently act as boundary spanners.

We should clarify that our perspective differs from the one adopted in the literature on "boundary organizations," following the concept developed by Guston (Guston 1999; Guston

2001). Boundary organizations are defined as "exist[ing] on the frontier of two relatively distinct social worlds with definite lines of responsibility and accountability to each" (Guston, 1999, p. 93). Specifically, Guston studied the Science-Government frontier in the Office of Technology Transfer at the US National Institute of Health (NIH). Boundary organizations as defined by Guston share two characteristics: (*i*) they help to create and legitimize "boundary objects" (Star and Griesemer 1989), artifacts such as prototypes, standardized reporting forms, firm-university collaborative research and development agreements ("CRADAs"), invention disclosures or patents; and (*ii*) they involve the participation of representatives from the several institutional spheres that they serve, such as scientists and policy makers in the case of the OTT at NIH. Unlike the literature dedicated to these boundary spanning organizations, we do not focus on these organizations *per se* but on the role of a boundary spanner in the creation dynamics of HAOs. Our concept of "HAOs" also differs from Guston's "boundary organizations" in two ways. First, boundary organizations' main role is to *stabilize* the boundary rather than *integrate* different institutional spheres like HAOs do. A second distinction is that the principal-agent theoretical framework in which the "boundary organization" concept is rooted has limited application in our perspective. It is necessary to include a missing sphere in the "boundary organization" model —the industry— which is important for innovation and Triple Helix dynamics. Beyond the principal-agent perspective, HAOs are autonomous entities and are not controlled by any principal that would give the organization a clear objective.

Overall, the boundary spanning/spanner literature considers boundaries as a clear demarcation between distinct spheres. It is therefore valuable to enrich this perspective by envisioning the boundary spanner's role within a Triple Helix configuration of overlapping spheres.

Combining these findings with the Triple Helix perspective suggests the following proposition.

Proposition 2: *An individual carrying out a Triple Helix boundary spanning activity (i.e. a Triple Helix boundary spanner) can play the role of a catalyst in the creation process of HAOs.*

4. Methodology

Our two propositions describing a "boundary space" model are illustrated with three case studies of HAOs. The case studies are not meant to be generalizable but rather to inform theoretical developments on the creation process of HAOs. Case studies are particularly relevant when the objective is to analyze processual and interdependent mechanisms and to answer a "how" question (Eisenhardt and Graebner 2007).

Originally, we examined two cases (StartX and Atlanpole). The objective was to analyze the creation and activities of organizations supporting innovation and operating in boundary spaces: existing between institutional spheres without belonging to any of them. Our initial empirical data analysis revealed that the HAOs' creation was a complex, multistep process involving key individuals (later called 'boundary spanners'). We consequently focus the study on this intriguing issue.

Cases were chosen for theoretical reasons. Because we were looking for common features regarding HAOs' creation process, their heterogeneity made our findings more robust. Similarities observed in cases that are likely to differ are more valuable than those observed in homogeneous cases. The third case (ARD) was added later in the study, once the focus was on the HAOs' creation, as an "extreme or "unique" case (Yin 2009, p. 47). The goal was to strengthen the validity of our theoretical developments by integrating an additional and prototypical case on which the whole notion of "hybrid organization" had been developed in Triple Helix research. As Table 1 illustrates, the three cases are heterogeneous in terms of their organizational characteristics (year of creation, size, stakeholders) and in the services that they provide to entrepreneurs (see "Results" section). The institutional context in which they operated at creation time is also heterogeneous. For ARD and Atlanpole, the context was one of low science-industry boundary porosity, whereas the actors in the StartX case conceived the boundary to be very porous.

The French case was selected for its legitimacy and non-uniqueness. It is currently the sixth largest incubator in France (MESR 2010), and is recognized by French incubation professionals and by its stakeholders as successful and competent. It was not among the first incubators created in the wave that started in France in the late 1970s (Fache 2006), nor does it specialize in a specific technological field. It employed 27 people at the end of 2014. It nurtured 15 to 32 new venture creations yearly between 2010 and 2013 in a support program that could last up to five years.

We selected cases of organizations supporting new venture creations from academia because these new ventures can be regarded as the quintessence of boundary spanning between

university and industry. They constitute the newest form of university-industry boundary spanning in knowledge-based economies, often benefiting from significant public policy support.

Data consist of both primary and secondary data. Thirty-four semi-directed interviews with representatives (founders, mentors, administrators) from Atlanpole and StartX and with entrepreneurs were carried out by both authors between 2012 and 2015. Questions were aimed at understanding the impetus for the organization's creation, the creation process, the organization's characteristics, and its activities to support entrepreneurs. Entrepreneurs were asked to explain why they came to the support organizations, and what they did, and did not, obtain from them. We stopped the interviews when information saturation was reached. We also conducted a press review on Atlanpole, which comprised 30 articles from the French general and specialized press. A similar press review was done for StartX in the regional press. We supplemented the data with archival information obtained from secondary sources including reports and brochures. The ARD case is mostly based on archival secondhand data that had already been finely analyzed by one of the authors in a historical monograph (Etzkowitz, 2002). In the next section (5), in which we present our empirical findings, we draw on these data and written analysis for the ARD case. For StartX and Atlanpole, we present quotes from the interviews. In the Atlanpole case, the quotes mainly come from two interviews carried out with its founder, J.Y. Delaune, which were the most illustrative ones.

Data were manually coded and analyzed in order to identify and compare the impetus and key features of each HAO's creation process. This work was checked and refined by each author, resulting in a final set of mechanisms: the three steps of HAO creation, presented in the "Results" section. Following the principles of inductive theory building (Eisenhardt 1989), we conceived our two propositions using an iterative process in which empirical findings were repeatedly cross-checked with conclusions from the Triple Helix and boundary spanning literature.

Table 1: Characteristics of hybrid organizations studied in their first years of activity [1]

	ARD	**StartX**	**Atlanpole**
Date of creation	1946	2009	1987
Location	Boston (USA)	Palo Alto (USA)	Nantes (France)
No. of	5-6 (in the first years)	16 (in 2014)	5 (in 1988)

employees			
No. of projects accompanied	About 6 yearly. 1st significant project after 10 years of operation, founding of Digital Equipment Corporation , which ignited the mini-computer industry.	136 (2009-2013) 12 per academic quarter 90 start-up launches in first 2 years of StartX activity	12-20 new venture creations yearly (1987-1992)
Main sources of funding	Investors, including MIT, Rice University, Boston financial firms and individuals	Company donations (e.g. Greylock Partners, Microsoft); From 2014 Stanford University ($1.2 million per annum); $3.6 million investment fund for 10% of Series A	- mostly local governments (region, department, Nantes city) - Symbolic: 60 local firms, University/Hospital (1%)
Governance: shareholders / stakeholders	Board of Directors: 1/3 business 1/3 academics 1/3 politicians	Board of Directors, mainly comprising the former student founders	Managing Board of directors: representatives of Nantes University, Research Hospital, other public research org., regional/department and city governments, 60 firms, chamber of commerce

[1]Sources: Archives, authors' press review and interviews.

5. Case analysis: the catalyst roles of a boundary spanner as conditions for HAOs to exist in a boundary space

To address our research question, we analyzed the creation process of hybrid autonomous organizations that support innovation and that exist in a "boundary space" ("HAOs"), as well as their main characteristics and activities.

In this section, we empirically illustrate the two propositions by showing how a boundary spanner catalyzed the creation of HAOs in the three cases by fulfilling a tripartite role: recognizing the existence of a gap; bringing Triple Helix representatives together and helping create consensus; and finally, helping to design a solution. This boundary spanner is tripartite in the sense that he or she has knowledge of and ties to the three Triple Helix spheres.

5.1. Recognizing a gap

ARD

The creation of ARD in 1946 resulted from the activities initiated in the 1930's by MIT President Karl Compton (Etzkowitz, 2002). During an economic crisis triggered by the decline of the textile and shoe industries, Compton was invited to join the New England Council. The Council was a gathering of top New England leaders in universities, business, and politics, and had been mandated by the governors of the six states to find a solution to revive the regional economy. Compton apparently came up with the idea of forming firms from university research, to fill the gap of economic stagnation, and make up for an insufficient number of companies created based on university research findings with commercial potential.

Compton had already launched the idea of forming firms from academic science in the past as a member of President Roosevelt's Scientific Advisory Board in the 1930s, but this idea had not been supported by the full committee at the time.

Compton was a physicist with a practical bent and administrative talent, which led him to be recruited as President of MIT during the 1930s, when the university was in crisis. He had a long record of government science service, beginning as an assistant scientific attaché on Roosevelt's Scientific Advisory Board and serving as head of a division of the Office of Scientific Research and Development during World War II. He had also been involved with industry as a scientific consultant to corporations and as a proponent of the establishment of the venture capital firm while serving as President of MIT.

StartX

StartX was founded by Cameron Teitelman and other students who collectively identified a gap in the educational process at Stanford University. StartX resulted from Teitelman's "attempt [as an undergraduate student in the Engineering School's Technology Management program] to start and scale a company [which] was marred by the amount of time and effort spent on locating the right people and resources" (Mac, 2012). Teitelman felt that there were gaps in the knowledge and training delivered in Stanford undergraduate entrepreneurship courses. These courses provided simulations of firm formation but stopped at the end of each academic semester. Assigning students to teams sometimes created disputes over intellectual property when the nascent firm was otherwise ready to take off.

To address this problem, Teitelman, then a master's student in organizational sociology at Stanford, organized a group of fellow students to develop an extra-curricular project through Stanford's student government. Since its founding in 1891, the student government has been independent from the university. The project investigated the problems of student entrepreneurship and gaps in the interface between Stanford and Silicon Valley by interviewing Stanford alumni in the venture capital industry and start-ups. Teitelman thus identified what was missing within the Stanford ecosystem and developed a model to improve the entrepreneurial process. Specifically, he detected a mentorship gap. The imagined solution lay in the untapped resources available from Stanford alumni and in Silicon Valley companies to support student entrepreneurship. Teitelman and his colleagues also saw the need to develop a method to identify potentially successful firms, focusing on entrepreneurial teams rather than technology projects or business models.

Teitelman's background combined Triple Helix elements. He had attempted to start a business while a Stanford undergraduate student, and subsequently drew on his ties with Student Government to establish a project that laid the basis for StartX.

Atlanpole

The creation of Atlanpole in 1987 arose from the conviction of a single man, Jean-Yves Delaune, who had been impressed in the 1970s and early 1980s by international examples of cities favoring science-industry interactions, particularly Boston. As head of a not-for-profit local development organization ("Ouest Atlantique") in charge of attracting international activities to the region, he identified the lack of interaction between industry and research in western France as a gap. Such interaction was crucial to overcome the industrial economic downturn the region faced as a result of the shipyard crisis. Delaune underlined this issue in a report that he authored in 1986. Based on this report, the President of the Region (Olivier Guichard) asked Delaune to "create a technopole in Nantes (…) to make Nantes the capital of France's Great West" (Delaune's interview, June 17, 2014). Nantes was a relative latecomer in this area: several French cities, including Nice/Sofia Antipolis and Grenoble/Meylan, had already created their "technopoles" many years earlier (Fache 2006).

Delaune was convinced that innovation should be generated from inside the region. He believed that instead of encouraging firms to settle next to each other, regions should offer "engineering services" to help local science and industry players collaborate within

innovation projects. This would require numerous and regular exchanges and interactions among representatives from University, Industry and Civil Society:

> "A technopole is a smart city, that is, in which the evolution of knowledge, those producing knowledge are intimately intertwined in the city life. They diffuse their knowledge so that actors from civil, economic and social life are on the same page. (…) To get there, an engineering process is needed way before a physical space, a place. (…) In my view, when you have this as an objective, immaterial aspects must come first, and real estate aspects second. The engineering process is about starting by creating the accompanying and animation tools allowing the different knowledge, 'knowing people' and 'doing people' to meet around the vision that you have of your territory and its development potentialities." (Interview with Delaune, June 17, 2014)

Delaune's individual background integrated Triple Helix spheres. He had been in charge of regional economic development (Government) in the Great West for more than 15 years before creating Atlanpole: first in the Cholet region, where he initiated the creation of a cluster in the fashion sector, and then in the Nantes region. These activities led him to develop a strong understanding and network within local scientific institutions (University). He had also co-founded and managed several companies and was an active member of the main French employer's union ("CNPF") in the early 1980s.

A summary of the three cases is presented in Table 2 below.

Table 2: Boundary spanner and gap involved in the creation of three HAOs

	ARD	**StartX**	**Atlanpole**
Boundary Spanner's Name, Individual Background (Triple Helix position)	**Karl Compton** MIT president (University) Experience in science (Government) Experience as consultant to corporations (Industry)	**Cameron Teitelman** Stanford University student. Prior venture creation attempt Ties with Student Government	**Jean-Yves Delaune** Head of a regional development agency (Government). Civil servant. Prior experience in company creation and management / Extensive network within Industry Existing ties with university/research representatives
Gap identified	Insufficient number of companies created based on university knowledge (in a context of economic stagnation)	Educational gap for entrepreneurs	Lack of interaction between industry and research in the region (in a context of deindustrialization and economic stagnation)

5.2. Bringing Triple Helix representatives together and helping create consensus (consensus space)

As discussed earlier, a second role of the boundary spanner as a catalyst for the creation of HAOs pertains to bringing Triple Helix representatives together and creating a consensus between them. This process includes creating a commonly accepted formulation of the problem, convincing relevant others of the existence of a gap, and agreeing on a solution – a set of activities belonging to the "consensus space" (Etzkowitz, 2008). This can occur at different times, including right after the identification of a gap by a few individuals, or much later in the process, as the StartX case illustrates.

ARD

Starting from the 1920s and 1930s, discussions took place within the New England Council to imagine and implement various solutions to the economic downturn. MIT President Compton placed his idea of creating firms from scientific findings on the table for discussion. He pointed out that firms had been created from the research generated by Harvard and MIT in scientific instruments and management consulting.

Compton convinced other members of the New England Council that expanding upon these experiences could be a sound solution. His arguments were reinforced by studies done by sub-groups of the Council that concluded that the focus should be on enhancing the establishment of new enterprises. These studies also identified capital and business advice as the main resources needed. This is how the New England Council, inspired by Compton, came up with the idea of a new organization offering seed capital and business advice. Compton and his colleagues revisited the long-standing notion that the solution to the region's economic ills could come from new product development. Expanding new product development from existing firms to new firms emanating from the university created a pathway from the university to industry. Academia, rather than industry, was the newfound source of advanced technologies.

Compton's concept was perceived as viable given that large-scale government funded research at MIT and other US universities had expanded significantly during World War II. Without this impetus and financial support from government, the concept of university-originated firms would have been unlikely to gain traction.

StartX

In the case of StartX, the consensus building process did not take place at its inception, or when the solution of a support structure for assisting entrepreneurial projects had been conceived. The foundation of StartX did not trigger large debates initially, but only later on, when the existence of the gap, and therefore of an independent organization addressing it, was contested by Stanford University.

When Teitelman created StartX, Stanford executives did not believe that students should undertake start-up projects during their degree programs. While allowing that it was appropriate to train students in entrepreneurship, the university was concerned that more extensive engagement with entrepreneurship would interfere with academic progress. Moreover, the official position of the Office of Technology Licensing (OTL), the Stanford arm responsible for the university-industry interface, was (and still is) that the external environment of the university in Silicon Valley was so rich with resources for firm formation that it was unnecessary for the university to develop its own incubator facility.
OTL's position was that it would introduce inventors who sought to develop a firm based on their inventions to a venture capitalist; it assumed that the knowledge and resources needed to take advantage of such an introduction were readily available. However, as evidenced by StartX founders and users, while this might be the case for experienced entrepreneurs, inexperienced neophyte faculty and student entrepreneurs often lacked networks and other links to trusted sources of enterprise development. Seeking support from unknown sources could place their intellectual property at risk.

In 2013, four years after StartX was founded, a few senior representatives from the university contested the existence of this organization and attempted to shut it down. StartX student supporters drew up a petition and lobbied the administration in favor of StartX, and the university administration was forced to back down. In a surprising twist, rather than close StartX, the university decided to invest in it (see below).

Atlanpole

After being asked by the President of the Region to create a technopole, a cluster of cooperating innovative firms, universities and research centers, Delaune started by hiring a

team of four people who all had "entrepreneurial experience and dimension" (Delaune, 21/07/2014), on top of a scientific, government, administrative, or city planning background. Together with his dually qualified team, Delaune engaged in brainstorming activities. He conducted interviews with 300 people from the Triple Helix spheres in the region (representatives from firms, university labs and other research centers, unions, chambers of commerce and agriculture, government) to draft a technopole project that he would propose to the Region President six months later. To do so, he strongly relied on "[his] personal network of 200 to 300 people in the region" (Interview with Delaune, June 17, 2014) and his solid knowledge of the research institutions of the Region.

This large collective brainstorming took the form of face-to-face interviews with a maximum of three to four people. This approach enabled Delaune to carefully identify the expertise, resources and needs of the region, as well as existing collective projects (for example, collaborative actions initiated by the chambers of agriculture and commerce in electronics or informatics). They also allowed him to involve actors who recognized the gap (lack of interactions between science and industry) to conceive a solution based on local strengths, and to have local actors "share the global vision" (Delaune, 21/07/2014) that he proposed. Five knowledge areas were identified as regional assets and potential sources of innovation: materials-shipbuilding, agro-food, mechanics, and electronics, which were quite mature fields, and immunology-health, which was a more emergent research sector in the region. A technopole project ("Atlanpole") was conceived around these five knowledge areas and was placed in five locations throughout the city, with each location adjacent to the main research/higher education centers of the field (for example, National Institute for Agronomic research "INRA", University Hospital, "Centrale Nantes" Engineering School). This is a distinctive feature of Atanpole, which was not conceived as an incubator located in a single place, but as an incubator with different locations throughout the city, each close to specific knowledge production sites.

Atlanpole's mission was to "diffuse the 'atlanpolitan' spirit", that is, to enhance innovation projects through science-industry cooperation, especially through new academic venture creations. To do so, Atlanpole would offer engineering services to help scientists and potential entrepreneurs conceive their project (see 5.3.). The long consultation process enabled Delaune and his team to integrate most of the actors' activity fields, cognitive frameworks and interests. As a result, a consensus on the solution that they imagined was easily found.

5.3. Helping design an ad hoc solution (innovation space)

Boundary spanners also help implement the organization's identified solution or, in our context, solutions aimed at enhancing the creation of new innovative ventures. This process is part of creating an *innovation space* (Etzkowitz, 2008); it involves drawing and recombining elements from the different Triple Helix spheres and securing needed resources, including funding. The implemented solution can be "ad hoc" in the sense that it responds to specific local constraints and resources.

ARD

ARD was created in 1946 as the first venture capital corporation in the Western world, offering equity funding and business advice to newly created academia-based ventures. The New England Council managed to raise money from financial institutions in Boston, and, thanks to Compton's efforts and contacts, to obtain an endowment from MIT and fellow technology universities such as Rice University. This money was earmarked for investment in new technology venture creation projects, and enabled staffing for ARD. George Doriot, Professor of Entrepreneurship at Harvard Business School, was recruited as head of ARD, and technology scouts and business advisors were also appointed. MIT President Compton devoted a small proportion (5%) of his time to serving as an ARD advisor, facilitating the identification of MIT commercializable technologies and reinforcing the credibility of the venture capital firm and of the broader concept of science-based new venture creations.

ARD fundraising was facilitated by changes in the regulatory framework for financial institutions, advocated by ARD's proponents. These changes made it possible for large financial institutions bound by the so-called "prudent man rule" to invest a small proportion of their assets in new risky ventures such as ARD that would provide seed funding to new firms.

In addition to equity financing, ARD provided an on-the-job educational process to train academics who were experienced managers of government-funded research projects to move out of the university and lead independent start-up firms. Researchers like Ken Olsen, the founder of Digital Equipment, were not organizational neophytes; they were used to managing people and deadlines within the non-profit framework provided by a university and its ancillary research organizations. By providing mentors from its staff to serve on their

Board of Directors, ARD helped such academics manage the transition to organizational independence.

ARD combined elements from the Triple Helix in its design. On top of its *pro bono* mission, and its staff from MIT and Harvard Business School, it drew on tools and other mechanisms from the financial industry. Both Compton and Doriot were inspired by advisory groups with investment funds that wealthy family business owners like Rockefeller had created in earlier decades to invest in new technology firms.

StartX

Stanford University's student government provided a base for StartX to develop as the Stanford Student Enterprises Lab (SSE Lab) while it applied for not-for-profit status. One of the first activities Teitelman and his team carried out was to negotiate for free space from a firm in a building adjacent to the university. This enabled StartX to offer free office space to other founders who were expected to learn from each other (see Table 3 below).

A second task was to create an application process for recruiting potential new firm founders from Stanford – including undergraduates, PhDs, postdocs and professors. Following the traditional venture capital approach, the selection criteria focused on the dynamics of the start-up team rather than the business or technological aspects of the project. The strength of the team, including balance of skills and harmonious working relationships, was the most important criterion assessed. Information about team dynamics was gathered from a variety of sources, including from a psychologist. This information also served as the primary basis for assigning mentors to projects during the accelerator program.

Third, Teitelman also played a key role in recruiting mentors from the Stanford alumni community who were active in start-ups and the venture capital industry. These mentors provided valuable experiential educational coaching and mentoring to Stanford potential founders by assisting them with product, leadership and corporate development.

Fourth, he designed "demo days" that allowed StartX firms to pitch to a large room of investors, StartX advisors and media. This helped the new firms attract both investors and attention from the media and potential partners. Each selected entrepreneurial team was coached during a three-month program, in which a key activity is the preparation and honing of a sales pitch presented in training sessions in preparation for the demo day graduation.

Finally, the StartX CEO facilitated the securing of financial resources through various sources, including Stanford student government, and company sponsors such as Microsoft and Greylock Partners. AOL also donated free space.

The StartX support organization is hybrid in that it incorporates modified elements of academic, government, and business practices in its organizational design. It is a not-for-profit (government-like) entity that adapted the private accelerator (business) model of a limited time support and training structure, as well as the individualistic Stanford (University) student admission process by creating an application process for entrepreneurial teams wishing to enter the accelerator. Mentors are volunteers who are generally successful Stanford graduate entrepreneurs and venture capitalists (Etzkowitz 2013).

StartX also benefits from its position of being physically external to Stanford: the Stanford University intellectual property regime applies only to IP developed on campus, and not in the accelerator facility. Thus, StartX is an independent organization.

Table 3: StartX support activities for new venture creation

Activities	Description & Illustrative verbatim
Office space	Providing free office space where new venture projects are co-located (on top of $5,000 of free legal support from the top lawyers in Silicon Valley, free banking, up to $20K of free web server space and free software). Informal interaction encouraged by propinquity is expected. *The main room at StartX is populated with rows of long tables with computers, with firms grouped by area of activity, and with small meeting rooms alongside the main room. The set-up is conducive to fostering a community where different teams can work together. Each row hosts firms in a given technology/business area. (Author's on-site observation)* *"(…) people that you just met or just formed relationships with are willing to bend over backwards to help you. Everyone is looking out for each other." [While the money and the investment was important], "there's nothing like a community that you can lean on."(Entrepreneur in the StartX program, G. Cannon)*
Application process	Evaluation and selection of entrepreneurial teams (rather than individuals or businesses or technologies) *"What we're focused on is optimizing the education for these founders. So when we first started we did a ton of research to understand exactly what was missing within the Stanford ecosystem so that founders out of Stanford could actually learn faster." (C. Teitelman)*
Mentoring	Two types of mentors: (i) lead mentors (more involved; meet one-on-one with the company multiple times during the company's time in the program); (ii) board mentors

	serving as a mini-board of directors, bringing experience and knowledge in fields where the entrepreneur feels weaker. Length of mentoring program: 3 months. *"StartX's mission is to provide the best resources possible to enable Stanford entrepreneurs to thrive." (StartX Mentor and Member of StartX Founding Team, J. Golden)*
Demo Day	Pitch to present the venture in front of investors. *"It's kind of a validating point now. (…). StartX provides a Rolodex, if you will, it puts people in front of the right people. It's a great gateway for financing." (StartX Mentor, B. Wang)*

Atlanpole

In the Atlanpole case, the solution was designed in the previous phase, that of consensus creation. Delaune, together with his team, had secured the operating resources needed for Atlanpole's functioning within the six-month consultation period (cf. section 5.2.). They had obtained lab and office space from universities and research institutes. Funding had been obtained from local governments (region, department and Nantes city) and, more symbolically, from companies and Nantes University. The team was formed, to provide mentoring to potential entrepreneurs in each identified technological field in the five locations. Delaune, along with one of his staff members, also convinced the regional and local governments to change highways' routes in the urbanization plan, to improve the connection between the different Atlanpole locations. Table 4 summarizes Atlanpole's main activities.

Table 4: Atlanpole's support activities for new venture creation (in first years of activity)

Activities	**Description & Illustrative verbatim**
Detection of projects /promotion	Detection of potentially commercializable technologies within academic labs by the Atlanpole team Detection of possible innovation needs within existing (mostly small) firms that would lead to an R&D partnership with academic labs or firms Promotion of services offered by Atlanpole *"We never were in our head office! We kept visiting academic labs on the five Atlanpole locations!" (Delaune, June 17, 2014)*
Selection	Evaluation and selection of entrepreneurs with a new venture project or a technology

process	commercialization project. Criteria: Intellectual property protected (patentable/patented techno), existence of a market potential/need, based on national and international benchmarks, ability of the entrepreneur to work in a team and to understand clients' perspective
Lab and office spaces	Reduced-rate lab and office space, offered in one of the 5 Atlanpole locations (Agronomic research Institute ("INRA"), University Hospital ("CHU"), 'Centrale Nantes' Engineering School, specific buildings in two other locations - Carquefou and Chantrerie) Access offered to "technological platforms" (expensive equipment and machines) in each of the 5 locations
Mentoring	Mentoring of projects (with no time limit): entrepreneurs could receive advice on business plan and on how to create value added Contact-making with academic labs, other firms, public and private funding partners Carried out mostly by Atlanpole team, together with external mentors (entrepreneurs, firm executives, consultants, financial institutions, chamber of commerce experts) *"Contact-making was much appreciated by the entrepreneurs: with other academic labs in the region, with firms,… and also the network linked with venture creations and innovation: the National Institute of Intellectual Property, financial service providers like [a local VC firm]" (Delaune, June 17, 2014)* *"We accompanied and incubated new ventures as long as they needed it. We had no administrative constraint regarding length of support." (Delaune, July 21, 2014)* *"We had built or developed 'technological platforms' in each of the five sites. They were equipment for trial and experimentation that researchers from firms, including those that we incubated, could access. (…) The platform was financed by public and private sources: the firms contributed." (Delaune, July 21, 2014)*
Urban Planning	Negotiation with City politicians and administration to have one highway connect the five Atlanpole locations more directly (if possible without traffic lights)

The models that Delaune had in mind when conceiving Atlanpole were those of cities with industries "facing a major turn and which had to go in new development directions" (Interview with Delaune, June 17, 2014). As a benchmark, he had visited several leading clusters (such as Boston, Bilbao, Italian districts, Baden Wurtemberg) when he was building another cluster in the early 1970s. Atlanpole combined elements from government (in its mission of local development, with local governments as main funders) and from industry (in that it aimed at generating viable and innovative firms). Nantes University, Nantes Research Hospital, and other research institutions provided Atlanpole's team with easy access to their labs to detect commercializable or commercially valuable technologies, as well as space for the incubated projects in their five buildings.

Table 5 below summarizes boundary spanners' activities during HAO creation.

Table 5: Boundary spanners' activities during HAO creation

	ARD	StartX	Atlanpole
Boundary spanner's first actions after recognizing the existence of a gap	Convince politicians, firms, and university representatives to accept the idea of science-based economic development.	Gain support from Student Government.	Convince politicians, firms, and university representatives to accept the idea of creating local endogenous innovation through increased science-industry linkages and support in knowledge production sites.
Elements drawn from the Triple Helix spheres	From Industry: funding; model of investment funds providing advice. From Government: *pro bono* mission. From University: funding; recruited head and employees; recruitment of technology projects and entrepreneurs.	From Industry: recruitment of mentors; funding; private accelerator (business) model of limited time support. From Government: not-for-profit structure and pro bono ethics; support from Student Government. From University: format of a training program with an admission process; recruitment among Stanford graduates and staff.	From Industry: entrepreneurial experience of recruited staff; funding (marginal); objective of generating viable and innovative firms. From Government: funding; mission of social good; reflection on urban planning. From University: space; identification of entrepreneurial projects.

6. Discussion

Implications for theory

Our presentation of the HAO creation process within a boundary space integrating several institutional spheres enriches the Triple Helix framework. It emphasizes how a Triple Helix of overlapping spheres can trigger the creation of hybrid autonomous organizations by drawing and combining elements from different spheres. Our research therefore addresses an overlooked issue in Triple Helix research, namely the creation process of HAOs (the 'innovation in innovation' process) as a micro-foundation of Triple Helix. We have thus provided new insights into an *outcome* rather than a specific configuration of Triple Helix structures and interactions. Despite temporal, geographical and institutional heterogeneity, similarities have been found in the three cases examined. The creation process is initiated by the existence of an innovation gap, and catalyzed by a boundary spanner who plays a three-fold role, finally leading to a Triple Helix configuration characterized by a *boundary space* – or a boundary integrating elements from different institutional spheres.

Our results prompted us to refine the Triple Helix framework by distinguishing between two configurations that can be called Triple Helix I and Triple Helix II. Both are models of science-industry-government interactions that can exist either singly or jointly.

In Triple Helix I, the institutional spheres are separate from each other, with interaction occurring across clear boundary lines. Here, boundary spanning occurs through organizations and individuals located within a single sphere. Typically, technology transfer offices operating either in universities or in firms arrange the terms for crossover of discrete items of intellectual property from university research groups to firms. This format leaves the fundamental traditional components of the Triple Helix intact.

In Triple Helix II, which is a more interactive form, the institutional spheres overlap. Boundary lines that divide the helices are transformed into boundary spaces that unite them. In these spaces new hybrid organizations are synthesized from elements of the various institutional spheres. This is the Triple Helix of independent incubators or accelerators: a group of people is trained to act as a firm, and elements of academia, industry and government are combined in new and creative ways. The unique and idiosyncratic combination of such elements allows these HAOs to remain independent and not be dominated by a single sphere. In this format, the loose interaction between the institutional spheres in Triple Helix I is overlain by a new set of dynamics in which the three strands interrelate in novel combinations. The hybrid organizations created within these boundary spaces, in turn, fulfill a boundary spanning function by helping scientists move across the science-industry boundary.

The two configurations may operate simultaneously and harmoniously, even following some initial friction, with each enhancing and filling gaps in the other's work. This dynamic was shown in the case of the initially difficult relationship between Stanford's Office of Technology Licensing and the Stanford student government's spinoff accelerator project StartX.

Our findings also make it possible to extend the *boundary spanner* concept. First, the evidence suggests a move from the traditional vision of a powerful individual connecting two stable spheres to a perspective that depicts an individual acting within a wider team and creating a new organizational sphere (a "boundary space") situated amid three established spheres. Far from the "super hero" vision that some of the literature on boundary spanners

conveys, the studied boundary spanners acted as catalysts in an organizational creation process that was enabled by the actions of many other individuals (HAO employees, network of mentors, supporters). These other individuals were a key part of the creation process of new hybrid organizations, which remained strongly collective. Their role was typical of a boundary spanning one in that they articulated different objectives and logics, and created a dialogue between these logics (Mangematin, O'Reilly et al. 2014).

However, their activity did not primarily consist in diffusing existing knowledge or in creating cognitive closeness between separate actors in stable positions (Comacchio, Bonesso et al. 2012). Rather, their role revolved around creating new configurations and transforming the expectations and visions of existing representatives from various university, industry and government spheres. Their efforts aimed at gaining material and symbolic support from these representatives by drawing elements from the different spheres and combining them in novel ways, to create new hybrid organizations supporting innovative ventures. In that sense, the boundary spanners that we studied acted at three boundary levels (Battard, Donnelly et al. 2013): physical (by drawing and combining material and human resources from the different spheres), social (by creating new social links between formerly separated groups) and mental (by transforming the cognitive framework of various professionals).

In this vision of boundary spanning as the creation of a new social space (*boundary space*) situated between existing spheres, the independence of the hybrid organizations populating the boundary space is a key feature. Unlike boundary organizations such as the Office of Technology Transfer at NIH (Guston 1999) belonging to one sphere, the hybrid organizations studied remained independent. They are not controlled by any actor in particular but are accountable to several different stakeholders belonging to distinct spheres.

It should also be noted that the empirical cases that illustrated our boundary space model all presented a “tripartite” boundary spanner: an individual with knowledge and ties in the three spheres. Their subsequent network position (Friedman and Podolny 1992) and cognitive framework facilitated the drawing of resources from the various Triple Helix spheres and thus provided legitimacy in the different spheres. Unlike Levina and Vaast (2005), we do not argue that boundary spanners are more efficient when peripheral to the fields that they bridge. On the contrary, belonging to two spheres – like university and science government for Compton, university and new ventures for Teitelman, or regional government and business management for Delaune – and having ties and knowledge in the third sphere were a condition of success for each of these boundary spanning individuals. This raises an important question for future

research: to what extent can a dual boundary spanner, connecting only two spheres, enact the creation of an independent hybrid organization supporting innovation and occupying the space between spheres?

Second, our results invite others to consider the boundary spanner not so much as a conflict manager but rather as a proselytizer and a resource provider. The boundary spanning literature has focused on the role of conflict endemic to the task of reconciling diverse expectations and diverging demands stemming from disjoint groups (e.g. Friedman and Podolny, 1992; Parker and Crona, 2012). We build on the few contributions that have argued that the role of conflict manager might be less fundamental than previously believed and that different roles (like those of academic scientist and of user) can be harmoniously combined in practices (Baglieri and Lorenzoni 2014). When creating new organizations to enhance science-industry interactions in the form of new venture creations, boundary spanners initially targeted their efforts at convincing different Triple Helix groups of the existence of a gap. The solution was the one that would be collectively accepted and that could be implemented. Second, they mobilized their efforts toward gaining resources and support from distinct spheres. When the main challenge was to solve a collective problem, the boundary spanner's effort consisted less in managing tensions than in creating a consensus and in enhancing the implementation of the imagined solution. As noted by the StartX case, however, conflicts may occur when an existing organization belonging to one sphere feels threatened by the existence and activities of the newly created independent hybrid organization, which questions the model and legitimacy of pre-existing operating modes.

In the specific case of labor negotiations, scholars have argued that the boundary spanning function need not be performed by only one person, but may be assumed by several individuals who take on differentiated roles, like "representatives," "gatekeepers," brokers of socio-emotional ties, or brokers of task-oriented ties (Friedman and Podolny 1992). This role differentiation enables boundary spanners to avoid the role conflict inherent in their function because these individuals connect groups that have conflicting expectations of the boundary spanner. In the case of a boundary space creation process, we focused, in contrast, on the absence of differentiation of boundary spanning roles between several people: we analyzed how a boundary spanning function was fulfilled by one person (Compton, Teitelman, Delaune). This absence of role differentiation, which might be called "role integration within

a single person," enhanced the boundary spanner's ability to create a consensus between the convened Triple Helix representatives. The reason for this ability is that only a single individual can defend the solution with involved parties and, thus, make it widely acceptable and viable in negotiating with the involved actors. At the time of an HAO's creation, both the existing innovation gap and the organizational solution needed to be embodied within one person.

This research suggests that the "boundary spanner" be considered in a more collective sense that moves it closer to the Triple Helix "Innovation organizer" (Etzkowitz 2008). The boundary spanner is an individual with convening capacity, i.e. who can bring individuals and groups together across institutional boundaries to brainstorm, invent and implement new organizational designs for solving innovation blockages. The innovation organizer is the group that comes together from across the Triple Helix to realize the project (*Ibid.*). The boundary spanner envisions, synthesizes (knowledge, expertise), convenes and federates existing initiatives and actors. The innovation organizer aggregates resources and implements a concept that is clarified and modified during this process. A transition occurs from spanning to organizing.

Implications for practice

Our results can be translated into practical recommendations for managers and policymakers wishing to foster innovation by creating support organizations operating at the interface of science-industry-government spheres. The identified catalyst's roles describe a three-step process that these actors should follow when creating such organizations: recognizing and naming an innovation gap, bringing Triple Helix representatives together to create a consensus on the gap and a possible solution, and designing *ad hoc* and contingent solutions by recombining elements from the different spheres. A similar process took place in other settings, for example in German territories following the implementation of the 'BioRegio' cluster-based technology policy from 1995 onwards (Champenois 2012; 2006; Dohse, 2007). This policy strongly stimulated biotechnology entrepreneurship in Germany in the second half of the 1990's. It triggered in numerous territories the creation of HAOs supporting scientists in the transformation of science into commercial products, especially through new science-based venture creations. For example, in the region around Heidelberg, one of the model regions chosen by the Federal Ministry of Research, the *BioRegio* HAO was twofold. It consisted in an association and in a seed funds, both assisting scientists in their

entrepreneurial projects. The collective genesis process of this HAO was as follows: (1) recognizing and naming a gap (insufficient transformation of science into commercial products) by the Dean of Heidelberg University after the launch of the *Bioregio* program (year 1995); (2) gathering representatives from the Triple Helix spheres (research institutions, pharmaceutical and biotechnology companies, state ministries, technology parks and finance institutions) who worked in workgroups to create a consensus (on the university's mission of commercializing academic knowledge, on regional strengths and weaknesses), to make an inventory of the regional capabilities in biotechnology and to agree on a local project to support innovation (1995-1996); (3) implementing the designed project by drawing elements from the different spheres, especially securing funding for the new *BioRegio* HAO from Federal research ministry, region-based industry and banks (1996-1997) (Champenois, 2012). An individual boundary spanner played a key catalyst role in these dynamics: Ulrich Abshagen, a professor in clinical pharmacology and former CEO of a pharmaceutical company (Boehringer Mannheim), strongly linked to the Heidelberg University. Abshagen was recruited to coordinate the collective process of conceiving a local support project. He organized the securing of resources before and after becoming Head of the newly created *BioRegio* seed funds in Heidelberg.

Practitioners should note that this process will inevitably be lengthy and time consuming, as evidenced by the ARD, Startx, Atlanpole and *BioRegio* support organization cases.

The importance of an individual boundary spanner's acting as a catalyst in this organizational creation also suggests that the main proponents of creation of a new HAO (often policymakers or administrators) must carefully select the individual whom they ask or approve to create such a support hybrid organization. To be legitimate and to be able to secure resources from different spheres, this individual should ideally have a consistent network in all the involved spheres, prior experience, and solid negotiation skills. Compton, Delaune and Abshagen had decades of experience and large networks in several spheres (academia, industry and government), which gave them contacts and legitimacy to secure the required resources.

Further, the creation of hybrid support organizations is a collective task. The individual boundary spanner should have the ability to work successfully within a team. Boundary spanners must be given the means to recruit an internal team as well as an external network of mentors and advisors from the different spheres (mainly entrepreneurs and venture

capitalists). Compton, Teitelman, Delaune and Abshagen constituted from the beginning a team around them and recruited various complementary competences.

Finally, the independence of the hybrid organizations that occupy a boundary space is likely to have various positive effects. Independent HAOs envision their mission as integrative, or combining elements from the distinct Triple Helix spheres, rather than fulfilling a task that will benefit a single institution. For example, the *Bioregio* seed funds in Heidelberg was able to gather resources from pharmaceutical companies, banks and federal government to fund promising scientific projects originating from various local universities, because it was independent. In contrast, a university's TTO aimed at commercializing licenses on IP, like the NIH Office of Technology Transfer (Guston 1999), or a science park operated by local governments wishing to build and then find occupants for new buildings represent missions that are primarily influenced by one sphere. Because HAOs' goals are not defined by sponsors belonging to a particular sphere, such organizations can be expected to have a greater ability to take independent action than non-autonomous organizations do. This autonomy of HAOs is especially important because it allows HAOs to detect and meet specific local needs to enhance Triple Helix interactions and innovation. StartX exemplifies the benefits of autonomy: its independence allowed it to conceive and implement a support solution for student entrepreneurs despite the initial opposition of the University and its OTL.

7. Conclusion

In this article we analyzed three experiments in the creation of hybrid autonomous organizations (HAOs) to address innovation blockages. This allowed us to identify three steps in the formation process of such organizations. We argued that their creation opens up a "boundary space" that, unlike a boundary line, which clearly distinguishes separate spheres, integrates elements from overlapping spheres. We identified the individual role of a boundary spanner in this dynamic. The presented results enrich both Triple Helix and boundary spanning research and have implications for practitioners.

Our chosen cases were heterogeneous and exploratory. Future confirmatory studies could focus on more similar cases to test and refine our boundary space model. They could test whether the model holds for hybrid organizations integrating two —rather than three— institutional spheres. Future research may also consider the conditions under which boundary lines that separate open up into spaces that integrate. Further, studies may also identify under

what conditions hybrid organizations remain autonomous or, on the contrary, are absorbed by a particular sphere.

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