Grenoble–GIANT Territorial Innovation Models

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Grenoble–GIANT Territorial Innovation Models: Are Investments in Research Infrastructures Worthwhile?

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Abstract

Over the past decades, the EU heavily invested in Research Infrastructures (RI). What are the expected returns of such investments? In the present article we address the question of returns on public funds/public infrastructures.

We consider the role of RI and universities from an economic, social, and entrepreneurial perspective from various Territorial Innovation Models (TIMs): (1) Italian industrial districts, (2) innovative milieus, (3) regional innovation systems, (4) new industrial spaces, and (5) regional clusters.

We conducted our empirical study on Grenoble Isère Alpes Nanotechnologies (GIANT), which is composed of large scientific instruments, universities, and engineering and management schools.

Our microeconomic methodology measured the socioeconomic and entrepreneurial effects of GIANT with respect to budget, employment, and spin-off generation. We contribute to the existing body of knowledge on TIMs by (1) comparing the long-term investments to the generation of wealth, the creation of employment, and the development of start-ups; (2) adding new insights to the debate opposing positive and negative impacts empirical studies; and (3) offering recommendations for the use of public resources. In our discussion, we compare the GIANT model as a very localized RI-university club to the Grenoble model as localized cluster.

Keywords: territorial innovation models; research infrastructure; university; socioeconomic impact; start-up; return on investment

Introduction

To catalyze economic growth, the European Union nations are developing Research and Innovation Strategies for Smart Specialization (RIS3). RIS3 strategies "focus on policy support and investments on key national/regional priorities, challenges and needs for knowledge-based development [, and] they are evidence-based and include sound monitoring and evaluation systems" (European Commission, 2011, p. 2). Overall, the aim is to promote coherent and structured investments, to catalyze innovation and research, to support the economic development in Europe, and to reduce the differences between European regions (Midtkandal & Sörvik, 2012).

In that context, Foray et al. (2012) argued that the knowledge triangle of education, research, and innovation is relevant in the context of smart specialization. In that sense, the concept of "smart cities" raised important questions related to human capitals, social capitals, economic aspects, training, and education. Caragliu, Del Bo, and Nijkamp (2011) argued that the availability of an educated labor force and long-term investment explains the rapid urban growth and the success of cities. Moreover, past researches have shown spending on infrastructure has been very important in the EU over the last decade (Del Bo & Florio, 2012).

However, we know much less about the impact of infrastructure on economic activities, which prompts these questions: What are the investments worth? What are the expected returns of such investments? Considering the scarce availability of public resources, the question of returns on public funds/public infrastructures is of increasing interest. For instance, Breznitz, O'Shea, and Allen (2008) argued that there is increasing pressure on universities to generate economic returns and to contribute to employment of a skilled workforce. Lee, Peng, and Song (2013) also argued that "In a world of increasing uncertainty, policy makers are recommended to focus on the implications of that long-lasting variability for societal value creation." (p. 342).

The question related to the return on investment of RI is not new. Rosenberg (1992) had argued that the impact of large scientific instruments on the economy requires further study. Similarly, O'Gorman & Kautonen (2004) encouraged further studies to measure policy interventions. More recently, Del Bo & Florio (2012) studied the returns on investments of infrastructures in European regions and pointed out that "the empirical evidence on the relationship between infrastructure and growth is still debated" (p. 1469). While a majority of empirical studies have concluded that the impacts are positive, some other researches highlight the negative impacts. There is consequently a need to better understand the return on investment of RI not only from an economic perspective but also from a more holistic perspective (Sable, 2007a). Consequently, we argue that answering such a question should be taken from not only an economic but also a social and an entrepreneurial perspective.

Socioeconomic and entrepreneurial regional development has been studied in the geographical economics literature by different Territorial Innovation Models (TIMs). We specifically consider the five following streams of literature that specifically consider the role of RI and universities from an economic, social, and entrepreneurial perspective in the following: (1) Italian industrial districts, (2) innovative milieus, (3) regional innovation systems, (4) new industrial spaces, and (5) regional clusters.

To explore the economic, social, and entrepreneurial impact of RI and universities, we have chosen to conduct our empirical study on Grenoble Isère Alpes Nanotechnologies (GIANT), a geographical network of RI, large scientific instruments, universities, engineering, and management schools. We posed the following research question: In light of existing TIMs, are the investments in RI in GIANT worthwhile from both a socioeconomic aspect and an entrepreneurial aspect?

Our intent is to contribute to the existing body of knowledge on TIMs by (1) comparing the long-term investments made in RI to the generation of wealth, the creation of employment, and the development of start-ups; (2) adding new insights to the debate opposing positive and negative impacts empirical studies; and (3) offering recommendations for the use of public resources for sound investments. Consequently, our research is meaningful and can guide policymakers in future decisions (Del Bo & Florio, 2012).

The article presents the theoretical background related to TIMs by focusing on economic, social, and entrepreneurial aspects that are relevant to the specific case of RI and universities. We consider the investments in GIANT, composed of eight scientific and academic partners located in the Grenoble Polygon, and measure the socioeconomic and entrepreneurial impacts of GIANT through a microeconomic analysis of competitiveness. We compare the intensive public investment in RI to the socioeconomic and entrepreneurial returns and further discuss the two different co-existing TIMs: The GIANT model and the Grenoble model. Finally, in our conclusion section, we suggest recommendations to policymakers.

1. Theoretical Background

1.1. Regional governance

The role of RI has been strongly studied in literature dealing with the territorial approach. Five different streams of literature are relevant in our study: Italian industrial districts, innovative milieus, regional innovation systems, new industrial spaces, and regional clusters. Those streams are relevant because they focus on the economic, the social, and the entrepreneurial outcomes of the spatial agglomeration in which both RI and universities are playing a significant role.

The implication of RI within the regional development was first studied in the stream of literature named *Italian Industrial Districts*, which was guided by Becattini (1989). Becattini (1990) argued that an industrial district can be considered as a socioeconomic organization in which we cannot separate the economic factors from the social factors in a *socioeconomic vortex* (Becattini, 2003). Based on that study, we likewise argue that to best understand the impact of RI, we cannot dissociate the economic aspect from the social aspect. In a study of industrial districts, Markusen (1996) discussed different typologies, and one specific typology, the state-centered, raises our interest. In the state-centered typology, there is the domination of one or a few large public or non-profit organizations such as universities/RI that collaborate with both large and small firms. In such a setting, start-ups benefit from external economies, the availability of a skilled labor force, and the reduction of transaction costs (Amin & Thrift, 1992). Moreover, De Marchi and Grandinetti (2014) argued that spin-offs can easily be developed within such industrial districts.

At about the same time, those in innovative milieus were studying the interaction between innovation activities and space (Aydalot, 1986; Camagni, 1991; Camagni & Maillat, 2006; Ratti, 1989). Camagni (1991) specifically argued that an innovative milieu can learn from its universities thanks to social aspects, such as collective learning. Similar to the Italian industrial districts, such networks can be approached from not only a social but also an economic aspect.

In comparing countries, states, and metropolitan areas, Jaffe, Tratjenberg, and Henderson (1993) argued that knowledge spillovers are geographically localized and concentrated. The smaller the geographical area is, the more significant the localization of spillovers. A city can also be a rich context for developing networks, and in support of this, Capello (2000) argued, “Non excessive city sizes in fact facilitate environmental equilibrium, efficient mobility and the possibility of conserving a sense of belonging as far as the population is concerned” (p. 1926).

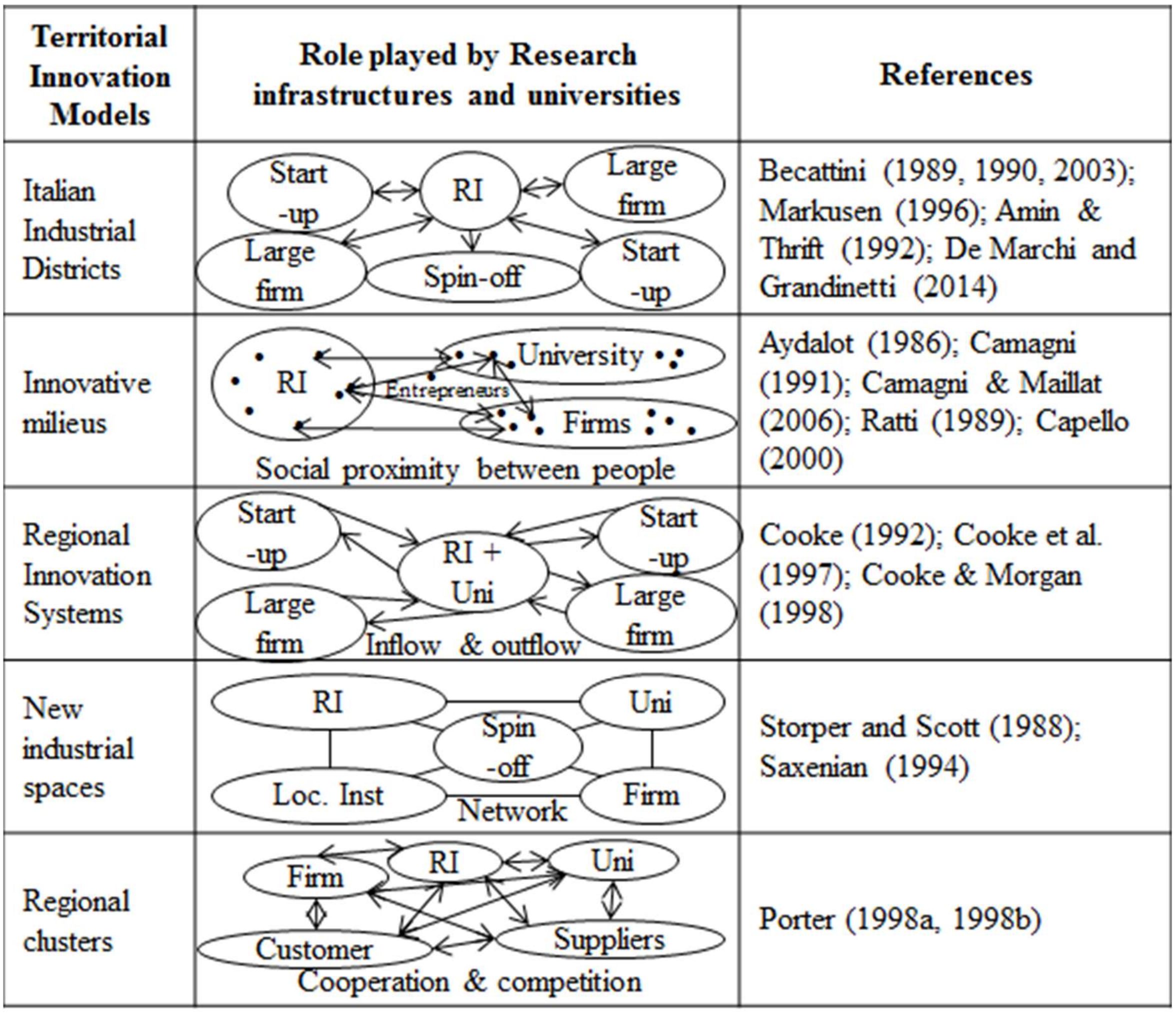
However, the concept of city does not have the same features as the notion of innovative milieux (Maennig & Ölschläger, 2011; Rémy, 2000). Maennig and Ölschläger (2011) argued, If exchange and interaction between the city and the milieu exist, two types can be distinguished. Firstly, the entire city forms the physical basis and the milieu is constituted through the urban relational capital and collective learning processes. Secondly, a single specialized industry within a city constitutes a milieu. In this case, the physical basis is an urban production system” (p. 443). Cities rely on geographical proximity, but innovative milieus depend on social proximity between individuals.

Regional Innovation Systems (RIS) were developed by Cooke (1992) to analyze the inflow of external knowledge and the interactive learning process between various organizations (Asheim & Coenen, 2005; Tödtling & Trippl, 2004). In this stream of literature, much attention is dedicated to RI (Asheim & Coenen, 2005; Cooke, 1992; Cooke, Gomez Uranga, & Etxeberría, 1997). The organizations, whether they are large firms or start-ups, taking part in RIS benefit from external knowledge developed by RI and universities (Asheim & Coenen, 2005; Iammarino, 2005; Lundvall, 1992). Public institutions are currently involved in animating innovation activities and encouraging local stakeholders to develop social linkages to boost regional growth (Cooke & Morgan, 1998).

Storper and Scott (1988) introduced the concept of new industrial spaces and scrutinized the contribution of various stakeholders. Saxenian (1994) provided an explanation of regional economic competitiveness and argued that in order to nurture technopolises, networks must encourage entrepreneurial initiatives. After studying the two stages of emergence and growth of the cities of Cambridge and of Grenoble, Druilhe and Garnsey (2000) argued that dominant firms, local universities, and policymakers are seeding new technopolises. A technopolis is highly path dependent and relies on knowledge developed by RI, especially for the creation of technological spin-offs.

Porter (1998a, 1998b) considered regional clusters a socioeconomic organization in which firms and other organizations, such as universities and RI, not only cooperate but also compete. Porter (1998b) argued that technology transfers are important in clusters and involve scientific institutes. Asheim & Coenen (2005) distinguished the role of public from private RI. Using the regional cluster framework, Andersson, Evers, and Griot (2013) studied local and international networks for Small and Medium Enterprises (SMEs) in the regional cluster dedicated to medical technology in the Rhône-Alpes region in France. They argued that local networks occur in a region where firms benefit from RI and universities.

Overall, the RI and the universities are considered differently according to the various TIMs. RI and universities play a central role in the Italian industrial district and in the Regional Innovation Systems, but they are rather considered one of the stakeholders of a regional network in the innovative milieu, new industrial space, and regional cluster. The interaction between such stakeholders can be considered from an economic perspective or a social perspective, or both. Finally, the creation of spin-offs and the creation of regular start-ups appear as being central to the TIMs. Figure 1 synthesizes the five TIMs we are considering by presenting the different roles played by RI and universities.



Territorial Innovation Models	Role played by Research infrastructures and universities	References
Italian Industrial Districts	Start -up, RI, Large firm, Large firm, Spin-off, Start -up	Becattini (1989, 1990, 2003); Markusen (1996); Amin & Thrift (1992); De Marchi and Grandinetti (2014)
Innovative milieus	RI, University, Entrepreneurs, Firms; Social proximity between people	Aydalot (1986); Camagni (1991); Camagni & Maillat (2006); Ratti (1989); Capello (2000)
Regional Innovation Systems	Start -up, RI + Uni, Start -up, Large firm, Large firm; Inflow & outflow	Cooke (1992); Cooke et al. (1997); Cooke & Morgan (1998)
New industrial spaces	RI, Uni, Spin -off, Loc. Inst, Firm; Network	Storper and Scott (1988); Saxenian (1994)
Regional clusters	Firm, RI, Uni, Customer, Suppliers; Cooperation & competition	Porter (1998a, 1998b)

Figure 1: The roles of the RI and universities in various TIMs

1.2. Critics of existing Territorial Innovation Models

The different TIMs are not free from criticisms. First, the diverse models and typologies presented in the previous part are not applicable to real clusters. In their study of 15 clusters in the United States, He and Fallah (2011) argued that "the real-world clusters rarely feature any single type of typology; a mixed type of typology is much more prevalent in reality" (p. 945) because those concepts have been built in specific contexts and have different origins. And this is normal; industrial districts are just not homogeneous (De Marchi & Grandinetti, 2014). In other words, clusters are unique. In comparing California's Silicon Valley and Massachusetts' Route 128, it is noted that innovation processes and governance between local actors are different and unique. Because clusters are unique, one problem faced by policymakers is the difficulty, if not the impossibility, to replicate a successful cluster in a new place because of the lack of past agglomeration subject to path dependency.

Second, empirical studies have highlighted both the positive and the negative impacts of RI; consequently, there is strong disagreement among scholars regarding the impacts. From their empirical study on Taiwan's national science parks, Huang and Lin (2014) concluded that the presence of local RI positively impacts the R&D investment of private firms. Del Bo and Florio (2012) argued that investments made in information and communications technology (ICT) accessibility have a positive impact on wealth creation. Steinfield, Scupola, and López-Nicolás (2010) studied the importance of ICT in knowledge-intensive clusters by taking the example of the Medicon Valley Biotech Cluster. O'Connor, Link, Downs, and Hillier (2015) studied both the economic and health impact of public investment in medical imaging technology. Their empirical findings suggest that the benefit-to-cost ratio is positive (between 6.66-to-1 and 9.99-to-1). O'Gorman & Kautonen (2004) argued that with investment in R&D activity, infrastructures, and universities, RI is the source of future commercialization of new knowledge. However, positive impacts are not limited to the production of specialized knowledge. For instance, Zucker, Darby, Furner, Liu, and Ma (2007) argued that non-nanotechnological knowledge transfer between various organization has a positive impact on the production of nanotechnology patents.

Many empirical studies documented the fact that such positive impact is directly measured in the localized economy. According to Duranton and Puga (2001), the concentration of an economic activity within a certain geographical area has a positive impact on innovation. In the same vein, Bronzini and Piselli (2009) argued that investments made in public infrastructure have a positive spillover effect on regional productivity. Also considering the spatial aspect, Crescenzi, Rodríguez-Pose, and Storper (2007) argued that local innovative efforts and the agglomeration of research activities occur simultaneously in U.S. innovation hot spots. Crescenzi and Rodríguez-Pose (2013) studied the socioeconomic impact of R&D expenditure on regional innovation in the United States and argued that the local R&D investments predict regional innovative performance. Lehto (2007) argued that firm's R&D and past R&D have a positive impact on productivity located in the same sub region.

Universities and RI are extremely localized and therefore have a positive impact on the local economy, and universities also have a positive effect on economic development (Clarysse, Wright, Lockett, Van de Velde, & Vohora, 2005; Di Gregorio & Shane, 2003; Shane, 2004). In the American context, Jaffe (1986) argued that both research spending in universities and R&D spending in firms have a positive impact on corporate patenting. Acs, Audretsch, and Feldman (1992) argued that R&D conducted in a university has a positive impact in terms of spillovers, especially in terms of innovation. Breznitz et al. (2008) studied the impact of universities on economic development through technology transfer and argued universities have an impact on the economic development of regional bioclusters. One important aspect of the impact of universities is the creation of spin-offs (Breznitz, O'Shea, & Allen, 2008). For instance, O'Shea, Allen, Chevalier, and Roche (2005) argued that research universities create 1.91 spin-offs per year in the United States, and MIT alone creates 31 spin-offs per year. Often associated with universities, RI are playing an increasing role in multi-scalar innovation policy supporting the economic development of nations (Clark, 2010). Hervas-Oliver, Albors-Garrigos, De-Miguel, and Hidalgo (2012) argued that there is a need for further research to investigate the different typologies of technology centers.

However, those positive impacts are balanced with a number of negative impacts. Sable (2007) studied the potential negative impact of biotechnology on local economic development by using the example of Boston and San Diego. They argued that low- and semi-skilled people may suffer from transportation congestion, rent increases, and gentrification. Baptista

(2001) studied the innovation diffusion in geographical clusters and argued that the diffusion of technology is spatially variable and inter-firm networking is crucial in knowledge transfer/diffusion. In today economy, the co-location of various institutions does not guarantee technology transfer (Boschma, 2005; Camagni, 1991). Pouder and St. John (1996) argued that when belonging for some time to a given cluster, firms in clusters can be negatively affected by discontinuous change. Asheim (1996) found that clusters benefit from the adoption and the diffusion of incremental innovation as opposed to radical innovation in clusters. Del Bo and Florio (2012) stated, “When considering the rate of return to infrastructure, the main problem is that the infrastructure economics has the features of imperfect markets: market failures, political objectives and constraints, and regulatory and distributional issues move the returns of investment in infrastructure away from the market signals given for them” (p. 1395).

Therefore, further study of the socioeconomic and entrepreneurial impact of RI and universities of a real-world cluster is needed. Consequently, we will study the following research question: In light of existing Territorial Innovation Models, are the investments in RI in GIANT worthwhile from a socioeconomic aspect and an entrepreneurial aspect?

2. Methods

Our intent is to measure the socioeconomic and entrepreneurial impacts of RI and universities within GIANT. GIANT is composed of eight scientific and academic partners—the Atomic Energy Commission (CEA), the National Polytechnic Institute of Grenoble (INPG), the Joseph Fourier University (UJF), Grenoble Ecole de Management (GEM), the National Centre for Scientific Research (CNRS), the Laue Langevin Institute (ILL), the European Synchrotron Radiation Facility (ESRF), and the European Molecular Biology Laboratory (EMBL)—located in the Grenoble Polygon.

2.1. Measurement of socioeconomic and entrepreneurial impacts

Economic studies take the form of either accounting assessments of the economic impact of spending or analyses of the regional economy using input-output tables and/or econometric models, Keynesian income-expenditure calculations, or social cost-benefit accounting methods (Thanki, 1999). In addition to these, Li and Chen (2005) included partial and general equilibrium models as other tools to assess regional impacts. Overall, four commonly used methods have been considered: (1) Input-output, (2) computable general equilibrium, (3) econometric models, and (4) survey.

According to Drucker & Goldstein (2007), each of the four commonly used methods – surveys, input-output, production function and econometric models – have their own unique advantages and drawbacks. The vast majority of input-output and Computable General Equilibrium (CGE) impact studies use limited indicators describing the activities carried out by higher education institutions. As stated by Liu (2006), CGE approaches suffer from limitations associated to assumptions about "the functional form of the behavior of economic agents in consumption, production, and so on" (p. 1659). Li, Blake, & Thomas (2013) pointed out that most studies have applied the assumption of perfectly competitive markets. Many models might use inappropriate elasticities and parameters (Seung & Lew, 2013). Different econometric models lead to a large variety of divergent conclusions and their relevance is highly dependent on the quality and adequacy of data (Ragona & Mazzocchi, 2008).

TIMs strongly influenced our choice to conduct a study on both social and economic factors. It has been demonstrated in past researches that both factors are important in industrial district (Becattini, 2003), innovative milieu (Camagni, 1991), and regional cluster (Porter, 1998a, 1998b). First, while the input-output, computable general equilibrium, econometric models methods rather concern the measurement of the economic impact solely; the survey method is relevant to measure the socioeconomic impact. Second, the survey method was preferred to other impact assessment methods because there is no available input-output information at such micro-level. To evaluate the socioeconomic impacts, we had to use the survey method to collect primary data from all stakeholders.

In our research, we measure the economic effects following the method used by Carroll & Smith (2006). Carroll & Smith (2006) measured the economic effects based on four types of expenditures: (1) capital and operational expenditures of the university/RI, (2) spending by employees, (3) spending by students, and (4) spending by visitors.

First, regarding the measurement of the capital and operational expenditures, we consider the wages (Qiao, 2015; Kim & Chon, 2009; Connaughton & Madsen, 2007; Vandyck & Van Regemorter, 2014; Cassey, Holland, & Razack, 2011; Lee, 2015; Chandler, 2012; Roberts & Eesley, 2009; Jobs, Burris, & Butler, 2007; Larsen, Mier, & Loop Capital Markets, 2012), operating costs (Qiao, 2015; de Arce, Mahia, Medina, & Escribano, 2012; Lee, Lee, & Chen, 2012), investment (de Arce, Mahia, Medina, & Escribano, 2012; Li, Blake, & Thomas, 2013; Lee, Lee, & Chen, 2012; Lu, Lei, & Ge, 2012; Pressman, Guterman, Abrams, Geist, & Nelsen, 1995; Viederyte & Skeivyte, 2014), and share of Rhône-Alpes spending in euros. Each partner provided its budget without personnel expenses, and using that figure, each evaluated the amount spent locally with local partners.

Second, regarding employee spending (Taks, Késenne, Chalip, Green, & Martyn, 2011), a distinction was made between permanent and provisional work contracts and between full- and part-time workers. Each partner reported the number of people employed within its laboratory and the number of people employed in joint laboratories. The activities of joint laboratories required a specific attention not to count workers twice.

Third, regarding student spending (Pastor, Pérez, & de Guevara, 2013), we made a distinction between students spending more than 50% of their time in the scientific polygon and those spending less than 50%. Each academic and research partner provided the number of students, and we distinguished between students in universities and in engineering and business schools and the students working in GIANT R&D units. Linked to students, we measured the number of awarded degrees (bachelor's, master's, doctoral, and habilitation for supervising research) per year and in total.

Fourth, regarding visitor spending (Llop & Arauzo-carod, 2012; Kim & Chon, 2009; Santos, Grado, & Hunt, 2016; Seung & Lew, 2013; Li, Blake, & Thomas, 2013; Taks, Késenne, Chalip, Green, & Martyn, 2011; Pastor, Pérez, & de Guevara, 2013 ; Larsen, Mier, & Loop Capital Markets, 2012; Zheng & Hung, 2012), we considered not only the number of visitors, the number of equivalent full-time days, and the geographic origin but also the dissemination aspect with the number of days dedicated to scientific dissemination. Each partner measured its scientific dissemination outside GIANT and also, and more importantly, measured its' capability of hosting scientific meetings, conferences, etc.

Referring to the Regional Innovation System and to regional cluster, we want to examine the impact of public institutions on regional growth (Cooke & Morgan, 1998; Asheim & Isaksen, 2002; Krugman, 1998; Porter, 2000). The various expenses are direct, indirect, or induced (Connaughton & Madsen, 2007; Santos, Grado, & Hunt, 2016; Cassey, Holland, & Razack, 2011; Aries & Sclar, 1998; Venckus & Gaidelys, 2011). Total direct expenses are increased by a multiplier to consider interdependencies with local economic activity and to assess both indirect and induced expenditures. The median multiplier is 1.8, according to Siegfried, Sanderson, and McHenry (2007).

Our intent is to avoid the methodological issues noted by Siegfried et al. (2007), including the basis for measurement of impact with and without a given institution, the definition of a limited geographical area, the quality and reliability of data, potential issues of double counting and assimilation of expenditures/jobs that should not be attributed to an organization, and the integration of multipliers.

Based on De Marchi and Grandinetti (2014), we want to understand the impact of the industrial district on the creation of spin-offs. In our study, we also measured the entrepreneurial impact of GIANT, and consequently, we measured the creation of new ventures by the former students of higher education institutions and the former employees of public research units. The analysis of spin-offs from universities, colleges, and RI is important in qualifying the economic dynamism induced by these education and research institutions.

2.3. Data collection

The eight GIANT partners were mobilized collectively, and all partners answered positively to the invitation for collaboration. The CEA was a key partner because it had already attempted to conduct a similar study on economic impact at the research center level. To carry out our study, each institution dedicated one, two, or three people to collect the data.

Linked to the previous section, a template for collecting data related to (1) capital and operational expenditures, (2) employee spending, (3) student spending, and (4) visitor spending was provided to the eight GIANT partners. To insure the homogeneity of the data collection, detailed notes for each measurement were provided. The measurement instruments were presented in a meeting to assure those in charge of the data collection fully understood them. This meeting aimed to address the comments and questions from the people in charge of the data collection at the eight institutions. Following this meeting, some adjustments and further details were added to the initial template.

Once the template had been validated, each institution started to collect data. To increase control of the data collection, a follow-up review was performed on data collection organization by organization. Some partners were very proactive; however, others faced issues regarding the feasibility of the data collection. For those experiencing difficulties in the data collection, we either assisted them or collected the data ourselves.

The consolidated estimation of the total impact of GIANT was then calculated after the addition of the data provided by each partner. Overall, we collected the data from all eight partners.

3. Analysis

To highlight whether the impact of RI and universities on the local economy is worthwhile, we first need to identify the major investments made and second, identify the socioeconomic and entrepreneurial impacts.

3.1. Large investments in GIANT

Since the creation of this scientific polygon in the mid-1950s, large investments have been made in the Center for Nuclear Studies of Grenoble (CENG), CNRS, ILL, ESRF, EMBL, and MIcro- and NAno-TEChnologies (MINATEC: a campus for innovation in microtechnologies and nanotechnologies). More broadly, the Grenoble area has benefited from massive public investments (by state and local authorities) on the occasions of the establishment of the campus of Saint-Martin d'Hères (1963–1966), the holding of the Olympic Games (J.O. 1964–1968), the establishment of the Zone for Innovation and Scientific and Technological Development (ZIRST, founded in 1972 and becoming Inovallée in 2005), together with the National Centre for Telecommunications Research (CNET) and the National Institute for Research in Computer Science and Control (INRIA), and the creation of Villeneuve de Grenoble-Echirolles (early 1970s).

The Grenoble area has also greatly profited from a national research policy and funding from central government institutions, including the Advisory Committee on Scientific and Technical Research (CCRST, created in 1958), the General Delegation for Scientific Research and Technology (DGRST, founded in 1959), and the Delegation for Spatial Planning and Regional Action (DATAR, founded in 1963).

Table 1 presents a first evaluation of total investments (excluding staff costs) expressed in constant euros based on the National Institute of Statistics and Economic Studies (INSEE) construction price index. The total amount is estimated at 2.81 billion euros.

Source	Billions of Euros
Olympic Games	1.28
ILL	0.28
MINATEC	1.33
INRIA	0.12
ESRF	0.79
EMBL/ Partnership for Structural Biology	0.17
CENG	N/A
TOTAL	2.81

Table 1: Investments in Grenoble

Sources: Press cuttings, Minatec documents, Parliamentary Office for the Evaluation of Scientific and Technological Decisions, interviews (INRIA, ESRF, and EMBL), Bruneteau, 1998; Frappat, 1991; Fremont, 1987.

Nearly €3 billion in today's prices was invested into the Grenoble area by GIANT partner organizations during the 1968 Olympics. This sum does not include urban development investments (Villeneuve, ZIRST) or the investments of CENG, CNET, and EMBL (data not available).

3.2. Socioeconomic impacts

Direct employment

The eight GIANT partners currently employ 7,609 people, out of which 7,519 are employed by one partner only and 90 are employed in joint laboratories. As to the 7,609 people employed, €443,939,162 represents annual wages. For this study, only contractors working more than 12 hours per year were considered. The direct economic impact was calculated based on the propensity to consume set at 0.847, according to the national average published by INSEE in the National Accounts of 2008 (Aviat, Houriez, & Mahieu, 2009). Consequently, we obtained a local effect estimated at €376,016,470 per year. As to the 90 people working in joint laboratories, we obtained a local effect estimated at €1,448,141. Consequently, the total local effect of the 7,609 people directly employed is evaluated at €377,464,611.

Students

In GIANT, we counted 25,757 students. We dissociated the students registered in universities, engineering schools, and business schools (24,632 students) from the students of R&D units (1,125 students). When considering the 24,632 students from universities, engineering schools, and business schools, we divided them into two categories: the students spending more than 50% of their time working in the scientific polygon (4,927 students) and the students spending less than 50% of their time working in the scientific polygon (19,705 students). For the students spending more than 50% of their time working in the scientific polygon, we considered a monthly budget of €950. Consequently, the local impact can be estimated at €4,680,650. We also considered the 19,705 students spending less than 50% of their time working there. We allocated a monthly budget of €300 to be spent in Grenoble. Consequently, the local impact could be evaluated at €5,911,500. We also counted 1,125 students working in GIANT R&D units, out of which 1,043 were registered in Grenoble and 82 registered elsewhere and allocated a monthly spending of €950 for them. We estimated the annual spending of students from GIANT R&D units to €1,068,750. Overall, the total local effect of the 25,757 students is evaluated at €11,660,900.

Alumni

Out of the 25,757 students, 6,352 degrees have been awarded (bachelor's and master's) and 344 doctorates/habilitation for supervising research. In GIANT, we counted a total number of 217,000 alumni, and according to INSEE regional data, 22.2% of those alumni are currently working in Isère with an average annual salary of €41,300. We also took into consideration €18,997 as the gross disposable income per capita in the Rhône-Alps area. Overall, the total local effect of the 217,000 alumni is evaluated at €80,924,777.

Dissemination/ Visitors

In 2008, GIANT partners were involved in scientific dissemination by presenting their works in conferences, seminars, etc. We counted 2,092 days dedicated to scientific dissemination outside GIANT. Consequently, there are no local impacts associated to the scientific dissemination. However, GIANT has also been very active at hosting scientific meetings, conferences, etc., and 10,655 visitors came to GIANT in one year. We counted 56,416 days spent in GIANT per year. The economic effect of visits was evaluated based on the following average costs: €30 for intra-regional visitors, €170 for visitors from other French regions, and €250 for foreign visitors. Overall, the total local effect of the 56,416 visitor days is evaluated at €12,360,145.

Budget

The total annual budget of all eight partners is evaluated at €1,065,278,419 per year. Because we already considered the impact of direct employment on the local impact, we considered the budget of the GIANT partners without personnel expenses. Overall, this budget has been estimated at €413,512,330 per year. The largest part of this budget has been dedicated to activities outside the geographical area we are interested in. Still, part of this budget has been spent locally with local partners. Overall, the total local effect of the budget of the eight partners without personnel expenses is evaluated at €172,595,547.

Total local effect

By adding the total local effect of (a) the 7,609 people directly employed (€377,464,611), (b), the 25,757 students (€11,660,900), (c) the 217,000 alumni (€80,924,777), (d) the 56,416 visitor days (€12,360,145), and (e) the budget of the eight partners without personnel expenses (€172,595,547), we obtained a total of €655,005,980 in 2008.

Total direct and induced effect

Referring to Siegfried et al. (2007), we used a median multiplier of 1.8. Consequently, the annual local effect of GIANT, considering both direct and induced effect, can be estimated at €1,179,010,764 (Table 2).

Units		Number	Euros	Local effect
Direct employment	Direct employment: Staff	7,519	443,939,162	376,016,470
	Direct employment: Staff in joint laboratories	90		1,448,141
Total	**Direct employment**	**7,609**		**377,464,611**
Students	Students in universities, engineering and business school ≥ 50% present on GIANT site	4,927		4,680,650
	Students in universities, engineering and business school < 50% present on GIANT site	19,705		5,911,500
	Students in GIANT R&D units registered in Grenoble	1,043		990,850
	Students in GIANT R&D units registered elsewhere	82		77,900
Total	**Students**	**25,757**		**11,660,900**
Alumni	Granted degrees before doctorate	6,352		0
	Granted doctoral degrees	344		0
Total	**Alumni**	**217,000**		**80,924,777**
Dissemination	Number of days for scientific dissemination	2,092		
Visitors	Number of visitors per year	10,655		
Total	**Number of visitor days per year**	**56,416**		**12,360,145**
Budget	Budget		**1,065,278,419**	
Total	**Budget without personnel expenses**		**413,512,330**	**172,595,547**
TOTAL	**LOCAL EFFECT IN ISERE**			**655,005,980**
TOTAL	**WITH INDUCED EFFECTS**			**1,179,010,764**

Table 2: Total Socioeconomic Impact

Overall economic impact

According to AEPI (2008), it is important to also consider the economic impact of jobs in the microelectronics and computer industry. Consequently, the total effect on the economy of Isère is close to €2.2 billion for 2008. When also including the impact of other industries and services, the total impact is approximately €3.2 billion.

The Grenoble-Alpes Metropole body includes 27 municipalities and 400,000 inhabitants (or 36.5% of the Isère population population, generating a GDP that can be estimated at €12 billion due to the urban concentration of economic activities and jobs. With a total impact of

GIANT estimated at €3.2 billion, we can argue that GIANT represents 25% of the GDP generated by the Grenoble-Alpes Metropole.

3.3. Entrepreneurship impact

Using the methodology defined by Roberts and Eesley (2009), we measured the entrepreneurship impact within the eight GIANT partners. As an example, we present with more detail the analysis made in Grenoble Ecole de Management (GEM).

A questionnaire was e-mailed to 9,727 GEM alumni with registered e-mail addresses. At the end of 2008, there were 11,747 graduates since the creation of the business school in 1984. Responses were received from 1,594 alumni, yielding a gross response rate of 16.4%. The net response rate was 18.6%, given 1,159 e-mails never reached their destination either because e-mail addresses were incorrect or e-mail was blocked by anti-spam software. In parallel, the same questionnaire was sent to 411 faculty and staff of the school; 171, or 41.8%, responded.

Incomplete responses—in particular, when a former student claims to have founded a company but did not specify the method of origin (creation or acquisition of shares) or to have created several companies but supplied only partial details (number of employees, turnover, and number of patents)—were corrected by the average turnover, average number of employees, and average number of patents. Furthermore, the data were corrected for the rate of equity participation. For example, for a company owned by 20% of its total shareholders, 20% of the workforce, turnover, and number of patents were computed.

The weight of non-respondents was incorporated to extend the evaluation to the entire population of graduates. In the GIANT study, much of the target population did not respond for a variety of reasons, including incorrect e-mail addresses, anti-spam software blocking, and lack of time. To estimate the number of businesses created by GEM entrepreneurs, we conducted a second extrapolation by multiplying the extrapolated data above by a scaling factor. For all indicators, the scale factor was 6.102 for former students and 2.404 for faculty and staff. For the alumni, the 6.102 ratio was obtained from a population of 9,727 alumni, of which 8,568 received the questionnaire and 1,594 responded. To obtain 9,727, we multiplied 1,594 by 6.102 (9,727/1,594). Similarly, out of a population of 411 faculty and staff, only 171 responded, yielding a scale factor of 2.404 (411/171).

Starting with Grenoble Ecole de Management, alumni, faculty, and staff have been mobilized. Alumni have created or rescued 2,923 companies, whereas faculty and staff have created or rescued 55 companies, with a total of 2,978 still operational in 2009. The vast majority of originations, 2,227 units (76%), are start-ups, whereas 13% are takeovers of existing businesses. Twenty-seven percent of the 2,978 businesses are located in the Rhône-Alpes region, 38% are located in other parts of France, and 35% are located abroad, thanks to foreign students (Grenoble Graduate School of Business).

At the end of 2008, these 2,978 companies employed 96,150 individuals, of which only 3,241 were based in the Rhône-Alpes region. They generated adjusted revenue of €217 million in 2008, including €57 million in the Rhône-Alpes region. Although development of entrepreneurship is relatively new, entrepreneurship increased significantly in 2003 and has accelerated since 2006. Fifty percent of the companies indicated that their activities are linked to new technology and innovation, with 332 holding patents and 485 exploiting patents.

We also replicated the same methodology for the other eight partners, and we found spin-offs from public RI and higher education institutions are also a major source of job creation. Since the mid-1980s, the CEA has been an incubator for spin-offs that have contributed significantly to the creation of high-tech jobs in the Grenoble area, including such companies as SOFRADIR, ULIS, SOITEC, TRONICS, and CROCUS. According to Zylberberg (2005), more than 2,000 jobs have been created through various CEA initiatives. The CEA has estimated that since 1984, it has contributed to the creation of 102 technology companies and more than 2,500 direct jobs, with an accumulated turnover of €500 million (CEA, 2008). With the 1971 creation of the EFCIS (*Etude et Fabrication de Circuits Integres Speciaux*: Study and Manufacturing of Special Integrated Circuits), the first spin-off of LETI, the CEA generated "one of the seeds of what became ST Microelectronics with a long history and several regroupings" (Therme, 2005).

According to official data, INPG has created 30 new start-ups, whereas the UJF has created 28, representing 330 jobs. Overall the GIANT entrepreneurship impact can be evaluated at 2,500 jobs created by spin-offs and 3,200 jobs created by entrepreneurial alumni.

4. Discussion: Localized and very-localized co-existing TIMs

4.1. GIANT model: Very-localized RI–university club

In light of the existing literature findings on geographical economics that portray the differences between TIMs, we argue that the GIANT model stands at the intersection of Italian industrial districts (Becattini, 1990) and regional innovation systems (Cooke, 1992) and is very close to the state-centered typology of industrial districts depicted by Markusen (1996). Holding 48% of the entire workforce of GIANT, 39% of the total budget, 54% of total budget without personnel expenses, CEA is making the greatest local impact in Isère with (36.81%), far more than CNRS (14.86%), ESRF (12.23%), UJF (10.26%), ILL (9.99%), GEM (9.67%), INPG (4.85%), and EMBL (1.32%). This marks the CEA as the real impetus behind the regional electronic component industry and the source of the development of the microelectronic industry in the area. CEA has properly fulfilled the role of anchor tenant, as defined by Agrawal and Cockburn (2003), by stimulating both academic and industrial research. Spin-offs emerge from such centralized structures.

If the CEA would not have initiated the creation of a center of excellence in microelectronics and the EFCIS spin-off in 1971, it is likely that the vast majority of companies in the high-tech industry, including ST Microelectronics, NXP (Philips), Freescale (Motorola), E2V, Trixell, Thales, Tronics Microsystems, ULIS, Crocus, XENOCS, Alcatel Vacuum, SUSS Microtec, Applied Materials, LAM, SOITEC, and Tracit, would not have a local presence today. Based on estimates of AEPI (2008), one should also recognize that such decisions helped attract many large corporations in the electronic equipment industry, such as Hewlett Packard, Xerox, Schneider Electric, Bull, and France Telecom–Orange. The GIANT model was also inspired by Regional Innovation Systems (Cooke, 1992) because the RI play a significant role in supporting social connections between localized organizations, knowledge inflows and outflows, and regional growth.

4.2. Grenoble model: Localized cluster

Beyond the collaboration between partners in a very localized RI/university club dominated by the CEA, the same RI and universities are also part of what we will call "the Grenoble model," a much broader TIM, at the intersection of new industrial spaces (Storper & Scott, 1988) and regional clusters (Porter, 1998a, 1998b). However, this broader scope goes beyond the range of our empirical study and consequently offers paths for further investigations.

Grenoble can be considered as a new industrial space (Storper & Scott, 1988) in which various stakeholders such as RI, universities, firms, and public institutions are making specific contributions. As argued by Druilhe and Garnsey (2000), the dominant firms, in combination with RI and universities, are offering a favorable industrial space for the creation and growth of spin-offs. Very similarly and referring to the regional clusters according to Porter (1998a, 1998b), the cooperation and the competition between firms, RI, and universities exist at the cluster level. Such a collaborative and competitive environment strongly affects technology transfers between RI and other co-located organizations.

While most of the past research has argued that a specific model fits a specific case (De Marchi & Grandinetti, 2014) or that specific cases are unique and match the mix of several models (He & Fallah, 2011), we argue that a specific region can be managed by different models simultaneously and cumulatively. In our empirical study, we argue that the greatly localized GIANT model and the localized Grenoble model are two co-existing TIMs developed around the CEA (Figure 2).

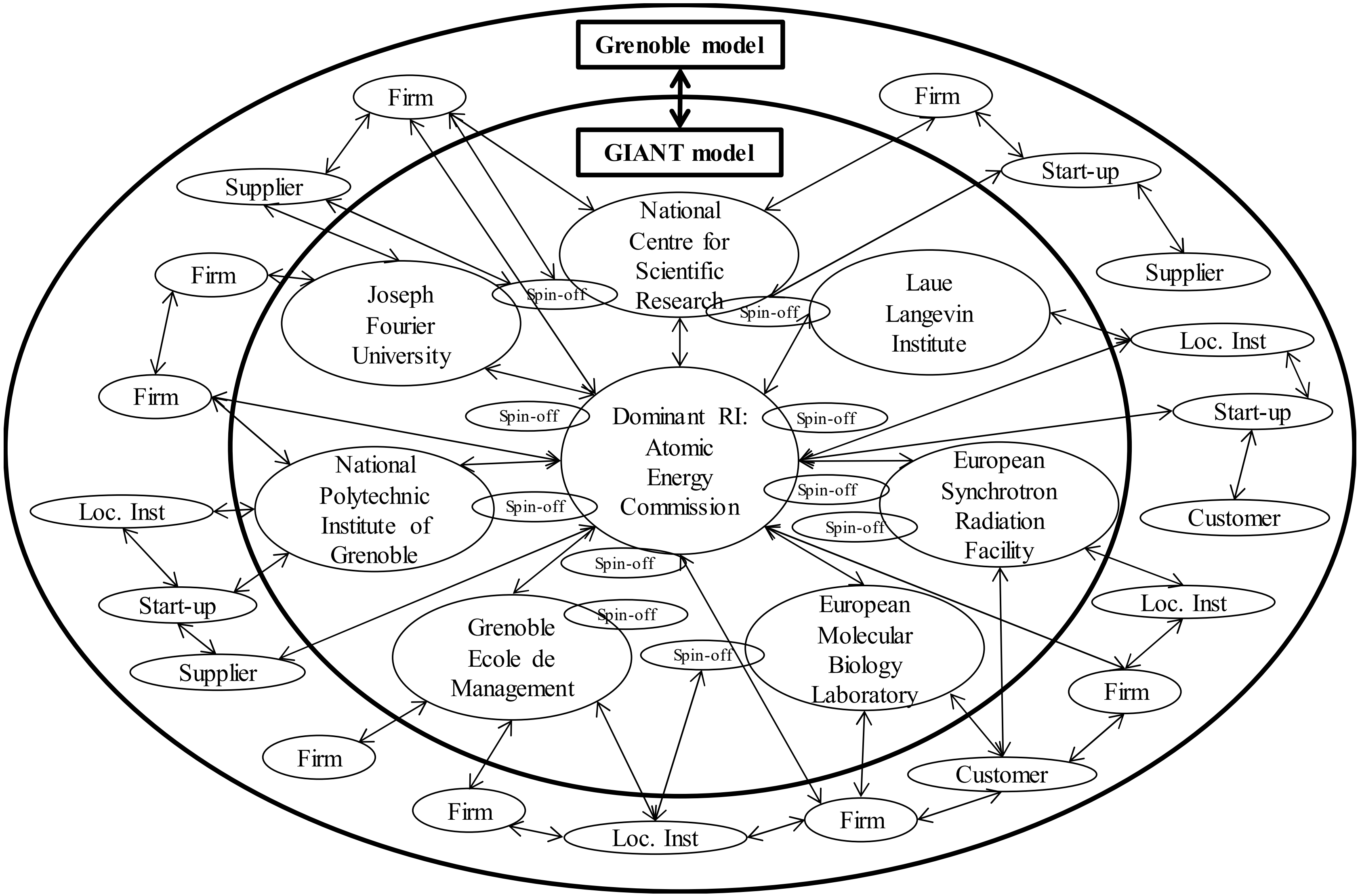


Figure 2: The co-existence of the GIANT model and the Grenoble model

Conclusion

In conclusion, we argue that the investments made in GIANT (€2.81 billion) are worthwhile from a social aspect (7,609 direct employment, 25,757 students, 217,000 alumni, and 56,416 visitor days), from an economic aspect (annual induced economic impact of €1.2 billion and an annual total economic impact of €3.2 billion), and from an entrepreneurship aspect (5,700 jobs created by spin-offs and by entrepreneurial alumni).

Our empirical study compared the long term investments made in RI to (1) the generation of wealth, (2) the creation of employments, and (3) the development of start-ups. Overall, we argue that sound investments offered good socioeconomic and entrepreneurial returns. Therefore, our work first contributes to strengthen the literature studying the positive and negative impacts of RI.

Our second contribution is related to further discussing the existing literature on TIMs. We argue that the GIANT model fits the Italian industrial districts and regional innovation systems. We further argue that the CEA, as an anchor tenant, is leading a state-centered industrial district that catalyzed the development of the regional electronic component industry, the creation of spin-offs, and regional growth. What differs from existing literature is the maintenance of different TIMs simultaneously in the same geographical area. We argue that the GIANT model has been created to supplement the Grenoble model, and we associate the existing Grenoble model with a mix of new industrial spaces and regional clusters. In that setting, the eight members from GIANT collaborate with other co-localized stakeholders from the Grenoble model. Consequently, the Grenoble model is much broader in space and scope than the GIANT model *stricto sensus*. Consequently, our research diverges from associating one TIM or a mix of several TIMs to a given real case. In contrast, we argue that several TIMs can fit a multi-scalar real case simultaneously and cumulatively in a localized and a much localized geographical space. As encouraged by Del Bo and Florio (2012), our last contribution concerns the development of recommendations to policymakers. Policymakers frequently ask for guidance on the following questions: (1) What factors contribute to performance? (2) What timing? (3) What scope? and (4) Which TIM?

First, we recommend the creation of performance indicators by equally considering social, economic, and entrepreneurial factors. This will ensure a blending of long-term- and short-term-oriented indicators. The monitoring of the performance should not be made post-investment but rather during investing to take corrective actions if needed and to best allocate scarce resources.

Second, to make decisions, policymakers should first define the expected range between the time for investing and the time for expecting returns. Such maturation time is industry specific and stakeholder specific. In the specific case of universities/RI in industrial districts, the time for expecting returns is longer than a regular cluster mainly composed of firms.

Third, the design and the monitoring of evaluation systems require the development of systematic and generalized measurement instruments. Such unified measurements should enable the comparison between different European initiatives. There is a need to define the geographical scope because we cannot compare a neighborhood (GIANT) to a city (Grenoble) or to a region (Rhône Alpes). The scope is dependent on the type of stakeholders (e.g., the impact of universities and RI is more localized than for firms).

Fourth, we recommend revisiting the European governance on RIS3 in light of existing TIMs. The EU should take greater advantage of the understanding of TIMs by European scholars (the industrial districts in Italy, the innovative milieu in Switzerland, regional innovation model in UK, etc.) to guide the decision-making process. Such governance should encourage an effective mix of TIMs to offer a true source of competitive advantage and ban the multiplication of TIM in a given region, if only aiming at obtaining cumulative public funds.

Our study has some limitations. From a methodological aspect, non-responses were treated with a simple linear interpolation, although a bias in favor of creators is likely because they likely have a strong propensity to discuss their creations and thus responded to our survey. However, it is reasonable to suppose that many entrepreneurs failed to respond due to time constraints and multiple demands. Moreover, one of the main limitations is linked to our focus on the positive aspects of RI, while neglecting the negative aspects.

This study is focused on the single case of GIANT and is an empirical attempt that cannot be generalized. Are our empirical results better or worse than other clusters? This specific question is still open and requires further empirical studies that can enable the comparison between clusters. There is consequently an urge to further study the economic, social, and entrepreneurial impacts of RI in various contexts.

Moreover, we encourage scholars to monitor the progress of socioeconomic and entrepreneurial indicators in longitudinal studies, which would put in perspective the cluster life cycle described by He and Fallah (2011). It would be interesting to study the embryonic, established, mature, and declining stages of a cluster and to also observe how policymakers anticipate the decline in the life cycle of industrial districts (Corò & Grandinetti, 2001) by creating new TIMs in the same geographical area. Will the embryonic GIANT model replace the mature Grenoble model? A study of the co-existence and the evolution of different TIMs and analysis of any modification of their typology over time are necessary to best understand the social, economic, and entrepreneurial of its RI and universities.

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