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Place, platform, and knowledge co-production dynamics: Evidence from makers and FabLab

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Summary: FabLabs (fabrication laboratories) have become popular but the academic literature on this entrepreneurial phenomenon is scant. This paper provides some insight into the sources of Fablab performance based on original data on the characteristics and interactions between (n = 48) FabLabs and their ecosystem. A FabLab is a geographically located, intermediary platform which reduces the matching and searching costs to stakeholders involved in an entrepreneurial endeavor. We find that a FabLab is less productive if disconnected from its ecosystem. Innovation production is highest when the FabLab acts as a platform allowing interactions between small explorative firms, and large exploitative firms. Its innovation remains explorative if the interaction involves only small explorative firms. Our study has some implications for the management of FabLabs and their ambiguous impact on the overall innovation ecosystem in relation to resilience, smart specialization and diversification.
Keywords : FabLab, platform, knowledge, entrepreneurship, diversification, bricolage
JEL Code : D20, L10, O32, R11

1. Introduction

The recent cluster and knowledge networks literature discusses the locus of innovation performance and suggests that increasing relational and R&D densities (Martin and Sunley, 2003 ; Broekel et al., 2015), and combining and linking complementary and useful pieces of knowledge (Suire and Vicente, 2014 ; Crespo et al., 2014) help to ensure sustained innovation success. Many papers focus on the role of diversity as a source of competitiveness. Indeed, combining related variety (Frenken et al., 2010; Aarstad et al., 2016) among technologies, or mixing ethnic based perspectives (Vandor and Franke, 2016) can increase opportunity recognition, regional

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diversification (Boschma et al, 2016) and the development of new products for new markets. Jane Jacobs (1961) was one of the first to suggest that the diversity of peoples, ideas, and skills makes large cities more powerful than smaller ones. Currid (2008) provides a nice example of such a chaotic and creative place, describing New York City as an *entrepreneurial city*. It seems that innovation and entrepreneurship are "*in the air*" in a context of sometimes latent and disconnected but diverse people, skills, ideas, and locations.

Public policies combining these aspects in an efficient way could lead to better targeted actions and could encourage cities and regions to focus more on their technological and capabilities strengths in a "smart" way (Foray et al., 2009). In the last several years, some new innovation actors have entered the scene including fabrication laboratories (FabLab) which are promising a technological revolution (Anderson, 2012) and threatening to *change the world* (Hatch, 2013). This phenomenon has spread worldwide and in 2016 there are more than 600 FabLabs across the globe.[2] However, there has been little research on how FabLabs interplay or co-exist with the existing innovation ecosystem including clusters. FabLabs are physical places and "agent of structural change" (Neffke et al., 2014) where individuals, “makers”, come together to make in order to learn, i.e. to combine some existing knowledge and know-how and to learn from others, with sometimes diverse objectives (Bosqué and Kohtala, 2014). These makers may repair existing objects, produce novelty from scratch or add variety to existing technologies, or increase their level of human capital. Experimentation is at the heart of this collective dynamic and in a nutshell, makers are involved in a "bricolage" mode of innovation (Baker et al., 2003 ; Stinchfield et al., 2013). It has been pointed out by Martin (2010) as critical process for new path creation in regions but this is not further elaborated.

In many respects, makers are a local/global epistemic community (Bathel and Cohendet, 2014) which produce knowledge that would collide with the knowledge bases in existing firms and/or organizations. The micro mechanisms explaining entrepreneurial trajectories and these market and non-market interactions have not been explained (Rijnsoever et al., 2015); in this paper, we suggest that these actors might be part of the explanation. Our aim therefore, is to propose a general analytical framework based on the platform literature (Hagiu and Wright, 2015 ; Gawer and Cusumano, 2014) and an empirical test, relying on an original survey of 48 international FabLabs, in order to understand the micro foundations of the co-production of innovation.

[2] https://www.fablabs.io/

We consider FabLabs to be a category of localized intermediary platforms which produce novelties by combining complementary explorative and exploitive knowledge.

The findings in this paper shed new light on the role and importance of the physical place for matching different knowledge stakeholders. Scheppard (2002) points out that places are more than ever relevant in a globalized and networked world. We follow up this idea. The findings also shed light on what an "agency" based explanation of regional diversification would be (Boschma et al, 2016).

The sociology of networks and the evolutionary economic geography and innovative studies literatures stress the role played by intermediaries within a system. These literatures suggest that the role of intermediary often is associated to performance - of whatever kind. For instance, filling a structural hole leads to a strategic position (Burt, 1992, 2004). Cattani and Ferriani (2008) show how movie studios benefit from the explorative scenarios of independent studio on one side, as well as the know-how of major studios and the other side are also those who perform better in awards competitions. Del-Corte-Lora et al. (2005) show that being overly creative is not compatible with a marketable and desirable innovation and a moderate position helps to do better. Crespo et al. (2014) suggest that to be resilient a cluster must combine some specific structural network properties from core and exploitative and vertically organized firms with more agile, peripheral and explorative behaviors. Cohendet et al. (2010) suggest that a creative city whose aim is to produce sustainable and blockbuster video games relies on a continuum of complementary actors from underground, very explorative and outsider actors to mainstream, institutionalized, visible actors, the "upperground". In the case of the Cubism movement art, these authors highlight that *middleground* or intermediary places and spaces are necessary to allow disruptive ideas to emerge from the shadows into the limelight and attract large audiences.

By asking FabLab about with whom they interact, who are the makers, and what do they produce with the help of the "place" and the epistemic community, we provide some original results on FabLab performance. We find that if the FabLab is disconnected from the innovation ecosystem it will perform less well than if it interacts with incumbent innovative firms. We show also that the higher performing FabLabs are those who intermediate explorative coming from smallest firms and exploitative behaviors coming from largest ones. These results contribute to literature on the roles of such physical place as facilitators allowing reduced searching and matching costs between complementary and innovative stakeholders. However, the main function of a FabLab is to "play" with the unknown; the results of a collective entrepreneurial project are never guaranteed.

The paper is structured as follow. Section 2 sets out the main theoretical ideas and describes the flourishing maker movement. It justifies our platform framework to capture the FabLab's main features. Section 3 describes the methodology and the data. Specifically, we test our research hypotheses by comparing the FabLab performance to produce innovative spin-off projects or new projects based on statistics and econometric methods. Section 4 presents and discusses the findings and section 5 concludes with some implications for policy and management.

2. FabLab as a platform

In the early 2000s, Professor Niels Gershenfeld established the first FabLab at the Center for Bits and Atoms at MIT. His idea was to provide students with some tools to accompany the course *"How to make almost anything"* with the aim of "becoming a protagonist rather than just spectators". With the help of digital tools including among others the 3D printer, Arduino electronic hardware, laser cutters, water jet cutters, it is possible to make anything, anywhere, and to address personal or collective needs. Learning by doing oneself or in interacting with others following the open source principles is an underlying promise of FabLab. According to Cowan et al. (2000) epistemic communities are *"small group of agents working on commonly acknowledged subset of knowledge issues and who at the very least accept a commonly understood procedural authority as essential to the success of their knowledge activities"*. Thus, the first task for the original FabLab maker is to create a "manifesto" of rules to guide the community's cognitive work. This should set out the codes, norms, and practices which members of the community should adhere to. It is valuable for convincing others to join community. The MIT Charter[3] or the Manifesto of Hatch (2013) are examples of the rules that makers follow. Basically, makers embrace a Do It Yourself (DiY) and Do It With Others (DiWO) philosophy. They combine existing knowledge or produce new knowledge by making or prototyping in order to learn. *"All types of understanding gained trough experience or study"* (Hess and Ostrom, 2007) can be shared within fast growing communities[4] which include different cognitive and geographic proximities (Boschma, 2005). To some extent, a FabLab is an infrastructure which mixes different proximities and results in the development of skills and capabilities, and also knowledge spillovers which benefit the socio-economic and technological environment.

By definition, the community's objectives are heterogeneous and are associated with the local maker members of the FabLab (Bosqué and Kohtala, 2014). Thus, FabLab production is place and path dependent. Since the early 2000s, the industrial

3 MIT charter : http://fab.cba.mit.edu/about/charter/

4 http://www.fabfoundation.org/

organization literature has been developing a platform theory described as two-sided markets, or multi-sided markets, or two (multi)-sided platforms (Evans, 2003; Hagiu and Wright, 2015). The most important mechanism involves is the indirect network effects between different sides of the market or platform. In other words, all of its sides need to "be on board"; if one is missing, the platform will produce low or no value. Hagiu and Wright (2015) suggest that a platform is a virtual or a physical place where search and coordination costs are reduced, where pricing strategies are non-neutral on transactions, and which enable asymmetrical pricing strategies as well as some negative prices (subsidies). Indirect network externalities are the core mechanism. In the case of two sided platforms, each side values the presence of and the social and economic interactions with the other side. We investigate the usefulness of this framework to demonstrate how FabLab operates and can become the basis of a simple economics of such a place.

Without loss of generality, we consider that makers / sides can be of two types (a, b), defined by an original skill, knowledge, idea, or need. Platform (X_i) is a place where the co-production of knowledge (Y_i) is the result of a complex process and a mix of competencies acquired through learning processes (Antonelli, 1999). Therefore, we denote $e(a_i,b_i)$ as the indirect network effect or the local knowledge spillover between stakeholders.

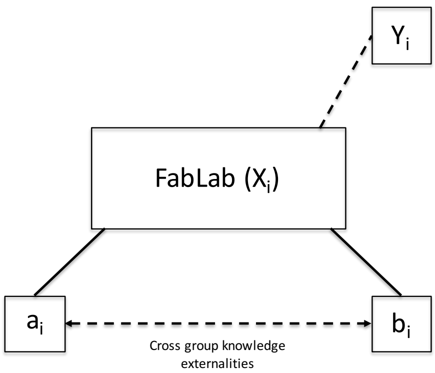

Figure 1 - Simple economics of FabLab

This highlights two aspects that typify the FabLab. Its production is heterogeneous (Gershenfeld, 2005). This means that Y_i can take different forms and values including zero ($Y_i = 0$). In the latter case, and if $e(a_i,b_i)\neq 0$ then FabLab produces only some knowledge spillovers for protagonists and makers. It also produces spillovers for the socio-economic environment and for the region or city in which it is embedded through human capital. To some extent, the FabLab plays in this case the role of a local university devoted to digital fabrication. Audretsch et al. (2005) point out that a technology start-up can choose to locate close to a university which produces relevant knowledge spillovers. Similarly, it can be expected that if a FabLab is associated with a local creative process, and has a strong identity and strong values, it will act as an attractor of human capital and firms to the region (Bathelt and Cohendet, 2014) (Kohtala and Bosqué, 2014). This could lead to smarter specialization in the host territory.

A FabLab can produce two kinds of output based on a cumulative knowledge process. The first type (Y_{i1}) is a draft or a documented project. When a maker produces something new, the steps of production must be codified in detail. The codebook is freely available and helps other community members to absorb and reproduce the project/object[5]. However, the prototype could not be available. First, it becomes the maker's intellectual property (IP) and is subject to rights according to internal FabLab rules. In this case, the FabLab does not follow MIT Charter and can self-named differently (e.g. a Techshop, a Fabmake, etc). Second, the prototype is protected either because it is of no use to the end user or because the maker considers it should not be made public. Consequently, the visible output (Y_{i1}) is part of a non visible collective work based on a trial and error process.

The second type (Y_{i2}) is a project considered as useful to the market or the end-user, and satisfies an external demand or need. It is considered as a FabLab spin-off without necessary a viable business model.
Finally, we explore the different sides of the platform based on three cases.
Case 1 : $e(a_i,b_i) = 0$ is a very specific case where the FabLab does not produce any knowledge spillover despite geographical proximity and co-location among stakeholders. To some extent, this is typical of a type of co-working space (Capdevilla, 2015) like a *Starbuck café* which are typified by an important cognitive distance among members (Noteboom, 2000) and are defined by Oldenburg (1991) as third places.
Case 2 : When $e(a_i,b_i) \rightarrow +\infty$ or symmetrically $e(a_i,b_i) \rightarrow -\infty$, then one side of the platform produces more knowledge spillovers than the other side.
Case 3 : When $e(a_i, b_i) \in [\underline{e}, \overline{e}]$ we consider that there is a range of optimal cognitive distances among stakeholders, and cross knowledge externalities lead to a co-production process.

(a_i) and (b_i) are the makers or members of the FabLab. They may be incumbent technological firms, start-ups, small and medium sized enterprises (SMEs). They may be retirees, young people (e.g. FabKids in Barcelona), unemployed individuals, citizens, etc. They may be concerned about the environment, and sustainability (e.g., Green FabLab in Barcelona) or recycling (Repair Café), etc. In what follows, we restrict

[5] e.g., www.thingiverse.com or www.instrucables.com are digital platforms where source files and projects are documented and accessible.

the discussion to an existing firm demography by considering that makers only come from existing companies exhibit different innovative profiles.

March (1991) and Duncan (1976) suggest that in order to be competitive, firms need to achieve a "balance" between explorative and exploitative innovative activity, or to be ambidextrous. Following Tushman and O'Reilly (1996) we define ambidextrous organizations as those that invest a in both directions. Therefore, if a company has an internal normalized stock of resources of size 1 for R&D and innovation, it can be defined by an ambidextrous ratio $amb = \frac{(exploitative)}{(exploration)}$. If all internal resources (human and financial) are devoted to explorative activity then (*amb = 0*); and if all internal resources are oriented toward exploitation and assuming that competitive intelligence is never null, then ($amb \rightarrow +\infty$). Crespo et al. (2014) and Balland et al. (2013) suggest that firm size is a good proxy for the profile innovation. Balland et al. (2013) show that the larger the firm, the more specific and market oriented their output. In contrast, small companies or start-up are more explorative and are searching for either a business model, a market, or a standard (Suire and Vicente, 2014).

Based on the evolution of firm demographics along the industry life cycle, (Crespo et al., 2014, Frenken et al., 2014, Klepper, 1997), we hypothesize that $\frac{d(amb)}{d(size)} > 0$,i.e. the smaller the firm the more they engage in exploring innovation and new markets while bigger firms exploit their knowledge stock in mature markets (Eisingerich et al., 2012). We therefore hypothesize that:

H1 : If the FabLab has an organizational proximity to and relationships with explorative firms its output will be more explorative (Y_{i1}).

H2 : If the FabLab combines knowledge from explorative and exploitative firms it will be more productive (Y_{i1} and Y_{i2}).

3. Data and methodology

Data were drawn from an original sample of N=48 FabLabs. The questionnaire was designed to provide insights into the detailed internal characteristics of the FabLabs (location, frequency of usage, business model, equipment, etc.), their production (documented projects, spin-offs), and their local and pipeline relationships (partners' size, type, and location). The web-based survey was addressed to the FabLab manager or individual responsible for managing the FabLab between January 2015 and March 2015. From a total of 350 questionnaires we received 48 usable responses -a return of 13% which is somewhat lower than comparable web surveys (Fan and Yan, 2010). This low response rate was perhaps due to the topic which is quite new, problems with identifying the right respondent, or the extensive specific questions asked. However, as far as we know, this represents a first attempt to measure the innovative and entrepreneurial performance of these places.

The majority of our respondents are from the European Countries (66.67%), with 16.67% from North America, 8.33% from South America, and 8.33% from Asia. Among the FabLabs surveyed, 43.75% were located in a city with less than 100 000 inhabitants and 14.58% were in cities with more than 1 000 000 inhabitants. More than 50% of surveyed FabLab had been established during the period 2013-2015.

Territory	Responses
	16.67%
South-America	8.33%
Asia	8.33%
Europe	66.67%
> 200 000 inhabitants	18.75%
> 100 000 inhabitants	22.92%
< 100 000 inhabitants	43.75%

Table 1 - sample

The questionnaire was designed to collect information on the FabLab production, and managers were asked about: 1/ the number of documented projects (Y_1) produced by the Fablab; 2/ the number of new companies or spin-offs (Y_2). To account for any bias from year of establishment, we used the midpoint in interval responses and divided it by the number of years since establishment, or fraction if the current year 2015 (see table 2)_.

Y_1	Y_2
11.14 projects / year	2.125 spin-off / year
S.E = 9.05	S.E = 1.99
Min = 0	Min = 0
Max = 35	Max = 5

Table 2 - FabLab outputs

In what follows, we investigate only the determinant of a high production regime, defined as above the median value. A FabLab can be in two exclusive states (low, high) for both types of production.

We asked FabLab Managers whether (and with whom) they had established local relationships. If yes, they were asked to indicate the size of these partners in terms of number of employees. Figure 3 shows the distribution of the responses.

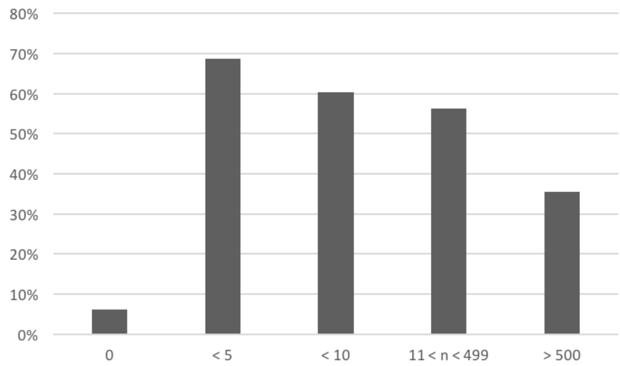

Figure 2 - Size of the partners

It appears that almost 6% of FabLabs have no relationships with external firms; almost 70% have a relationship with firms with less than 5 employees; and 35.45% of FabLabs have relationships with very large companies (over 500 employees).
We also considered some control variables that might affect FabLab production.

City size

We expect that the larger the city, the more intensive the FabLab production. Several authors find a positive relationship between innovation and city size. Indeed, knowledge externalities are more likely in cities which are best exploited by their dense concentrations of diverse people (Jacobs, 1961 ; Carlino et al., 2007 ; Feldman and Audretsch, 1999). Levels of knowledge, Ideas, people, and talent are higher present in large cities; even if only a fraction of them are members of the FabLab, this should influence its production positively.

Business model

The economy of a Fablab is diverse. Some are established based on a business model; most are searching for an appropriate business model. Some are public funded and have a variety of objectives; others are profit oriented, e.g. Techschop, and sell prototypes or expertise to external partners. Some receive temporary funding to enable identification of a trajectory. Participants in the Fab10 Barcelona world congress noted that the crucial phases in the life cycle of the FabLab is , "funding, business model and community building" (Van den Hijden and Juarez, 2014). To some extent, it might be expected that a stable economic model would have a positive influence on the level of production because all internal resources (human, cognitive) are oriented towards well-defined objectives.

Permanent FabLab manager

Based on the above, having a FabLab manager contributes to organizational stability. This individual could play the role of boundary spanner (Tushman, 1977) and would be familiar with the processes (know-how). The manager would be familiar also with the concepts (know-what), and why (know-why) things are done, and would be able to activate local and global social networks to know who to contact. The manager would enable communication and sharing of expertise by linking groups which might be separate in terms of location or function (Levina and Vaast, 2005). It can be assumed that a permanent FabLab manager would ensure organizational stability and affect production positively.

Smart specialization

Foray (2015) argues that one source of regional competitiveness is smart specialization focused on local strengths and specific assets. It is beyond the scope of this paper to discuss how to identify smart and what it means (Heimeriks and Balland, 2016). We assume that the FabLab is able to produce for the incumbent and an already specialized industry. The FabLab could become the technological infrastructure supporting new cognitive developments at the frontier in an existing technology field or industry. If the FabLab is an extension of a related knowledge based industry this allows exploration, capabilities building, and increased comparative advantage (Hausmann and Hidalgo, 2009). Therefore, we expect a positive relationship between FabLab performance and the degree of territorial specialization.

4. Getting into Fablab

The FabLab platform acts as an intermediary matching needs to create and make. The density and variety of interactions with the existing actors will influence what is produced. Our preliminary statistical analysis provides some interesting insights. The figure 3 crosses high level of production and partner sizes.

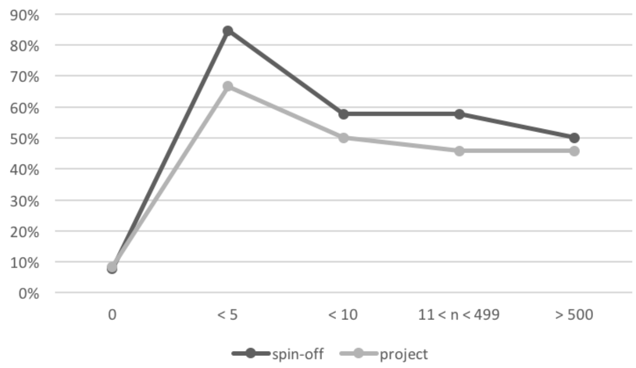

Figure 3 - Regime of high production and size of the partners

First, there is a decreasing relationship between high production level (Y_1, Y_2) and partner size measured by number of employees. Second, if the FabLab has no relations with external partners, the probability of a high level of production is reduced. This supports the idea of a stream of knowledge externalities between the Fablab and its ecosystem. These correlations show that the FabLab is more productive (whatever the type of production) if it interacts with small sized enterprises.

Finally, we are interested in whether FabLab performance is a function of its structural position within the ecosystem. As previously stated, an intermediary position in an ecosystem or between distant actors could provide strategic advantage (Crespo et al., 2016a; Cattani and Ferriani, 2008 ; Cohendet et al., 2010 ; Burt, 1992, 2004). So, we would like to figure out if FabLabs are most efficient when acting as a platform to match complementary knowledge bases? To investigate this, we define four exclusive states {S_0, S_1, S_2, S_3} and consider that the two sides of the platform are respectively (a_i = small firms) and (b_i = large firms).

S_0 : if FabLab declares no relationship with its ecosystem ($a_i = 0$, $b_i = 0$) and they are 6.25% in this state.
S_1 : if FabLab declares a relationship only with small firms ($a_i > 0$, $b_i = 0$), i.e. firms with less than 10 employees. They are 25% in this state.
S_2 : if FabLab declares a relationship only with large firms in the ecosystem ($a_i = 0$, $b_i > 0$) i.e. firms with 11 to 500 employees. They are 8.33% in this state.
S_3 : if FabLab declares a relationship with both small and large firms ($a_i > 0$, $b_i > 0$); They are 60.42% in this state.
The distribution of (Y_1, Y_2) over these different states is depicted in figure 5.

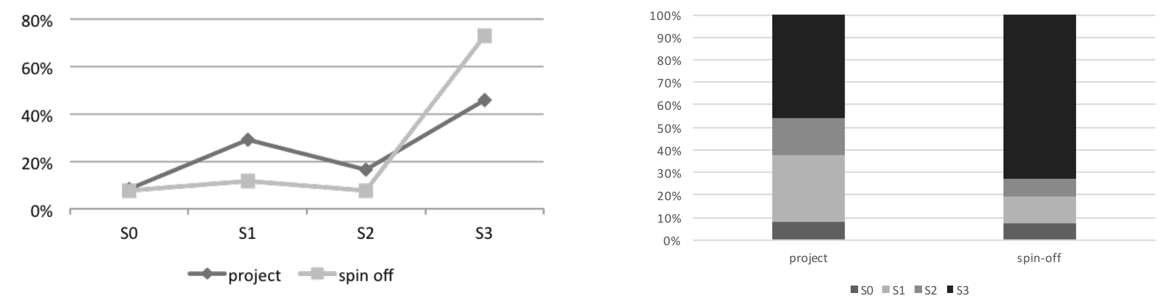

Figure 4 - structural state of FabLab and performance

This allows us to take account of how FabLabs produce entrepreneurial performance from their socio-economic embeddedness. In particular, state S_0 represents lower performance of the FabLab. More than 70% of spin-offs and 45% of projects depend on the role of the FabLab in matching small and large firms, i.e. in state S_3. This result is interesting in identifying FabLab as a crucial and new connector and gatekeeper in an existing innovative ecosystem. We find also that when FabLab interacts only with large firms (S_2 state), its level of production is quite low. This might be explained by a too high cognitive distance between FabLab and large companies, and/or a risky attitude to explorative interactions. Finally, an intense production of spin-off and documented projects is observed when the FabLab is in state S_3 followed by state S_1 for documented projects.

Thus, overall, FabLabs which act as intermediaries between different but complementary knowledge bases are also those that produce more documented projects and spin-offs. Since state S_2 appears to be less advantageous, it can be assumed that knowledge spillovers are more frequent or intense for small firms than large companies.

Although more research is needed on this topic, performance would seem to be based on the ability of the FabLab to reduce search costs between potential and latent complementary partners. The FabLab would appear to be a new knowledge infrastructure facilitating entrepreneurship within the ecosystem. In what follows, we control for the stability of these results using some simple econometrics.

5. Econometrics and discussion

To take account of the sample size we use a limited number of control variables.

Stable business model (binary answer)	Mean = 0.45	SE = 0.5	Max=1	Min=0
Permanent Fab Manager (binary answer)	Mean = 0.56	SE=0.5	Max=1	Min=0
Smart specialization[6]	Mean=0.29	SE=0.45	Max=1	Min=0
City size (1,4) 1: < 100 000 2 : > 100 000 3 : > 200 000 4 : > 1 000 000	Mean=2.04	SE=1.11	Max=4	Min=0

Table 3 - Control Variables

In order to compare the performance of FabLabs we run different regression models aimed at estimating the probability to be an intensive producer (Y_1, Y_2). The basic equation is specified as :

$$Pr[Yi = 1|X] = \Phi(\beta_0 + \beta_1 stable\ business\ model + \beta_2 permant\ fab\ manager + \beta_3 smart\ specialization + \beta_4 city\ size + \beta_5 a_i + \beta_6 b_i)$$

where $\Phi(.)$ denotes the cumulative normal distribution function, and X is a vector of the regressors; a_i takes the value 1 if a FabLab declares interactions with small companies (i.e. with 5-10 employees) and zero otherwise; b_i takes the value 1 if the FabLab declares interactions with large firms (i.e. 11 -and plus 500 employees) and zero otherwise. In table 4 we present only the marginal effect which is the slope of the probability curve of each regressor X to $Pr[Yi = 1|X]$ holding the other variables constant.

[6] The question in the survey asked « would you say that your Fablab is related to the specialization of your local industry? »

Table 4 – Probit regressions / marginal effects

	Project / year (model 1a)	Spin-off / year (model 1b)	Project / year (model 2a)	Spin-off / year (model 2b)	Project / year (model 3a)	Spin-off / year (model 3b)	Project / year (control)	Spin-off / year (control)
Stable business model	0.124 (.151)	-.102 (.159)	.132 (.157)	-.109 (.167)	.108 (.157)	-.080 (.163)		
Permanent Fab Manager	.100 (.149)	.273** (.146)	.116 (.154)	.280** (.153)	.169 (.156)	.234 (.154)		
Smart specialization	.187 (.165)	.359** (.145)	.206* (.170)	.380** (.150)	.212* (.170)	.352** (.148)		
City size	.093** (.068)	.044 (.070)	.069 (.070)	.070 (.074)	.075 (.069)	.063 (.072)		
$a_i > 0$			.405** (.165)	-.113 (.160)			.404** (.159)	-.079 (.200)
$b_i > 0$			-.113 (.165)	.363** (.160)			-.111 (.158)	.310** (148)
$(a_i > 0 * b_i > 0)$					-.335** (.147)	.287** (.155)		
N	48	48	48	48	48	48	48	48
Pseudo R2	0.0731	0.1369	0.1446	0.2064	0.1438	0.1825	0.0760	0.0605

All results are marginal effect
Standard error in parenthesis
* significant at 0.1 level
** significant at 0.05 level
*** significant at 0.001 level

Models 1a and 1b are estimated in order to identify the main determinants of the intrinsic performance of a FabLab, i.e. without explicit consideration of the interactions with partners. Only city size is positive and significant in model 1a indicating that as expected, city size has a positive influence on the project production stream. Makers from large cities are certainly more diverse and more heterogeneous as are their skills and needs. The results of model 1b are more interesting; and a permanent FabLab manager and smart specialization are positive and significant determinants of spin-off production. Beyond a set of rules, collective and creative dynamics often need minimal institutionalization and a set of routines to demonstrate to their audience that what is proposed makes sense. This has been confirmed in the case of artistic communities (Cohendet et al., 2014) and technology and innovative activity (Balland et al., 2013). In all these sometime epistemic communities, a minimum of order is built around a level of coordination around certain key actors, key places, and key directions. The FabLab manager introduces some order into the chaotic creative activity within the FabLab. The manager acts as a boundary spanner who facilitates the emergence of long-term projects such as spin-offs. This spin-off production is more frequent if the FabLab is part of an already specialized ecosystem. To some extent, this infrastructure can produce new varieties for incumbents and innovation at the knowledge or technological frontier, by fostering both entre- and intrapreneurship.

Models 2a and 2b test research hypothesis H1. Frequent interactions with the smallest firms which are considered more explorative have a positive and significant interaction with the production of documented projects considered themselves as more explorative. All else being equal, frequent interactions with large companies lead to more production of spin-offs. Thus, H1 is not rejected.

Hypothesis H2 is partially accepted according to models 3a and 3b which provide some ambiguous and interesting results. When the FabLab acts as an intermediation platform, this has a positive and significant effect on the stream of spin-off production but a negative and significant effect on the stream of documented projects production. All things considered, it seems that the Fablab faces a trade-off in creativity when it develops partnerships with large companies: market performance (i.e. spin-off production) increases but exploring through prototype projects decreases. This finding requires further investigation but it can be assumed that behind size differences among partners there are differences in levels of absorptive capacity (Cohen and Levinthal, 1990). Moreover, start-ups and small technology companies often are described as *Fabless* firms, i.e. some upstream companies produce knowledge without fabrication while the downstream firms are large groups using knowledge and transforming it into products (Arora and Merges, 2004). In the absence of intellectual property among the different knowledge stakeholders, hold-up becomes an issue. Is this support for the idea that in the absence of regulations, FabLab would become a passive supporter of a hold-up strategy from large firms?

6. Implications and conclusion

In this paper we explored the performance of FabLabs from the perspective of their being part of the innovation ecosystem. This research was triggered by two issues. First, FabLab has become a worldwide phenomenon and part of public policy and managerial discourse. Systematic research on what happens within a FabLab, and how it interplays with the innovation ecosystem, to our knowledge is scant. Second, we have argued that FabLab is a new infrastructure which can support and enhance entrepreneurial capabilities but which has ambiguous effects on the overall ecosystem. We collected original data from an international survey, and proposed a theoretical framework based on a two sided platform theory. We found that the more FabLabs interact with small and explorative firms the more they produce documented projects. Theses projects are the consequence of knowledge accumulation which benefits the epistemic community of makers but benefits the market and end-users less immediately. FabLabs help to develop a spirit of entrepreneurships by facilitating bricolage, prototyping and learning by interaction. However, when FabLabs interact with both sides of the innovation ecosystem, i.e. with both explorative small firms and exploitative large firms, production is more spin-off and less project oriented. The explorative function of the FabLab decreases when the frequency of partnering with large groups increases.

Theoretical and practical implications

Most Fablabs - especially those adopting the MIT Charter - are to some extent open third-places. Therefore, in the absence of IP rules, what is produced within the FabLab belongs to the community. Based on two-sided framework, some strategic principles can be suggested (Hagiu and Wright, 2015). The theoretical literature points out that when one side of a two-sided platform is valued more highly than the other, there is a need for some subsidization of the "losing" side which receives no benefit from indirect network externalities. In the case of FabLabs, and as suggested by our results, if large companies benefit more from co-location with small companies than vice versa, they should be charged more. The FabLab manager needs to consider this knowledge externalities asymmetry in making decisions about regulations.

There are some very recent studies on third-places, co-working spaces (Capdevila, 2015), incubators, and accelerators. These places are presented in many respects, as a new way to imagine, work, co-produce, and innovate. However, we lack micro-foundations and managerial rules based on a rigorous theoretical framework, and empirical proof of good practice. Our paper tries to fill some of these gaps. It investigated the question of local public policy aimed at supporting territorial entrepreneurship and smart specialization. Clearly, if the FabLab can act as a new infrastructure, it must develop interfaces with existing clusters and the ecosystem especially if the objective is to design a sustainable innovation ecosystem, a creative milieu towards regional diversification (Boschma et al., 2016 ; Boschma, 2015 ; Crespo et al., 2014). Some scholars (Vicente, 2014) have called for a "surgery connecting" strategy meaning that matching complementary actors based on their knowledge profiles is more efficient than subsidizing relational density of a cluster per se. This might be successful although very costly for the public authority to identify the best partner matches. We suggest that an intermediary such as a FabLab, could play this role by facilitating the matching between knowledge bases. In this way, *funding joint research* and *projects* with identified partners, should be complemented by *funding places* to explore and produce variety for the local innovation system and make the territory more diversified in a smarter way.

Limitations and future research

Our findings need to be confirmed by other studies, in particular because they are based on a rather small sample. Future research on the FabLab concept should take account of how these new places for entrepreneurs and makers interplay with the existing innovation ecosystem and how they can help to increase the resilience of a territory through the production of related social and technological innovations. In particular, it would be interesting to investigate how FabLabs transform the structural properties of knowledge networks (Suire and Vicente, 2014 ; Crespo et al., 2016b). This initial investigation needs to be extended to examine the potential for opportunistic behaviors and unintended knowledge spillovers among between different stakeholders. The optimal cognitive distance and its management are important issues in the context of mutually beneficial innovation projects.

Finally, how some embryonic innovations progress from prototype to successful standard is largely unknown. We suspect that this transition requires structuration and a hierarchy among skills, community, and objectives. These issues provide opportunities for more research on entrepreneurship, places, and co-innovation.

References

Aarstad, J., Kvistastein, O. and Jakobsen, S-E. , 2016, "Related and unrelated variety as regional drivers of enterprise productivity and innovation: A multilevel study", *Research Policy*, 46, p844-856.

Anderson C., 2012, *Makers : The new industrial revolution*, Crown Business.

Antonelli C., 1999, "The evolution of the industrial organization of the production of knowledge", *Cambridge Journal of Economics*, 23, p243–260

Arora A., Merges, R., 2004, " Specialized supply firms, property rights and firm boundaries", *Industrial and Corporate Change*, 13, p451–475.

Baker, T., R.E. Nelson, 2005, "Creating something from nothing: Resource construction through entrepreneurial bricolage", *Administrative Science Quarterly* 50, 329–366

Balland P.A., Suire R., Vicente J., 2013, "Structural and geographical patterns of knowledge networks in emerging technological standards: evidence from the European GNSS industry", *Economics of Innovation and New Technology*, 22, p47-72

Bathelt H., Cohendet P., 2014, "The creation of knowledge : local building, global accessing and economic development – toward an agenda", *Journal of Economic Geography*, 14, p869-882.

Boschma R., 2015, "Towards an evolutionary perspective on regional resilience", *Regional Studies*, 49, p733–751.

Boschma, R., 2005, "Proximity and innovation: a critical assessment", *Regional Studies*, 39, p61–74.

Boschma R., Coenen L., Frenken K., Truffer B., "Towards a theory of regional diversification", PEEG Working paper 16.17

Bosqué C., Kohtala C., 2014, « The Story of MIT-Fablab Norway: Community Embedding of Peer Production », *Journal of Peer Production*, 5

Broström A., 2010, "Working with distant researchers : distance and content in university-indsutry interaction", *Research Policy*, 39, p1311-1320.

Burt, R., 1992, *Structural holes: the social structure of competition*. Harvard University Press

Burt, R., 2004, "Structural holes and good ideas", *American Journal of Sociology*, 110, p349–399.

Capdevila, I., 2015, "Co-Working Spaces and the Localized Dynamics of Innovation in Barcelona", *International Journal of Innovation Management*, 19, p1540004-1-28.

Carlino, G., Chatterjee, S., Hunt, R. ,2007, "Urban density and the rate of invention." *Journal of Urban Economics*, 61, p389-419.

Cattani, G., Ferriani S., 2008, "A core/periphery perspective on individual creative performance: social networks and cinematic achievements in the Hollywood film industry", *Organization Science*, 19, p824–844.

Cohen W, Levinthal A., 1990, "Absorptive capacity: a new perspective on learning and innovation", *Administrative Science Quarterly*, 35, p128–152.

Cohendet, P., Grandadam, D., Simon, L., 2010, "The anatomy of the creative city", *Industry and Innovation*", 17, p91–111.

Cowan, R., David, P. A., Foray, D., 2000, "The explicit economics of knowledge codification and tacitness", *Industrial and Corporate Change*, 9, p211–253.

Crespo J., Suire R., Vicente J., 2014, "Lock-in or lock-out : How structural properties of knowledge networks affect regional resilience", *Journal of Economic Geography*, 14, p199-219

Crespo J., Suire R., Vicente J., 2016a, "Network structural properties for cluster long run dynamics. Evidence from collaborative R&D networks in the european mobile phone industry", *Industrial and Corporate Change*, 25, p261-282

Crespo, J., Vicente, J., Amblard, F., 2016b, "Micro-behaviors and structural properties of knowledge networks: toward a "one size fits one" cluster policy", *Economics of Innovation and New Technology*, 16, p553-552.

Currid E., 2008, *The Warhol Economy : How fashion, art, music drive New York City*, Princeton Press.

Del-Corte-Lora V., Vallet-Bellmunt T., Molina-Morales F.X., 2015, "Be creative but not so much. Decreasing benefits of creativity in clustered firms", *Entrepreneurship and Regional Development*, 27, p1-27.

Duncan R., 1976, "The ambidextrous organization: Designing dual structures for innovation", In R. H. Kilmann, L.R. Pondy and D. Slevin (eds.), *The management of organization design: Strategies and* implementation, North Holland, p167-188.

Eisingerich A, Falck O, Heblich S, Kretschmer T, 2012, "Firm Innovativeness across Cluster Types", *Industry and Innovation*, 19, p233-248

Evans D., 2003, "Some empirical aspects of multi-sided platform industries", *Review of Network Economics*, 3, p191-209.

Fan, W., Yan, Z., 2010, "Factors affecting response rates of the web survey: A systematic review", *Computers in Human Behavior*, 26, p132-139.

Feldman, M., Audretsch, D. (1999). "Innovation in cities: science-based diversity, specialization, and localized competition", *European Economic Review,* 43, p409-29.

Foray, D, David, P, Hall, B., 2009, "Smart Specialisation - The Concept", Knowledge Economists Policy Brief no. 9, European Union Report.

Foray D., 2015, *Smart Specialisation: Opportunities and Challenges for Regional Innovation Policy*, Routledge.

Frenken K., Van Oort F., Verburg T., 2010, "Related variety, unrelated variety and regional economic growth", *Regional Studies*, 41, p685-697.

Frenken K., Cefis E., Stam E., 2014, "Industrial Dynamics and clusters : a survey", *Regional Studies*, 49, p10-27.

Gawer A., Cusumano M., 2014, "Industry platforms and ecosystem innovation", *Journal of Product Innovation Management*, 31, p417-433.

Gershenfeld N., 2005, *Fab: The Coming Revolution On Your Desktop – from Personal Computers To Personal Fabrication,* Basic Books.

Hagiu A., Wright J., 2015, "Multi-sided platforms", Harvard Business School, working paper 15-037

Hatch M., 2013, *The makers movement manifesto*, Mc Graw Hill

Haussman R., Hidalgo C., 2009, "The building blocks of economic complexity'. *Proceedings of the National Academy of Sciences*, 106, p10570–10575.

Heimeriks G., Balland P.A., 2016, "How smart is specialisation ? An analysis of specialization patterns in knowledge production", *Science and Public Policy*, forthcoming

Hess, C. and Ostrom, E., 2007, *Understanding knowledge as a commons. From theory to practice*, MIT Press.

Jacobs J., 1961, *The death and life of great American cities*, Vintage.

Klepper S., 1997, "Industry life cycles", *Industrial and Corporate Change*, 6, p145–182.

Levina N, Vaast E., 2005. "The Emergence of Boundary Spanning Competence in Practice: Implications for Implementation and Use of Information Systems," *MIS Quarterly*, 29

Maietta O.W., 2015, "Determinants of university-firm R&D collaboration and its impact on innovation : a perspective from a low-tech industry", *Research Policy*, 44, p1341-1359.

March J.G., 1991, "Exploration and exploitation in organizational learning", *Organization Science*, 2, p71-87.

Martin, R., 2010, "Roepke lecture in Economic Geography – Rethinking regional path dependence: Beyond lock-in to evolution", *Economic Geography*, 86, p1-27.

Martin, R., Sunley P., 2003, "Deconstructing clusters: chaotic concept or policy panacea?", *Journal of Economic Geography*, 3, p5–35.

Neffke, F., Hartog, M., Boschma, R. and Henning, M. , 2014, "Agents of structural change. The role of firms and entrepreneurs in regional diversification", Papers in Evolutionary Economic Geography 14.10, Utrecht University.

Nooteboom, B., 2000, "Learning by interaction: absorptive capacity, cognitive distance and governance", *Journal of Management and Governance*, 4, p69–92.

Porter, M, 1998, "Clusters and the new economics of competition", *Harvard Business Review*, 76, p77–90.

Rijnsoever F., Van den Berg J., Koch J., Hekkert M., 2015, "Smart innovation policy : how network position and project composition affect the diversity of an emerging technology", *Research Policy*, 44, p1094-1107.

Rochet J.C., Tirole J, 2004, "Two-sided markets : an overview", MIT Working paper.

Scheppard E, 2002, "The spaces and times of globalization : place, scale, networks, and positionality", *Economic Geography*, 78, p307-330.

Stinchfield, B.T., Nelson, R.E. and Wood, M.S, 2013, "Learning From Levi-Strauss' Legacy: Art, Craft, Engineering, Bricolage, and Brokerage in Entrepreneurship", *Entrepreneurship Theory and Practice* 37, 889-921.

Suire R., Vicente J., 2014, "Life cycle of cluster or cluster for life : critical factors for resilience", *Entrepreneurship and Regional Development*, 26, p142-164

Tushman M., O'Reilly C., 1996, "The ambidextrous organization: managing evolutionary and revolutionary change", *California Management Review*, 38, p1-23

Tushman, M. 1977., "Special boundary roles in the innovation process", *Administrative Science Quarterly*, 22, p587-605.

Vandor P., Franke N., 2016, "See Paris and…found a business? The impact of cross-cultural experience on opportunity recognition capabilities", *Journal of Business Venturing*, 31, p388-407.

Van Der Hijden P., Juarez B., 2014, "The FabLab life cycle", Fab10 Barcelona report.

Vicente J., 2014, "Don't throw the baby out with the bath water: network failures and policy challenges for cluster long run dynamics", PEEG Working paper 1420.