Internationalization of biotechnology start-ups: the role of geographical location:

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Abstract

The purpose of this study is to determine the extent to which location specificity is associated with international alliance formation. In developing our research hypotheses, we have drawn on agglomeration theory, cognitive theory, and cluster evolution theory. These hypotheses were tested on a sample of US biotechnology start-ups. Our results show that merely being part of a geographical cluster does not in itself enhance the probability of forming a new international alliance. Within clusters, internationalization of start-ups through alliances mainly results from mimetic behaviour.

Key words: cluster, small business, internationalization, biotechnology

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1. Introduction

Small biotechnology companies tend to cluster in geographical areas to benefit from reciprocal technology spillovers (Almeida & Kogut, 1999), information flows (Porter, 1990), capital venturing (Powell et al. 2002), and collaboration opportunities with institutes and universities (Audretsch & Feldman, 1996) or other firms (Scott, 1989). Clusters have been an important factor in the growth of local industries (Porter, 1990) and in the success of small and medium companies. Clusters have also become a key issue connected to the role of location in the global economy (Amin & Cohendet, 2004), given that knowledge dynamics demonstrate a dual local-global pattern of knowledge flows. Research shows that firms in high-technology industries are proactively pursuing the creation of formal alliances. Collaboration within the industry is best handled at a short geographical distance where there is an abundance of strong and weak ties (Lorenzen & Foss, 2002).

However, previous studies indicate that this is not entirely the case. In an extensive study of biotech collaborations in Sweden, McKelvey et al. (2003) found that even when co-location and intra-regional knowledge collaboration exist they cannot be considered a significant characteristic of the biotech sector. In a follow-up study, Dahlander and McKelvey (2003) found that collaboration is generally more likely to be global than regional. In a study on several US biotechnology clusters, Coombs et al. (2006) show that location-specific technologies attract foreign partners and contribute to international alliance formation. Zaheer and Georges's work (2004) suggests that in the context of technology-intensive industries such as biotechnology, firms may require combination of local collaborations and out-cluster collaborations to access knowledge. They consider that the information flows and knowledge spillovers available to all members of a geographical cluster could limit the exposure of firms in geographical clusters to information diversity.

By analyzing US biotechnology firms, Zaheer and Georges (2004) show that firms with a greater number of alliances outside their geographical cluster outperform firms with fewer alliances outside their geographical cluster.

The process of internationalization of small and medium-sized technology-based firms has attracted considerable attention (Al-Laham & Souitaris 2008; Jones, 2001; Manolova et al., 2002; Majocchi and Zucchella, 2003). Jones (2001) stresses that there are difficulties in applying comprehensive theories or explanations to the decisions of small firms' internationalization process. Internationalization appears to be grounded or embedded in successful local networking (Keeble et al., 1998).

Thus, the biotechnology industry is characterized by two phenomena: a clustering phenomenon and an aggressive partnering with other firms through international alliances (Keeble et al., 1998; Fontes, 2003).

The juxtaposition of these two trends raises several important questions. Does membership in a geographical cluster enhance the formation of an international alliance? Biotechnology SMEs develop and grow both through international inter-firm relationships and spatial proximity. What then are the characteristics of a geographical cluster that will enhance international alliance formation?

In developing our research propositions about cluster characteristics and their effects on the probability of an international alliance, we draw from the following research streams: agglomeration theory, cognitive theory, and cluster evolution theory. The structure of the paper is as follows: section 1 reviews the existing literature and formulates the hypotheses; section 2 presents the empirical analysis and section 3 the empirical findings. The final section presents some of the findings' policy implications.

2. Key role of international alliances and cluster effect

International alliances refer to collaborations formed between a local entity and an overseas counterpart (Saffu, & Mamman, 2000). Why are international alliances so important? Lu and Beamish (2001) suggest that geographic expansion is one of the most important paths for a firm's growth. By analyzing the formation of joint ventures, Lu and Beamish (2001) show that Japanese SMEs forming joint ventures with non-Japanese firms improved the performance of internationalizing SMEs. Other studies on alliances have pointed to several benefits including risks minimization (Hagedoorn, 1993), and more specifically a better access to foreign resources and knowledge or "network resources" such as capital and information (Phene et al., 2006; Hanna and Walsh, 2008). External knowledge is vital to firms in industries characterized by dynamic and complex technological environments, as is the case with biotechnology firms. Individual firm capabilities are limited in guaranteeing the firm's success (Phene et al., 2006; Powell et al., 1996). The motivation for international relationships is often driven by access to new indigenous technology, because firms are actively looking for international knowledge in its diversity (Chung & Alcacer, 2002; Cantwell & Janne, 1999). This diversity of knowledge in a local context is expected to provide valuable knowledge for innovation.

International alliances are thus facilitated when firms are embedded in knowledge-intensive regional clusters and national research-alliance networks (Al-Laham & Souitaris, 2008). Firms that first gain experience at the national level are then able to develop valuable capabilities for international alliances. Kurokawa et al. (2007) demonstrate that the more active a company is in international alliances, the higher is the technology-related knowledge flow.

This trend can be applied at the cluster level. We retain here the narrow definition of a cluster proposed by Isaksen and Hauge (2002: 14): "a concentration of 'interdependent' firms within the same or adjacent industrial sectors in a small geographic area". Technology generated within clusters attracts foreign enterprises (Coombs et al., 2006). This means that the investment made in clusters by local firms generates productivity growth for foreign firms. In turn, firms in clusters gain significantly from inward knowledge and inward investments. By analyzing regional development and clusters in the UK, De Propris and Driffield (2006) show, for instance, that foreign direct investment into a cluster generates gains for the host economy and that, in turn, interaction with the domestic sector generates productivity growth for the foreign firm.

2.1. Agglomeration theory

In 1920, Marshall recognized that firms benefit not only from their own resources but also from many aspects of their geographical location. Three primary benefits can accrue to firms locating in clusters: access to a pool of specialized labour, access to a pool of specialized input providers and technological input spillovers. These benefits increase with the number of firms in a location due to agglomeration economies. Indeed, the proximity of various economic and other activities leads to declining average costs while increasing the amount of information. More specifically, one of the most striking characteristics of biotechnology firms in terms of localization is their strong concentration in nodes of excellence (Cooke, 2001; Feldman, 2001). One of the main indicators defining star centers is the number of dedicated biotechnology firms. Folta et al. (2006) show that the cluster size in which a company is located has a positive effect on the probability that a firm will contract a strategic alliance. When clusters are larger, firms appear to be more likely to raise capital through private equity placements, more likely to patent (up to a certain cluster size), and more likely to enter into alliances (Folta et al. 2006). This research does not distinguish between local, national and international alliances.

Foreign firms actively develop relationships with biotechnology firms embedded in particular geographic locations featuring munificent technological environments. Biotechnology firms located in munificent technological environments gain access to informed investors (e.g. corporate partners), specialized resources and information not available to non-local firms. The cluster's technological munificence is indisputably linked to cluster size; it attracts foreign partners and promotes international alliance formation (Coombs et al., 2006). This suggests that foreign firms are investing in access to region-specific, as opposed to country-specific, advantages and confirms Almeida's (1996) conclusion that local knowledge is more important to foreign firms than to similar domestic firms. This argument leads to the following hypothesis:

Hypothesis 1a: The probability that any firm i will form an international alliance in period t increases with the size of the cluster in which it is located.

Proximity of similar firms increases cooperation between firms, resulting in lower average costs (Lambooy, 1996). The cooperation model is not necessarily true for international strategic alliances. At a country level, Narula and Hagedoorn (1999) note that firms from small countries tend to have a higher involvement in international investments and a greater propensity to engage in international strategic alliances compared to firms from large countries. This is because local demand is often sufficient to achieve economies of scale in large countries, while small country firms must seek overseas markets to achieve similar economies. In this sense, cluster size may have a negative effect on international alliance formation. This argument leads to the following hypothesis:

Hypothesis 1b: The probability that any firm i will form an international alliance in period t decreases with the size of the cluster in which it is located.

2.2. Cognitive theory

According to cognitive theory, individuals tend to make decision on the basis of their beliefs and their mental scheme (Schwenk, 1984). Although they may intend to evaluate information rationally, managers are not able to incorporate all the information available in their decision model due to cognitive limitations (Schwenk, 1994). Consequently, the use of a cognitive scheme is essential in any perceptual act. Cognitive schemas are the lenses through which decision-makers interpret information and translate it into organizational actions (Huff, 1982). Cognitive schemas encourage strategic actions; they act as filters on the information that strategic managers are paying attention to, act on managerial diagnosis by enabling decision-makers to postulate cause–effect relations in the midst of ambiguous information, and shape the firm's responses to environmental change and type and range of competitive behaviour (Nadkarni and Narayanan, 2007). It has been shown that cognitive schemas influence managers in their evaluations of collaborative opportunities (Tyler and Steensma, 1995).

"Untraded interdependencies", inter-firm communication and interactive processes of localized learning play decisive roles in spatial clustering (Storper, 1997; Maskell and Malmberg, 1999). Social and professional interactions, recruitment from a common professional labour pool and high rates of employee mobility lead to a high level of information exchange (Porter, 1990; Reger and Huff, 1993; Saxenian, 1994; Scott, 1989). Consequently, within a same cluster "several factors create a propensity for managers and key technical employees to have similar cognitive frameworks or mental maps" (Pourder and St John, 1996: 1200). Indeed, "cognition is not an individual process". It is "the result of a social activity, since the existing stock of knowledge exceeds the range available to any one individual" (Walsh, 1995: 286). Mental maps and individual knowledge structure are built on past experiences in an informational environment. According to Reger and Huff (1993), people who work in the same industry environment are expected to develop shared perceptions of the competitive environment over time. Calori et al. (1992) show that the complexity of CEOs' cognitive maps depends on the industry in which their firms are found. Pourder and St. John (1996) suggest that the mental models of managers in different clusters will be greatly influenced by their local competitors. According to Nooteboom (2006: 6), "cognition as a mental activity by definition cannot apply to aggregates such as firms, organizations", and hence clusters. However, he adds that "such aggregates can be seen as engaging in the use and production of knowledge, and people in an organization" or, within a cluster, "can share views, interpretations, understandings, values and norms of behavior, which are not shared outside the organization" or outside the cluster.

It is likely that executives who share mental models may reach similar strategic choices. This could explain the mimetic behaviours often noticed within clusters (Vincente et al., 2006). Within a cluster, firm acts dependently with regard to the actions of others within the cluster.

The phenomenon of mimetism is frequently employed to explain alliance formation. It has been shown that within an industry imitation provides one explanation for the dynamics of alliance formation (Garcia-Pont and Norhia, 2002). More specifically, a study of Zaim and Imm Ng (2006) shows that network relationships trigger and motivate firms' initial internationalization intention. Given that people linked within the same cluster tend to know what others in their own cluster know, the reputation of international partners comes through these bridge ties. Hence, a social network facilitates the identification of international exchange partners, minimizing the risks of internationalization (Zaim and Imm Ng, 2006). International alliance intensity in a cluster has a signalling effect and attracts more potential international partners (Lowe & Gertler, 2005). In analyzing German biotechnology clusters, Al-Laham and Souitaris (2008) show that the greater a regional cluster's international alliance intensity, the greater the probability that a new venture will internationalize via international research alliances. According to Garcia- Pont and Norhia (2002), it is a mistake to assume that industries consist of homogeneous firms that are equally likely to adopt legitimate organizational practices. Hence, it is necessary to take into account the heterogeneity among firms in an industry. Mimetic behaviour and shared mental maps occur among similar firms which follow similar strategies and present the same characteristics (Reger & Huff, 1993; Haveman, 1993). The dynamic of local mimetism suggests the following hypothesis:

Hypothesis 2: The probability that any firm i in a cluster will form an international alliance in period t increases with the density of international alliances formed by firms presenting the same characteristics in period t.

2.3 Cluster evolution theory

Clusters evolve and change over time as they go through life-cycle stages due to both external and internal forces. Pourder and St. John (1996) suggest that the strength of economies and diseconomies of agglomeration varies with the age of geographic clusters. They propose that geographical clusters evolve through three evolutionary phases: origination of the cluster and emergence of the hot spot identity, convergence of clustered firms, and firm reorientation (Pourder and St, John, 1996). In early stages, managers' mental models of competitors become similar, contributing to a macro-culture, which, in turn, leads to homogeneity and inertia. Over time, clusters enter in a reorientation phase during which firms consider alternatives outside of geographical boundaries and recognize the dangers of conformity. The mimetic behaviours appearing in the early stage and which also explain the rationales of the firm’s location choice (Vicente et al., 2006) disappear to give way to new, more autonomous behaviours. Indeed, mimetic behaviours are rational responses initiated by agents facing uncertainty in emergent contexts (Di Maggio and Powell, 1983), and are therefore more likely to come about in the early years of the cluster. In an emergent context, it would be more rational to imitate agents than to spend time and money to search for solutions and experiment with them. This suggests that cluster age may moderate the mimetic behaviour of firms, making mimetic behaviours less salient in old clusters.

This argument leads to the following hypothesis:

Hypothesis 3a: The cluster age of a firm i will moderate firm i's mimetic behaviour in the cluster.

In the early stages of development, clusters experience rapid growth and the opportunity space should exceed the number of firms in the cluster. However, as industries or clusters grow beyond a certain point, the marginal benefits of being in a cluster decline (Folta et al., 2006). As the size of a group increases, access to information becomes difficult. Theoretical works on networks show that network size has a curvilinear effect on the pathway number (Borrett & Patten, 2003). This means that the size of a system has more influence on the growth of the system structure (number of connections) in smaller networks. Relational proximity as defined through the interaction structure appears to be higher in small clusters. Phlippen and van der Knaap (2007) show that variety in a cluster enhances local link formation for small clusters. This suggests that large clusters operate as global hubs, which leads to the following hypotheses.

Hypothesis 3b: The international neighbourhood is expected to have a curvilinear effect on the likelihood of international alliance formation by a firm i in a cluster j.

Hypothesis 3c: Cluster size has a moderate effect on firm i's mimetic behaviour in a cluster.

3. Empirical research

3.1 The sample

The data for this study comes from the *BioScan* Directory, which is part of an electronic Biotechnology Industry Reporting Service from Thomson American Health Consultants. Researchers have used *BioScan* extensively in earlier studies (e.g. Zaheer and Georges, 2004). There are approximately 1207 biotechnology companies in the US, including 630 companies with fewer than 50 employees, of which 175 are start-ups founded after 2000. Our sample is composed of these 175 companies because of our interest on the impact of cluster characteristics on the internationalization of young and small firms through international alliances. About 51 % of biotechnology start-up alliances are international alliances and 14% of the 175 biotechnology start-ups have established at least one alliance with a foreign partner.

Geographical clusters

Geographical clusters are usually formed around sets of common technologies and dense networks of exchange and other relationships between firms in the cluster (Zaheer and Georges, 2004). Clusters have been studied in a variety of ways because of a lack of geographical precision and consensus. Studies have relied on the state as the unit of location (e.g., Audretsch and Feldman, 1996; Prevezer, 1997), on zip codes to identify geographic clusters (Zaheer and Georges, 2004), on the Metropolitan Statistical Area (e.g., DeCarolis and Deeds, 1999; Coombs et al., 2006; Folta et al., 2006). The MSA level was chosen as the boundary for cluster activity in this study for one main reason: since a majority of biotechnology agglomeration studies have used this level of analysis, this choice ensure that it will be easier to compare findings.

Firms in our sample are mainly located within nine clusters (San Franscisco-Oakland-San Jose, CA; New-York-Newark-Bridgeport; Boston-Worcester-Manchester; San Diego-Carlsbad-San Marcos; Washington-Baltimore-northern Virginia; Los Angeles-Long Beach-Riverside; Raleigh-Durham-Cary; Philadelphia-Camden-Vineland; and Seattle-Tacoma-Olympia, WA). Four percent of the 175 firms are in any geographical cluster. Figure 1 illustrates the total number of biotechnology start-ups active in the US in 2005.

INSERT FIGURE 1 HERE

3.2 Statistical model

We constructed an event history for each company. In the real world, changes occur at any point in time. Nevertheless, continuity is belied here by the data: measures of time are imprecise and given by year. Consequently, data are discrete. Event history data for discrete-time processes record the dependent variable as a series of binary outcomes denoting whether or not the event of interest occurred at the observation point (Box-Steffensmeier and Jones, 2004). Each firm's history began at the time of its incorporation and ended at the time of an event (such as an alliance) or at the end of the year, whichever came first. The second period began in the following year and ended at the time of the event or at the end of the year. This pattern continued until the firm exited or until the end of the observation period.

A discrete time-repeated event history with time-varying covariates was used to test our hypotheses. The complete and general specification of the model used was as follows:

$\text{Log}\ [P(IA_t =1)/(1- P(IA_t = 1) = \beta_0 + \beta_i (X_i) + \beta_i (X_k{*}X_j)$

where *P (*IA = 1*)* is the probability of an international alliance being contracted by a firm in period *t*, and X_i is the vector of independent variables *i*, $X_k{*}X_j$ the interaction term. The data include the date the first alliance was contracted, allowing us to correct for any left-censoring problem. A maximum likelihood estimation of a logit model was used to assess the effects of the independent variables on the likelihood of an international alliance being formed between one firm and a foreign partner in period t. The significance of the coefficients β_i tests our various hypotheses and indicates which of them are supported by the data.

Dependent variable

The purpose of this paper is to understand the factors that may affect the likelihood that any given small biotechnology start-up will form an international alliance during any period *t.* In our sample we identified 173 international alliances contracted by 175 small firms for the entire 5-year period examined here.

Our dependent variable was coded as 1 if a firm had formed an international alliance in the year and 0 if the firm had not formed an alliance in that year.

Independent variables

Specialized geographical cluster membership

Following Rothaermel (2002), we determined an implicit cut-off point in such a way that for the area to qualify as a regional technology cluster, at least 3.5% of all biotechnology firms must be located in the same geographic region. Hence, geographical cluster membership is a binary variable indicating whether a firm belongs to a biotechnological geographical cluster (1 if it does, 0 otherwise).

Cluster size

We tested Hypothesis 2 using cluster size, i.e., the number of other biotechnology firms that were active in the firm's MSA during the 5 periods. Data was coded from the *Bioscan* database. Clusters are composed of firms with similar and complementary capabilities. Similarity and complementarity determine clusters' dimensions. The vertical dimension is composed of firms with dissimilar activities and the horizontal dimension of firms with similar activities (Maskell, 2001). We viewed a cluster as a group of firms within one industry based in one geographical area. Hence, we retained the horizontal dimension to determine cluster size. Biotechnology firms cover 87 MSAs (each counting as a cluster) throughout the United States. Small companies with fewer than 50 employees, established after 2000, represent 14.5 % of the firms. Our sample covers 37 MSAs. As in Folta et al. (2006), cluster growth rate was also introduced in the models. "Cluster growth rate is used as a control variable because it may correlate with trends and future expectations in the cluster that may otherwise be attributed to cluster size" (Folta et al., 2006).

International neighbourhood

It has been suggested that mimetic isomorphism occurs among firms of similar size (Hannan and Freeman, 1977; Haveman, 1993). The third hypothesis states that the likelihood that a small firm will enter an international alliance depends on the number of other firms located in the same cluster which have contracted an international alliance in the previous year.

International neighbourhood of a firm *i* located in a cluster *j* is the number of other small firms in the cluster *j* which have contracted an international alliance during the period *t-1*.

$$\mathrm{IN}_{\mathrm{ti}} = \sum_{i-1}^{N_j} n_{ijt} - prob\ \ IA_{it}$$

Where n_{ijt} is the number of firms *i* in cluster *j* during period *t* and *Prob* IA_{it}.is the probability that firm *i* has contracted an international alliance during period *t*. *Prob* IA_{it} takes the value 1 or 0.

Cluster age

We measure cluster age (in years) by subtracting the starting date for the existence of the biotech cluster from the date of the event. Following Al-Laham and Souitaris (2008), we consider that the founding of a biotech cluster dates from the time of the first founding of a biotech firm in the region.

Control variables

Cluster attractiveness as control variable We measure cluster attractiveness through the proportion of large biotechnology companies (more than 500 employees) that are located in the cluster.

Furthermore, to isolate the effect of cluster characteristics on international alliance formation, we controlled for a number of possible confounding effects including a firm's size, age, innovativeness and product diversity. We also controlled whether the firm was public or private, a subsidiary of a foreign firm or a U.S. firm, and we included the number of previous international and national alliances.

Firm size

Although we have only analyzed small enterprises, we use employees (the number of company workers) as a control variable given the potential organizational differences between firms with 50 employees and those composed of one or two individuals..

Firm age

We are only interested in biotechnology start-ups established in 2000. Nevertheless we control for start-up age, defined as the number of years since founding. Previous research has shown how and why age and size affect start-up performance (Baum et al. 2000).

Prior national and international alliances

A cumulative count of the firm's prior national alliances was included to control for the effect it might have on the firm's internationalization (Al-Laham and Souitaris, 2008).

A cumulative count of the firm's international alliances was included to control the effect it might have on the internationalization probability (Garcia-Pont and Norhia 2002).

Products in development and products in market

We control for the degree of innovativeness and products in market. Baum et al. (2000) show that the greater the start-up's new product development, the higher its attractiveness as an alliance partner for large incumbent firms. Deeds et al. (2000) demonstrate that the concentration of biotechnology firms in a firm's geographic area will have a positive relationship with the number of new products developed by the firm.

Ownership

We control for ownership, distinguishing private from public firms. It has been shown that public ownership has a positive influence on the capacity of firms to attract alliance partners (Rothaermel, 2002).

Subsidiaries

We also include an indicator variable to distinguish between independent firms or national subsidiaries and international subsidiaries, assuming that international subsidiaries may establish more international alliances than national firms.

Table 1 presents a description of the variables.

INSERT TABLE 1 HERE

4.1. Results

In 2005, 14.6 % of the start-ups were public, 69.2 % were located in a specialized geographical cluster (at least 40 biotechnology firms), and 1.7% of the firms were subsidiaries of a foreign firm.

Descriptive statistics of the variables and correlations are presented in Table 2.

INSERT TABLE 2 HERE

Table 2 shows that several independent variables are significantly correlated with one another. Consequently, multicollinearity diagnostics were examined. The results of these analyses indicated that multicollinearity was not a significant issue as none of the variance inflation factors approached 10.0 (Hair et al., 1995).

Table 3 summarizes the results of the logit analysis. Reading from left to right across the table, models 1 and 2, explore the independent effects of cluster size and cluster growth rate, and international neighbourhood. In order to test hypothesis 4a, suggesting that the strength of mimetic behaviour is non-monotonic, model 3 includes a square term of the measure in the analyses. Model 5 tests the main effects of the principal variables. The next models (models 4 and 6) introduce the interaction term. To test these interaction effects, we mean-centered all three independent variables, created a separate multiplicative term between cluster size and international neighbourhood and cluster age and international neighbourhood and entered each multiplicative term into separate models accordingly. Model 7 explores the effects of the main variables simultaneously, and model 8 explores the effects of the nine control variables.

Model 9 is a multivariate model that simultaneously introduces all the independent variables in our study and all the control variables. For each model, the finding of non-significance of the Hosmer and Lemeshow test demonstrates that models adequately fit the data.

INSERT TABLE 3 HERE

Our models showed no support for cluster size effect as postulated in hypothesis 1a and hypothesis 1b. The effect of cluster size is negative but insignificant in the univariate model (model 1- this model is not significant) and also in the next models.

Our results provide strong support for hypothesis 2, indicating that the likelihood that a particular firm will form an international alliance depends on the cluster firms' behaviour regarding international alliances. The overall model is significant at $p < .001$. The coefficients remain significant in all subsequent models (at or smaller) where they are introduced.

The significance of the quadratic term for international neighbourhood further suggests that the international influence through the other firms' behaviour has a diminishing effect on the likelihood of international alliance formation after a certain saturation point. The relation is non-linear and the results support hypothesis 3b.

Model 5 introduces the interaction effect between cluster age and internationalization of the neighbourhood. The main effect of cluster age is not significant in any model, nor is the interaction effect. Hypothesis 3c is not supported.

Model 7 introduces the interaction effect between cluster size and internationalization of the neighbourhood. The interaction term is negative and significant ($p < 0.001$ in model 7, and $p < 0.05$ in models 8 and 10), implying that the rate and intensity of international alliance formation decrease as the cluster size increases. Hypothesis 3c is supported.

The significance of some control variables in the models suggests that the formatio of international alliances observed in the data can in part be due to the existence of previous alliances and to some firms' characteristics. These results replicate prior findings that international alliance formation is influenced by past domestic alliances (Al-Laham and Souitaris, 2008), by past international alliances (Garcia-Pont and Norhia, 2002), by firm size (Coombs et al., 2006; Al-Laham and Souitaris, 2008) and by ownership (Rothaermel, 2002).

In accordance with past research, we find no relationship between firm age and the probability of international alliance formation (Shan et al., 1994; Al-Laham and Souitaris, 2008). In accordance with past research, we also do find a relationship between the probability of international alliance formation and products in development or products in market (Coombs et al., 2006).

Discussion and conclusion

The purpose of this study was to determine the extent to which location specificity was associated with international alliance formation. Our results show that the international density in a geographical cluster plays an important role in international alliance formation. These results support several works (Coombs et al,. 2006; Al-Laham and Souitaris, 2008) that demonstrate that international alliance formation depends on location-specific characteristics such as technological munificence within the cluster and the attractiveness of the cluster because of the importance of R&D activities and previous R&D alliances with institutes. Zaheer and Georges (2004) stress that maintaining both dense ties within the cluster and beyond the cluster are important in the biotechnology industry.

One of the goals of our research was to discern not only whether a relationship exists between geographical location and international alliance formation, but to discover the motive of the relationship by mobilizing different theoretical frameworks. Our results reveal that merely being part of a geographical cluster does not enhance international alliance formation. Our findings show no support for cluster membership or cluster size as motives for the formation of international alliances by small start-ups. It has been shown that economies of agglomeration benefit firms in their ability to innovate through patenting, to attract private equity, and to attract alliance partners (Folta et al. 2006), more specifically large firms (Rothaermel, 2002). These studies do not distinguish alliances within the cluster from alliances beyond the cluster with national partners and/or international partners. In terms of internationalization, cluster size does not have a significant effect. Geographic grouping of firms which establish international alliances, and hence adopt the same strategic development, tends to exist. Like previous findings by Garcia-Pont and Norhia (2002), our results indicate that the dynamics of alliance formation can be explained primarily in terms of a process of local mimetism. Al-Laham and Souitaris (2008) stress that biotech firms benefit from the presence of internationally-connected organizations in their local cluster. These international connections reduce uncertainty and risk concerning internationalization, favour internationalization of the firms and augment mimetic behaviour. This phenomenon is well documented in sociological and managerial researches. Though formal or informal networks of information, firms copy each other (Di Maggio & Powell, 1983). Mimetism also occurs inside a given industrial group, a formal group, a strategic group or an informal business group. Nevertheless the growth to internationalization through alliances is limited and non-linear. While international alliances are enhanced with prior international connections in the cluster, more extensive interconnections do not appear to improve international alliance formation over more limited international connections in the cluster. The scope of mimetism is limited and this is consistent with the evolutionist theory. In order to reduce uncertainty, firms and their managers imitate each other. Even if mimetism can appear to be a rational economic behaviour, a cognitive perspective justifies the non-linearity of such behaviour. The common pattern of the managers' cognitive maps at a certain point gives the possibility of mimetism and justifies the non-linearity of the phenomenon.

While the study makes contributions to the international alliance literature, several potential limitations should be noted. First, this research is based on secondary data. This provides limited insight into the temporal aspects of cluster evolution and the internationalization process of the firms. Second, further work should introduce more specific characteristics of the cluster, such as the number of universities and public institutions or the amounts of government funding, for instance, to determine the cluster's degree of attractiveness.

Our results suggest that some specific cluster characteristics enhance the degree of interdependence across certain clusters, which favours mimetic behaviour. Is local mimetism, the primary dynamic that explains the formation of international alliances in clusters? What informal cluster characteristics favour mimetic behaviour? What informal local network characteristics favour mimetism? These are some of the issues worthy of further examination.

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Figure. 1. Distribution of small biotechnology firms (less than 50 employees) among geographic clusters in 2005

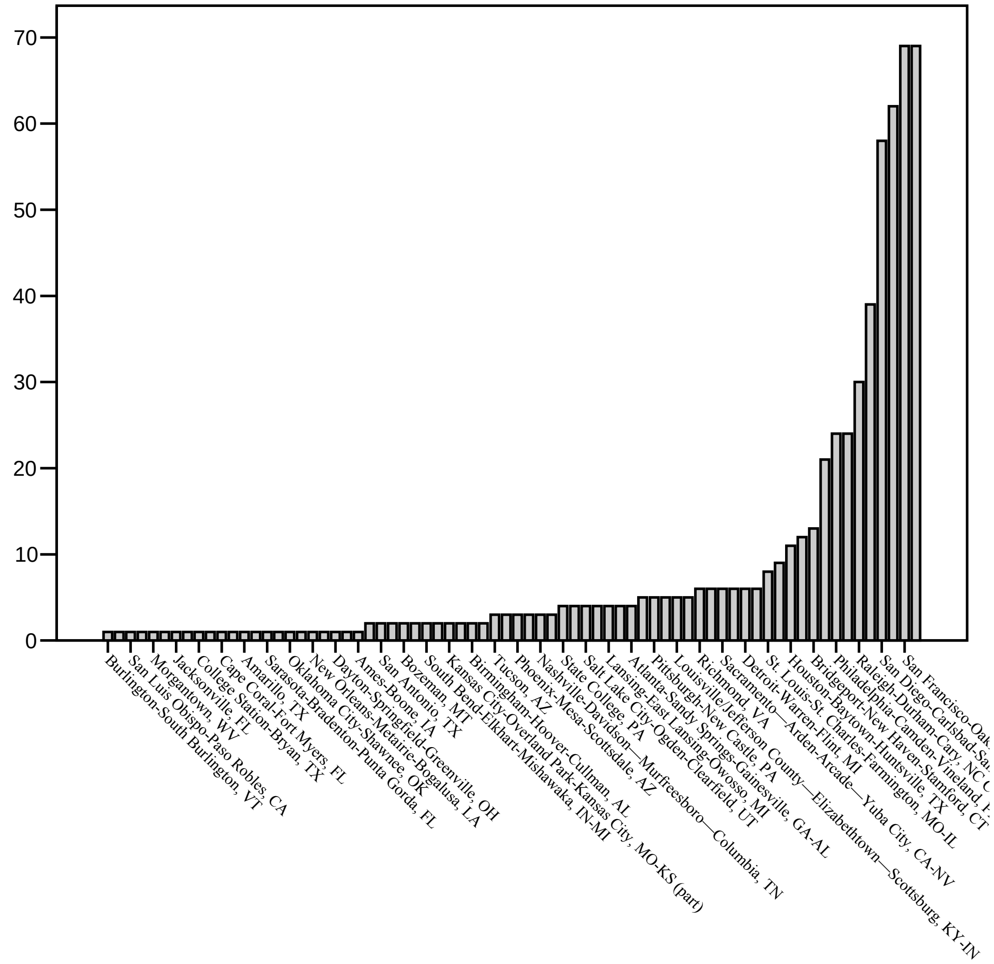

Table 1. Description of variables

Cluster size	Number of active biotechnology firms in the cluster in period t
Growth rate	Growth rate of the cluster
Cluster attractiveness	Proportion of large firms in the cluster in period t
International neighbourhood	Number of firms having founded an international alliance in period t
Cluster age	Number of years since the founding of the cluster .The founding of a biotech cluster is the number of years since the founding of a biotech firm in the local cluster.
Prior firm domestic alliances	Firm's number of local and national alliances established between its founding to the *t-1* period.
Prior firm international alliances	Firm's number of international alliances established between its founding and the *t-1* period.
Product in development	Firm's number of products in development.
Products in market	Firm's number of products on the market.
Firm age	Number of years since the founding of the firm.
Firm size	Log of the number of employees.
Ownership	Indicator variable that differentiates between public and private ownership, with 0 for public firms.
Subsidiary	Indicator variable that differentiates subsidiaries of international firms from others (independent or subsidiary of national firm), with 0 for national subsidiary and independent firm

Table 2. Summary Statistics and Correlations among Continuous Variables in the Models

	Variables						Variables								
	Name	Minimum	Median	Mean	S.D	Maximum	1	2	3	4	5	6	7	8	9
1	Cluster size	1	64.00	73.40	54.70	164									
2	Growth rate	0	.04	.04	.02	.22	-.184***								
3	International neighbourhood cluster	0	1.00	2.43	3.23	15	.643***	-.067							
4	Attractiveness	0		8.95	7.60	26	.866***	-.204**	.481**						
5	Prior national alliances	0	0	.42	.97	8	.066	-.070	.234**	.018					
6	Prior international alliances	0	0	.13	.43	4	.035	-.092*	.122**	.006	.290**				
7	Nb. products under development	0	1	2.13	2.83	14	.026	.014	-.002	.069	.024	.043			
8	Nb. products in market	0	0	2.08	12.80	240	-.077	.005	-.044	-.074*	-.027	.038	-.052		
9	Firm age	0	3	2.95	1.55	6	.024	-.093	.316**	-.031	.298**	-.303**	.014	-.031	
10	Firm size	1	15	19.69	13.23	50	.188	-.028	.024	.059	-.104	-.100	.088	-.055	-.033

Table 3. Results of repeated event history analysis

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Constant	-2.011***	-2.357***	-2.209***	-1.795***	-1.995***	-1.741***	-1.804***	-3.500**	-2.506**
Geographic cluster member									
Cluster size	- .158				-.130	-.372	-.397		-.601
Growth rate	-9.344				-10.769	-11.173	-12.4		-12.320
International neighbourhood		.304**	.844***	1.574**	.376**	.996***	1.384***		1.441***
International neighbourhood square			-.209***				-.428*		-.445*
Cluster age				-.015			-.023		-,046
International neighbourhood * Cluster age				-.036			-.260		-.252
International neighbourhood * Cluster size						-.449***	-.411*		-.395*
Cluster attractiveness								.006	.018
Prior firm domestic alliances								.265*	.197^{+}
Prior firm international alliances								.4394*	.496*
Product in development								.025	.028
Products in market								.007	.008
Firm age								.056	.-.114
Firm size								.396*	.462*
Ownership								-.612*	-.744*
Subsidiary								-18.578	- 18.626
Likelihood ratio	460.0	455.9	447.6	453.4	452.94	446.04	439.4	428.1	409.5
Goodness-of-fit	3,9 (ns)	8,2**	16.4***	19.4**	11.02**	17.018***	24.6***	34.6***	53.8***
Hosmer-Lemeshow test		.10	.64	.11	.344	.12	.77	.30	.62

Standard Errors in Parentheses; $^{+}p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.