ELSEVIER

Journal of Business Venturing 18 (2003) 333–359

JOURNAL of BUSINESS VENTURING

Academic networks in a trichotomous categorisation of university spinouts

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Received 1 January 2001; received in revised form 1 May 2002; accepted 1 June 2002

Abstract

The paper adopts a network perspective in an attempt to understand the underlying mechanisms generating the different university spinout structures. In this respect, we propose a trichotomous categorisation of university spinouts into orthodox, hybrid and technology spinouts and argue that the academic's embeddedness in a network of exoinstitutional and endoinstitutional ties influences the type of spinout initiated. We draw from some of the recent network research that has adopted a contingency approach in explaining the value of social networks.

Keywords: Trichotomous; University spinout; Social network

1. Executive summary

Networks are of catalytic importance in entrepreneurial ventures. This paper examines the influence of network structure in the generation of university spinout structure. University spinouts involve the direct commercialisation of intellectual property developed within the university and their importance for the economic vitality of a region or nation cannot be emphasised enough. Nevertheless, only a small number of studies have focused explicitly on university spinouts. As the field has been plagued by definitional inconsistencies, we propose the following definition of university spinouts. Spinouts involve: (1) the transfer of a core

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0883-9026/02/$ – see front matter
doi:10.1016/S0883-9026(02)00118-0

technology from an academic institution into a new company and (2) the founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution.

Within this, it is clear that there may be variations in the involvement of the key academics and we propose a trichotomous categorisation of university spinouts. In this respect, an *orthodox* spinout involves both the academic inventor(s) and the technology spinning out from the institution. A *hybrid* spinout involves the technology spinning out and the academic(s) retaining his or her university position, but holding a directorship, membership of the scientific advisory board or other part time position within the company. The scenario involving some academics spinning out and some retaining their university affiliation is also subsumed under this category. Last, a *technology* spinout involves the technology spinning out but the academic maintaining no connection with the newly established firm. However, the possibility of the academic having equity in the company and/or offering advice on a consultancy basis is not discounted.

Our contention is that the academic's embeddedness in a network of exoinstitutional and endoinstitutional ties influences the type of spinout initiated. In other words, we aim to evaluate the impact of the network structure at the idea evolution stage on the type of spinout initiated. We draw from Burt's (1992, 2000a) structural holes proposition and Coleman's (1988, 1990) social closure theory for guidance in the generation of our hypotheses. In view of some of the recent conciliatory approaches, we adopt a contingency approach in explaining the value of social networks. In this respect, content as a contingency factor examines how the value of social capital is differentially related to the nature of contacts.

This trichotomous categorization is important to university officials, venture capitalists and researchers for a number of reasons. First, from a typological perspective, it portrays the different modes of opportunity exploitation. Second, it describes the academic's operational role in the newly established company and portrays the extent of the relationship between the university and the spinout. For example, academics involved in hybrid spinouts, may not only constitute role models and act as a source of advice to other academics wishing to spin out, but may also exhibit a higher propensity of becoming habitual spinout entrepreneurs. Third, we believe that different types of spinouts may be associated with different growth trajectories and different evolutionary patterns. Fourth, the different types of spinouts may have different implications on the rates of entry of new technology-based firms in an industry.

2. Introduction

Networks play a protagonistic role in many aspects of organizational emergence (Birley, 1985; Aldrich and Zimmer, 1986; Larson and Starr, 1993; Renzulli et al., 2000; Aldrich, 1999; Johannisson, 2000). They constitute critical avenues for the acquisition of information and resources. Indeed, we echo Aldrich and Zimmer's (1986) remark that entrepreneurship is channelled and facilitated or constrained and inhibited by people's positions in social networks. Our purpose here is to utilise social network concepts to guide our understanding of the underlying structures generating university spinouts. In this respect, spinouts are

becoming increasingly important as a mechanism for technology transfer from academic institutions and involve the direct commercialisation of intellectual property developed within the university. They are a source of wealth creation and job opportunities in the economy (Birch, 1987; Steffenson et al., 2000) and a direct way of recouping economic dividends from a nation's investment in higher education and research (Mian and Plosila, 1998).

The importance of spinouts for the economic vitality of a region or nation cannot be emphasized enough. A recent study by BankBoston shows that there are over 4000 MIT-related companies, creating over 1 million jobs worldwide and generating annual sales of $232 billion (BankBoston, 1997). In France, a study by Mustar (1997) estimated that spinouts constitute 40% of the high-tech firms established between 1987 and 1997. Moreover, a comparison of income from university equity sales in start-up companies to income generated from licenses, reveals that the average value of equity is significantly greater than the average annual revenue from a license (Bray and Lee, 2000).

Although a number of studies have examined various types of academic entrepreneurship (e.g., Louis et al., 1989; Chrisman et al., 1995), very few studies focused explicitly on university spinouts. We argue that rather than representing a unique, undifferentiated outcome, there is more than one way in which the academic inventor may be involved in the spinout process. We thus propose a trichotomous categorisation of university spinouts into orthodox, hybrid and technology spinouts. We then propose the use of network concepts as the epicentre of our understanding of the spinout trichotomy. Our contention is that the academic's embeddeness in a network of endoinstitutional and exoinstitutional[1] ties influences the type of spinout initiated.

While there is broad agreement about the catalytic role of social capital, there are two schools of thought with respect to the social structure that is most facilitative. On the one hand, some scholars have argued that it is a cohesive or densely embedded network that confers a competitive advantage (Coleman, 1988, 1990; Walker et al., 1997; Ahuja, 2000). On the other hand, some have found that a sparsely connected network full of structural holes is the precursor of this advantage (Burt, 1992, 2000b). In this respect, we adopt the contingency perspective that has recently developed, and which reconciles the two sources of social capital (Podolny and Baron, 1997; Burt, 1997a, 2000a).

The first part of the paper examines the role of social networks in organizational emergence and delves briefly into the spinout literature. The second part investigates definitional issues and presents a typological framework of the spinout phenomenon. We then construct a network model to guide our understanding of the mechanisms generating the different spinout structures. We finally conclude with implications of the model and directions for future research.

[1] Exoinstitutional refers to outside the academic institution, while endoinstitutional refers to inside the institution (terms derived from the Greek prefixes endo and exo). The distinction is important as the "conditions for entrepreneurial action outside organizations are qualitatively different than those inside organizations" (Aldrich, 1999, p. 85).

3. Conceptual background

We first outline two critical elements that constitute the conceptual spine of our model: first, the role of social networks in organizational emergence and, second, the university spinout phenomenon.

3.1. Social networks in organizational emergence

Social networks play a protagonistic role in organisational emergence. In this respect, the prolegomena of social network analysis lie in an exchange and dependency perspective. Social exchange theory (Homans, 1950, 1961; Blau, 1964) purported to explain the occurrence of a dyadic relationship on the demand and supply of resources that each person in the dyad had to offer. The framework was extended beyond the dyad, to encapsulate more macroscopic social structures by Emerson (1962, 1972), who argued that power resides implicitly in another's dependency. Pfeffer and Salancik (1978) subsequently utilised some of Emerson's (1962, 1972) ideas in formulating resource dependency theory. They argued that managers structured their resource linkages to buffer the organization from the impact of external threats.

Networks facilitate organisational emergence by providing four substantive benefits: they augment the opportunity identification process, provide access to a loci of resources, engender timing advantages, and constitute a source of status and referrals.

3.1.1. Opportunity identification

Networks greatly enhance the entrepreneurs' opportunity recognition capabilities (Hills et al., 1997). In this respect, Venkataraman (1997) draws from Hayek's (1945) observation about the dispersion of information in the market and argues that "the possession of useful knowledge varies among individuals and... this strongly influences the search for and the decision to exploit an opportunity" (Venkataraman, 1997, p. 123). In other words, the discovery of entrepreneurial opportunities depends, in part, on the distribution of information in society (Kirzner, 1973). As human action is embedded in ongoing systems of social relations (Granovetter, 1985), social networks can be argued to be of significant importance in accessing and harnessing this information.[2] Indeed, a number of scholars have provided a fine-grained analysis of the antecedent role of social networks in opportunity identification. For example, Hills et al. (1997) differentiated between solo entrepreneurs, who had recognised the business opportunity themselves, and network entrepreneurs, who had recognised the opportunity through their social networks. Similarly, Sigrist (1999) utilised a cognitive mapping approach and proposed a distinction between constructor-type and discoverer-type entrepreneurs; the former type discovered the opportunity themselves, while the latter discovered the opportunity through the right personal contact.

[2] Contrast this opportunity 'discovery' perspective with the opportunity enactment perspective where opportunities are the outcome of the sensemaking activities of individuals (Gartner et al., 2001; Sarasvathy, 2001; Venkataraman and Sarasvathy, 2001).

Singh et al. (1999) found that the size and number of weak ties in an entrepreneur's social network were positively related to the number of new venture ideas identified and new venture opportunities recognised. They found that network entrepreneurs identified significantly more opportunities than solo entrepreneurs. Ardichvili and Cardozo (1999) used an embedded case study design with the entrepreneurial opportunity as the unit of analysis. They found that in seven out of eight cases analysed, access to extended social networks was a prerequisite to successful opportunity discovery.

One of the most comprehensive models of the opportunity identification process which describes the recognition, evaluation and development of an opportunity is provided by Ardichvili et al. (in press). With regard to present concerns, they identify social networks as one of the antecedents of entrepreneurial alertness, which constitutes a necessary condition for opportunity identification. Under a different lens, De Koning and Muzyka (1999) conceptualise opportunity formation as a socio-cognitive process. They identify four types of relationships within an entrepreneur's social context; these include the inner circle (with whom the entrepreneur has long-term stable relationships), the action set (people recruited by the entrepreneur to provide the necessary resources for the opportunity), the partners (team members involved in the start-up) and a network of weak ties (used to gather general information and possibly future resource providers). The entrepreneur develops the opportunity through a trilogy of cognitive activities with these four groups, that includes information gathering, thinking/articulating and resource assessing. Moreover, each group within the social context plays a role, which is distinctively different from the roles played by the other groups.

3.1.2. Access

Networks help entrepreneurs because the business foundation process requires a variety of resources (Aldrich et al., 1987). In this respect, Starr and MacMillan (1990) stress the importance of social contracting as a means to resource cooptation. More specifically, individuals embedded within broad networks will be more likely to identify potential exchange partners and consequently capitalise on potential exchange opportunities (Rangan, 2000). Moreover, social capital enhances small business owners' access to business loans, while it may also lower the cost of loans (Uzzi, 1999). From a different lens, it may constitute a source of emotional support. Indeed, "regardless of their personal networking abilities, nascent entrepreneurs who occupy impoverished social locations may find themselves cut off from... critical resources" (Aldrich, 1999, p. 98).

The importance of networks in resource acquisition is also exemplified by the duality in the level of analysis exhibited "in the simultaneity of an entrepreneur's network and an emerging firm's initial network" (Hite and Hesterly, 2001, p. 277). In this respect, Larson and Starr (1993) explore the development and transformation of unidimensional dyadic relationships into multidimensional inter-organisational exchange relationships. Their network model appreciates the social embeddedness of economic relations and describes the formation of an organisation as the crystallisation of an individual/organisational network. Similarly, others have even described the birth of a new venture as "the institutionalisation of a part of the entrepreneur's personal network into a venture" (Johannisson, 2000, p. 373).

3.1.3. Timing

Networks have important timing implications. Embeddedness promotes economies of time and enables actors to capitalise quickly on market opportunities (Uzzi, 1997). As the availability of time is the economy's most fundamental resource, it has profound implications on economic outcomes (Juster and Stafford, 1991). Indeed, an assumption of social network approaches is that a person has a finite amount of time and energy to invest in social relationships (Seibert et al., 2001).

3.1.4. Status and referrals

Networks constitute a source of referrals that provide feedback effects and generate legitimacy in entrepreneurial actions. For example, venture capitalists are more inclined to invest in companies that they know or have been referred to by trusted resources because this tends to alleviate informational asymmetry problems (Sorenson and Stuart, 2001). In other words, social ties are often conceived by external agents as certifications of an individual's social credentials (Lin, 2001).

3.2. The spinout phenomenon

Roberts (1968) and Cooper (1971, 1973) were among the first to study the spinout phenomenon. The Roberts study examined spinouts from MIT laboratories and academic departments while Cooper's work focused on corporate spinouts in what was to become Silicon Valley. Since then, a number of studies spanning different countries have been undertaken including the US (Smilor et al., 1990; Brett et al., 1991; Roberts, 1991; Steffenson et al., 2000), the UK (Blair and Hitchens, 1998), Italy (Chiesa and Piccaluga, 1998) and Canada (Doutriaux, 1987). Nevertheless, in the majority of studies, spinouts constitute only one of a number of technology transfer mechanisms examined. In fact, only a few systematic empirical studies focusing exclusively on technology spinouts have been conducted (Lindholm, 1997). Indeed, 30 years on, Cooper's (1971, p. 2) remark that a ''systematic investigation of the subject is still at its infancy'' seems to hold. A reason might be that identifying the academics who took the 'from profs to profits' (Piccaluga, 1992) route, and measuring the exact degree of university 'leakage' through informal channels (Birley, 1992, 1993) is not an easy task (Chiesa and Piccaluga, 1999). In this respect, Chrisman et al. (1995) argue that any attempts at measurement will underestimate the extent of faculty entrepreneurship. They quote Vesper and McMullan (1988) who note the existence of an 'iceberg effect' in the identification of faculty generated ventures.

The literature has also been mainly atheoretical (Autio, 2000) and noncumulative. Apart from a small number of studies (e.g., Louis et al., 1989; Roberts and Malone, 1996), the majority have focused on a single university or on a very small number of institutions making it hard to draw any generalisations. It also remains mainly US biased although there has been a recent upsurge in European research (see Oakey and During, 1998). Moreover, a large number of these studies have been conducted in technopoles—i.e., technology cities—where there are numerous spinouts (Route 128, BankBoston, 1997; University of New Mexico, Steffenson et al., 2000; Austin, TX, Smilor et al., 1990;

Cambridge, Wicksteed, 1985) but where the prevalence of network externalities may considerably bias the results.

The majority of the limited literature has approached the spinout phenomenon from four dimensions. First, some have examined personal characteristics as a predictor of entrepreneurial activity (Louis et al., 1989; Roberts, 1991; Kassicieh et al., 1996). In this respect, Roberts (1991, p. 341) concluded that "although the entrepreneur is more extroverted than his rather introverted technical colleagues, the high technology entrepreneur still emerges looking more like an inventor than any other unique role." Second, some have examined the effect of institutional structures and policies. At this level, factors affecting technology spinouts include the official university policy (Segal, 1986; Smilor et al., 1990; Roberts and Malone, 1996; Chiesa and Piccaluga, 1999; Bercovitz et al., 2001), the university reward system, which is usually based on the academic's publication record (Franklin et al., 2001; Howells et al., 1998), ideological conflicts between the traditional role of the university and entrepreneurial academic orientations (Bok, 1982; Stankiewicz, 1986; Samsom and Gurdon, 1993) and issues involving intellectual property rights (IPR). Third, departmental norms have also been found influential in engineering technical entrepreneurship. In this respect, Louis et al. (1989) argue that behavioural expectations are reinforced at the departmental rather than institutional level and find a relatively strong effect of local norms on individual behaviour. Fourth, a number of researchers have examined the importance of external influences, and especially those related to processes and institutions associated with national innovation systems (Nelson, 1993) and their differential effects on spinout rates. For example, a significant stimulus in the generation of spinouts was the ending of the British Technology Group (BTG) monopoly in the UK and the implementation of the Bayh-Dole Act in the US (Hague and Oakley, 2000; Mowery et al., 2001; Nelson, 2001).

4. A trichotomous categorisation of university spinouts

4.1. Defining a spinout

One of the issues that we face is that there is no universal definition of a university spinout. In this respect, Smilor et al. (1990) defined spinout companies in two ways: (a) the founder was a faculty member, staff member, or student who left the university to start a company or who started a company while still affiliated with the university; (b) a technology or technology-based idea developed within the university. Radosevich (1995) differentiated between inventor–entrepreneurs and surrogate–entrepreneurs. The former were laboratory employees who sought to commercialise their own inventions, while the latter were those who acquired the rights to commercialise the technology from the university. Roberts and Malone (1996) identify four principal parties involved in the spinout process: the technology originator, the entrepreneur, the R&D organisation and the venture investor. They argue that the interactions between these parties vary considerably and propose five different variations of the above. The first model assumes independence between the four principal groups while the second describes the situation involving an entrepreneurial technologist. The third model

involves both an entrepreneurial inventor and an internal venture capital fund. The fourth scenario involves an internal venture capital fund but distinguishes between the inventor and the entrepreneur, while the fifth model assumes the provision of venture capital by the entrepreneur. Carayannis et al. (1998) investigated seven spinouts from US Federal R&D laboratories in New Mexico and Japanese government laboratories and universities. They argue that we should either define a spinout as a new company that is established by transferring its core technology, founders or other resources from a parent organisation, or limit the concept of a spinout to specific resource transfers, such as in the case of a technology spinout, a founder spinout or a venture capital spinout. In this respect, we provide the following definition, which is both encompassing and parsimonious. Spinouts[3] involve:

1. The transfer of a core technology from an academic institution into a new company.
2. The founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution.

4.2. The spinout trichotomy

From the above, it is clear that there may be variations in the involvement of the key inventors. Indeed, we agree with the conclusions of Miner et al. (2001, p. 33) who argue that "rather than representing a single, undifferentiated outcome driven by a universal process, there may be distinct types of USBNVs [University Science Based New Ventures] and different processes or fields which give rise to them." With respect to the process, we focus on the network underpinnings of spinout structure. With respect to the nondistinctiveness of the spinout phenomenon, we propose the following trichotomous categorisation of university spinouts.

(a) An *orthodox* spinout involves both the academic inventor(s) and the technology spinning out from the institution.
(b) A *hybrid* spinout involves the technology spinning out and the academic(s) retaining his or her university position, but holding a directorship, membership of the scientific advisory board or other part time position within the company. The scenario involving some academics spinning out and some retaining their university affiliation is also subsumed under this category.
(c) A *technology* spinout involves the technology spinning out but the academic maintaining no connection with the newly established firm. However, the possibility of the academic

[3] Companies established by current or former members of a university which do *not* involve the commercialisation of intellectual property arising from academic research are not subsumed in the definition of a spinout. Indeed, Hague and Oakley (2000, pp. 5 and 7) clearly differentiate between *spinouts* and *start-ups*. The latter "may be set up by current or former students and members of staff, drawing on knowledge and expertise (usually not research) in all areas and on innate or acquired entrepreneurial skills... Founders of start-ups establish their companies to exploit expertise and knowledge gained during their careers and not, in contrast to spinoffs, from specific research projects."

having equity in the company and/or offering advice on a consultancy basis is not discounted.

This trichotomous categorization is important for the following reasons:

- From a typological perspective, it portrays the different modes of opportunity exploitation. As a result, we expect to observe distinct network patterns and structures underlying the university spinout trichotomy.
- It describes the academic's operational role in the newly established company and portrays the extent of the relationship between the university and the spinout. For example, academics involved in hybrid spinouts may not only constitute role models and act as a source of advice to other academics wishing to spin out, but may also exhibit a higher propensity of becoming *habitual spinout entrepreneurs* (MacMillan, 1986; Birley and Westhead, 1993; Alsos and Kolvereid, 1998; Rosa, 1998; Westhead and Wright, 1998; Wright et al., 1998).
- We believe that different types of spinouts may be associated with different growth trajectories and different evolutionary patterns. In this respect, Doutriaux (1987) found a growth differential between firms maintaining university links and those, which were completely independent. He argues that manufacturing firms completely 'independent' from the university grew faster. Similarly, Olofson and Wahlbin (1984), in their study of Linkoping University, found that the firms with the highest growth rates were the ones involving academics who left the university. This could be because the direct involvement of the inventor increases the effectiveness of technology transfer (Roberts and Hauptman, 1986); it thus ensures a speedier route to the market. However, it jeopardises the maintenance of a long-term research relationship with the university that could ensure a flow of future development knowledge. This flow of development knowledge could be a source of technological advantage for hybrid and technology spinouts and may give rise to continuous innovation and more frequent product updates. Increased innovation may give rise to a more diversified range of products, which may in turn diversify the commercial span of the spinout. Moreover, the different types of spinouts may have different implications on the rates of entry of new technology-based firms in an industry.

5. A model for a network theory of spinout structure

Building on the above, we now bring the network literature and the trichotomous categorisation together through the use of network concepts as the epicentre of the underlying mechanisms generating the different spinout structures. Our contention is that the academic's embeddedness in a network of exoinstitutional and endoinstitutional ties influences the type of spinout initiated. In other words, we aim to evaluate the impact of the network structure at the idea evolution stage on the type of spinout initiated. Fig. 1 is illustrative. It shows how endoinstitutional intradepartmental and interdepartmental net-

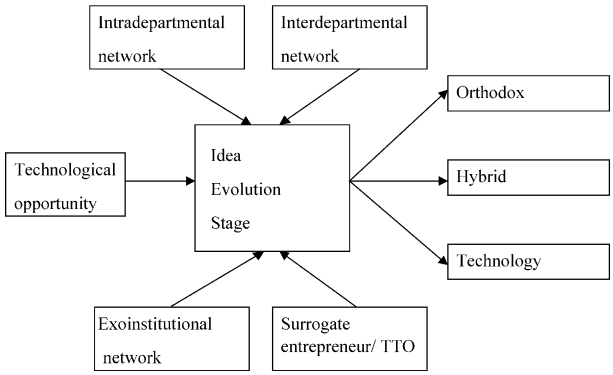

Fig. 1. The impact of the network structure at the idea evolution stage.

works, exoinstitutional networks, the technology transfer office and the presence of the surrogate entrepreneur feed in at the idea evolution stage and generate different types of spinouts.

5.1. Theoretical boundaries

Before investigating these issues in detail, we apply the following boundary delineation criteria in selecting the independent constructs. First, constructs should be the most relevant in explaining the spinout trichotomy and fall within the theoretical boundary (Dubin, 1969) specified by the network literature. Second, constructs should have received sufficient empirical and theoretical support in the literature and should be conceptually distinct from each other (Gnyawali and Madhavan, 2001). Third, we focus attention on egocentric network measures in order to make the model more amenable to empirical testing. Egocentric network analysis involves data gathered for the set of ties surrounding sampled individual units (Marsden, 1990). The advantage of ego network analysis "lies in its capacity for including information on an actor's relations across a wide range of social settings" (Gabbay and Zuckerman, 1998, p. 201). On the other hand, complete network analysis utilises sociocentric data which requires "information among all the relevant actors in a relatively bounded social group" (Gabbay and Zuckerman, 1998, p. 201). Indeed, most of the rhetoric surrounding network analysis is grounded on complete networks (Scott, 1991; Wasserman and Galaskiewicz, 1994; Degenne and Forse, 1999), as "complete enumeration of a closed population is essential for [these] analytical techniques" (Marsden, 1990, p. 438). However, sociometric data miss the social relationships that cross local boundaries (Gabbay and Zuckerman, 1998). Fourth, we attempt to be sensitive to the competing virtues of comprehensiveness and parsimony (Whetten, 1989). Comprehensiveness refers to the inclusion of all relevant factors, while parsimony refers to the deletion of factors that contribute marginally to our understanding of spinout structure. In other words, "constructs must... sufficiently, although parsimoniously, tap the domain of the phenomenon in question" (Bacharach, 1989, p. 506).

5.2. Contrasting perspectives on networks as social capital

Although most scholars agree on a social capital metaphor that confers distinct advantages, disagreements arise when the metaphor is made specific as to which medium gives rise to these benefits. For example, in what constitutes the first approach to the conceptualisation of social capital, Granovetter (1973, 1974) advocates the significance of weak ties in yielding valuable knowledge, information and resources. Weak ties are a good port of access (Ibarra, 1993) and require less effort to maintain (Granovetter, 1982). Granovetter argues that a strong tie cannot be a bridge to new and dissimilar information and that all bridges are weak ties. He cautions, however, that a weak tie does not automatically constitute a bridge. Krackhardt (1992), on the other hand, attempts to revalue the importance of strong ties. He argues that "strong ties constitute a base of trust that can reduce resistance and provide comfort in the face of uncertainty... change is the product of *philos*" (pp. 218, 238). Moreover, Rowley et al. (2000) argue that, in the literature, strong ties are associated with two primary advantages. First, strong ties provide quality information and tacit knowledge. Second, strong ties serve as a trust-based governance mechanism.

Burt (1992), however, argues that it is not so much the strength or weakness of a tie that is important but rather the structural hole that it spans. Whether a relationship is strong or weak is irrelevant; information benefits are generated when we have a bridge over a structural hole. He defines a structural hole as a relationship of nonredundancy between two contacts. Contacts are redundant if they are connected in some way and so provide network benefits that are overlapping rather than additive. Tie weakness is a correlate and not a cause of information benefits; the causal agent is whether it is nonredundant (Burt, 1992).

The table below attempts to portray the natural distribution of relationships by cross-tabulating ties by strength and location in social structure (Burt, 1992). Tie strength is divided into strong and weak ties while location is categorised into redundant ties to people within your cluster versus nonredundant ties to people beyond your cluster. Information benefits differ between the columns of the table and are greater through nonredundant contacts. Burt argues that the weak tie argument is about the second column of the table. "It predicts that nonredundant ties, the bridges that provide information benefits, are more likely weak than strong" (Burt, 1992, p. 29). However, Granovetter (1973) ignores the rare cell in Table 1, despite information benefits being capable of travelling over all bridges, weak or strong.

Table 1
Strength of ties and location in social structure

Strength	Location in social structure		Total
	Redundant tie within cluster	Nonredundant tie beyond cluster	
Weak tie	Many	Some	More
Strong tie	Some	Rare	Less
Total	More	Less	

Burt (1992, p. 29).

Indeed, the structural holes that Burt (1992, 1997a) advocates generate both information and control benefits. The latter give certain players an advantage in negotiating relationships as they act as the broker between otherwise disconnected players. The information benefits are access, timing and referrals.

McEvily and Zaheer (1999) argue that a firm's embeddedness in a network of ties influences its acquisition of competitive capabilities. Drawing from Burt (1992), Granovetter (1973) and Friedkin (1980), they define bridging ties as those that link a focal firm to contacts in economic, professional, and social circles. However, their conception of bridging ties differs from Granovetter and Burt in two ways. Unlike Granovetter who assumes that all bridges are weak ties they maintain, in agreement with Burt, that bridges are not always weak ties. In contrast to Burt, who argues that a bridge is a chasm spanned and the chasm itself, they argue that the "structural hole (chasm) presents information opportunities, but the bridging tie (span) is how an actor exploits these opportunities to realize certain benefits" (McEvily and Zaheer, 1999, p. 1137). They conceptualise bridging ties as embodied in three elements: nonredundancy (structural holes), infrequency of interaction (weak ties) and geographic dispersion. The latter is a proxy for face-to-face interaction. They view these concepts as complementary as each "captures in a different way the potential for bridging ties" (p. 1137). Nonredundancy, infrequency of interaction and geographic dispersion refer to the structural configuration, tie strength and spatial location of contacts, respectively. Their results indicate a positive relationship between nonredundancy and the acquisition of competitive capabilities. However, their hypothesis of a positive relationship between infrequency of interaction and competitive capabilities is not supported.

The antithetical argument to Burt's structural hole proposition rests within Coleman's (1988, 1990) social closure argument. Coleman advocates a different type of structural embeddedness in relation to social capital, which in operational terms implies a closed or densely connected network. Closure promotes trust and facilitates cooperation and conveys a "set of effective sanctions that can monitor and guide behaviour;. . .[it] is important not only for the existence of effective norms but also for. . . the trustworthiness of social structures that allows the proliferation of obligations and expectations" (Coleman, 1988, p. S107). In fact, one could argue that the prolegomenon of the closure argument rests within the 'boundary spanning' literature, which emphasised the stress experienced by the boundary spanner and the frequent role conflicts that arose (Whyte, 1949; Kahn et al., 1964; Spekman, 1979). Similarly, albeit from a different (i.e., class) perspective, Bourdieu (1986) argues that repeated exchanges within a dominant group reinforced and reaffirmed its social capital and preserved the group's dominant position. Recently, Ahuja (2000) found that the benefits of increasing trust, improving collaboration routines and reducing opportunism provided by a densely connected network increased the firm's innovation output.

A number of studies have lately attempted to reconcile the two different sources of social capital. Such an approach essentially implies that Burt's structural holes hypothesis and Coleman's social closure theory hold in different contingencies. Indeed, Burt (2000a) acknowledges five contingency factors that affect the performance association with social

capital: personality and culture, network content, number of peers and task uncertainty, network structure within and beyond groups, and borrowed social capital. For example, Gabbay and Zuckerman (1998) argue that the network effects are contingent on whether the task is basic research or product development, while Walker et al. (1997) argue that structural hole theory may apply more to networks of market transactions than to networks of cooperative relationships. Podolny and Baron (1997) examine how social networks in the workplace affect intraorganisational mobility. They disaggregate social ties into five specific ties and show that Burt's predictions apply only to a restricted class of network contacts. "Given our finding that the effects of structural holes on promotion are positive for ties that convey resources and information and negative for ties that transmit identity and expectations, the standard practice in network research of aggregating disparate kinds of ties when relating network structure to mobility seems ill-conceived. . .. In supplementary research, we adopted Burt's approach and calculated aggregate measures of network size and structure. There was no net effect of overall network size or structure on mobility" (p. 689).

Indeed, as Ahuja (2000) argues, the debate about the appropriate form of social structure may be comprehensively enlightened by recourse to an established doctrine of organisation design: that the optimal structural design is contingent on the actions that the structure aims to facilitate (Lawrence and Lorsch, 1967). In other words, specifying the advantage sought from a social structure is likely to be vital in identifying the form of social structure that is most likely to be facilitative (Ahuja, 2000).

5.3. Academic business discussion and social support networks

Consequently, we do not pursue the orthodox approach of aggregating different kinds of ties. In this respect, content as a contingency factor examines how the value of social capital varies with different kinds of relationships (Burt, 2000a). It may thus be argued that all structural holes are not of the same colour; some are 'white holes,' while others are 'black holes' (Podolny and Baron, 1997). In our particular context, we differentiate between business discussion and social support networks in the academic's exoinstitutional network structure.

The general distinction between instrumental and expressive relationships has been quite prominent in the network literature (Tichy et al., 1979; Fombrun, 1982; Ibarra, 1993). Indeed, "the aggregate network can be viewed as an overlapping set of networks of different transactional content. The only conceptually meaningful strategy of analysis is to distinguish each network by its content, [and] analyse it separately" (Fombrun, 1982, p. 280). However, and although the distinction had been made quite early on, it was not until Podolny and Baron's (1997) work that serious questions linking network content and the structure of social capital were asked. Indeed, as Burt (1997b, p. 357) argued, "network content is rarely a variable in the studies—analysts agree that informal coordination through interpersonal networks is important as a form of social capital, but their eyes go shifty like a cornered ferret if you push past the network metaphor for details about how specific kinds of relations matter." In their study, Podolny and Baron (1997) distinguished among

five types of ties, including task advice and social support contacts in their analysis of intraorganisational mobility in the workplace.[4]

We believe that benefits of nonredundancy in exoinstitutional business discussion networks will stimulate the academic to act more entrepreneurially. The four benefits of opportunity enhancement, access to resources, timing and referrals accrue to the inventor academic:

(a) He is in an advantageous position to better identify market niches and may adapt his invention accordingly. Shane (2000), for example, conducted eight case studies of entrepreneurs who exploit a single MIT invention and showed how differences in prior information influence who discovers entrepreneurial opportunities to exploit the new technologies.
(b) A nonredundant network can provide the academic inventor with access to information he could not otherwise obtain and often constitutes the linking knot between seemingly unrelated resources. Indeed, one of the technology entrepreneurs in Nohria's (1992, p. 243) study argues that "a high-technology venture is like a jigsaw puzzle. Each of the pieces is unique and must fit together perfectly if you want the venture to be a success. So the chase in which everybody is involved—be it the entrepreneur, the venture capitalist, the management candidate or whoever else is in the game—is the search for those perfect 'matches' that will help put the puzzle together." For example, Smilor et al. (1989) developed the conceptual framework of a technology wheel to describe the process of high technology development in Austin, TX. Although they emphasised the importance of each of seven segments of the wheel, they argued that the most critical factor was the ability to link and network the segments in a synergistic way. Allen (1970) found high performing engineers in R&D laboratories to have a larger range of contacts not only within their area but also outside their specific field. Harmon et al. (1997) studied the transfer process of 23 technologies at the University of Minnesota over a 10-year period. They suggest that technology transfers occur principally through established relationships between inventors and their corporate contacts. Similarly, Khavul et al. (1998) examined high-tech entrepreneurial ventures in Israel and found a high reliance on informal networks for the transfer of institutional information. Mustar (1997, p. 38) emphasised the significance of the network phenomenon in his examination of French spinouts, "The driving force behind the creation of a high-tech

[4] We make two cautionary remarks about content distinctions in network research. First, some ties fall in more than one category. For example, some network relationships are both instrumental and expressive (Ibarra, 1993), for example, a mentor–protégé relationship (Kram, 1988). Nevertheless, the literature found limited overlap in contacts elicited (Burt, 1997b, 2000c); Burt (1997b), for example, asked nine name generating questions about different contacts, but found relatively small joint probabilities for each pair of name generators. A second caution about content as a contingency factor is that "two kinds of connection are substantively similar in a person's mind to the extent that the two kinds of connection occur together in the same relationships. If your friends are all people with whom you work, for example, you will have trouble deciding where work ends and friendship begins" (Burt, 2000c, p. 135). In this respect, the premise in network analysis is that behavioural distinctions precede cognitive distinctions (Burt, 2000a).

enterprise comes from the network.... Researchers who create their own businesses have little in common with the heroic and solitary Schumpeterian entrepreneur. Researcher entrepreneurs can do nothing alone. To succeed they need to be integrated into networks allowing interaction between a wide variety of actors."

(c) The academic obtains the information early, which is of protagonistic importance in R&D. This is significantly magnified by the importance of timing in patenting.

(d) Through referrals, the academic's interests are represented in a positive light at the right places. For example, venture capitalists and business angels are more inclined to invest in spinouts that they know or have been referred to by trusted resources as this tends to alleviate informational asymmetry problems. In this respect, Shane and Stuart (2002) examined the life histories of 134 firms founded to exploit MIT-assigned inventions and found that the presence of direct and indirect ties to venture investors before the creation of the firm increased the likelihood of a firm attracting venture capital backing and significantly decreased the hazard of mortality. Similarly, Shane and Cable (2002) used a multiple methodology to show that social ties influenced the chances of a spinout being funded, by reducing the information asymmetry between entrepreneurs and potential investors. The first stage of the study comprised of unstructured interviews with 106 individuals involved in 50 MIT spinouts. In all spinouts examined, the minimum informant set included the founder and the lead investor. The following quote, from a biotechnology entrepreneur exemplifies the importance of social ties in the investment decision. "One of the most important lessons that I learned in that process is how limiting it is when you try to obtain VC financing without the right contacts." Similarly, an investor argued that "it would be fair to say that if I had not known [entrepreneur W] and had him work for me prior to coming to me with this business plan, I never would have invested in this business." The results were confirmed by a survey of seed stage venture capitalists and business angels, which emphasised the role of reputation and the use of social networks in gathering information about the venture team.

Concerning exoinstitutional social support networks, we believe that the presence of structural holes in these networks, which are more akin to 'black holes' as far as spinout orthodoxy is concerned, will not generate enough emotional closeness, support and encouragement to induce an academic to follow the orthodox route. In this respect, Lin (2001) argues that if the outcome of interest is to preserve or maintain resources (i.e., expressive as opposed to instrumental actions) then denser networks provide a relative advantage. Indeed, the argument about how closure is linked to support ultimately relates to Durkheim's (1897/1952) contention that social integration promotes mental health (Walker et al., 1993). In this respect, albeit in a different context, Pescosolido and Georgianna (1989) found that densely knit networks provided greater support than disintegrated networks. Monge and Contractor (2000) quote Cummings (1997) who found that individuals receiving greater social support from their network had a higher propensity for generating radical innovation. Academics face an enormous challenge in leaving their ivory tower (Bok, 1982) and becoming actively involved in the spinout through the

orthodox route. Therefore, it is the closure argument that enhances spinout orthodoxy in this type of network.

5.4. Spinout process

We now link the benefits of social capital to the spinout process in an attempt, not only to exemplify the importance of networks, but also to shed some light in this direction. The spinout process, which constitutes the actual series of events that take place in technology transfer via the spinout route, has baffled researchers and has been something of a black box. We draw from Roberts and Malone (1996) and focus our attention on four stages: disclosure, evaluation, product development and business development stage. First, at the disclosure stage, the benefits of nonredundancy and closure will induce an inventor not merely to disclose the invention but also to indicate an attractive interest of being directly involved in the spinout. At the evaluation stage, social capital may provide additional information about the assignment of IPRs and thus generate a more favourable equity split for the academic inventors. In most revenue splitting schemes, equity is divided between the inventor, the departmental unit and the university (Stevens and Bagby, 2001). In reality, however, this constitutes a very stressful bargaining process for the inventors. At the product development stage, favourable social capital increases the likelihood of the academic demonstrating knowledge of the commercial feasibility of the invention. In addition, he is more likely to identify and choose between alternative commercialisation routes. Finally, at the business development stage, networks can facilitate the acquisition of venture capital backing. In this respect, Shane and Cable (2002) showed that social ties influenced the chances of a spinout being funded by potential investors. Most significantly, the availability of venture capital backing is the largest contributor of a new venture undergoing an IPO (Shane and Stuart, 2002), while firms with prominent partners go to IPO faster and earn greater evaluations at IPO than firms that do not possess such connections (Stuart et al., 1999).

The benefits of closure and structural holes in the respective networks analysed above alter the cost parameters necessary to create that value and hence encourage the entrepreneurial academic to pursue the *orthodox* route to commercialisation. This is because the decision to exploit an opportunity entails weighing the value of the opportunity against the costs to create that value and the costs to create value in alternative ways (Shane and Venkataraman, 2000). Indeed, ''individuals... decide to exploit or not to exploit a potential opportunity by comparing the subjective returns to becoming an entrepreneur with the subjective returns of performing any alternative income-producing activity'' (Minnitti and Bygrave, 1999, p. 41). Similar to Eisenhauer (1995) and Douglas and Shephard (1999), we view the decision to be involved in an orthodox spinout as a career choice. A favourable exoinstitutional network structure can provide a plethora of resources to make the academic feel positively supported to consider leaving the university environment to focus exclusively on the spinout. As an entrepreneurial venture entails various resource commitments made under conditions of uncertainty (Arrow, 1974), a beneficial network structure is of prime importance in reducing the inherent uncertainty in establishing a new firm (McGrath, 2001).

Accordingly, we propose:

H1: The greater the number of nonredundant contacts in the academic's exoinstitutional business discussion network, the greater the propensity for an orthodox spinout.

H2: The lower the number of nonredundant contacts in the academic's exoinstitutional social support network, the greater the propensity for an orthodox spinout.

We believe that a single entrepreneurial technologist with no intra-institutional collaborative *research* ties is more likely to follow the orthodox route to commercialisation. The issue of IPRs is significant here as a single entrepreneurial inventor faces a less complicated and less strenuous procedure. In this respect, spinout initiation requires a strong intellectual property base on which to develop new products. In addition, a single entrepreneurial technologist encounters less informational asymmetries than a partnership does, and issues of trust and reliability are not applicable. As Rappert and Webster (1997, p. 116) argue, "the process of rendering scientific knowledge a commodity owned by just some and not others is not straightforward."

On the other hand, if an invention is generated through collaborative research it is highly unlikely for all inventor–technologists to leave the university. Technological synergy involving a number of actors is unlikely to lead to spinout orthodoxy. In this scenario most inventors will retain their university position but hold directorships, memberships of the scientific advisory board or other positions within the company. This leads to a hybrid spinout. Consequently, we hypothesise the following with respect to the research network associated with the specific spinout project.

H3: The greater the size of an academic's endoinstitutional research network, the greater the propensity for a hybrid spinout.

H4: The lower the size of an academic's endoinstitutional research network, the greater the propensity for an orthodox spinout.

Interdepartmental collaboration complicates matters even further. First, IPRs issues become substantially more entangled. Second, departmental norms may differ endoinstitutionally. Louis et al. (1989) found that local group norms were important in predicting active involvement in commercialisation. They argue that this may be due to self-selection, which produces behavioural consensus, and behavioural socialisation, where individuals are influenced by the behaviour of their immediate peers. Similarly, a study of spinouts from Canadian universities showed that the entrepreneur's faculty was more influential than the university and its technology transfer office (Doutriaux, 1991). We hypothesise that interdepartmental diversity in the spinout-related research network is conducive to a hybrid spinout.

H5: The lower the interdepartmental diversity of an academic's research network, the greater the propensity for an orthodox spinout.

H6: The greater the interdepartmental diversity of an academic's research network, the greater the propensity for a hybrid spinout.

The rights to commercialisation are sometimes acquired by a surrogate entrepreneur who then spins out the technology. Radosevich (1995) outlines the advantages and disadvantages of the surrogate entrepreneur model versus the inventor entrepreneur model. Advantages include previous entrepreneurial experience and established professional networks, easier access to risk capital, and lower dependence upon the existence of a supportive infrastructure. Disadvantages include less commitment to and knowledge of the technology, and the lack of a relationship to the technology source to facilitate technology transfer. Franklin et al. (2001) examined the attitudes of individuals at the academe-industry interface concerning the advantages and disadvantages of inventor and surrogate entrepreneurs in 57 UK universities. They found that previous commercial experience is the most important advantage of surrogate entrepreneurship but are in disagreement with Radosevich (1995) with respect to the possible disadvantages. The most significant disadvantages they identified are different objectives to the university, different objectives to the academic–inventor and unreasonable equity requirements. Their study also found that the ten most successful universities in promoting spinouts are more predisposed to surrogate entrepreneurs than other universities.

Often the technology transfer office has a dual role in this respect. First, it may engineer interdepartmental technological synergy by promoting the combination of different technologies. Second, it may facilitate technology transfer, in the case of an academic disinterested in spinning out, by bringing in a manager to run the spinout company. However, the identification and enticement of suitable individuals to lead the ventures constitute the most significant barriers to the successful implementation of a surrogate entrepreneurship program (Franklin et al., 2001).

We propose:

H7: The identification and attraction of a befitting surrogate entrepreneur increases, the propensity for a technology spinout.

6. Discussion and implications

We have presented a typological framework of the spinout phenomenon based around different modes of opportunity exploitation and have proposed the use of network concepts to guide our understanding of the underlying mechanisms generating the different spinout structures. Our contention remains that the academic's embeddedness in a network of ties influences the type of spinout initiated.

The model presented is directly amenable to empirical testing. In this respect, survey methodology is particularly suitable. The names of inventors involved in spinouts could be provided by the technology transfer offices of the universities; the inventors could then be approached directly. The study has a number of implications for research on university

spinouts and social networks. We first focus attention on the former and outline implications and promising areas for research.

6.1. Implications/future research direction for spinouts

First, Burt (2000b, p. 2) argues that there are "substantively meaningful shades of grey between the extremes of entrepreneurs and not." The trichotomy has been an attempt to shed some light in this direction. Indeed, we encourage researchers to differentiate between types of entrepreneurial ventures if they are to determine the antecedents and consequences of new venture creation. The practice of aggregating entrepreneurial firms together seems ill-conceived.

Second, university–industry technology transfer may have considerable educational implications (Stephan and Everhart, 1998; Stephan, 2001). In fact, there are various educational issues that arise from the trichotomy, as "universities... are discrete structures, and find it very difficult to support multiple social goals simultaneously" (Argyres and Liebeskind, 1998, p. 452). For example, a prevalence of orthodox spinouts would essentially involve an exodus of academics from a university. This can severely impede scientific and technological progress if a number of top academics decide to leave the university to concentrate fully on their spinouts. The significance of this is magnified if we consider that most of the academics involved in spinouts are highly published scholars. Indeed, Debackere's (1999) analysis of Katholieke Universiteit Leuven Research and Development found that top academic performers were the top generators of spinout companies. Similarly, Zucker et al. (1998) found, using data on California biotechnology, that scientific 'stars' collaborating with firms had substantially higher citation rates than pure academic 'stars.' On the other hand, involvement in a hybrid spinout will tend to divert academics away from students and the curriculum, and towards the quest for venture capital funding and commercialisation routes. From an educational perspective, technology spinouts may thus be the best way to capture the best of both worlds.

Third, the increased involvement of academics in hybrid and technology spinouts might promote the acceptance of the spinout phenomenon as a viable technology transfer route. In this respect, Stankiewicz (1986) notes that academic institutions have particular ideologies, which exercise a strong influence on their members. This often manifests itself in a general discontent against any sign of business-related activity. Some researchers even use the Trojan Horse metaphor to describe the perceived reaction of colleagues to venturing attempts within their environment (Samsom and Gurdon, 1993). Bok (1982) cautions that the magnet of commercial success may corrupt and degenerate academic research, while Rosenberg and Nelson (1994) argue that the division of labour between universities and industry should be respected. Universities, they argue, should not be drawn into an environment where decisions are made with respect to commercial criteria. Although Lee (1996) found that US academics were more favourably disposed toward technology transfer in the 1990s than in the 1980s, the majority were still against start-up assistance or equity investment. In this respect, the presence in the university of an increased number of academics who have spun out companies may moderate anti-commercialisation feelings. Indeed, as Schumpeter (1934, p. 198) argues

"successes. . . draw an ever increasing number of people in their wake." Nevertheless, it may also give rise to tension between departments within a university which are 'successful' and 'unsuccessful' in technology transfer (Nelson, 2001).

Fourth, the ongoing relationship at the academe–industry interface should be much more prominent in the case of a hybrid spinout. The hybrid spinout may absorb more college graduates and provide a larger number of research grants to the university. In addition, a number of researchers from the university may also be employed part-time in the spinout.

Fifth, the spinout typology may also have differential effects on profitability. On the one hand, no one has greater knowledge about the technology than the academic and this may significantly speed up the route to market. In addition, it enables the academic to concentrate his energy fully on the spinout. On the other hand, too much involvement of the academic in the day-to-day running of the company propagates a culture clash with unhealthy economic consequences for the spinout.

Sixth, we encourage more research on IPR issues. This constitutes a virgin area for entrepreneurship research. Considering its importance, the absence of studies examining IPR issues is puzzling (Autio, 2000).

Finally, more process studies on spinouts are required. In this respect, we have linked the benefits of social capital to different stages in spinout formation in an attempt to shed some light in this direction. As in most areas in entrepreneurship research, longitudinal studies that follow the development of the spinout and the different trajectories pursued are greatly encouraged (Aldrich and Martinez, 2001).

6.2. Implications/future research directions for networks

Burt (2002) argues that "although entrepreneurship is inherently an exercise in the social capital of structural holes, the topic remains virtually untouched by theory and empirical research on the network forms of social capital." One of our aims has been to partially bridge this structural hole that exists in the literature. Indeed, there exist a number of structural holes that researchers need to span. First, it would be interesting to study networks that may incur liabilities and have negative implications for the venturing process. Recent research has examined drawbacks of social networks (Hansen et al., 2000; Gabbay and Leenders, 1999; Adler and Kwon, 2000) but none so from an entrepreneurship perspective. Second, researchers need to develop a contingency-based approach for analysing the value of networks in entrepreneurship. In this respect, entrepreneurship scholars should devote greater attention to examining the boundary conditions of nonredundancy and closure in stimulating entrepreneurial activity. Moreover, we encourage more analysis on content distinctions in entrepreneurial networks. Third, further research could hypothesise specific benefits for opportunity recognition, access, timing and referrals that stem directly from the network structure of the academic inventor. Indeed, we echo McEvily and Zaheer's (1999, p. 1154) remarks that "the finer grained process through which network structure translates into the acquisition of competitive capabilities is an interesting and important area for future research." In this respect, Seibert et al. (2001) found support for the role of access to information, resources and career sponsorship as mediators in their study of the relationship

between social capital and career success. Fourth, limited research at present "goes beyond identifying how these ties are constructed and what sort of information flows between them at various stages in the venture" (McGrath, 2001). Indeed, dynamic analyses of the evolution of entrepreneurial networks will generate critical insights into the genesis of firms. Researchers need to examine the evolution of entrepreneurial networks and move away from static models (Salancik, 1995; Aldrich and Reese, 1993; Steier and Greenwood, 2000; Hite and Hesterly, 2001). Fifth, research also needs to examine how the huge increase in the use of information technology has influenced the networking patterns of entrepreneurs (McGrath, 2001; Johannisson, 2000).

Acknowledgements

Earlier versions of this paper were presented at the 10th Annual Global Entrepreneurship Research Conference, at the ESRC Seminar on Innovation and Networking, at the EIASM Rent doctoral seminar and at Seminars at Imperial College. We would like to thank conference and seminar participants, and in particular Ming-Jer Chen, Brian McGrath, Rita McGrath, Asko Miettinen and Joe Tidd, for helpful comments and suggestions. We are also grateful to the Editor and the two anonymous reviewers for their excellent advice and comments. Financial support from the Leventis Foundation is gratefully acknowledged.

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