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Venture capital: The effect of local and global social ties on firm performance*

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Abstract. Firm financing literature has been dominated by a relatively 'undersocialized' and 'aspatial' view. We approach this gap by applying a social capital and economic geography informed lens to financial transactions. We explore if and how the early growth performance of venture capital backed organizations varies with the structural and physical location of their investors in syndication networks. Drawing on longitudinal data of Belgian firms and their venture capital investors, it is demonstrated that inter-firm relational ties and, especially cross-border linkages expand organizational outcome. In that, we show that not only social relations shape financial activity, but that also spatial patterns of co-investment networks deserve notice.

JEL classification: R1, G24, L26, Z13

Key words: Venture capital, financial geography, social capital, internationalization, firm performance

1 Introduction

The importance of network ties instead of arm's length transactions between atomistic financial actors is forwarded in a growing number of studies (Granovetter 1985; Podolny 1993; 2001). Looking at mutual fund portfolio profits, Cohen et al. (2008) find that portfolios where managers share a strong educational bond outperform those investments where no such link exists. Similarly, for mergers and acquisitions, social ties between acquirer and target executives established via a shared educational or employment background reduce the occurrence of strongly deviant returns (Ishii and Xuan 2014). In both cases, the interaction between actors leads to the dissemination of information and knowledge, reducing information asymmetries (Uzzi 1997; Inkpen and Tsang 2005).

Besides a common employment or educational background, social ties between actors take a wide range of modes including more formal alliances such as trade associations and interlocking

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board memberships and informal friendship contacts (Inkpen and Tsang 2005). In the venture capital (VC) industry, social networks among actors are prevalent in the form of syndication linkages (the joint investment of two or more venture capitalists in the same financing round of a specific target firm). Benefits from the maintenance of a multitude of co-investment ties with other VC investors, and especially those that are well-networked themselves, get reflected in higher fund returns and earlier exits of portfolio companies (Hochberg et al. 2007).

Social capital theory suggests that in many networks access to knowledge flows is asymmetrical and largely dependent on the structural network position of an actor (see also Uzzi 1996; Zaheer and Bell 2005; Gulati et al. 2006). A vocal assumption in social network theory is that an actor's position in a network is a reflection of its power. In that, a central location in a network facilitates actors to access and to exploit the knowledge and information flows that exist between network partners (Podolny 2001; Tsai 2001; Gulati et al. 2006). On the contrary, a peripheral position impedes and largely deprives actors from benefiting from the capabilities and resources exchanged between network parties. Hence, their structural position affects the ability of an actor to leverage network ties in order to source knowledge and skills (Ibarra and Andrews 1993; Tsai 2001; Whittington et al. 2009). The concept of centrality hereby often gets measured in two contrasting ways: A rather straightforward approach is to regard those actors as most central who maintain the largest number of links to other nodes in the network. Second, centrality is associated with an actor's capability to bridge structural holes, meaning the actor's attainment in connecting otherwise detached actors (Burt 1995).

Similar to economics, (Podolny 2001; Tsai 2001; Gulati et al. 2006). On the field of economic geography has also for long been 'undersocialized' and dominated by a neglect of micro-level socio-political factors that shape regional disparities. More recently, however, increasing attention is paid to the analysis of linkages and networks between firms. Central to the 'relational turn' in economic geography (Bathelt and Glückler 2003; Boggs and Rantisi 2003) is the observation that relationships between actors and their embeddedness in space impact economic activities. It is therefore suggested that, in addition to the social topography, also the geographical configurations of social networks matter for economic actions. For example, formal and informal network relations of the entrepreneur in foreign target markets are found to positively impact the likelihood of international expansion and the consequent performance of small firms (Bell 1995; Coviello and Munro 1997; Majkgard and Sharma 1998; Ellis 2000; Sharma and Blomstermo 2003).

The growing importance of finance in economies, which also extends to the regional level, makes it indispensable to incorporate the analysis of the role and spatial patterns of finance into the regional economics literature. In addition to a 'relational turn', the economic geography literature has lately devoted increasing attention to the 'financialization debate' (Engelen and Faulconbridge 2009; Krippner 2005), recognizing the proceeding dominance of financial relations for economic development. The exploration of a distinct financial instrument, namely venture capital, and how VC networks are geographically shaped as well as the implications of their patterns for small firm performance, delivers an important contribution to this debate.

The aim of this paper is to explore if and how structural and spatial patterns of investment syndication networks are advantageous for VC backed young firms, consequently referred to as 'portfolio companies', or, interchangeably, 'target companies', in their early growth phase. It is tested whether domestic and international relational linkages are qualitatively different in scope, making it essential to analyse them independently. We argue that especially international relational ties, bridging structural holes, are transmitters of non-redundant information and innovation-triggering knowledge which strengthen the resource-base of a firm and increase organizational performance. Contrary to the traditional focus on US ventures in the existing literature on venture performance, Belgian portfolio companies are at the centre of our analysis. The

Belgian VC market is characterized by openness towards foreign investors, while at the same time registering an active domestic VC scene (see Table 1) Avdeitchikova 2012, providing us with the opportunity to observe both domestic and international syndication networks. In addition, given the small size of the country compared to the US, the local and domestic sphere can be regarded as congruent, facilitating the comparison of local and, respectively, domestic versus international social capital.

Linking structural and spatial network characteristics of VC co-investment networks to the early growth performance of portfolio companies, this paper also makes several distinct contributions to the entrepreneurship and economic geography literature: Taking into account cross-border syndication ties, our research broadens the geographical scope of earlier analyses focusing on the structure and performance implications of domestic VC co-investment networks (Sorenson and Stuart 2001; Hochberg et al. 2007). In line with work on relational issues in economic geography, we detail that not only the social topography of a network, but also the spatial diversification of relational ties shape financial action. By using longitudinal data on the performance-related parameter employment growth, we also provide unique evidence about the early growth trajectory of start-ups that transcends the focus on survival related performance measures, such as the event of an initial public offering (IPO) or an acquisition, dominating existing studies (Das et al. 2011).

The paper proceeds in the following way. In the next section, an overview is provided of the VC investment process and the role attributed to social capital in this context. Section 3 presents a detailed description of network analysis techniques referred to in this paper. The data is described in Section 4, whereas our empirical strategy to address the effect of local and global networking on portfolio firm performance is presented in Section 5. Finally, Section 6 discusses the empirical results and Section 7 concludes and proposes future research directions.

2 Social networks, knowledge transmission and geography

VC is regarded as a special form or subset of private equity. Gompers and Lerner (2001, p. 146) define VC as 'independent, professionally managed, dedicated pools of capital that focus on equity or equity-linked investments in privately held, high growth companies'. Besides supplying incumbent innovative firms with funds, venture capitalists[1] provide advisory and monitoring services to the firms in their portfolio ('portfolio companies') including the identification of potential business partners, customers, market opportunities, and the development of business-related skills and capabilities (Bygrave 1988; Gorman and Sahlman 1989; Sapienza 1992; Sapienza et al. 1996). Reverting to their vast professional knowledge and personal contacts, their 'social capital', venture capitalists frequently facilitate the entry of startups into existing industry networks (Gorman and Sahlman 1989; Steier and Greenwood 1995). Especially in the early growth phase of a portfolio company, when making first experiences in the market environment, 'liability of newness' related problems (Stinchcombe 1965) such as low levels of legitimacy, strong competition from established businesses and frequent strategy adaptations are common. In this phase the abundant expertise and resources of the venture capitalist are of particular importance (Brander et al. 2002; Freeman 2002; Devigne et al. 2013).

In order to spread financial risk and reduce investment uncertainties, investors often invest in form of a consortium counting two or more VC funds . The syndication of investments leads to the establishment of social networks among venture capitalists (Bygrave 1988). Previous studies

[1] In accordance with the literature, we use the terms 'venture capitalist' and 'investor' interchangeably in this paper. Both terms refer to the VC fund and its managers that are participating in a deal with a target company. This is not to be confused with the 'limited partners', the investors of the fund including pension funds, large corporations, insurance companies, and family offices, which, in turn, equip the VC fund with capital to invest.

Table 1. VC activity in belgium (1997-2013)

Year	Total VC (Number of investments)	Incoming VC (Number of investments)	Incoming VC (%)	Domestic VC (Number of investments)	Domestic VC (%)	Number of Portfolio companies
1997	4	1	25	3	75	3
1998	18	4	22	14	78	9
1999	63	15	24	48	76	27
2000	90	27	30	63	70	39
2001	90	35	39	55	61	36
2002	65	23	35	42	65	17
2003	61	25	41	36	59	17
2004	36	15	42	21	58	11
2005	9	3	33	6	67	3
2006	41	10	24	31	76	14
2007	46	11	24	35	76	18
2008	36	6	17	30	83	11
2009	39	7	18	32	82	10
2010	18	4	22	14	78	9
2011	30	6	20	24	80	11
2012	37	16	43	21	57	12
2013	51	6	12	45	88	16
Grand Total	734	214	29	520	71	263

Data Source: Zephyr (2014)

AQ3

have found performance enhancing effects for portfolio companies resulting from receiving funding from an investor syndicate as opposed to a stand-alone investor (Brander et al. 2002; De Clercq and Dimov 2008; Das et al. 2011). In the case of syndication, the combination of different sets of capabilities and resources aids the coaching and monitoring of the portfolio company after a deal has been closed (Timmons and Bygrave 1986; Gorman and Sahlman 1989; Macmillan et al. 1989).

A distinction has to be made between investment syndication and network integration (embeddedness). Hochberg et al. (2007) forward robust results showing that rather the syndicate underlying factors such as the increased interconnectedness of actors than the fact that a portfolio firm is supported by an investor syndicate is positively associated with organizational performance. In that, portfolio companies benefit from syndication linkages of their investors even in cases where the investment at hand is not syndicated, but where the investor jointly invested with other venture capitalists during previous deals in other firms. This implies that investors not only source knowledge from those partners they currently invest with, instead, they rely on their entire network consisting of former and current investment relations to obtain resources. Consequently, the social web resulting from past and present syndication can be taken as proxy for the overall information network of a venture capitalist.

Knowledge transmissions between network partners are nevertheless not space blind. The diffusion of knowledge, and particularly that of non-codified tacit information, is more vivid between geographically localized or 'proximate' actors as the co-location of actors facilitates (personal) interaction and by that promotes knowledge exchange (Maskell and Malmberg 1999). Besides geographic proximity, also other dimensions of proximity are found to facilitate collaboration and knowledge transfer between actors. Boschma (2005) disentangles five types of proximity: social, cognitive, organizational, institutional and geographical, whereby the former act mutually reinforcing and partially substitute geographical proximity in the interactive learning process. In this paper, we concentrate on the first and the last type, namely the socio-spatial dimension of co-investment relations between VC funds. To better understand the role that the geographic configuration of relational ties plays for economic transactions and firm performance, we augment social network theory by insights from economic geography in the following subsections. The notion of 'relational tie' hereby refers to the connection that arises between two VC funds, that is, their managers, through the joint investment in a company.

2.1 Local linkages

The insight that geographical proximity is still important for knowledge transfer, despite a reduction in communication costs during the last decennia, gets reflected in a number of recent studies (Morgan 2004; Whittington et al. 2009). Empirical work using patent data has shown that knowledge spillovers between inventors are more frequent when they are co-located than when agents are separated by large spatial distances (Jaffe et al. 1992). When exchanging critical and, particularly, tacit resources, agents are inclined to rely on those connections that are more parochial in nature and with whom they subsequently interact on a more frequent base, than on their, in geographical terms, extended network contacts (Jaffe et al. 1992; Feldman 2000; McPherson et al. 2001; Whittington et al. 2009).

Also in the case of VC activity, a tendency towards space sensitivity is observed. For the VC investment process to be successful, the need for physical proximity between investors and investees is repeatedly emphasized (Zook 2004; Mäkelä and Maula 2006). The co-location of investors and investees facilitates regular face-to-face encounters, which ease the tapping of 'non-monetary' resources such as the investors' social capital (Mason and Harrison 1995; Powell et al. 2002; Sunley et al. 2005). Geographic distance between a venture capitalist and the entrepreneurial firm, instead, increases transaction costs associated with the exchange of

knowledge and causes information asymmetries (Sorenson and Stuart 2001). Given the lower intensity of interaction between more geographically distant partners, distance between a portfolio company and its investors is negatively related to the startup's probability of a successful exit (Cumming and Dai 2010).

2.2 Global linkages

The antagonism between the importance of geographic proximity for knowledge spillovers and the peril of lock-in or overembeddedness due to too restricted contacts is repeatedly stressed in the regional economics literature on industrial clusters (see Uzzi 1997; Bathelt and Taylor 2002; Bathelt et al. 2004). Besides relying on local networks, successful dynamic clusters are dependent on external, international linkages. Global contacts are important in that they feed local clusters with new knowledge generated in innovative hubs elsewhere. By inducting 'new knowledge', outside relations guard to some extent against lock-in and too rigid, innovation hampering networks (Uzzi 1997; Bathelt et al. 2004).

Most prominently, in his seminal work, Granovetter (1973) emphasized the importance of 'weak ties' for innovative processes. Open networks, which are characterized by a multitude of 'weak ties' appear to be less prone to problems such as innovative lock-in associated with predominantly inwards oriented networks. Though originally rooted in the realm of sociology, the concept got quickly adopted in economic geography work on learning and knowledge flows. Here, Granovetter-like 'weak ties' often get ascribed to the global context, whereas 'strong ties' are equated to the local context. Also more recently, benefits for innovation and learning arising from non-local ties are stressed (see Grabher and Ibert 2014).

Local and international linkages are not only different in a geographical context, also their formation process and aim is diverging (Bathelt et al. 2004). Whereas local knowledge flows are a relatively automatic process triggered by the co-presence of actors in a cluster, international linkages, also referred to as 'international pipelines', are consciously established connections with partners situated in more distant innovative hot spots around the world. Due to the distance constraints associated with the transmission of knowledge, it is unlikely that new knowledge created elsewhere finds its way to the cluster in a timely manner, if it were not for directly established contacts with those distant innovative hubs. The industrial district literature therefore regards 'international pipelines' as particularly value-adding for firms with respect to innovation, growth and the achievement of competitive advantages.

The local buzz (Storper and Venables 2004) and global pipeline concept (Bathelt et al. 2004) is nevertheless not without its criticism. In more recent studies (Moodysson 2008), it is contested that knowledge is free flowing at the local level, that is, an open and all-embracing local buzz exists, whereas more distant knowledge linkages are planned and consciously established. In other words, a shortcoming of the buzz-pipeline approach is its oversimplified distinction between knowledge linkages mainly on basis of their degree of formalization (Trippl et al. 2009). We address this gap by focusing on a single type of formalized knowledge linkages namely co-investment relations of VC investors and by assessing their effect on knowledge creation, and, in turn, firm performance, on different spatial levels. Besides fuzziness regarding the formalization and mechanism of knowledge diffusion, dissensions also exist with regard to the interplay of local and global knowledge linkages. Are the different knowledge sources complementary, accumulative, interchangeable or mutually exclusive for innovative activities? Traditionally, studies have pointed at the interplay of knowledge connections (Wolfe and Gertler 2004; Maskell et al. 2006). More recently, a growing body of work however regards specifically 'international pipelines' as value-adding for firms with respect to innovation, growth and the achievement of competitive advantages (Moodysson 2008; Fitjar and Rodríguez-Pose 2011).

The buzz-pipeline approach is closely related to social network theory, where we find evidence of the benefits associated with 'weak ties' (Burt 1995) or 'outside' relations. More

diversified and broader networks offer more varied information, consequently, actors that possess a more diverse network oftentimes perform better (Molina-Morales and Martínez-Fernández 2008a; Molina-Morales and Martínez-Fernández MT 2008b; Taheri and van Geenhuizen 2011). Also agents that are able to bridge 'structural holes' between different network players or separated clusters of interconnected actors generally show an accelerated performance (Burt 2004). Their structural position enables them to tap resources from otherwise peripheral or weakly connected parts of the network (Burt 2000). The generally more diversified and non-redundant knowledge, in turn, has the potential to bring fresh impetus to the individual or organization and increase its innovative capacity (Zaheer and Bell 2005).

Given their distinct knowledge content, domestic and international linkages may act complementary. Therefore, we suppose that investors that maintain local co-investment linkages as well as ties with non-domestic investors have a more diverse knowledge base and are consequently better equipped to support the early-growth process of their portfolio companies. At first instance we therefore hypothesize that the interconnectedness of VC investors within the VC syndication network is positively related to the initial growth performance of their portfolio companies. Given the originality of the knowledge and information acquired from international ties, we nevertheless expect international linkages to be of a slightly higher value addition with respect to venture performance than their domestic counterparts.

3 Network analysis

A network is established when actors (nodes) are connected via direct or indirect linkages (edges) (Wasserman and Faust 1994). In this paper, we suppose that VC investors who co-invest in the same portfolio company (event) establish a relational tie. The network underlying is a binary adjacency matrix where $x_{ijt} = 0$ represents the absence of a tie between investors i and j in year t and $x_{ijt} = 1$ refers to the existence of a co-investment relation. Given that investors are mutually aware of their presence in the syndicate, the network graph is undirected.

The concept of degree centrality (Freeman 1978), offering an uncomplicated indication of the total amount of connections an actor maintains, is applied to estimate the network centrality of investors quantitatively (Hanneman and Riddle 2005). Actor i's degree centrality is defined by:

$$C_D(i) = \sum_{j}^{N} x_{ijt}, \tag{1}$$

whereby N reflects the total number of nodes in the network. To take into account the changing nature of co-investment relations over time when some investors drop out and new investors enter the market, an actor's degree centrality is normalized by the maximum number of connections in the network n in year t. Formally, the normalized degree centrality of an actor is described by:

$$\frac{C_D(i) = \sum_{j}^{N} x_{ij}}{(n_t - 1)}. \tag{2}$$

4 Methods

4.1 Data

To estimate the effect of the structural and spatial network position of an investor on the economic performance of its venture, we obtained data on VC investments from Zephyr, a collection of publicly available information on private equity and VC deals, initial public offerings and

AQ4 merger and acquisitions around the world with a focus on Europe Bureau van Dijk 2014. A comprehensive set of VC deals involving portfolio firms headquartered in Belgium that have received their initial VC financing round between 2001 and 2008 is developed based on this data. Zephyr provides data on VC deals since 1997, however, the selected time frame coincides with a broader availability of data on Belgian VC deals and the development of the Belgian VC market (Table 1). The Belgian VC market, like the continental European VC market in general, solely chronicles a negligible number of VC investments before the millennium with as exception the investment hype in Internet-based firms at the end of the 1990s, eventually leading to the 'dotcom bubble' of the year 2000. Given the relatively small size of our dataset, the exceptional circumstances of the dot-com boom (1997–2000), causing a severe distortion in global VC investment patterns, potentially strain the robustness of any statistical analysis and provide another rational for choosing the post-crisis year 2001 as starting date.

VC deals were identified as follows: We searched the Zephyr database for deals categorized as venture capital. Not included are thus deals that indicate a more advanced development stage of the target company like mergers and acquisitions, buyouts and other types of investments that are generally subsumed under the category of private equity. Furthermore, we excluded investors with missing Bureau van Dijk identification numbers (non-identifiable investors). This step also eliminated any remaining business angel investors. After cleaning the data using these restrictions, we obtained a sample of 200 eligible investor-target company relations, compared to the initial dataset including 248 cases.

Our sample consist of both private and public sources of VC, whereby private investors prevail. Of the 200 times investors were involved in Belgian target firms (132 unique investors), 32 investor-target dyads (13 unique funds) are ascribed to public VC investors, including the Flemish Innovation Fund, the investment company of the Belgian region of Limburg and several university funds. Public VC funds were part of the consortium of venture capital investors in 19 Belgian target companies. The low share of public VC funds is ascribed to the general tendency of Zephyr to underreport public deals (see Bringmann and Verhetsel 2014).

A restriction of the Zephyr data set is that it solely provides information on the VC fund that underwrites a deal. No details are available concerning the broader corporate structure a fund belongs to; consequently, we consider networks of VC funds in this study and not VC firms. Potentially, this might lead to an underestimation of the size of investors' social capital. It is assumed that VC fund managers' knowledge and contacts diffuse in the VC firm rather than that they remain limited to the individual fund under their management.

For information on target firm performance, we consulted financial statement data provided by the National Bank of Belgium (NBB) resulting in a unique dataset of employment growth as performance related indicator of young private firms. Closing the period of observation at 2008 allows us to measure growth performance over a 4-year period including the year of the initial VC round for any given company. For the full 4-year period or at least two consecutive years, employment data was available for 51 companies leading to a total of 161 observations T2 (see Table 2). No distinction is made between portfolio firms that successfully exit (trade sale

Table 2. Descriptive statistics

Statistic	N	Mean	St. Dev.	Min	Max
1. Employment (FTE)	161	19.042	26.802	0.100	158.800
2. Local embeddedness	161	0.410	0.474	0.000	2.919
3. International embeddedness	161	0.026	0.045	0.000	0.246
4. Deal size (in 1,000 USD)	161	9,973	13,983	125	70,000
5. Age target (days)	161	972	1,327	1	6,064

Table 3. Correlation matrix (Spearman's rho)

	1	2	3	4
1. Employment (FTE)				
2. Local integration	−0.226			
3. International integration	0.373	−0.066		
4. Deal size	0.516	0.035	0.612	
5. Age (target)	0.474	−0.324	0.197	0.192

or IPO) during this time and those that fail (bankruptcy). In that, our dataset is unlikely to entail any survivorship bias.

Overall, it is assumed that focusing on young ventures allows for a relatively homogeneous sample of firms in terms of business development, their business orientation on often highly innovative new technologies and processes, and firm size. The geographical focus on Belgian portfolio firms ensures that external economic conditions such as labour market regulations are alike. Given the similar context of venture-backed startups in contrast to non-VC financed young firms, we consider the early development paths of portfolio companies as generally comparable (Davila et al. 2003). To further increase the comparability of firms, industry sector variations in growth cycles are accounted for. Consequently, it is regarded reasonable to compare the growth performance of the sample firms and to test by means of the obtained data whether there is an association between network integration, spatiality and firm growth.

4.2 Measures

In the following subsections, variables applied to test the hypotheses advanced in Section 2.2 are presented. Table 2 provides descriptive statistics of our data. Spearman rank correlation coefficients showing the statistical dependence between key variables are presented in Table 3. T3

4.2.1 Dependent variable: portfolio company performance

The goal of the dependent variable is to reflect firm performance. Earlier studies on firm performance have stressed that companies exhibit diverging growth patterns depending on the growth measure that has been chosen (Delmar et al. 2003). To account for heterogeneity in growth trajectories, it is therefore suggested to include different types of performance measures in the analysis (Wiklund and Shepherd 2005). With respect to small and unquoted firms, growth-related financial data is nevertheless sparse (Davila et al. 2003). Though often the event of a successful exit or the time it takes a company until that day are taken as outcome proxies, such data is only sparsely available in our case. Given the currentness of the Zephyr data, many firms in the dataset have not yet reached the stage of maturity where an exit is feasible. Taking only into account companies that launched an IPO or trade sale severely impacts data availability. An alternative proxy for young venture performance is *employment growth* (Bruton and Rubanik 2002), which has been found to be closely related to equity valuation (Davila et al. 2003). We take the natural logarithm of the absolute change in the number of full-time equivalents (FTEs) as dependent variable. All data is collected for the period 2001-2011.

4.2.2 Independent variables

We distinguish between local and international structural network characteristics of a stand-alone investor or investor syndicate. The distinction between local and international syndication partners is necessary in order to clearly determine the importance of local versus international social capital on portfolio company performance. As local integration we understand the number of ties of domestic investors to other domestic (Belgian-based) VC investors, whereby the nationality

of a VC fund is defined by means of its headquarter. Degree centrality scores are calculated over trailing 4-year periods with the first window ending in t-1, the year preceding the initial deal. By applying 4-year windows, we account for the fact that ties once established through a common investment are likely to be extant also after several years. Local integration scores are consequently constructed annually per portfolio company, reflecting the sum of the normalized degree centrality scores of all Belgian investors involved in the company. The average local integration score equals 0.41 (see Table 2).

F1 Figure 1 shows a simplified VC investment network including both investors and portfolio companies in a given year *t*. VC funds, resembled by a circle, invest in portfolio companies represented by a square, whereby blank nodes describe local actors and filled forms their international

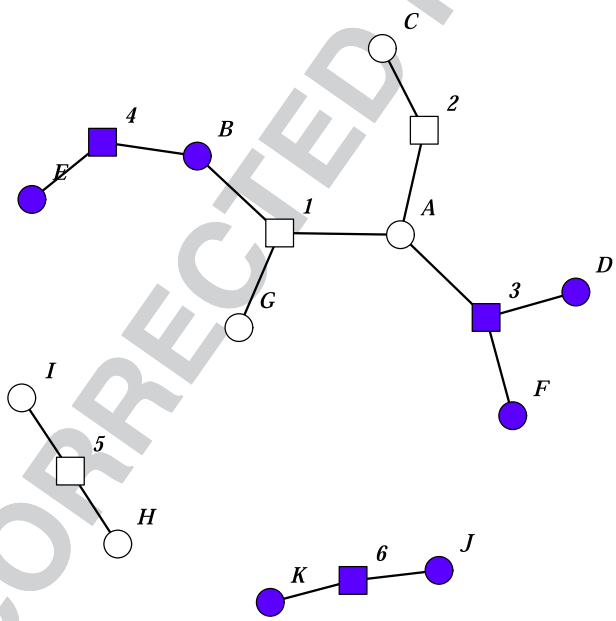

Fig. 1. Network analysis example

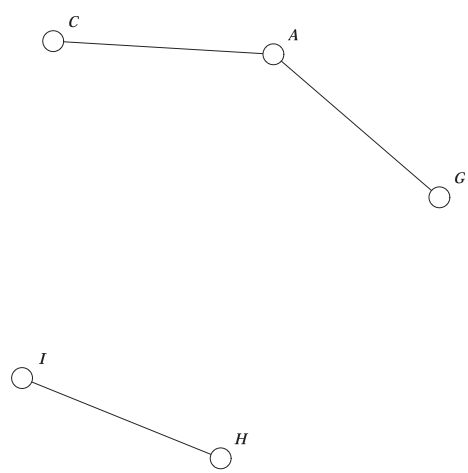

Fig. 2. Local syndication network

counterparts. Lines depict investment ties. The local co-investment network (one-mode network) derived from the two-mode network graph in Figure 1 is displayed in Figure 2. Through its local investor A, portfolio company 1 possesses over relational ties to investors C and G. Investor C solely co-invests with investor A. In that, the local degree centrality of the investor syndicate of portfolio company 1 equals 0.75, the sum of the normalized degree centrality scores of its domestic investors A ($C_{Dloc}(A) = \sum(x_{ij}/(n-1) = 0.5)$) and C ($C_{Dloc}(C) = 0.25$).

A co-investment network is constructed including VC investors active in Belgium (domestic and foreign) and their respective syndication partners in investment deals involving non-Belgian portfolio companies. On the basis of the attained network, centrality scores are estimated in the same way as described above. From the perspective of portfolio company 1, the international network integration score of its investor syndicate equals 0.5. This is the sum of the co-investment ties its investors maintain through portfolio companies not headquartered in Belgium and their non-Belgian investors (see Figure 3 for the investor-investor network). Investment fund A co-invests with foreign investors D and F in foreign target company 3, consequently its normalized international degree centrality is $C_{Dint}(A) = 2/6$. Investor B forms a syndicate with investor E to finance foreign portfolio company 4. His international normalized degree centrality is $C_{Dint}(B) = 1/6$.

4.2.3 Control variables

Besides the network topology related key independent variables, a range of other factors are potentially affecting firm performance. As control variable we therefore include firm age, deal size and an industry dummy variable.

It is anticipated that younger businesses have a tendency to grow faster than more mature firms (Evans 1987; Hart 2000). Thus, we control for firm age in our model. Age is measured in the number of days between the incorporation of the portfolio company and the closing date of the VC deal. In cases where only the year of incorporation was available, 30 June of that year is stipulated as day of incorporation. The natural logarithm is taken to account for any non-linear effects.

We anticipate a positive relation between deal volume and early growth performance. Firms receiving a higher amount of capital are found to be better able to secure resources crucial for their further development process such as skilled labour, specialized equipment, and product advertisement. (Devigne et al. 2013; Lee et al. 2001). The variable deal size is the amount of

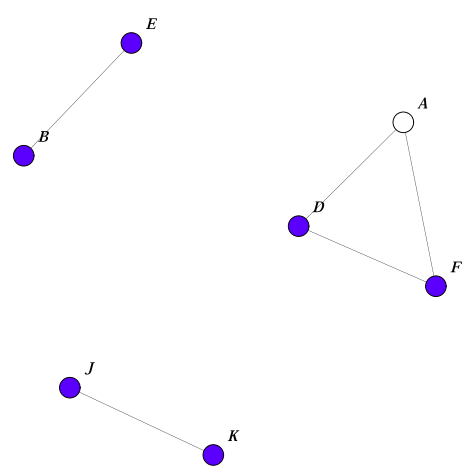

Fig. 3. International syndication network

VC the portfolio company obtained during the full 4-year period of observation. Deal volumes appear to be highly heterogeneous in our sample (Table 2). On average, portfolio firms received about 9.97 million euro for their first VC round or in additional VC rounds up until 3 years after the year of their initial VC injection, however as indicated by the large standard deviation, there exists much variation in the sample. We use the natural logarithm to take into account any non-linear effects.

To control for industry effects we add a biotech dummy variable (*Biotech*) to our model that takes on the value of one if the portfolio company is primarily active in the biotech sector and zero otherwise. Due to the necessity of often long-standing clinical trials, biotech startups are characterized by longer development phases than startups in other knowledge-intensive sectors, which, in some cases, defers their growth pattern. Consequently, we anticipate a negative effect on growth if a portfolio company belongs to the biotech sector.

5 Empirical strategy

A longitudinal multilevel model of change is employed to estimate the effect of structural and geographical VC syndication network characteristics on the growth behavior of portfolio companies (Bliese and Ployhart 2002; Singer and Willet 2003; Pinheiro et al. 2014). In contrast to conventional multilevel models that regard individuals to be nested within groups, we view the observations over time of a distinct variable to be nested within a subject (portfolio company) (Hox 2010). The performance of portfolio company i,...n_t at time $t(t = 0, 1, 2, 3)$ is estimated as a random slope multilevel regression model taking the form:

$$Y_{it} = \alpha_0 + \beta_{10}T_{it} + \beta_{20}X'_{it} + \beta_{01}D'_{i+}u_{1i}T_{ti} + u_{0i} + e_{it}, \tag{3}$$

where α_0 is the regression intercept. Time varying covariates, most importantly, the degree centrality score per investor syndicate of portfolio company i at time t are given by vector X'_{it}. A vector of time-invariant covariates that solely fluctuate across firms including deal size, age at the initial investment and industry scope is represented by D'_i. The residual error at the occasion level is represented by e_{it}. To reflect differences in the initial development and performance level of startups, a random intercept term u_{01} is introduced at the firm level. To account for the fact that firms exhibit different growth rates over time, the random term u_{1i} is added to the coefficient of time. This allows the growth curve of each firm to differ in slope. A model contrasting approach based on chi-square likelihood-ratio testing is applied to establish the goodness of fit on a model-per-model basis and to arrive at the most parsimonious model.

6 Results

The negative correlation between the intercept and slope (model not reported here[2]) shows that portfolio companies with a higher number of employees at the time of their initial VC investment demonstrate a smaller employment growth (weaker slope) in the years following the investment than companies that only recorded few employees (steeper slope). Also the size of the VC deal as well as the age of a portfolio company at its initial VC round have a statistically significant and positive effect on FTE growth. In accordance to our expectations, biotechnology-related firms are characterized by slower initial growth in employment after their first round of VC.

The positive and statistically significant coefficient of the domestic degree centrality score in model (2) signals that portfolio companies supported by locally more embedded VC investors denote on average a higher growth in FTEs than those businesses financed by less locally

[2] All models are available on request from the authors.

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Table 4. Multilevel models of employment growth

	(1)	(2)	(3)	(4)	(5)
Fixed effects					
Intercept	1.97^{+}	−2.72***	−0.01	−2.80***	−2.57**
	(0.18)	(0.97)	(0.11)	(0.98)	(0.99)
Time	0.21^{+}	0.11	0.10	0.10	0.11
	(0.04)	(0.07)	(0.06)	(0.07)	(0.07)
Ln (int'l. integration)[b]		6.77**	0.23**	10.09***	6.32**
		(3.01)	(0.10)	(3.74)	(3.10)
Ln (local integration)[b]		0.59***	0.13*	0.87**	0.62*
		(0.33)	(0.07)	(0.37)	(0.33)
Ln (age target)		0.27***	0.37***	0.27***	0.26***
		(0.08)	(0.12)	(0.08)	(0.08)
Ln (deal size)		0.37***	0.41***	0.37***	0.35***
		(0.13)	(0.14)	(0.13)	(0.13)
Industry (target)		−0.74*	−0.27*	−0.80**	−0.79
(=1 if Biotech, 0 otherwise)		(0.39)	(0.14)	(0.39)	(0.40)
Int'l. × Local Embeddedness				−8.77	
				(5.99)	
Market					0.28
(=1, if US & UK, 0 otherwise)					(0.43)
Random effects	Variance[a]				
Intercept	1.24 (1.11)	1.01 (1.01)	0.65 (0.81)	1.03 (1.01)	1.02 (1.01)
Time		0.16 (0.40)	0.11 (0.32)	0.16 (0.40)	0.16 (0.40)
Residual	0.32 (0.46)	0.07 (0.26)	0.05 (0.21)	0.07 (0.26)	0.07 (0.26)
AIC	409.30	326.31	256.11	326.12	327.88
BIC	421.63	360.21	290.01	363.09	364.86
Log likelihood	−200.65	−152.16	−117.06	−151.06	−151.94
Num. obs.	161	161	161	161	161
Num. groups	51	51	51	51	51

Notes: $^{+}p < 0.001$, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors are in parentheses. All models are estimated using hierarchical linear models with random intercepts and slopes. Model (3) shows standardized regression coefficients using grand mean centring.

[a] Standard deviances in brackets.

[b] A constant of 1 has been added before logarithmic transformation

interconnected VC funds. This suggests that geographically proximate domestic ties offer opportunities for the exchange of information, accelerate growth and constitute a competitive advantage for the venture. Also the coefficient of the international degree centrality score is positive and statistically significant. The access, via their investors, to non-local social capital improves the organizational outcome of a portfolio company in form of employment growth. The correlation coefficients in Table 3 do not point out any multicollinearity issues between local and international centrality scores that may impact the estimation of parameters when included in the same model.

The standardized coefficients in model (3) indicate that, although the control variables age and deal size have a larger effect on firm performance, international as well as local co-investment ties also have a non-negligible impact. Here, international linkages are almost twice as value-adding for organizational outcome than domestic investment ties. It is proposed that the larger effect on portfolio company growth of international ties compared to local co-investment linkages results from the lower degree of resource redundancy in international networks and the 'bridging' character of these ties. Thus, in cases where portfolio companies, via their VC investors, gain access to both local and global knowledge flows, we presume that more benefits are arising from the international relatedness.

Model (4) includes an interaction effect between the local and international integration scores. We estimate this model in order to assess if domestic and international investment ties act complementary. The coefficient of the interaction term enters negatively, but not statistically significant. This suggests that the effect of either local or global ties on the dependent variable does not vary with changes in value of the respective other included variable. Put another way, the effect of 'global pipelines' on organizational outcome does not vary with the local centrality of an investor syndicate and vice versa. This suggests that domestic and international co-investment ties are distinct in their value creating capacities.

We also test if there is a difference in outcome between social ties established with investors situated in more developed and liquid VC markets by introducing a dummy variable distinguishing between the US and UK market and other VC markets (model (5)). Given the positive though statistically insignificant coefficient, there are no signs that portfolio companies benefit more from ties connecting them to more mature markets. At first sight, the statistically insignificant positive result appears counterintuitive. The US has for long been regarded as the most mature and largest VC market worldwide, subsequently valuable knowledge and experience spillovers are expected. A possible explanation is however that ventures growth strategy matches their investors' value-adding capacities. Consequently, there are no a priori differences in value addition between investor networks that are US or UK based and, respectively, European, as the choice of investors is depending on their usefulness for and alignment with a company's strategy. This also fits to the conclusions of the buzz-pipeline literature, where it is forwarded that maintaining extra-regional knowledge ties, 'global pipelines', is more laborious than local connections and their formation is therefore a more selective, target-oriented decision. Further research on this issue is however highly advised. A possible avenue for future analyses would be to test if the insignificant relationship also holds for a larger, cross-sectional sample of countries including other developed European VC markets.

Finally, we look at whether the growth enhancing impact of investors' social capital decreases with increasing maturity of the portfolio company. For this we include interaction terms between the age variable and the local as well as the global degree centrality scores (model not reported here). There is no indication that the positive impact of investors' social ties changes during the early business development phase of their target firms. The negative sign of the local degree centrality score interaction term, though not statistically significant, is in line with prior studies on 'liability of newness' related problems of starting businesses and the crucial role of VC investors' expertise at this stage (Brander et al. 2002;Freeman 2002; Devigne et al. 2013).

Summing up, the empirical results show that the employment stock of portfolio companies is increasing over time and that both the local and international interconnectedness of venture capital investors have a statistically significant and positive effect on portfolio company growth. By integrating both centrality scores in the same model, we furthermore observe that international and local co-investment ties are not congruent in scope, but seemingly provide portfolio companies with different capabilities. Especially geographically expanded co-investment networks, encompassing cross-border ties, increase economic effectiveness. The findings stress that in denser networks as the domestic VC network, it becomes essential to maintain outside relations or, in other words, to bridge structural holes to improve economic outcome. In that, the results relate to Uzzi (1996; 1999) emphasizing the importance of 'non-embedded' external ties to prevent the innovation hampering perils of too dense, overembedded networks.

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6.1 Robustness tests

We test the robustness of the analyses by constructing a number of models that take into account different covariance structures. Due to its longitudinal nature, we expect a large degree of

interdependence in the data. First-order autocorrelation is found to be higher in models that solely allow for a random intercept. However, by integrating a random slope term into the models, autocorrelation problems largely diminish.

A second issue that potentially inflates goodness of fit measures is the existence of heteroscedasticity in the data. A comparison of models accounting for heteroscedasticity and those assuming homoscedasticity by means of log likelihood testing reveals that, at first sight, we have to presume a small degree of heteroscedasticity. However, subsequently introduced more complex models accounting for heteroscedasticity do not fit the data notably better. Visual inspection of the residual plots precludes any severe violation of the homoscedasticity assumption. Hence, the more compact random slope model is kept.

A third concern addresses the issue of reverse causality. It is evident to assume that better networked investors might also be more capable in selecting startups for their portfolio that are already more promising from the outset. After their initial round of VC, these ventures are then likely to continue to show an increased growth performance. In this case however, the largest impact of investor' social capital would have been realized in the selection phase and not during the business development and monitoring phase as assumed in this paper. Prior studies have embraced this problem and concluded that, although the 'selection hypothesis' cannot be neglected, investor syndicates (Brander et al. 2002) as well as better networked funds (Hochberg et al. 2007) are in general not denoting any large advantages in the selection of investment targets. Rather, performance differences between portfolio companies arise *ex post* deal closure and are linked to differences in investor involvement.

To test for selection bias, we collect performance data of portfolio companies from the two years preceding the year of the initial VC injection. This leads to a sample of 17 firms for which it was possible to obtain pre-deal growth figures. We apply ordinary least square regression analysis (OLS) to test whether firms that show an increased employment growth before their initial VC round where eventually selected by a particular sort of investor. We do not find any statistically significant estimators confirming a 'selection hypothesis'. Consequently, it is imputed that in the case of our sample of portfolio companies reverse causality problems do not impact the validity of the modeling results.

7 Conclusion

There has been a renunciation of the arm's length principle with regard to economic transactions. Instead, the importance of social networks for financial markets is emphasized. In this paper, we contribute to the emerging literature on economic geography and social capital in finance by examining the effect of the structural and spatial network position of VC investors on the early growth evolution of their portfolio companies. Given the accelerated development of international VC activity during the past years, particular attention is hereby paid to the value addition of global co-investment linkages compared to domestic networks. For the analysis, we collected data on Belgian-based VC deals and those investors' international engagements between 2001 and 2008 and traced FTE growth of the involved portfolio firms over a period of 4-years.

Using longitudinal multilevel modeling, we find that early growth trajectories of portfolio companies are impacted by structural as well as geographic co-investment features associated with their respective VC investors. Overall, a higher international integration of domestic VC investors, in form of a larger number of relational ties with foreign investors, impacts the economic performance of a venture positively. A slightly weaker growth enhancing effect is found for local syndication linkages of domestic investors. We propose that the larger effect of international ties on organizational outcome is associated with their properties to serve as sources of novel information, which consequently allow for a better combination of resources, enhancing the competitive advantage of portfolio companies. Whereas knowledge assets stored in the

local environment may be taken up via other channels, knowledge and skills acquired through non-local linkages are not gained if it was not for the international 'bridging' relationship. Following on, it is suggested that investors that possess external contacts bridging structural holes are particularly beneficial to organizational performance in that they are able to provide unique resources to their portfolio companies. In the light of the positive effects of international as well as domestic network ties, optimally, firms integrate both sorts of relationships in their network. Given the additivity of domestic and international ties, an investor acting under resource constraints adds more to his social capital by establishing an international co-investment relationship if he only possesses local syndication partners than by adding an additional tie to his local network.

Prior studies investigating the spatiality of VC activity generally assert that the co-location of VC investor and target company is favourable with respect to economic effectiveness. While not disputing the relevance of geographical proximity in the VC investment process, we pointed out that from the perspective of the portfolio company also the social network of its investor matters. Here, contrary to what has been found concerning the physical location of investor and target, local but especially more distant, cross-border relational ties act performance enhancing.

These findings are also in contrast to traditional Marshallian economic geography theories focusing on the importance of local agglomerations and the interaction between proximate, co-located actors for knowledge creation. They are however in line with more recent approaches that accentuate the crucial role of extra-regional and national knowledge exchange and the additivity of local and global knowledge diffusion for dynamic innovation. In congruence with our results, these studies highlight the outstanding role of consciously established global linkages, compared to local interactions, in spurring firm innovation (see Fitjar and Rodríguez-Pose 2011).

For public policymakers these results suggest that both the deepening of networks, but especially the spatial diversification of knowledge linkages are important factors fostering the growth of young and innovative firms. Potential policy actions should therefore aim at the strengthening of the attractiveness of domestic VC markets to foreign investors, but also at the engagement of domestic VC investors abroad. Both scenarios are probable to lead to a gain in non redundant knowledge flows for high growth firms.

Summing up, this paper provides a detailed analysis of the impact of structural and geographical VC syndication network features on portfolio company performance. Many central issues however still remain unresolved and are subject for future discussions. We limit our focus in this study on the Belgian VC market. This raises the question of how far the results are indicative for other countries. Prior research generally emphasizes that VC practices vary across markets analogous to differences in the institutional and cultural context (see Bruton and Ahlstrom 2003). This also affects the degree of investor's *ex ante* involvement in value-adding activities and, in turn, the importance attached to investor's social capital in the growth process. Nevertheless, large similarities exist between developed VC markets (see Sapienza et al. 1996; Jeng and Wells 2000). Thus, we are confident that the results of this study are also applicable to other European markets as well as the US, nevertheless more detailed research testing this assumption is strongly encouraged. In contrast, social ties seem to play a much larger role still in emerging countries (e.g., China). Performance differences based on diverging social ties may therefore appear even more explicit when investigating emerging VC markets. It is therefore advised that future work validates the results for a larger cross-section of countries including both mature and emerging VC markets.

Prospective research should consider weighting the potential for social capital spillovers between investee and investors proportionally to the latter's stance in the investment. Prior research has shown that in syndicated investment deals not all investors are involved to the same degree. Instead, one investor often acts as lead investor whereas the other investors take on a

more passive role. It is likely that portfolio companies benefit more from the capabilities and contacts of the lead investor than from that of more passive coinvestors. Closely linked to the previous issue is the question whether there are qualitative differences between relational ties and whether ventures benefit more from some ties than from others. Variations in the strength of social ties caused by the frequency of interaction, leading to differences in the level of trust between actors, need to be explored here.

Furthermore, referring to the discussion on overembeddedness, it has to be examined if there exists any threshold level with respect to network integration beyond which value-adding effects are inverted. Lastly, it is worthwhile to look into other forms of relational ties such as a shared professional background or a common educational history and their effect on the value-adding capabilities of VC managers. To provide an answer to these issues, more fine grained VC figures are however needed.

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AQ9	AUTHOR: Pinheiro et al. 2014 - please provide full publishing details.	

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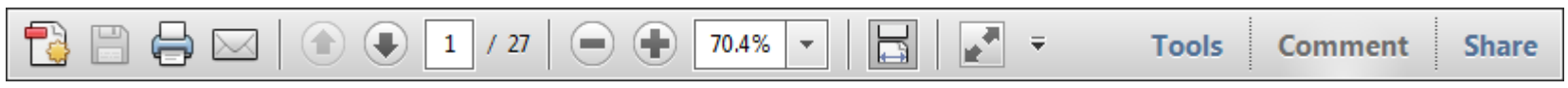
AQ10	AUTHOR: Zaheer and Gulati 2000 - please cite in the main text or delete.	

WILEY

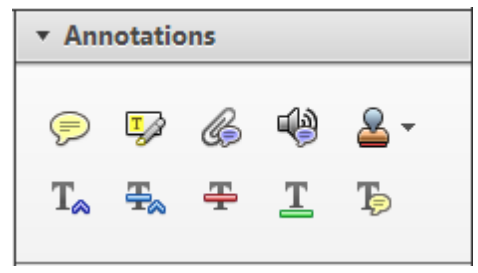
USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

Required software to e-Annotate PDFs: Adobe Acrobat Professional or Adobe Reader (version 7.0 or above). (Note that this document uses screenshots from Adobe Reader X)
The latest version of Acrobat Reader can be downloaded for free at: http://get.adobe.com/uk/reader/

Once you have Acrobat Reader open on your computer, click on the Comment tab at the right of the toolbar:



This will open up a panel down the right side of the document. The majority of tools you will use for annotating your proof will be in the Annotations section, pictured opposite. We've picked out some of these tools below:

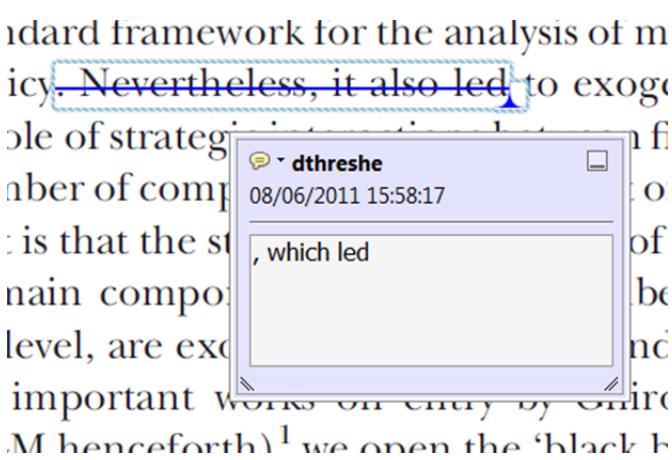


1. Replace (Ins) Tool – for replacing text.

Strikes a line through text and opens up a text box where replacement text can be entered.

How to use it

- Highlight a word or sentence.
- Click on the Replace (Ins) icon in the Annotations section.
- Type the replacement text into the blue box that appears.

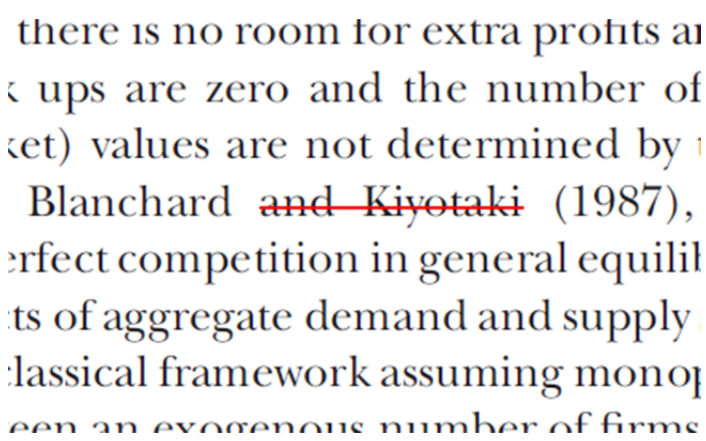


2. Strikethrough (Del) Tool – for deleting text.

Strikes a red line through text that is to be deleted.

How to use it

- Highlight a word or sentence.
- Click on the Strikethrough (Del) icon in the Annotations section.

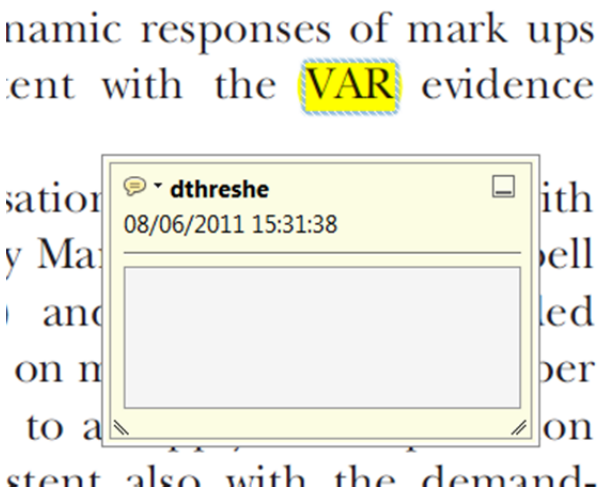


3. Add note to text Tool – for highlighting a section to be changed to bold or italic.

Highlights text in yellow and opens up a text box where comments can be entered.

How to use it

- Highlight the relevant section of text.
- Click on the Add note to text icon in the Annotations section.
- Type instruction on what should be changed regarding the text into the yellow box that appears.

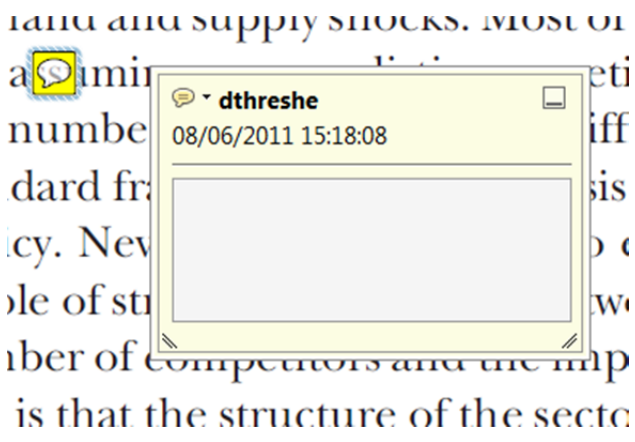


4. Add sticky note Tool – for making notes at specific points in the text.

Marks a point in the proof where a comment needs to be highlighted.

How to use it

- Click on the Add sticky note icon in the Annotations section.
- Click at the point in the proof where the comment should be inserted.
- Type the comment into the yellow box that appears.

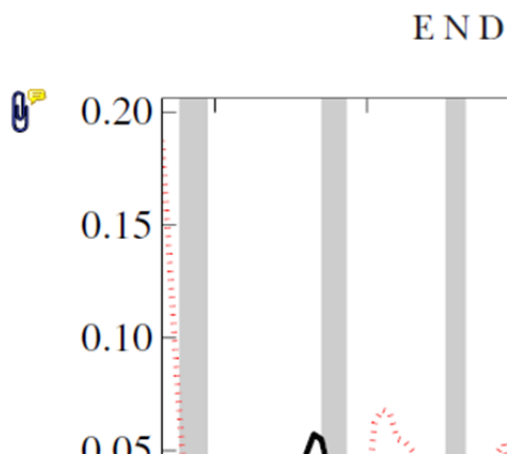


5. Attach File Tool – for inserting large amounts of text or replacement figures.

Inserts an icon linking to the attached file in the appropriate pace in the text.

How to use it

- Click on the Attach File icon in the Annotations section.
- Click on the proof to where you'd like the attached file to be linked.
- Select the file to be attached from your computer or network.
- Select the colour and type of icon that will appear in the proof. Click OK.

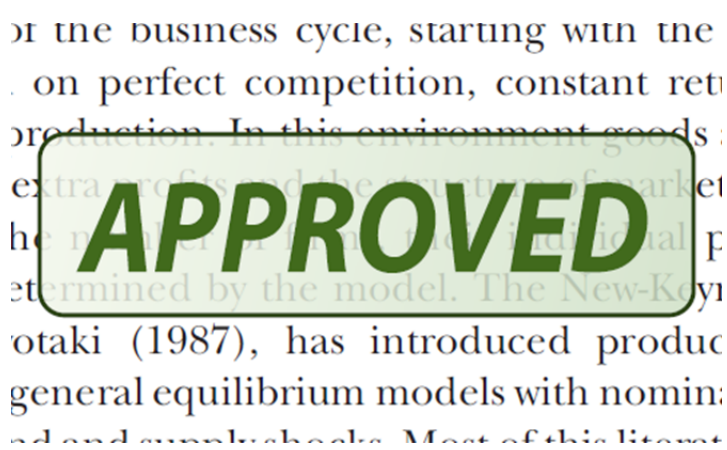


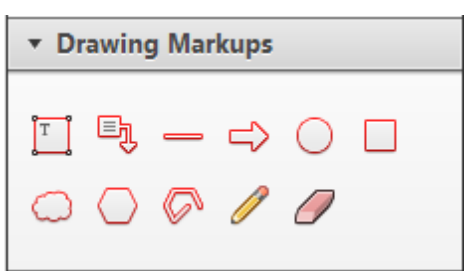
6. Add stamp Tool – for approving a proof if no corrections are required.

Inserts a selected stamp onto an appropriate place in the proof.

How to use it

- Click on the Add stamp icon in the Annotations section.
- Select the stamp you want to use. (The Approved stamp is usually available directly in the menu that appears).
- Click on the proof where you'd like the stamp to appear. (Where a proof is to be approved as it is, this would normally be on the first page).



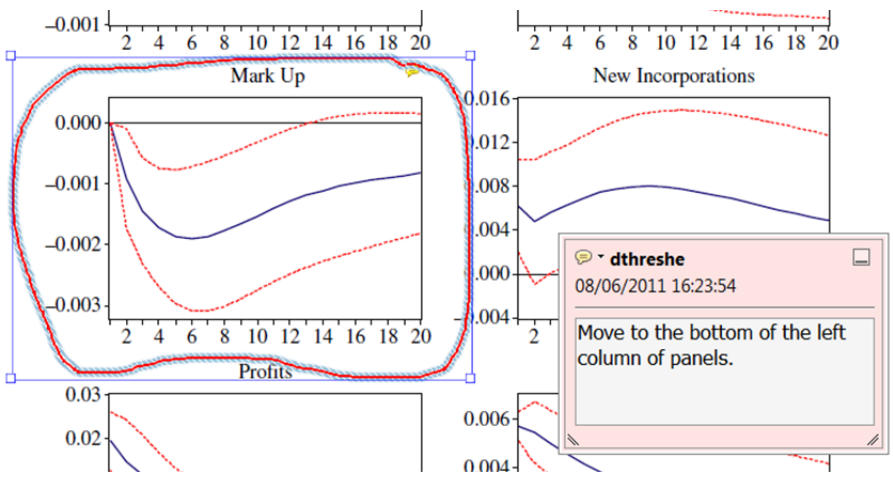


7. Drawing Markups Tools – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks.

Allows shapes, lines and freeform annotations to be drawn on proofs and for comment to be made on these marks..

How to use it

- Click on one of the shapes in the Drawing Markups section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
- Double click on the shape and type any text in the red box that appears.



For further information on how to annotate proofs, click on the Help menu to reveal a list of further options: