

Syndication in Venture Capital Financing

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First Draft: January 2003

This Draft: September 2009

We examine syndication in venture capital investments between 1980 and 2005. We argue that VC firms syndicate investments to mitigate human capital and financial constraints within individual VC firms and to reduce uncertainty about firm value. Our results are consistent with those arguments. We find that syndication is more likely for firms in the earliest stage of development and firms in the last stage of development as private firms (when human capital investments are greatest), for firms requiring the largest amounts of financial capital, and for firms with greater growth opportunities (those that are most difficult to value).

Keyword: Venture capital, syndication, financial policy

JEL Classification: G24, G32, D23

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1. Introduction

Previous researchers consider the benefits associated with alternative organizational arrangements. Syndication is an organizational arrangement common to the venture capital industry. In a syndicated investment multiple venture capital (VC) firms make investments in a firm simultaneously. Syndication has been the subject of relatively little empirical examination. We find that surprising given that VC investments have risen from \$740 million in 1980 to a high of \$118 billion in 2000 (constant 2005 dollars) and that while syndication is common, it is not universal. In our sample, 63% of investments by VC firms are syndicated. What explains cross-sectional variation in the syndication of venture capital investments?

It is possible that syndication arises randomly, and if so, we would expect little systematic cross-sectional variation in the types of investments that are syndicated. We suspect, however, that syndicates represent a purposeful organizational (contractual) arrangement designed to facilitate the venture capital process. We make two simple arguments to motivate our predictions on cross-sectional variation in syndication—syndicates can help overcome resource constraints within VC firms (with respect to both human and financial capital) and, syndicates can help resolve uncertainty with respect to firm value (Lerner, 1994a). We test the predictions that flow from those arguments by linking resource demands and uncertainty to the characteristics of the firm seeking financing and the amount of financing demanded.

In particular, we argue that the likelihood of syndication is linked to the stage of firm development. We find that syndication is most likely for investments in firms at the earliest stage of development and for firms at the last stage of development (as private firms). For example, startup/seed stage (the earliest stage) firms and later stage firms are equally likely to receive syndicated financing, but expansion stage firms are over 8% less likely to receive syndicated

financing. We argue that it is at the beginning and end stages in a firm's development that VC firms are making the greatest investment of human capital. Thus, our empirical evidence is consistent with syndication helping to overcome meaningful human capital constraints within individual VC firms.

We also argue that the likelihood of syndication is linked to the amount of financing demanded. Again, relying on the assumption of resource-constrained VC firms, we predict that the likelihood of syndication is positively related to the amount of financing demanded. That result, as well, is confirmed in the empirical analysis. A two-standard-deviation increase in the amount of financing increases the likelihood of syndication by 23%. Thus, our results suggest that syndication helps overcome meaningful financial capital constraints within individual VC firms.

Additionally, we argue that entrepreneurial firms with larger amounts of future growth opportunities stand to benefit more from uncertainty resolution. We also argue that such firms are also likely to demand greater investment of human capital from venture capitalists (holding demanded financial capital fixed). Syndicates are a mechanism by which individual VC firms can overcome their human capital constraints. Those two arguments lead us to predict that the probability of syndication is positively related to the degree of future growth opportunities. That prediction is confirmed empirically. For example, high technology firms are 11% more likely to receive syndicated financing than non-high technology firms. Overall, by relying on two simple arguments with respect to the potential benefits of syndication, we are led to a set of factors which have meaningful predictive power for observed cross-sectional variation in the incidence of syndication.

We also examine the number of VC firms participating in a round of financing (as opposed to whether there are multiple VC firms). We find that the number of VC firms participating is greatest in the earliest stage of firm development and in the later stages of firm development. These results are consistent with syndication being used as a means of overcoming meaningful human capital constraints within individual VC firms.

Finally, we examine the distance between VC firms and the firms in which they invest. Petersen and Rajan (2002) find evidence suggesting that advances in technology have reduced the costs of communicating value-relevant information at a distance. If that is indeed the case, and if uncertainty in valuation is the only motive for syndication, then we would expect the distance between VC firms and the firms they finance to have increased with time. We observe just the opposite: the distance between VC firms and the firms they finance decreases over time. This result is not driven by the development of the venture capital industries in California and Massachusetts. That we observe the distance decreasing with time is consistent with VC firms making meaningful human capital investments, the importance of which has increased over time. We stress, though, that while those results highlight the importance of human capital investments, the results overall suggest that both uncertainty resolution and VC firm capital constraints (both human and financial) are important determinants of syndication.

Our research makes four important contributions to the literature. First, we find meaningful cross-sectional variation in the syndication of VC investments in US entrepreneurial firms. As noted earlier there is little prior systematic consideration of the structure of that investment. While studies examine syndication in other markets (Lockett and Wright, 1999, 2001; Brander, Raphael and Antweiler, 2002; Manigart, Lockett, Meuleman, Wright, Landstrom, Bruining, Desbrieres, and Hommel, 2002; and Hopp and Rieder, 2006), our discussion is focused

on the syndication of VC investments in US firms. Cumming (2001) and Cumming and Macintosh (2003) suggest that optimal contractual arrangements cannot be generalized across markets due to differences in institutional features, legal structure, etc. Hand (2004) also argues that returns to venture capital investments are specific to the markets in which they are made. We provide empirical evidence on the systematic cross-sectional variation in syndication of VC investments in US firms.

Other studies have examined the relation between characteristics of VCs and subsequent performance of companies. For example, Baker (2000), Brander, Amit, and Antweiler (2002), and Tian (2009) examine the relation between syndication and subsequent firm performance. Hochberg, Ljungvist and Lu (2005) examine the performance of companies that are financed by VCs as a function of the network centrality of the financing VC(s). Their focus is on the relevance of network centrality, as opposed to syndication, to firm performance. It is important to realize, however, that our study differs from these in that we are examining the choice of whether or not to syndicate an investment (in the first place) as a function of an equilibrium tradeoff between various costs and benefits associated with doing so rather than looking at performance as a function of the choice of organizational form. In an environment described by competitive equilibrium, we would not expect there to be differences in performance as a function of the choice of organizational form.

Second, we show that the structure of investment is important. Either investment by a single VC firm or syndicated investment by multiple VC firms can be economically expedient contingent on the nature of the firm seeking financing and the amount of financing being sought. We take the investment round as the central unit of analysis and show that the structure of the investment evolves in line with the transaction cost benefits of syndication. Thus, our results,

within the context of venture capital financing, are consistent with a broader literature examining tradeoffs between costs and benefits of alternative organizational arrangements in determining the structure of transactions (e.g., Coase, 1937; Klein, Crawford, and Alchian, 1978; Klein and Leffler, 1981; Williamson, 1975, 1985).

Third, we make an important contribution to the literature on optimal financial policy by emphasizing that financing early in a firm's lifecycle involves more than just the provision of financial capital. Unlike the traditional corporate setting in which there is specialization in management and the provision of financial capital, VC firms bundle human capital with financial capital when making an investment. To some extent, we can think of VC firms as a first step away from an environment in which the entrepreneur provides both the management for, and the financing of, a company.

Finally, our results highlight what appears to be an important institutional regularity associated with the venture capital industry—namely, that individual VC firms face meaningful constraints in terms of human and financial capital. Theoretically, all demanded human and financial capital could be supplied by a single large VC firm (without creating the agency costs endemic among syndicate members). The prevalence of syndication suggests diseconomies associated with VC firm scale. Those potential diseconomies have been largely ignored by the growing body of literature on the venture capital process.

2. Background and empirical predictions

2.1. Venture capital investments

Entrepreneurial firms seek financing at discrete intervals with those financings being generally referred to as “rounds” of financing. We rely on the basic intuition that entrepreneurial firms seek a given amount of investment (both in terms of human capital and financial capital)

and examine whether that investment is provided by a single VC firm or by multiple VC firms. That is, we examine whether the total investment for a given round is syndicated. Consequently, when we refer to a VC investment we are referring to a round of financing. Some rounds are an investment by a single VC firm (i.e., it is not syndicated) while other rounds are an investment by multiple VC firms (i.e., it is syndicated).

2.2. The benefits of syndication

We argue that there are two non-mutually exclusive arguments of why syndicates exist. The first, which we refer to as the constrained capital hypothesis, relies on the assumption that VC firms supply important human capital, as well as financial capital and that both are effectively constrained within an individual VC firm. Syndicates arise when the required human capital and financial capital investments would be too costly for any one VC firm to supply. The other reason that we argue syndicates exist, which we refer to as the certification hypothesis, relies on a benefit that arises when VC firms invest alongside one another (Lerner, 1994a; Cestone, Lerner, and White, 2007). Syndicates arise when there is greater uncertainty about firm value. Using univariate comparisons of survey data from the U.K., Lockett and Wright (1999, 2001) find evidence consistent with risk-sharing as a motivation for syndication. We discuss each of these hypotheses in turn.

We argue that VC firms supply human capital relevant to a firm's production function. For example, Gompers (1995) notes that "Venture capitalists claim that the information they generate and the services they provide for portfolio companies are as important as the capital infused." Our discussions with venture capitalists also suggest that they view the human capital they supply as being either just as important as or more important than the financial capital they provide.

Absent any additional considerations, the provision of human capital would appear to have little relevance to the question of syndication. We make the assumption, however, that capital (both human and financial) is constrained within a VC firm. VC firms consist of fairly stable (at least in the short term) sets of professionals each facing physical limits on the amount of time that can be dedicated to any set of tasks. Also, VC firms typically undertake an initial process during which they raise capital commitments; they then close the fund to new investment and switch to making investments in entrepreneurial firms. This suggests that the supply of both human and financial capital within a VC firm can generally be regarded as fixed. Alternatively, constrained human and financial capital can be motivated by the assumptions of poorly diversified venture capitalists and inefficient risk bearing. In other words, required rates of return on human and financial capital investments become infinitely large as the amount of investment increases leading, effectively, to a constraint on both.

Constrained human capital can also be motivated by diseconomies of scale. For example, Chen, Hong, Huang, and Kubik (2004) examine diseconomies of scale in the mutual fund industry. They suggest three sources of diseconomies in large mutual funds: (1) diseconomies related to bureaucracy and coordination costs (Williamson, 1975, 1988), (2) diseconomies related to influence costs (Milgrom and Roberts, 1988), and (3) diseconomies resulting from the mismatching of incentives and decision rights (Fama and Jensen, 1983a,b; Aghion and Tirole, 1997; and Stein, 2002). Similar diseconomies may exist in the venture capital environment.

Because it is not central to our analysis, we do not attempt to identify the precise reason why VC firms are constrained with respect to human and financial capital. We simply assume that, for whichever reasons, VC firms face meaningful human and financial capital constraints. Syndicates, then, can be regarded as providing the benefit of being able to meet the demand for

large amounts of human and financial capital when individual VC firms face meaningful constraints on both.

In addition to our constrained capital hypothesis, Lerner (1994a) argues that VC firms can benefit from investing alongside one another because the willingness of other VC firms to invest signals the appropriateness of the original valuation. Lerner's (1994a) prediction relies on the theoretical work of Sah and Stiglitz (1986) who investigate investment decisions under two circumstances—when investments require two investors to approve an investment and when investments require only one investor to approve. Agreement among multiple investors leads to better investment decisions. Lerner suggests the following.

Venture capitalists, upon finding a promising firm, typically do not make a binding commitment to provide financing. Rather, they send the proposal to other investors for their review. Another venture capitalist's willingness to invest in the firm may be an important factor in the lead venture investor's decision to invest.

Lerner's argument, then, suggests that syndicates, as an organizational arrangement, offer the benefit of value certification.

2.3. Why might we expect predictable variation in syndication?

Empirically, syndication does not strictly dominate non-syndication. Thus, it seems reasonable to assume that syndication involves costs as well as benefits. When the benefits of syndication are large relative to those costs we expect to observe syndication, but when the benefits are small relative to the costs, we expect to observe VC investments being made by a single VC firm. We assume that syndication involves greater agency costs than the alternative (Williamson, 1975; Jensen and Meckling, 1976). We have in mind the kind of shirking, monitoring, bonding, measurement, and enforcement costs typically associated with cooperative endeavors. We argue that it is the tension between the benefits of syndication and the agency

costs of syndication that determine whether a given round of financing will be syndicated. In the analysis that follows, we hold the agency costs of syndication fixed and allow cross-sectional variation in the benefits of syndication to predict when we will observe syndication.

To predict cross-sectional variation in syndication it is necessary to predict when the benefits of syndication will be large and when they will be small. In broad terms, we expect that the benefits of syndication will be largest when the demands for capital investments, either human, financial, or both, are large or, uncertainty about firm value is greatest. In what follows, we describe how demand for capital and demand for the resolution of uncertainty are likely to be related to firm characteristics and the amount of financing demanded.

Stage of development. It is possible that syndication is a function of the stage of development of the entrepreneurial firm. This is likely to be the case if the amount of human capital or the amount of uncertainty about firm value changes as a firm matures. Extant empirical research suggests that is likely to be the case, particularly for human capital investments. The investments of human capital appear to be particularly important in the earliest stage of a firm's development and in the last stage of development (just prior to firm being sold or going public). For example, Hellman and Puri (2002) find that venture capitalists are instrumental in securing professional management for firms at their earliest stage of development (prior to having a product). Kortum and Lerner (2000) find evidence that VC firms play an important role in facilitating product development. Barney, Busenitz, Fiet, and Moesel (1996) show that venture capitalists make greater human capital investments when managers are relatively inexperienced, a circumstance which is most likely to hold in the earliest stages of a firm's development. Smith and Smith (2000) note that in addition to helping to secure good management, VC firms may also help firms develop their concepts and prepare business plans. Thus, there is considerable support

for the notion that VC firms make large human capital investments early in a firm's development. This, in turn, suggests a greater degree of syndication early in firm development.

We suggest that VC firms also make important human capital investments in the last stage of a firm's development. Lerner (1994b) notes the importance of venture capitalists in providing counsel to management with respect to when and how to execute the going-public process. He notes that, "... venture investors have usually experienced many more IPOs than the firm's managers." Lerner suggests that additional experience results in the venture capitalists "taking the lead" in the IPO process. Megginson and Weiss (1991) also find that VC firms play an important role in securing a high quality investment-banking firm to take the firm public. In slightly different terms, VC firms make large human capital investments in firms at the end of their development as private firms.

The link between uncertainty resolution and the stage of a firm's development is less clear. For example, Barry, Muscarella, Peavy, and Vetsuypens (1990) and Megginson and Weiss (1991) find that IPOs of firms with venture capital investors are underpriced less than firms without venture capital backing. One interpretation of their results is that certification of firm value is an important consideration at the last stage of a firm's development. It could be argued, however, that uncertainty with respect to firm value is greatest at the earliest stages of firm development and diminishes as a firm matures. While certification may still be an important issue at the last stage of firm development, it may be less important, in relative terms, than it was at earlier stages of a firm's development. If this is the case, then we might expect to observe a monotonic decline in syndication across the stages of firm development.

The above arguments suggest that VC firms make differential investments of human capital across an entrepreneurial firm's lifecycle. Subscribing again to the assumption that VC

firms face human capital constraints, we have the implication that syndication will be of particular value when VC firms are making large human capital investments. In particular, the constrained resources hypothesis leads us to predict a greater probability of syndication for firms in the earliest stage of development and the final stage of development. The prediction under the uncertainty resolution hypothesis is less clear, but is suggestive of a decline in syndication as a firm matures.

Investment size. Another potential determinant of syndication is the size of the investment provided to the entrepreneurial firm. We assume that VC firms are capital constrained. This suggests that the benefits of syndication will be greater the greater is the amount of desired financing. Thus, we expect that, holding all else constant, the greater the amount of financing provided to a firm in a given round, the more likely is that investment to be syndicated.

Growth opportunities. Finally, it is likely to be the case that there is a greater degree of uncertainty about firm value in those instances where firms have large amounts of future growth opportunities. As a general proposition, we assume assets-in-place are easier to value than future growth opportunities. Thus, when firms have large amounts of future growth opportunities we expect the certification benefits of syndication to be the greatest. We also expect that the human capital benefits of syndication will be greatest when a firm's value is largely made up of future growth opportunities. Our expectation follows from the basic intuition that it is precisely when a large fraction of a firm's value is made up of growth opportunities that human capital is of the most value. Smith and Watts (1992) suggest that the marginal product of managers of future growth opportunities is greater than the marginal product of managers of existing assets. Because the human capital investments made by VC firms are of the greatest value when firms have large amounts of growth opportunities, we expect VC firms make the greatest investment of human

capital in such firms. This leads to the prediction that, holding all else constant, the greater the future growth opportunities of a firm, the greater is the likelihood of syndication.

In sum, we make three predictions with respect to variation in the syndication VC investments in entrepreneurial firms. First, we predict that syndication varies across a firm's lifecycle. Second, we predict that larger financings are more likely to be syndicated than smaller financings. Finally, we predict that financings of firms with greater growth opportunities are more likely to be syndicated than financings of firms with fewer growth opportunities.

3. Data and preliminary analysis

3.1. Sample description

We test our predictions using data from the VentureXpert database from Thompson Financial, Inc. VentureXpert provides data on private equity firms (i.e., VC firms, buyout firms, funds-of-funds, etc.) and the nature of their investments. We identify all investments made by venture capital partnerships in US firms between 1980 and 2005. We exclude data prior to 1980 because Thompson Financial data prior to 1980 are "backfilled" and may be less complete.

For each round of financing that a firm receives we collect the total amount invested by VC firms and the total number of VC firms investing. In those instances where there is more than one VC firm investing in a given round we classify the investment as having been syndicated. In those instances where there is just a single VC firm investing we classify the investment as not syndicated.

Table 1 reports the distribution of investments by venture capital firms (in constant 2005 dollars) across our sample period. There has been a large increase in VC investments from \$740 million in 1980 to a peak of \$118 billion in 2000 (constant 2005 dollars) with a subsequent decline thereafter. Although syndication appears to have been somewhat less common during the

1990s, there is no clear overall trend in syndication across the full sample period. Table 2 reports that our sample consists of 58,889 investment rounds in 21,595 companies. The average round investment is just over \$7.7 million. We note that given the large number of observations in our sample, it will be important that our empirical analysis demonstrates the economic, as well as statistical, significance of the relations we study.

VentureXpert classifies firm development into one of four broad stages (from least developed to most developed): (1) startup/seed, (2) early stage, (3) expansion, and (4) later stage.

VentureXpert defines each stage of development as follows.

- *Startup/seed.* Companies that have not yet fully established commercial operations, and may also involve continuing research and product development.
- *Early stage.* Companies that are beyond the startup/seed stage with potentially continuing product development, as well as initial marketing, manufacturing, and sales activities.
- *Expansion.* Companies that have products and services currently available, but may require additional capital to expand production to increase revenue.
- *Later stage.* Companies that have an already established product or service that has already generated revenue, but may not be making a profit. These companies may become candidates for IPO or acquisition.

We use VentureXpert's classification to create a set of indicator variables capturing the stage of firm development. Panel C of Table 2 reports the distribution of VC investments across stage of development with expansion stage firms receiving the largest number of investments (25,955) and later stage firms the least (8,447).

We have two basic arguments with respect to the stage of firm development. We argue that VC firms make the greatest investments of human capital early in a firm's lifecycle and later in a firm's lifecycle. The constrained resources hypothesis, then, suggests that the likelihood of

syndication will be greatest early in a firm's development and later in a firm's development. The certification hypothesis suggests that as a firm develops and firm value becomes more certain, the use of syndication as a mechanism for certifying value should decline. Thus, we would expect to observe a decrease in the likelihood of syndication for more mature firms.

We capture the size of an investment round by adding up each of the individual investments made by VC firms in a given round. As noted earlier, the average investment is just over \$7.7 million. The median, however, is only \$3.56 million. To account for the skewness in the distribution of investment size we take the natural log of VC investment where appropriate. While there is no obvious relation between the certification hypothesis and investment size, the constrained resources hypothesis suggests that the likelihood of syndication will increase with the size of the investment round.

To capture the nature of a firm's future growth opportunities we initially rely on VentureXpert's broad industry classification scheme for each of the firms receiving financing. VentureXpert classifies each firm into one of six categories: (1) biotechnology, (2) communications and media, (3) computers, (4) medical, health, and life sciences, (5) semiconductors, and (6) non-high technology. We classify all firms in the first five categories as high technology firms. All other firms are classified as non-high technology firms. Panel B of table 2 reports that firms in a computer related industry received the largest number of financings over the sample period (24,487) followed by firms in communications or media (9,842). Non-high technology firms received a total of 9,261 VC investments during the sample time period. We assume that high technology firms have greater growth opportunities than their non-high technology counterparts. In our later regression analysis, we use the median industry market to book ratio (Fama French 48 industries) as our measure of a company's future growth

opportunities. Both the certification hypothesis and the constrained resources hypothesis predict that investments in high growth firms are more likely to be syndicated. Thus, we expect that the probability of syndication will be greater for high technology firms than for non-high technology firms.

3.2. Preliminary analysis

Table 3 provides univariate analysis on the likelihood of syndication. Panel C of table 3 reports that with respect to the stage of firm development we find that 59.1%, 65.3%, 64.4%, and 73.9% of VC investments in startup/seed, early, expansion, and later stage firms, respectively, are syndicated. This pattern suggests an increase in the likelihood of syndication as firms mature and is not consistent with our expectation under either the certification hypothesis or the constrained resources hypothesis. We also perform preliminary analysis on the relation between investment size and the likelihood of syndication. In panel D of table 3 we first rank investments into five quintiles based on investment size. From investments in the smallest size quintile to investments in the largest size quintile the percentage of investments syndicated is 26.2%, 55.3%, 77.8%, 82.4%, and 88.7%, respectively. Consistent with our prediction, there is a monotonic increase in the likelihood of syndication across the five investment size quintiles

Our expectations with respect to growth firms are confirmed by the results on high technology and non-high technology firms. Overall, 65.2% percent of investment rounds are syndicated. For high technology firms the percent is 68.4% and for non-high technology firms the percentage is 48.3%. The difference in proportion is significant (p -value $< .001$). Thus, we find preliminary evidence consistent with our prediction that VC investments in firms with greater growth opportunities are more likely to be syndicated.

It is potentially the case, however, that our relatively simple preliminary analysis fails to control for some interaction among the explanatory variables or leaves out potentially important explanatory variables that lead us to make incorrect inferences about the determinants of the syndication of VC investments. For example, when we examine the unconditional relation between syndication and stage of firm development, it appears that syndication is positively related to the stage of a firm's development. We note, however, that the stage of firm development is also highly correlated with the amount of financing (Spearman correlation = .198). The omission of investment size could lead to incorrect inferences in the unconditional analysis about the relation between the probability of syndication and stage of firm development. To address this, we analyze the syndication of VC investments using regression in the next section.

4. Regression analysis

We define the dependent variable to equal 1 if a given round of financing is syndicated and zero otherwise. Let X represent an $N \times K$ matrix of observations of the K factors across the N financings in our sample, and let B be a $K \times 1$ vector of coefficients describing how each factor, on average, influences the probability a VC investment is syndicated. The probability that an investment is syndicated is defined as $P(\text{Syndication}) = F(XB)$, where F represents the logistical distribution: $e^{XB} / (1 + e^{XB})^{-1}$. We transform the estimated coefficients so as to capture the economic content of the relations. In the case of round size, the coefficient we report reflects the percentage change in probability implied by a two-standard-deviation increase in the investment size from the mean, relative to the probability implied by evaluating the function at the mean of each variable. In the case of a dichotomous variable, the coefficient we report represents the percentage change in probability implied when the variable takes the value of one relative to the

probability implied when the variable takes the value of zero. This construction allows us to examine both the economic and statistical significance of the relations.

It seems possible (perhaps even likely) that syndication of prior rounds could affect the likelihood of syndication for any given round (Admati and Pfleiderer, 1994). To deal with that possibility we restrict our sample to those firms which have received at least one round of prior venture capital financing. That restriction reduces our sample to 36,909 rounds of financing. Also, we include a dichotomous control variable that takes the value of one if there is a previous round of financing that was syndicated, and zero otherwise.

Lerner (1994a) suggests that at least some portion of the syndication decision is motivated by “window dressing.” Low reputation venture capital firms are argued to allow high reputation venture capital firms into syndicates of successful firms (in the hopes of increased business with the high reputation venture capital firm in the future). We control for that possibility in the following way. We total the amount of dollars invested by a particular VC firm for all years prior to an investment round. We define that as the venture capital firm’s reputation. We then sum the reputations of all the venture capital firms that supplied financing in the previous round. “Window dressing” would suggest a negative relation between our reputation variable and syndication.¹

The results are in table 4.² We provide several alternative specifications of the Logit analysis, but we focus on the specification in the last column of table 4 that includes each of the explanatory variables. We include dummy variables for early stage, expansion, and later stage firms in the specification so that the intercept term captures VC investments in startup/seed

¹ For the sake of robustness, we create a second reputation variable which is simply the reputation of the venture capital firm with the largest investment in the previous round. Our results are unchanged.

firms. The coefficients on each of the stage of development variables, then, capture the probability of syndication relative to a startup/seed firm.

The regression results are consistent with each of our three predictions. For example, consistent with the constrained resources hypothesis, table 4 confirms the expected u-shaped pattern between stage of development and the probability of syndication. Investments in early stage and expansion stage firms are both significantly less likely to be syndicated than investments in startup/seed firms (p-value equal to .043 and less than .001 respectively). There is a 6 percentage point drop-off in the probability that a VC investment in an expansion stage firm will be syndicated relative to an investment in either startup/seed stage firm. The 6 percentage point drop-off represents a 8.1% decline in the likelihood of syndication. The final regression of table 4 also shows that the coefficient for a VC investment in a later-stage firm is not statistically different from investment in a startup/seed stage firm. Thus, we find that VC investments in firms at the earliest stage of development and in firms in the last stage of development are the most likely to be syndicated. Additionally, table 4 confirms the predicted positive relation between round size and the likelihood of syndication.

One concern that arises when examining the relation between round size and syndication is the possibility that the presence of a syndicate may actually lead to a greater amount of financing in any given round. To make sure that that possibility is not driving our results we do the following. We create a variable which is equal to the average amount, per round, received by a firm in its previous financings. We then rerun our analysis using this predetermined proxy for round size. Our results, unreported, remain the same.

² As a robustness check, we also repeat our analysis while allowing for clustering at the firm level. Our results are unchanged.

We also find that VC investments in firms with growth opportunities are significantly more likely to be syndicated than investments in firms with fewer growth opportunities, though the relation is not large in economic terms. We represent growth opportunities with the median market to book ratio of the Fama-French industry. This measure may be noisy. Alternatively, when we use our high technology dummy (see table 3) we find that high technology firms are 8.2 percentage points (approximately 11%) more likely to have syndicated investments than non-high technology firms. We interpret the results as confirming our prediction that firms with greater growth opportunities are more likely to have syndicated venture capital investments.

It might reasonably be argued that the question is not one of whether there is a single investor or multiple investors, but one of how many investors. We examine the relation between the number of VC firms investing in a given round and our explanatory variables in table 5. Similar to the syndication results, we see in table 5 that the number of VC firms investing initially declines as a firm matures and then increases again for firms in later stages of development as private companies. We also see that the number of VC firm investors increases with the size of the investment and is greater for firms with more growth opportunities. Thus, our results on the number of investors are generally consistent with our previous results examining the likelihood of syndication.

5. Discussion and additional analysis

The results from the regression analysis are consistent with our predictions. Investments in firms at the earliest stage of development and at the last stage of development are more likely to be syndicated than are investments in firms in the middle of their development. Larger investments are more likely to be syndicated than smaller investments. Finally, investments in firms with large amounts of future growth opportunities are more likely to be syndicated than are

investments in firms with fewer future growth opportunities. Our results are consistent with both constrained resources (within individual VC firms) and value certification being important determinants of syndication.

As noted earlier, prior research focuses on the resolution of uncertainty as the principal motive for syndicating VC investments. Our results are consistent with that motive, but also suggest that the supply of human capital is important. For example, it seems likely that as a firm matures uncertainty with respect to its future prospects is resolved. In other words, uncertainty declines as a firm matures. Uncertainty resolution suggests that we might expect to observe the probability of syndication declining as firms mature. We see an initial drop-off in the probability of syndication as firms mature, but the downward trend reverses itself, with VC investments in later-stage firms being more likely than in expansion and early stage firms to be syndicated. We suggest that elements of both arguments are likely to be correct. That is, uncertainty can decline as a firm matures while the investment of human capital can be greatest when a firm is early in its development and when it is at a later stage of development. The increase in the probability of later-stage VC investments being syndicated, then, is a function of the effect driven by the increased investment of human capital dominating the effect of a decrease in uncertainty.

It is difficult to drive an empirical wedge between the hypothesis that VC firms form syndicates as a means of certifying value and the hypothesis that VC firms form syndicates to overcome meaningful human capital constraints. Recent research by Petersen and Rajan (2002) suggests one possibility, however. They find that the physical distance between firms and their lenders has increased over time. They contend that advances in technology have reduced the costs of conveying value-relevant information at a distance. If that is the case, and if value

certification is the primary motive for syndication, then we would expect that distance between VC firms and the firms they invest in to have increased over time. We investigate this below.

In table 6 we characterize the distance between VC firms and the firm they finance in two ways. First, we sum the distance between each of the VC firms providing financing and the firms receiving the financing (using VC and firm ZIP codes). Second, we calculate the average distance between the VC firms and the firms receiving the financing. In order to consider the effect of passage of time on distance between VC and firms they finance, we divide our sample into three periods (1980-1994, 1995-2000, and 2001-2005) and exclude observations from the middle period in some specifications to increase the power of our tests. We relate each of our distance measures to our explanatory variables, but also include interaction terms capturing if the investment was made in the early period of our sample. For the sake of comparison, we also include results using both periods, but with the interaction term capturing the earlier period of the sample.

California and Massachusetts have evolved into centers for venture capital financing. If we fail to control for a firm's presence in one of those states, we may incorrectly attribute an effect to changes in information technology when really they represent an effect specific to a state. Therefore, we include control variables for California and Massachusetts firms.

Before considering the effect of the passage of time, we note that the results on stage of firm development suggest that distance between firms receiving financing and VC firms initially declines across stage of firm development and then increases. Later stage firms tend to have VC financiers that are farthest away. The result is consistent with value uncertainty being resolved as a firm matures and, consequently, the desire for VC firms to be close to the firms in which they invest (to confirm value) is reduced.

The results for those terms including the early sample period interaction term (specifications 2 and 4) suggest that VC firms have actually become more closely located to the firms in which they invest with the passage of time. This result is inconsistent with value certification being the only motive for syndication and a decrease in information costs. If we are willing to believe that information costs have declined, these results suggest that the supply of human capital is an important part of the venture capital process and that it has become more important with the passage of time. We view the results of table 6 as providing incremental evidence that in addition to value certification, the supply of human capital is an important component of the venture capital process.

Finally, Admati and Pfleiderer (1994) suggest another motivation for syndication based on the resolution of uncertainty across time (rather than at a point in time). They argue that the VC firm that invested in the firm in the first round signals the true value of the firm to subsequent investors by taking a constant fraction of all future VC investments (where the fraction is the amount of the firm originally purchased). By maintaining constant proportional ownership the original VC firm signals that the current round of financing is fairly priced. Constant fractional participation, by definition, means that later rounds must be syndicated. Also, Baker (2000) argues that later round syndication (following rounds that are not syndicated) certifies the quality of the earlier round investments. We examine the relevance of prior financing by repeating our previous analysis, while controlling for the round of financing. We use our original sample that includes firms that had not received prior venture capital financing. We control for the round of financing in two different ways. First, we include the round number in the regression. Second, we include a variable that takes the value of one for all rounds after the first round, and zero for all initial rounds. Admati and Pfleiderer's (1994) analysis suggests that

later rounds should be more likely to be syndicated. Our results (not reported in detail) confirm the expectation: later rounds are associated with a greater likelihood of syndication. It is also the case, however, that even while controlling for information resolution across time the prior results on the relation between the likelihood of syndication and firm development remain. These results, then, also suggest that syndicates are a valuable mechanism for dealing with constrained human capital in venture capital firms.

6. Conclusion and future research

We suggest two motives for the syndication of venture capital investments—the desire to overcome meaningful human capital and financial capital constraints and value certification. Our results are consistent with both explanations. Our results with respect to the provision of human capital are important because while previous research has considered the role of human capital in the venture capital process, it has not considered how human capital investments affect the structure of venture capital investments. In slightly different terms, our results are important because they suggest that in trying to develop a rich set of positive theories describing the venture capital process, we should consider costs associated with human capital investments as well as those associated with financial capital investments. Our results with respect to value certification are important because they provide empirical evidence on a previously hypothesized motive for syndication in the context of a large cross-section of venture capital investments.

The strength of our findings with respect to the relation between syndication and the amount of financing suggests meaningful constraints on VC firm financial capital. Absent transaction costs, it is not clear why the financial demands of entrepreneurial firms are not met by a single large VC firm. Our results provide indirect evidence that VC firms face meaningful diseconomies of scale. The venture capital environment, then, may provide a particularly rich

environment for addressing questions dealing with the boundaries of the firm (Coase, 1937; Alchian and Demsetz, 1972; and Williamson, 1985).

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Table 1. Venture capital investments by year and firm type. Our sample consists of VC investments in US companies from 1980 to 2005. Our data are from the VentureXpert database from Thompson Financial Inc. The percentage of rounds syndicated is shown in parenthesis. All dollar amounts are in millions (constant 2005 dollars).

Year	Number of non-syndicated rounds	Number of syndicated rounds	Total number of rounds	Total investments
1980	90 (39.82%)	136 (60.18%)	226	740.48
1981	205 (36.09%)	363 (63.91%)	568	2081.73
1982	245 (32.45%)	510 (67.55%)	755	2812.52
1983	335 (28.13%)	856 (71.87%)	1191	5791.66
1984	368 (27.75%)	958 (72.25%)	1326	5876.13
1985	395 (30.13%)	916 (69.87%)	1311	5220.25
1986	459 (33.21%)	923 (66.79%)	1382	5602.23
1987	634 (40.00%)	951 (60.00%)	1585	5805.09
1988	589 (38.42%)	944 (61.58%)	1533	5747.17
1989	628 (40.86%)	909 (59.14%)	1537	5450.12
1990	704 (47.60%)	775 (52.40%)	1479	4380.05
1991	662 (52.00%)	611 (48.00%)	1273	3376.06
1992	663 (47.73%)	726 (52.27%)	1389	5192.32
1993	593 (49.96%)	594 (50.04%)	1187	5250.07
1994	552 (45.96%)	649 (54.04%)	1201	5387.58
1995	933 (50.08%)	930 (49.92%)	1863	10323.86
1996	1260 (47.58%)	1388 (52.42%)	2648	14320.41
1997	1308 (41.38%)	1853 (58.62%)	3161	18163.36
1998	1474 (40.17%)	2195 (59.83%)	3669	25213.87
1999	1748 (32.11%)	3695 (67.89%)	5443	62474.17
2000	2265 (28.85%)	5586 (71.15%)	7851	118406.92
2001	1442 (31.96%)	3070 (68.04%)	4512	45533.51
2002	810 (26.85%)	2207 (73.15%)	3017	23615.00
2003	762 (27.08%)	2052 (72.92%)	2814	20802.80
2004	667 (22.69%)	2273 (77.31%)	2940	23247.82
2005	691 (22.82%)	2337 (77.18%)	3028	23326.30
Total	20482 (36.99%)	38407 (63.01%)	58889	454141.48

Table 2: Summary statistics of the sample data. Data are from the VentureXpert database from Thompson Financial, Inc. for all VC investments in US firms over the period from 1980 to 2005. Panel A provides the description of financing amount at the company, round and investment level. The sample consists of 21,595 companies that received 58,889 rounds of financing.

Panel A: Financing at the company, round and investment level				
	Observations	Mean	Std dev	Median
Companies	21,595	21.03	34.13	9.26
Rounds	58,889	7.71	13.97	3.56
Investments	166,263	2.73	5.54	1.36
Panel B: Description of financing by industry				
Industry	Observations	Mean	Std dev	Median
Biotechnology	3,758	7.91	11.54	4.00
Communications and media	9,842	10.98	20.90	4.84
Computer Related	24,487	7.44	11.56	3.81
Medical/health/life science	6,981	6.21	9.22	3.14
Non-high-technology	9,261	5.93	14.41	2.11
Semiconductors/other elect	4,560	7.89	12.84	4.07
Overall	58,889	7.71	13.97	3.56
Panel C: Description of financing by stage of the company				
Stage	Observations	Mean	Std dev	Median
Startup/seed	8,761	3.46	8.00	1.66
Early stage	15,726	6.13	15.79	4.36
Expansion	25,955	9.15	15.79	4.36
Later stage	8,447	10.65	16.08	5.44
Overall	58,889	7.71	13.97	3.56

Table 3. Univariate analysis of the likelihood of syndication. The sample consists of 58,889 investments (rounds) in US firms from 1980 to 2005. Data are obtained from the VentureXpert database from Thompson Financial, Inc. In panel B, we classify firms as being high technology firms if they are in one of the following five industries: (1) biotechnology, (2) communications and media, (3) computers, (4) medical, health, and life sciences, (5) semiconductors, and as non-high technology firms otherwise. Round size is the total financing provided by all funds in a particular round of financing. We test for equality in proportion of rounds syndicated across quintiles based on round size and estimate the correlation between round size quintile and syndication variables

Panel A: Percent of VC investments syndicated.

	Syndicated	Not syndicated
	65.22%	34.78%

Panel B: Percent of VC investments syndicated across high technology and non-high technology firms.

	High technology	Non-high technology	χ^2 test for equality in proportions (p-value)
Firm Type	68.38%	48.26%	1394.00 (.001)

Panel C: Percent of VC investments syndicated across firm stage of development.

	Startup/seed	Early	Expansion	Later	χ^2 test for equality in proportions (p-value)	Spearman correlation (p-value)
Stage	59.10%	65.34%	64.39%	73.88%	432.09 (.001)	0.0665 (.001)

Panel D: Percent of VC investments syndicated across investment size quintile (Q1=smallest, Q5=largest).

	Q1	Q2	Q3	Q4	Q5	Spearman correlation (p-value)
Round Size	26.23%	55.29%	72.82%	82.42%	88.71%	.4503 (.001)

Table 4. Logit analysis of the syndication of VC investments. The sample consists of 36,909 investments (rounds) between 1980 and 2005 in US firms which previously had received at least one round of venture capital financing. Data are obtained from the VentureXpert database from Thompson Financial, Inc. The dependent variable is set equal to one when an investment is syndicated and zero otherwise. The coefficients we report represent the percentage change in probability associated with an indicator variable taking a value of one (versus zero), or, in the case of a continuous explanatory variable, a two-standard-deviation increase in the variable. These probability changes are assessed relative to the probability implied by evaluating the Logit function with all dichotomous variables set to zero and all continuous variables set equal to their means. *Market/Book* is the industry median market to book ratio of the industry to which the company belongs to based on the Fama French 48 industry classification. *Early Stage*, *Expansion* and *Later Stage* are dummy variables that takes the value of 1 if the company receiving financing is in that stage of development, zero otherwise. We exclude a dummy variable for startup/seed stage firms. Therefore, VC investments in startup/seed stage firms are captured by the intercept and the coefficients on the included stage variables capture effects incremental to startup/seed stage firms. *Round Size* is the natural logarithm of the total amount of financing provided in each round. *Lag_syndicated* takes the value 1 if the previous round of financing is syndicated, 0 otherwise. *Reputation* is the sum of reputation measures of the all the VC firms investing in a firm's previous round of financing. pseudo-R² is calculated as 1- [lnL(Ω)/lnL(ω)] where L(ω) is the likelihood function under the null hypothesis that all coefficients are 0, and L(Ω) is the likelihood function evaluated using the estimated coefficients. p-values reported in parentheses.

	(1)	(2)	(3)	(4)
<i>Intercept</i>	70.45 (.001)**	74.55 (.001)**	74.99 (.001)**	74.18 (.001)**
<i>Market/book</i>	5.55 (.001)**	2.97 (.001)**		2.54 (.001)**
<i>Early stage</i>	7.08 (.001)**		-2.11 (.029)*	-1.97 (.043)*
<i>Expansion</i>	7.31 (.001)**		-6.38 (.001)**	-6.00 (.001)**
<i>Later stage</i>	12.92 (.001)**		-0.08 (0.936)	0.21 (0.822)
<i>Reputation</i>	0.90 (.110)	-6.62 (0.001)**	-6.57 (0.001)**	-6.58 (0.001)**
<i>Round size</i>		23.51 (.001)**	23.18 (.001)**	23.17 (.001)**
<i>Lag_syndicated</i>	20.24 (.001)**	19.15 (.001)**	19.53 (.001)**	19.48 (.001)**
Pseudo-R ²	4.29	26.38	26.57	26.63
N	36909	36909	36909	36909

** and * indicate statistical significance at the 1% and 5% levels, respectively.

Table 5. Regression analysis of the number of investors. The sample consists of 58,889 investments (rounds) in US firms from 1980 to 2005. Data are obtained from the VentureXpert database from Thompson Financial, Inc. The dependent variable is the number of investors in each round of investments. *Early Stage*, *Expansion* and *Later Stage* are dummy variables that takes the value of 1 if the company receiving financing is in that stage of development, zero otherwise. We exclude a dummy variable for startup/seed stage firms. Therefore, VC investments in startup/seed stage firms are captured by the intercept and the coefficients on the included stage variables capture effects incremental to startup/seed stage firms. *Market/Book* is the industry median market to book ratio of the industry to which the company belongs to based on the Fama French 48 industry classification. *Round Size* is the natural logarithm of the total amount of financing provided in each round. *Reputation* is the natural logarithm of the sum of total amounts invested by all the VC firms investing in a firm's previous round of financing. p-values reported in parentheses.

	(1)	(2)
<i>Intercept</i>	1.92 (.001)**	2.28 (.001)**
<i>Market/book</i>	0.12 (.001)**	0.07 (.001)**
<i>Early stage</i>	-0.28 (.001)**	-0.22 (.001)**
<i>Expansion</i>	-0.08 (.002)	-0.07 (.164)
<i>Later stage</i>	0.70 (.001)**	0.46 (.001)**
<i>Reputation</i>		-0.00 (.992)
<i>Round size</i>	0.68 (.001)**	0.79 (.001)**
N	58889	36909
Adjusted R ²	24.35	27.05

** and * indicate statistical significance at the 1% and 5% levels, respectively.

Table 6. Regression analysis of the distance between company and its investors. The sample consists of 50931 investments (rounds) in US firms from 1980 to 2005 for which distance measure is available. Data are obtained from the VentureXpert database from Thompson Financial, Inc. The dependent variable in models (1) and (2) is the natural logarithm of the total distance between investors and the company in each round of investments. In models (3) and (4) the dependent variable is the natural logarithm of the average distance between investors and the company in each round of investments. The distance between an investor and the company is computed based on their zip codes. *Early Stage*, *Expansion* and *Later Stage* are dummy variables that takes the value of 1 if the company receiving financing is in that stage of development, zero otherwise. We exclude a dummy variable for startup/seed stage firms. Therefore, VC investments in startup/seed stage firms are captured by the intercept and the coefficients on the included stage variables capture effects incremental to startup/seed stage firms. *Market/Book* is the industry median market to book ratio of the industry to which the company belongs to based on the Fama French 48 industry classification. *Round Size* is the natural logarithm of the total amount of financing provided in each round. Early sample period dummy takes the value one if the investment is made anytime between 1980 and 1994, zero otherwise. *California company* and *Massachusetts company* take the value 1 if a company is located in these states, 0 otherwise. p-values reported in parentheses. In models (2) and (4) the sample consists of rounds of investments in US firms from 1980 to 1994 and 2001 to 2005 only.

	(1)	(2)	(3)	(4)
<i>Intercept</i>	-0.234 (.010)**	-1.386 (.001)**	2.569 (.001)**	1.811 (.001)**
<i>Market/book</i>	0.067 (.001)**	0.015 (.569)	0.017 (.257)	0.000 (.012)*
<i>Market/book * Early sample period dummy</i>		0.335 (.001)**		0.000 (.001)**
<i>Early stage</i>	-0.053 (.091)	-0.358 (.001)**	0.017 (0.566)	-0.063 (.002)**
<i>Expansion</i>	0.435 (.001)**	0.206 (.001)**	0.442 (.001)**	0.336 (.001)**
<i>Later stage</i>	0.733 (.001)**	0.535 (.001)**	0.578 (.001)**	0.500 (.001)**
<i>Early stage * Early sample period dummy</i>		0.803 (.001)**		0.556 (.001)**
<i>Expansion stage * Early sample period dummy</i>		0.507 (.001)**		0.301 (.001)**
<i>Later stage * Early sample period dummy</i>		0.324 (.001)**		0.209 (.002)**
<i>California company</i>	0.179 (.001)**	0.200 (.001)**	0.046 (0.018)	0.088 (0.001)**
<i>Massachusetts company</i>	-0.462 (.001)**	-0.492 (.001)**	-0.605 (.001)**	-0.611 (0.001)**
<i>Round size</i>	0.406 (.001)**	0.482 (.001)**	0.170 (.001)**	0.215 (.001)**
Number of Observation	50931	30406	50931	30406
Adjusted R ²	11.68	14.89	4.47	6.84

** and * indicate statistical significance at the 1% and 5% levels, respectively.