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# The Need for Diversification and its Impact on the Syndication Probability of Venture Capital Investments

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The number and size of venture capital (VC) funds have grown tremendously in recent years. In 2006 alone, $30.9 billion was raised by 222 VC funds, a 708% increase over 2002, when $3.8 billion was raised by 175 VC funds (National Venture Capital Association [2007]). Average fund size also increased dramatically over that period: from $21.9 million in 2002, to $139.1 million in 2006, a 537% increase (Exhibit 1).

Along with the rise in VC investing has come an increased interest in the forces that drive syndication. A syndicated investment is an investment in which a group of VC funds work together to provide funds for a portfolio company. There is usually one lead investor that coordinates due diligence and negotiation between the group of investors and the company. A syndicated investment is the opposite of a bilateral investment, which only involves one capital-seeking company and one investor. In VC financing, syndication is a typical form of joint investment to share risks and to combine resources from different VC funds in one company. In this study, we examine the impact of the investor's need for portfolio diversification given the likelihood of syndication. We start from Amit, Antweiler, and Brandner's [2002] theoretical model, which uses a decision tree methodology involving an investment manager in three different states: 1) investing alone when he is positive about future portfolio company prospects, 2) forgoing investing when he is negative about future prospects, and 3) syndicating when he is uncertain about future prospects. We examine whether diversification could be a fourth state in the Amit, Antweiler, and Brandner [2002] model. However, higher diversification generally means higher transaction costs, especially in the non-transparent and illiquid private equity sector.

Brennan's [1975] approach is ideal for calculating the degree of optimal diversification with fixed transaction costs, but for PE and VC financings, the absence of variable transaction costs makes less sense. In Patel and Subrahmanya [1982], investors invest only when the expected rate of return exceeds the sum of risk aversion and transaction costs.

Goetzmann and Kumar [2003] analyze private investor diversification behavior in exchange-traded stock portfolios. They find that the efficient diversification degree suffers under smaller portfolio sizes and investors' inability to divide the investment amount. But fixed transaction costs may tend to prevent investors with smaller portfolios from diversifying.

Barber and Odean [2000] estimate that active investors in exchange-traded stock portfolios incur total trading costs of 3.9% of their annual income. PE and VC deals may incur higher transaction costs than in public equity trading due to reasons such as due diligence,



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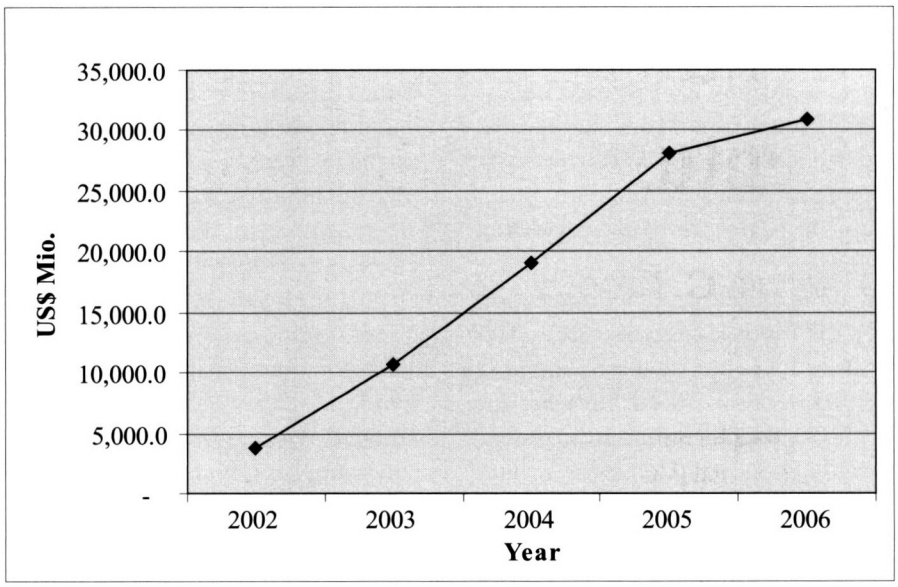
## EXHIBIT 1
**Capital Raised by VC Funds in the U.S.**




| Year | 2002 | 2003 | 2004 | 2005 | 2006 | Increase from 2002 till 2006 |
|---|---|---|---|---|---|---|
| **Capital raised by VC Funds ($ million)** | 3,824.0 | 10,621.3 | 19,004.8 | 28,117.3 | 30,883.1 | 708% |
| **Number of raised VC Funds** | 175 | 149 | 205 | 219 | 222 | 27% |
| **Average VC fund size ($ million)** | 21.9 | 71.3 | 92.7 | 128.4 | 139.1 | 537% |

*Source: NVCA Fundraising Report, New York, July 16, 2007.*

contract structuring, and negotiation costs. This is especially true for deals with high information asymmetries between the investor and the portfolio company. Syndication can lower the transaction costs related to buy or sell decisions.

Finally, Nooteboom [1993] describes the scale, scope, experience, and learning effects at the level of transaction costs. Bruining et al. [2005] find that transaction cost pressure can explain a small PE fund's decision to invite other investors to syndicate.

We seek to answer the following questions: Is it easier for larger funds to achieve the right measure of diversification? Can syndication help achieve sufficient diversification by sharing transaction costs and risks? We conduct empirical analyses based on a comprehensive dataset, and provide a diversification benefit calculation and syndication link to overcome the problem of relative transaction costs of PE and VC investments.

This study works with a unique dataset, generated by a merger of congruent investments contained in two databases: Venture Economics (www.ventureeconomics.com), and CEPRES (www.cepres.com). From this, we obtain detailed analyses on over 140 variables for each investment, including precise cash flow information. The dataset comprises 382 buyout/mezzanine investments and 629 VC investments provided by 55 different PE/VC funds belonging to 20 different investment management firms worldwide. Our sample time period is January 1983 through November 2003.

This study extends previous findings on the motives for syndication by providing precise measurement of the diversification benefit- and transaction cost-related factors



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for the probability of syndication (see, for e.g., Lerner [1994]; Lockett and Wright [2000]; Cestone, Lerner, and White [2005], and Hopp and Rieder [2005]). Our results show that transaction cost and fund size limitations are key restrictions to be considered when selecting PE and VC investments, and that syndication is a common instrument to overcome these limitations. More specifically, fund size and investment experience are negatively correlated with syndication probability, while early-stage investments and venture deals are positively correlated with syndication.

This article is structured as follows. The first section reviews the literature on the motives for syndication, followed by a section that introduces our database. The next section formulates three hypotheses about the need for diversification and its impact on the syndication probability of VC investments. The following section describes the methodology we use to calculate the marginal diversification benefit in consideration of transaction costs. We present empirical results in the next section, and end with our conclusions.

## MOTIVES FOR SYNDICATION

Syndication is considered a strong tool to mitigate the various difficulties inherent in PE/VC investments. It is ideal for risk-sharing, reducing information asymmetries such as moral hazard in a principal (investor)/agent (company) relationship, and for overcoming an investment manager's lack of experience in a certain field.

### Risk-Sharing

The risk-sharing perspective contains several approaches. Private equity investments may increase general portfolio risk depending on the level of risks already present. These include the portfolio company's own risk, its industry risk, and investment exit risk. Damodaran [2001] shows that the risk-sharing perspective is consistent with the investment approach of diversification.

We can separate investment risk into two components: market (systematic) risk, and firm (non-systematic) risk. Firm risk is reducible to approximately zero by diversification, relative to the total portfolio. Furthermore, Wilson [1968] describes risk reduction based on a large number of investments that do not overlap. The correlation coefficient between investments in a portfolio may restrict the risk reduction effect, however.

Jones and Rhodes-Kropf [2004], and Malkiel and Xu [2002] show that some traditional assumptions of the capital asset pricing model (CAPM) are violated in VC investments because of the lack of a secondary market for investments. This results in illiquidity and high transaction costs. The basic tenets of CAPM may also be violated by time restrictions on the part of the investment manager, and by asymmetric information distributions that are inherent between PE investors and portfolio managers. These are the primary reasons why VC portfolios tend to be riskier than exchange-traded stock portfolios.

On this basis, Schmidt [2004] highlights that portfolios composed only of VC investments have less diversification potential than comparable stock portfolios. Thus, syndication may be useful in helping a fund reach its maximum diversification potential through cost-sharing, as long as it complies with the funding requirements of the charter (e.g., how many shares can be held in one company).

De Clercq and Dimov [2004] show empirically that in later financing rounds, investment managers tend to have more syndication partners. This is consistent with the financial rationale for syndication, because mature portfolio companies have higher funding requirements. However, investment managers who invest in earlier-stage companies also tend to have more syndication partners. This seems inconsistent, because earlier-stage companies normally require smaller amounts of capital.

Lockett and Wright [2000] note that investment managers often syndicate-out and syndicate-in deals in order to ensure access to a wider range of investments. Any lack of industry expertise can be mitigated by using experienced lead managers. A wider industry focus is also helpful in raising the degree of active diversification. Manigart et al. [2006], in their study of six European VC firms, found that risk-sharing, portfolio diversification, and access to larger deals were more important than selection and monitoring of deals. Kaiser, Lauterbach, and Schweizer [2006] show that syndication may be used more frequently as a risk reduction tool in higher-profit and higher-risk deals.

Along these lines, Hopp and Rieder [2005]'s empirical study also shows that industries with higher risk profiles, such as biotechnology, have a significantly higher probability of syndication. They find more syndicated investments and larger syndications among these types of firms than for other industry investments. The study does not, however, use any specific risk measurements, but a more general approach.



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Lockett and Wright [2000] additionally find that a motive for risk-sharing is the constant need for capital. Lower degrees of diversification for smaller fund sizes should ceteris paribus increase total gross internal rate of return (IRR) variance. Higher levels of hypothetical variance show higher probabilities of underperformance comparable to peers. Thus, the pipeline of potential investors could be negatively affected by any significant underperformance in the time frame just prior to the investment.

### Portfolio Company Support (Returns-based Perspective)

The benefit of involving co-investors comes from the heterogeneous skills and information sets that different investment managers can add. Early-stage investments typically need such additional resources more than later-stage investments, mainly because investment managers at more mature companies tend to be more experienced.

Penrose [1959] describes the "value-added" component of the VC investment process as a collection of productive resources. Wernerfelt [1984] divides the resources that VC syndications can offer into financial and non-financial ones. The non-financials are more intangible, such as networking possibilities or valuable regional market or industry information.

Lerner [1994] additionally argues that experienced investors prefer the use of syndication to gain additional information from other experienced investment managers before acquiring company stakes. Lerner's study focuses specifically on VC funds in the biotechnology industry, and their syndication behavior is based on significant empirical evidence.

Amit, Antweiler, and Brandner [2002] also find that investors do not choose syndication primarily to optimize their investment, but for the value-added they will gain from the syndicated investor group. Additional levels of knowledge, networking skills, and greater experience can best be obtained through affiliation with a consortium of other investment managers. This value-added can both lower expenditures, and raise the chances for success.

Fenn, Liang, and Prowse [1995] describe geography as a rationale for syndication. The value of local monitoring depends on the relative distance between the portfolio company and its investment management (e.g., whether there are language or legal differences, as well as whether GAAP is applicable). The broader the distance, the higher the value-added when syndicating with investors who possess this knowledge.

Sorenson and Stuart [2001] note that, paradoxically, communications and logistics advances have done little to reduce the concentration of many industries in the U.S. Similar situations are seen in European countries. To obtain a well-diversified investment portfolio, industry and regional mixed investments should lower systematic risk. A lack of ability to closely monitor portfolio companies forces investment managers into syndication with investors who have the appropriate country and industry knowledge. The positive surplus value for the VA is negatively correlated with his experience level in that specific field.

Manigart et al. [2006] allude to the idea that the probability of syndication rises when the investment stage of the potential investment is not what the investment manager prefers or feels comfortable handling. It is conceivable that a portfolio will have a mix of companies in different stages of development. For example, some may be early-stage, some may be later-stage, some may be in an expansion stage, and some may even be in a turnaround stage. A portfolio mix between these different phases may make good market sense, but the requirements to be an effective investment manager at each stage may be quite different.

### The Need for a Second Opinion

Cestone, Lerner, and White [2005] use a theoretical approach on an asymmetric information model that highlights the moral hazards faced by VC syndications. They find that investment managers often seek second opinions from other VCs before choosing to fund projects, even if they are in possession of private information that indicates a project's profitability. The three-state decision tree model of Amit, Antweiler, and Brandner [2002] described in the beginning of this article describes a similar approach.

Empirical evidence supports Lerner's [1994] study on the biotechnology industry. He finds that in first round investments, established VC firms syndicate with other experienced investment managers. In later rounds, they may syndicate with less established organizations. These findings are consistent with the view that syndication allows established VC firms to obtain information when evaluating risky investment decisions.



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### Greater Diversity of Experience

Casamata and Haritchabalet's [2003] decision model also investigates the incentives for syndication. They note that syndication is based on the trade-off between the need for high-quality information about investment opportunities, and the need to earn as much profit as possible. Choosing to syndicate, which usually involves signing a co-investment contract, is costly for the investor in charge because he must forgo part of his potential profits.

Casamata and Haritchabalet's [2003] analysis differentiates between two primary types of syndication costs: 1) the difference between the stand-alone investment and the syndication's proportion of the profit (which increases concurrently with the degree of experience of the initial lead investment manager), and 2) the moral hazards that can arise from conflicts at syndications that share in ownership of the portfolio company (which decrease concurrently with the degree of experience of the investment manager).

One solution seems to be that experienced investment managers tend to syndicate with each other, while very experienced investment managers prefer not to take part in syndications at all. Of course, inexperienced investment managers have more of an incentive to seek out syndications, despite the higher probability of moral hazard conflicts.

Hopp and Rieder [2005] reached similar conclusions in their empirical study. They note that the most experienced investment managers do not need external expertise, and may find that the additional benefits of a syndication arrangement are not worth the additional costs associated with monitoring and coordinating a deal.

An additional empirical study by de Clercq and Dimov [2004] discusses investment managers' experience levels and industry knowledge, and finds they have a negative impact on syndication behavior.

### Managerial Advisory Restrictions

The payoff for using a managerial advisory structure depends on the degree of effort needed on the part of the investment manager, who can find himself facing time restraints. Thus, the ultimate degree of portfolio diversification remains limited. Cumming's [2006] empirical evidence shows that VC portfolios are usually limited to around 29 investments.

Following Cumming [2006], Schmidt [2004] finds that average portfolio size appears to be between 20 and 28 investments. Schmidt [2004] points out the important trade-off of diversification, between raising marginal risk on the one hand, depending on the number of portfolio assets, and raising managerial expenditures on the other.

In a VC model with double-sided moral hazards, Kanniainen and Keuschnigg [2003] describe the existence of incentives for entrepreneurial effort and for VCs more active involvement in their portfolio companies. This theoretical approach shows that with less managerial advice, the long-term prospects for portfolio companies become riskier. Investment managers can, thus, also use syndication to optimize the amount of time they have.

### Future Deal Flow

Obviously, to maximize time and money, it is imperative that investment managers have access to as many interesting deals as possible in order to pick the best projects. Manigart also finds that high-quality deal flow is an especially important resource for investment managers during times when competition heats up between VCs and the large amount of money available in the market. To ensure the flow of investment ideas, managers need to act more strategically by syndicating out to other managers with the expectation that they will reciprocate.

Sorenson and Stuart [2001] note that investment focus depends on the specific geographic and industry expertise of the investment managers. They find that individuals tend to prefer to interact in the same geographic area or in related industries. This suggests that investment managers may not be as likely to identify interesting investment opportunities that lie outside their usual investment area. Syndication can also be a solution to this problem, by extending geographic or industry investment scope. By frequently syndicating investments, a dense inter-firm network can ultimately disseminate information across experience boundaries most effectively.

Another viewpoint is found in De Clercq and Dimov [2004], who find that investment manager experience level and industry knowledge have a negative impact on syndication.

### Incentives to Hold Up an Investment

VC firms affiliated with large corporations can have additional motivations for syndicating. Hellmann [2002]



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finds that a stake in a new venture of the same industry can ensure operational influence for the VC firm. Voting rights or board seats can provide further strategic opportunities for maintaining investor influence.

An investment manager with a strategic background may also desire to influence the degree of association between his product and the final product of the portfolio company. This may involve ensuring distribution channels, or attaining valuable technical knowledge. This possible incentive for a strategic investor could result in holdups or delays for other syndication partners, however.

On the other hand, Bachmann and Schindele [2005] find that, in the context of R&D financing, the threat of a loss of investor reputation may be enough to solve the problems that can arise from issues such as intellectual theft. Syndicated VCs are better able to monitor investor behavior. The authors find that syndication can actually promote more open practices among investment managers and enhance entrepreneurial incentives for R&D.

However, investment managers may also use syndication as a way to send a message to stakeholders. The decision to syndicate the investment can be viewed as a public rejection of any possible delays.

### Window-Dressing

Lerner [1994] describes window-dressing, which results from the need for continual fundraising, as another motive for syndication. In order to create good publicity, avoid underperformance, and raise future funds, investment managers must discuss, as fully as possible, the performance of their previous funds. However, investment managers are well advised to learn how to play down or leave out certain details, such as whether the investment is early or later stage. For example, the "number of IPO companies in the portfolio" can be used as a measure of the performance of a private equity fund without confirming actual performance numbers. This can increase the fund's reputation, assuming that investment managers make sure to syndicate shortly before the IPO.

### Transaction Cost Reduction

Goetzmann and Kumar [2003] analyze the diversification behavior of private investors in exchange-traded stock portfolios. The efficient diversification degree is found to suffer for smaller portfolio sizes because investors may not be able to divide the investment amount. Fixed transaction costs may also prevent investors who hold smaller portfolios from diversifying.

In addition, Barber and Odean [2000] estimate that the trading costs of active investors in exchange-traded stock portfolios can total 3.9% of annual income. Both of these cost factors are probably higher for private equity investments, and syndication may help lower transaction costs related to buy or sell decisions. Nooteboom [1993] describes the scale, scope, experience, and learning effects at the level of transaction costs, especially for determinants like corporate governance.

## DATABASE

This study is based on a unique dataset, which is created by merging data from Venture Economics (www.ventureeconomics.com) and data from Cepres (www.cepres.com). The merged data includes four key items: 1) the name of the investment management firm, 2) the name of the fund, 3) the name of the observed portfolio company, and 4) the date of the initial investment from the fund to the company. Venture Economics provides details on each financing round, which is combined with the information on each fractional payment of a financing round (called the tranche), provided by Cepres.

The combined dataset contains more than 140 variables for each financing. Because both the Venture Economics and the Cepres data are gathered voluntarily, and both are based on partially audited due diligence and monitoring information, the merged sample is comprehensive, precise, and double-validated. Gompers [1995] uses the Venture Economics database, and a more detailed presentation of the Cepres database is given in Cumming and Walz [2004], and Schmidt [2004]. The merged dataset is introduced in more detail in Krohmer, Lauterbach, and Calanog [2006].

The level of detail and accuracy of this study extends previous empirical studies focusing on diversification and related motives for syndication. Several previous analyses faced limits on precise cash flow information and other quantitative data. The lack of information about cash-based IRR, or direct risk measurements like the yearly standard deviation of the IRR, is a disadvantage for studies such as Lerner [1994]; Lockett and Wright [2000], and Hopp and Rieder [2005].

The frequency distribution of our sample in regard to industries, countries, and over time is representative of



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the respective PE and VC market distributions. The complete dataset includes 1,011 PE and VC fully and partially realized investments in 914 different portfolio companies worldwide. It includes 55 different investment managers belonging to 20 fund management firms. These investments include 1,950 financing rounds with 3,299 precisely dated cash injections from the funds. The sample spans 20 years, from January 1983 through November 2003. Details of our distribution analyses are available upon request.

The highest number of investments in the dataset is in the U.S., with 603. The remainder are divided among 21 other countries in Europe, Asia, and Latin America. The second-highest number of investments is in the U.K., with 110, followed by 43 in France, and 42 in Germany.

The dataset is broadly diversified over more than 20 different industries and grouped into five industry clusters, with percentages broken down as follows: Technology: 27.3%, Consumer Products: 24.9%, Services & Others: 20.4%, Health Care & Life Sciences: 16.6%, Industrial Products: 7.3%, and Unspecified: 3.5%. Of the investments, 72.5% are early-stage (seed, start-ups, etc.), and 27.5% are non-early-stage investments (7.0% are expansions and acquisition financing, 18.5% are later stage, MBO/MBI, LBO, public to private, mezzanine, and 2% are turnaround and recapitalization); 62.2% are based on venture capital, and 37.8% on buyout/mezzanine capital (buyout 18.4%, mezzanine 17.6%, and generalist 1.8%).

Investors in PE or VC funds, called limited partners, usually select the risk class first (e.g., venture, buyout). They then select the fund manager, called a general partner, within the class (e.g., based on track record and team). Thus, PE and VC fund managers are usually restricted to investing with an agreed-upon investment focus (within a certain region, set of industries, or stage of company development). They must then focus diversification efforts on the number of investments within a fund portfolio.

Exhibit 2 gives the diversification frequency and distribution of investments within the dataset. Note that PE and VC funds must especially consider the permanent reallocation of the fair market portfolio derived from the CAPM.

Jones and Rhodes-Kropf [2004]; Cumming [2006], and Malkiel and Xu [2002] show that PE and VC investments tend to violate some traditional assumptions of the CAPM. Compared to public equity, the PE and VC market does not have an active secondary market for their investments. Liquidity is relatively poor, and it is difficult to assess current value as long as investments remain unrealized. The data sample includes only fully or partially realized investments to mitigate any reporting bias.

## EXHIBIT 2

### Frequency Distribution of the Data Set in regard to Diversification

Columns 1 and 3 give the number of portfolio companies in a VC/PE fund. Columns 2 and 4 show the frequency distribution of the dataset in regard to the number of portfolio companies in the fund to which the company belongs. For example, note there are two observed investments in the dataset belonging to funds with a total of three portfolio companies. The most frequent observations (82 investments) in the dataset belong to funds, which have 19 portfolio companies. The frequency distribution confirms the high spread of diversification from a minimum of three to a maximum of 173 investments per VC/PE fund.

| Number of Portfolio Companies in the Fund | Investment Distribution in the Class | Number of Portfolio Companies in the Fund | Investment Distribution in the Class |
|---|---|---|---|
| | # | | # |
| 3 | 2 | 30 | 19 |
| 5 | 1 | 31 | 2 |
| 6 | 3 | 32 | 44 |
| 8 | 15 | 33 | 27 |
| 9 | 14 | 34 | 19 |
| 10 | 8 | 36 | 24 |
| 11 | 10 | 37 | 1 |
| 12 | 39 | 38 | 21 |
| 13 | 30 | 39 | 4 |
| 14 | 16 | 42 | 1 |
| 15 | 20 | 43 | 5 |
| 16 | 29 | 44 | 10 |
| 17 | 68 | 47 | 22 |
| 18 | 19 | 58 | 31 |
| 19 | 82 | 60 | 15 |
| 20 | 48 | 63 | 26 |
| 21 | 9 | 64 | 5 |
| 22 | 24 | 70 | 59 |
| 23 | 14 | 71 | 36 |
| 24 | 4 | 77 | 34 |
| 25 | 26 | 79 | 3 |
| 26 | 64 | 92 | 4 |
| 27 | 19 | 137 | 20 |
| 28 | 2 | 173 | 7 |

*Sources: Venture Economics/Cepres; 1,011 VC and buyout/mezzanine investments worldwide between January 1983 and November 2003.*



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The gross IRR of an investment is one annualized return figure over the total investment period without deviation.

## HYPOTHESES

The need for diversification can be a problem for very small funds because it leads to relatively higher transaction costs. And the diversification potential for a fund is limited by fund size. Investments that are too small can be rendered inefficient because of higher transaction and monitoring costs.

Bruining et al. [2005] show that transaction cost pressure can explain a small PE fund's decision to invite other investors to join a consortium. Syndication can be an effective tool to increase diversification because syndicating investment managers share the investment amount, the risk, and the transaction costs. An example is the due diligence cost generated by an auditor, which occurs only once and can then be spread over several investors.

*Hypothesis 1: Fund size is negatively associated with syndication probability.*

Transaction costs are partially based on due diligence and monitoring expenses to overcome information asymmetries between the investor and the entrepreneur. The information asymmetries are especially high during the early stage of a company's development when tangible assets are low, as noted by Gompers [1995], and the risk of mortality is relatively high, as per Thornhill and Amit [2003]. Early-stage companies also tend to receive staged financing, according to Sahlman [1990], so the relative transaction costs are higher for these companies because of the higher information asymmetries and the relatively smaller financing amounts.[1]

VC funds differentiate between buyout and mezzanine funds because they focus on early-stage companies, those with innovative products, technologies, business ideas, and outstanding growth opportunities, but also higher levels of information asymmetries and risks of failure. Weidig and Mathonet [2004]; and Schmidt [2004] find that these different risk characteristics result in unequal gross IRR allocations at VC funds versus buyout/mezzanine funds.

Higher information asymmetries and risks might lead to higher transaction costs in proportion to the stage and, therefore, smaller amounts at each financing. This may mean that VC funds will conclude that the transaction costs for the additional investment in a portfolio are higher than the diversification benefits from that extra deal. VC funds can overcome this dilemma by syndicating deals.[2]

*Hypothesis 2: VC investments are positively associated with syndication probability.*

The more experienced the investment manager, the more efficient and certain he will be in selecting deals. With growing experience usually comes a growing network of contacts, better skills, and a higher level of expertise. And the more the investment manager can do himself, the less he will need to spend on external expertise.

As a proxy for experience, we can take the number of funds an investment manager has raised and managed previously. The more funds an investment manager has raised, we can assume the better he has become at assessing entrepreneurs, business ideas, and general investment issues.

*Hypothesis 3: Investment experience is negatively associated with syndication probability.*

## METHODOLOGY

Markowitz's [1952] theory of diversification benefits, as well as much of the secondary literature, discusses exchange-traded securities like public stocks. Damodaran [2001] shows how we can differentiate between market (systematic) risks such as the inflation rate, and firm (nonsystematic) risks such as management error. Diversification lowers individual firm risk relative to total portfolio amount.

Fisher and Lorie [1970], and Elton and Gruber [1977] provide evidence of diversifiable risk reduction of between 84% and 88% for stock portfolios with only eight investments. Hellevik and Hermann [1996] find that the percentage is 80% for portfolios of between nine and 19 securities. Statman and Klimek [2002] show that portfolios with 30 to 40 single assets can still be efficient.

To calculate the diversification benefit within a mean-variance context, we use the following algorithm for optimal portfolio selection with fixed transaction costs (see Patel and Subrahmanya [1982]):

$$\text{Max} \sum_{i=1}^{n} x_i R_i + x_0 R_f - \alpha_i \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \sigma_i \sigma_j p_{ij} - t \sum_{i=1}^{n} y_i \quad (1)$$

$$(1) \text{ Subject to } \sum_{i=1}^{n} x_i + x_0 = W$$



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$x_j$ = the amount invested in risky investment $i$
$x_0$ = the amount invested in a risk-free investment
$R_i$ = 1 + the expected rate of return on portfolio company $i$
$R_f$ = 1 + the risk-free rate
$\sigma_i$ = the standard deviation of portfolio company $R_i$
$\sigma_f$ = the standard deviation of the risk-free rate $R_f$
$\alpha_i$ = the investor risk aversion factor ($a > 0$)
$\rho_{i,j}$ = the return correlation coefficient between investments $i$ and $j$
$W$ = initial investor wealth
$\gamma$ = 1 if investment $i$ is part of the portfolio, and 0 otherwise
$t$ = the fixed transaction amount per investment, and
$i$ = the number of investments.

Investors will only invest when the expected rate of return on the investment is higher than the sum of the risk aversion and transaction costs. The relative risk aversion rate has been derived in studies by Szpiro [1986] and Friend and Blume [1975], who analyzed general risk aversion rates of between 1.2 and 1.8 for U.S. households. A realistic simplification for a more efficient calculation would take a factor of 1.0.

We assume that PE or VC fund managers would not invest in risk-free opportunities because of fund restrictions and the expected decrease of the fund's return on investment. Therefore, the determinant $x_0$ has a value of zero in further calculations and can be neglected. Based on Equation (1), we derive the following algorithm to calculate the diversification benefits of PE and VC portfolios:

$$\text{Max} \sum_{i=1}^{n} R_i - \left(\frac{1}{n}\sigma_i + \left(\frac{n-1}{n}\right) * p_i\right) - \left(t * i + T * x_i\right) \quad (2)$$

$$\text{(1) Subject to } \sum_{i=1}^{n} x_i = W$$

$$\text{(2) Subject to } \sum_{i=1}^{n} R_i - \left(\frac{1}{n}\sigma_i^2 + \left(\frac{n-1}{n}\right) * p_i\right) - \left(t * i + T * x_i\right) \geq R_f$$

$T$ = variable transaction costs depending on the investment amount, and
$n$ = the number of portfolio companies.

Following Markowitz [1952], and Statman [1987], we can simplify this by stating that the standard deviation ($\sigma$) of each $n$ investment is identical, all correlations ($\rho$) between pairs of investments are identical, and the weight of each $n$ investment is the same.

The determinants of Equation (2) are derived from the dataset. Individual approximations help overcome any problems of missing data. The objective is to calculate the optimal diversification level for PE or VC portfolios while taking transaction costs into consideration.

We find that the gross diversification benefit without transaction costs is related to an increasing number of portfolio companies. We calculate this measure by using the algorithms provided by Statman and Klimek [2002], and Goetzmann and Kumar [2003]. The gross benefit is calculated as only the first half of the effective benefit of diversification. In the second part, we must account for transaction costs, which increase concurrently with diversification.

Statman [2004] analyzed the diversification benefits for public equity portfolios, and assumed transaction costs of 0.06% per portfolio company and 0.20% for investments in Vanguard total stocks. His assumptions, however, are not directly applicable to VC and PE investments due to their higher respective levels of market opacity, illiquidity, information asymmetries, and related transaction costs.

To calculate relative transaction costs to investment amount, it is important to separate fixed transaction costs and variable transaction costs. Exchange-traded stock investments are linked to direct costs for clearing-related broker duties, for example. And PE and VC investment managers must decide how much to spend on items like due diligence. In general, we note that transaction costs accrue at both the purchase of the investment and at the sale. Due diligence is critical to overcoming information asymmetries between the company and the investor, which, as we have noted, are especially high for early stage and VC funds.

However, we also need to determine the critical transaction breakeven amount. For example, the point at which a fund becomes unprofitable differs for a $10 million, $100 million, or even $1 billion portfolio. The optimal amount of investments can be 10, 20, or 30.

## EMPIRICAL RESULTS

The marginal diversification benefit analysis defines the critical value at which transaction costs make a deal



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inefficient. We calculate the gross diversification benefit per investment in percent as ($\sigma$ investment − $\sigma$ diversified portfolio)/number of investments in the portfolio. The percentage decreases as the marginal benefit decreases and as the number of investments in the portfolio increases.

Exhibit 3 gives the marginal diversification benefit as the critical value for the marginal transaction costs for VC funds. The more investments in a portfolio, the less transaction cost amount is available for each investment. The absolute marginal benefit is the benchmark for transaction costs for each investment in the column "Investment Amount." The matrix shows that as fund size increases, it appears easier to comply with transaction cost restrictions. The diversification benefit dilemma occurs when the transaction costs for the additional investment in a portfolio are higher than the diversification benefits from that extra deal, especially for smaller funds.

Exhibit 4 shows the diversification degree curve and the correlation with fund size. Note that the investments are separated among syndicated and non-syndicated VC and buyout/mezzanine deals. It seems that fund size has a significant effect on diversification degree and on the monetary diversification ability. But both VC and buyout/mezzanine funds differ significantly in the way they choose to diversify. VC funds divide the portfolio more rapidly than buyout/mezzanine funds, probably to reduce risk and achieve sufficient diversification. The differences between syndicated and non-syndicated buyout/mezzanine investments are negligible.

The variations in diversification for syndicated VC portfolios are significant and different than non-syndicated VC portfolios. The data show a strong increase in diversification for funds up to $200 million in size, and a higher level of the syndication curve. This observation indicates that the diversification benefit dilemma of smaller funds may be overcome by syndication.

Exhibit 5 shows the relationship between a well-diversified portfolio, fund size, and syndication behavior as a tool to achieve sufficient diversification. The results again show that early-stage and VC investments are associated with a higher probability of syndication.

The absolute gross IRR is calculated on precisely dated cash flows between the fund and the portfolio company during the total investment period. This starts at the initial investment from the fund to the company, and ends at the final distribution from the company to the fund. Our dataset is comprised only of fully or partially realized investments. We would consider unrealized investments only if the $q$-value is 20% or less, based on the model of Diller and Kaserer [2004]:

$$q \geq \frac{RNAV_T}{\sum_{t=0}^{T} |CF_t|} \tag{3}$$

For this step, the residual net asset value ($RNAV_T$) of partially realized investments as of November 2003 is divided by the absolute sum of cash flows between the fund and the portfolio company.

Exhibit 6 shows the data distribution of the gross IRR of all investments of VC and buyout/mezzanine funds, separated into syndicated and non-syndicated investments. Note that syndicated VC investments have a more distinct W-formation than non-syndicated investments. This indicates that syndication is used more often in the case of higher-risk deals.

Investor experience can help reduce transaction costs as well as the need for syndication to achieve sufficient diversification. These results are in line with the arguments of De Clercq and Dimov [2004]; Lockett and Wright [2000], and Hopp and Rieder [2005]. The proxy for an investment manager's experience can be divided into six clusters, depending how many funds he has raised previously.

Exhibit 7 shows how three diversification indicators are related: 1) fund size, and 2) experience, have a negative effect on risk-sharing and transaction costs, with a decreasing need for 3) syndication, in order to achieve sufficient diversification. The negative association between syndication probability and investment manager experience seems obvious. An additional fact is that fund size increases with the experience level of investment managers, especially after the first two funds have been raised.

Exhibit 8 describes all the variables used in the binary logistic regression to test the hypotheses. Exhibit 9 presents the results for the binary logistic regression analyses on the determinants of syndication probability. Model quality can be quantified in a percentage of cases through the independent variables in the model. We used several tests to evaluate model quality as it pertains to forecast accuracy: Model quality is specified by the number of investments, the percentage of the model's prediction correctness, and three pseudo $R^2$ tests (–2Log, Cox & Snell, and Nagelkerke $R^2$). All five were robust.

The binary logistic regressions in Exhibit 9 confirm all our hypotheses and show significant associations



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## EXHIBIT 3

### Marginal Diversification Benefit

The relative marginal diversification benefit (columns 2–4) is the critical value for the marginal transaction costs of VC fund investments. The absolute marginal diversification benefit (columns 5–7) and the number of investments in a portfolio (column 1) must be considered in concert with fund size (columns 8–10). The marginal diversification benefit analysis can define the critical value at which an additional diversification could be inefficient due to critical transaction costs. The gross diversification benefit per investment in percent is calculated as ($\sigma$ investment – s diversified portfolio)/number of investments in the portfolio. The percentage decreases as the marginal benefit decreases, and as the number of investments in the portfolio increases.

| Number of Investments in Portfolio | Relative Marginal Benefit | | | Absolute Marginal Benefit | | | Investment Amount | | |
|---|---|---|---|---|---|---|---|---|---|
| | Fund Size (in million) | | | Fund Size (in million) | | | Fund Size (in million) | | |
| | 10 | 100 | 1000 | 10 | 100 | 1000 | 10 | 100 | 1000 |
| 1 | - | - | - | - | - | - | 10.00 | 100.0 | 1000.0 |
| 2 | 18.1% | 18.1% | 18.1% | 0.9040 | 9.0396 | 90.40 | 5.00 | 50.0 | 500.0 |
| 3 | 16.1% | 16.1% | 16.1% | 0.5357 | 5.3568 | 53.57 | 3.33 | 33.3 | 333.3 |
| 4 | 13.6% | 13.6% | 13.6% | 0.3390 | 3.3899 | 33.90 | 2.50 | 25.0 | 250.0 |
| 5 | 11.6% | 11.6% | 11.6% | 0.2314 | 2.3141 | 23.14 | 2.00 | 20.0 | 200.0 |
| 6 | 10.0% | 10.0% | 10.0% | 0.1674 | 1.6740 | 16.74 | 1.67 | 16.7 | 166.7 |
| 7 | 8.9% | 8.9% | 8.9% | 0.1265 | 1.2650 | 12.65 | 1.43 | 14.3 | 142.9 |
| 8 | 7.9% | 7.9% | 7.9% | 0.0989 | 0.9887 | 9.89 | 1.25 | 12.5 | 125.0 |
| 9 | 7.1% | 7.1% | 7.1% | 0.0794 | 0.7936 | 7.94 | 1.11 | 11.1 | 111.1 |
| 10 | 6.5% | 6.5% | 6.5% | 0.0651 | 0.6509 | 6.51 | 1.00 | 10.0 | 100.0 |
| 11 | 6.0% | 6.0% | 6.0% | 0.0543 | 0.5433 | 5.43 | 0.91 | 9.1 | 90.9 |
| 12 | 5.5% | 5.5% | 5.5% | 0.0460 | 0.4604 | 4.60 | 0.83 | 8.3 | 83.3 |
| 13 | 5.1% | 5.1% | 5.1% | 0.0395 | 0.3950 | 3.95 | 0.77 | 7.7 | 76.9 |
| 14 | 4.8% | 4.8% | 4.8% | 0.0343 | 0.3426 | 3.43 | 0.71 | 7.1 | 71.4 |
| 15 | 4.5% | 4.5% | 4.5% | 0.0300 | 0.3000 | 3.00 | 0.67 | 6.7 | 66.7 |
| 16 | 4.2% | 4.2% | 4.2% | 0.0265 | 0.2648 | 2.65 | 0.63 | 6.3 | 62.5 |
| 17 | 4.0% | 4.0% | 4.0% | 0.0236 | 0.2355 | 2.36 | 0.59 | 5.9 | 58.8 |
| 18 | 3.8% | 3.8% | 3.8% | 0.0211 | 0.2108 | 2.11 | 0.56 | 5.6 | 55.6 |
| 19 | 3.6% | 3.6% | 3.6% | 0.0190 | 0.1898 | 1.90 | 0.53 | 5.3 | 52.6 |
| 20 | 3.4% | 3.4% | 3.4% | 0.0172 | 0.1718 | 1.72 | 0.50 | 5.0 | 50.0 |
| 21 | 3.3% | 3.3% | 3.3% | 0.0156 | 0.1562 | 1.56 | 0.48 | 4.8 | 47.6 |
| 22 | 3.1% | 3.1% | 3.1% | 0.0143 | 0.1426 | 1.43 | 0.45 | 4.5 | 45.5 |
| 23 | 3.0% | 3.0% | 3.0% | 0.0131 | 0.1308 | 1.31 | 0.43 | 4.3 | 43.5 |
| 24 | 2.9% | 2.9% | 2.9% | 0.0120 | 0.1203 | 1.20 | 0.42 | 4.2 | 41.7 |
| 25 | 2.8% | 2.8% | 2.8% | 0.0111 | 0.1111 | 1.11 | 0.40 | 4.0 | 40.0 |
| 26 | 2.7% | 2.7% | 2.7% | 0.0103 | 0.1029 | 1.03 | 0.38 | 3.8 | 38.5 |
| 27 | 2.6% | 2.6% | 2.6% | 0.0096 | 0.0955 | 0.96 | 0.37 | 3.7 | 37.0 |
| 28 | 2.5% | 2.5% | 2.5% | 0.0089 | 0.0889 | 0.89 | 0.36 | 3.6 | 35.7 |
| 29 | 2.4% | 2.4% | 2.4% | 0.0083 | 0.0830 | 0.83 | 0.34 | 3.4 | 34.5 |
| 30 | 2.3% | 2.3% | 2.3% | 0.0078 | 0.0777 | 0.78 | 0.33 | 3.3 | 33.3 |

*Source: Venture Economics/Cepres; 1,011 VC and buyout/mezzanine investments worldwide between January 1983 and November 2003.*



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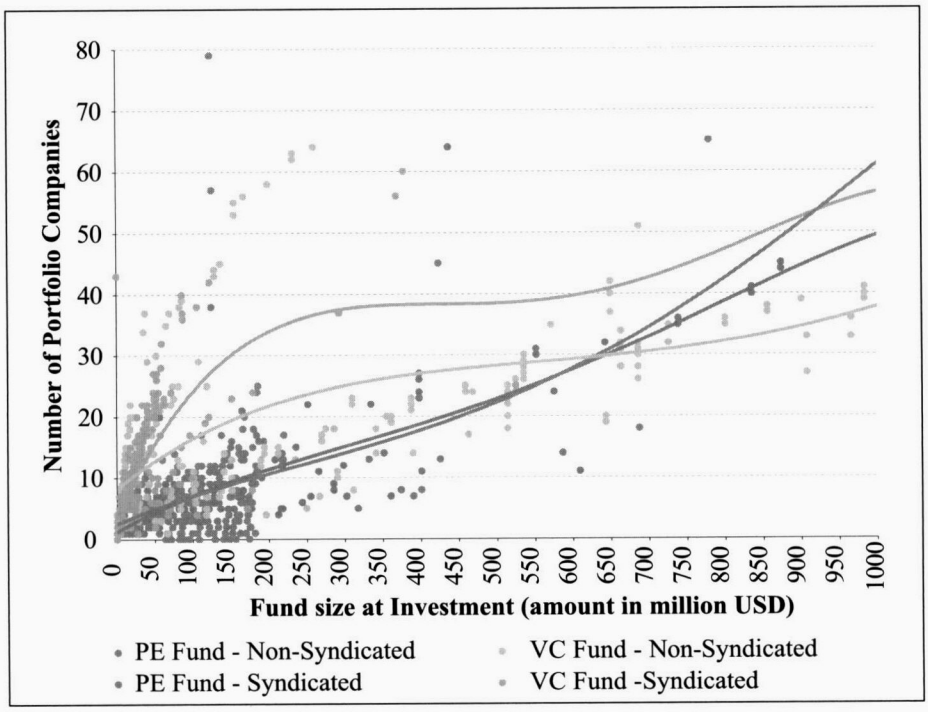
## EXHIBIT 4

**Diversification of Syndicated and Non-Syndicated Buyout/Mezzanine and VC Funds**




*Source: Venture Economics/Cepres; 1,011 VC and buyout/mezzanine investments worldwide between January 1983 and November 2003.*

## EXHIBIT 5

**Fund Size and Impact on Diversification and Syndication**

In the column "25th Percentile," note that the "Number of Portfolio Companies in Fund" does not fall significantly below 18, whether the fund is $3.3 or $880 million. That figure is impressive, especially in light of the calculated benefit of diversification and the critical value of transaction costs. In the first five fund size classes, nearly 50% of the investments are syndicated. When fund size grows above $400 million, syndication probability declines from 17.2% to less than 4%. The results emphasize the advantage of syndication, especially for smaller funds to save transaction costs and achieve sufficient diversification. A further factor will be to acquire expertise or experience.

| Fund Size Class | Included Investments | Fund Size Range in $ million | | Number of Portfolio Companies in Fund | | | | Syndicated Investment | | Syndication Rate |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 75th Percentile | Median | Mean | 25th Percentile | | | |
| No. | # | From | To | # | # | # | # | No | Yes | |
| 1 | 102 | 3.3 | 64.2 | 36 | 32 | 27.7 | 18 | 16 | 32 | 66.7% |
| 2 | 102 | 64.2 | 103.0 | 26 | 25 | 22.0 | 17 | 22 | 43 | 66.2% |
| 3 | 102 | 103.0 | 145.5 | 64 | 33 | 39.4 | 25 | 34 | 56 | 62.2% |
| 4 | 102 | 145.5 | 223.9 | 26 | 17 | 26.5 | 17 | 43 | 25 | 36.8% |
| 5 | 102 | 223.9 | 398.3 | 21 | 19 | 23.0 | 17 | 40 | 30 | 42.9% |
| 6 | 102 | 398.3 | 880.8 | 38 | 21 | 27.1 | 19 | 72 | 15 | 17.2% |
| 7 | 102 | 880.8 | 2498.8 | 70 | 58 | 51.0 | 32 | 85 | 6 | 6.6% |
| 8 | 103 | 2498.8 | 5674.9 | 71 | 70 | 75.3 | 70 | 86 | 3 | 3.4% |

*Source: Venture Economics/Cepres; 1,011 VC and buyout/mezzanine investments worldwide between January 1983 and November 2003.*



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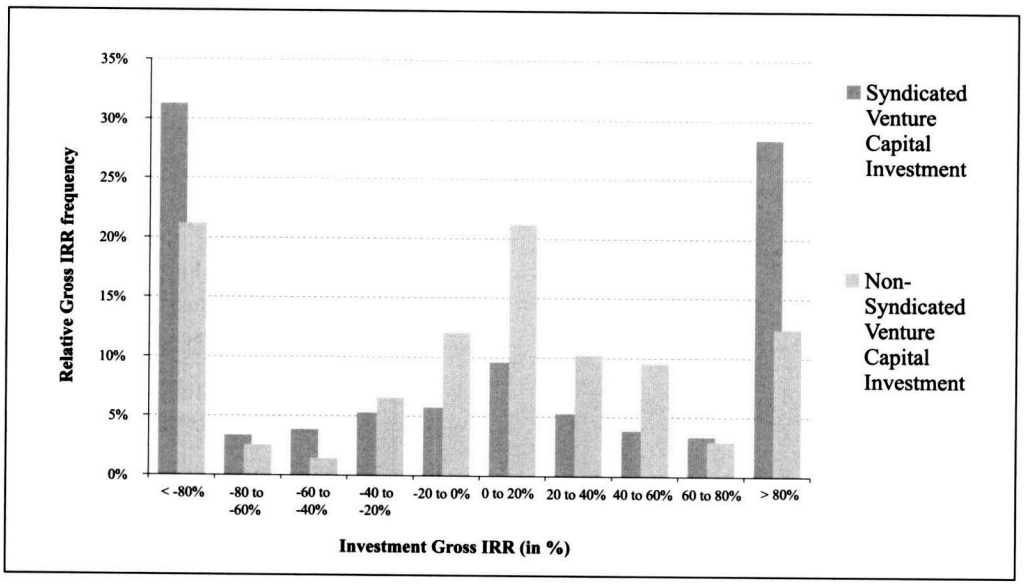
## EXHIBIT 6

### IRR Frequency for Syndicated and Non-Syndicated Venture Capital Investments

This exhibit shows the data distribution of the gross IRR of all investments of VC and buyout/mezzanine funds, separated into syndicated and non-syndicated investments. The gross IRR is calculated on the cash flows between the fund and the portfolio company.




*Source: Venture Economics/Cepres; 1,011 VC and buyout/mezzanine investments worldwide between January 1983 and November 2003.*

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## EXHIBIT 7

### Relationship among Investment Experience, Fund Size, and Syndication Rate

| Number of Funds the Investment Manager has Raised Previously | No. of Investments in class | Syndication (Yes, No) | | Fund size (in 2003 $ million) | Syndication Rate |
|---|---|---|---|---|---|
| | | No | Yes | | |
| | # | # | # | Mean | Count |
| 0 | 210 | 25 | 60 | 222.4 | 70.6% |
| 1 | 178 | 71 | 56 | 192.4 | 44.1% |
| 2 | 148 | 63 | 48 | 264.0 | 43.2% |
| 3 | 153 | 74 | 57 | 722.8 | 43.5% |
| 4 | 105 | 69 | 29 | 1694.8 | 29.6% |
| 5 | 54 | 38 | 7 | 2059.5 | 15.6% |
| >5 | 116 | 88 | 7 | 1735.7 | 7.4% |
| *The correlation degree between "Number of Funds the Investment Manager has Raised" and "Fund Size" is 0.254.**** | | | | | |

*Source: Venture Economics/Cepres; 1,011 VC and buyout/mezzanine investments worldwide between January 1983 and November 2003.*



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## EXHIBIT 8
**Description of Variables**

| Variable Class | Variable Name | Variable Description |
|---|---|---|
| Industry Risk Variables (25 CEPRES industry classifications were integrated into the following five classes) | Technology | A dummy variable equal to 1 for portfolio companies related to IT, high-tech, semiconductors, software, internet and media, or telecommunications |
| | Industrial Products | A dummy variable equal to 1 for portfolio companies related to industrial/manufacturing, construction, traditional products, materials, or natural resources/energy |
| | Services & Others | A dummy variable equal to 1 for portfolio companies related to financial services, fund of fund investments, the environment, logistics, waste/recycling, other services, or others |
| | Consumer Products | A dummy variable equal to 1 for portfolio companies related to consumer industry/food, hotels, leisure, retail, or textiles |
| | Health Care/Life Sciences | A dummy variable equal to 1 for portfolio companies related to health care or life sciences |
| Investment risk proxies | Early-Stage Investment | A dummy variable equal to 1 for early-stage investments |
| | Later-Stage Investment | A dummy variable equal to 1 for later-stage investments, expansions, or turnarounds |
| Fund risk proxies | Venture Capital Fund | A dummy variable equal to 1 for venture capital funds |
| | Buyout/Mezzanine Fund | A dummy variable equal to 1 for buyouts, mezzanine finance, or generalist funds |
| Diversification potential variable | Fund Size (in 2003 US$) | Fund size (in real 2003 US$) |
| Investment manager experience variable | No. of Funds the IM has raised previously | Number of funds the investment manager has raised previously |
| Control variables | IPO (Yes, No)? | A dummy variable equal to 1 for investments in private companies with an IPO (initial public offering) as the exit |
| | Write-Off (Yes, No)? | A dummy variable equal to 1 for investments in private companies with a write-off as the exit |
| | IRR of Investment | The exact internal rate of return based on investment cash flows |
| | Round 1 Amount | The amount of the first financing the IM receives (in real 2003 US$) |
| | Holding Period (all) Investments (in years) | Number of years between IM's initial investment and complete exit |



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## EXHIBIT 9

### Binary Logistic Regression Analyses on the Determinants of Syndication Probability

This exhibit shows five regression models separated into five industry clusters. The dependent variable is a dummy for syndicated investment (Yes = 1, No = 0). The independent variables are composed of five blocks: portfolio company industry cluster (Technology, Industrial Products, Services & Others, Consumer Products, and Health Care/Life Sciences), investment stage cluster (early-/non-early-stage), fund type cluster (venture capital, buyout/mezzanine funds), diversification potential (fund size), and investment manager experience level (number of funds the investment manager has raised previously). The control variables include three exit variables (exit IPO (Yes = 1, No = 0), exit write-off (Yes = 1, No = 0), and gross IRR based on the cash flows between the fund and the portfolio company), and additional variables (fund investment amount at the initial financing round, and the holding period in years). Several tests were conducted to evaluate model quality concerning forecast accuracy. The last five rows describe the model diagnostics. The model quality is specified by the number of investments, the percentage of the model's prediction correctness, and three pseudo $R^2$ tests (–2Log, Cox & Snell, and Nagelkerke $R^2$).

| Dependent Variable: Syndication (Yes = 1/No = 0) | | Model 1 Standardized Coefficients | | Model 2 Standardized Coefficients | | Model 3 Standardized Coefficients | | Model 4 Standardized Coefficients | | Model 5 Standardized Coefficients | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Constant | | 2.240 | *** | 2.341 | *** | 2.492 | *** | 2.561 | *** | 2.469 | *** |
| Industry | Technology | 0.580 | ** | | | | | | | | |
| | Industrial Products | | | 0.995 | ** | | | | | | |
| | Services & Others | | | | | -0.360 | | | | | |
| | Consumer Products | | | | | | | -0.559 | ** | | |
| | Health Care/Life Sciences | | | | | | | | | -0.220 | |
| Fund size | Fund size (in 2003 U.S. $) | -0.002 | *** | -0.002 | *** | -0.002 | *** | -0.002 | *** | -0.002 | *** |
| Stage | Early stage | 0.827 | ** | 0.825 | ** | 0.815 | ** | 0.853 | *** | 0.851 | *** |
| Fund type | Venture capital fund (Yes = 1/ No = 0) | 1.551 | *** | 1.631 | *** | 1.488 | *** | 1.601 | *** | 1.519 | *** |
| Experience | No. of Funds the IM has raised previously | -0.191 | *** | -0.196 | *** | -0.193 | *** | -0.199 | *** | -0.198 | *** |
| Performance | IPO (Yes = 1/No = 0) | -0.300 | | -0.252 | | -0.352 | | -0.259 | | -0.254 | |
| | Write-off (Yes = 1/No = 0) | -0.919 | ** | -0.912 | ** | -0.952 | *** | -0.870 | ** | -0.954 | *** |
| | Gross IRR of Investment | 0.016 | | 0.018 | | 0.015 | | 0.023 | | 0.016 | |
| | Round 1 amount | -0.000 | *** | -0.000 | *** | -0.000 | *** | -0.000 | *** | -0.000 | *** |
| | Holding Period (all) Investments (in years) | -0.344 | *** | -0.325 | *** | -0.338 | *** | -0.332 | *** | -0.343 | *** |
| Model quality | Number of investments (n) | 601 | | 602 | | 602 | | 602 | | 602 | |
| | Model prediction correctness (%) | 81.4% | | 81.6% | | 80.7% | | 82.1% | | 80.9% | |
| | -2 Log | 511.36 | | 511.52 | | 515.10 | | 512.36 | | 516.37 | |
| | Cox & Snell | 0.353 | | 0.353 | | 0.349 | | 0.352 | | 0.348 | |
| | Nagelkerke | 0.488 | | 0.488 | | 0.483 | | 0.487 | | 0.481 | |

*Source: Venture Economics/Cepres; 1,011 VC and buyout/mezzanine investments worldwide between January 1983 and November 2003.*
*Significance level: * = 10%, ** = 5%, *** = 1%.*

between the independent variables and the syndication decision. The results confirm that fund size is negatively associated with syndication probability. The greater the fund's capital under management, the higher the chance of achieving diversification without exceeding efficiency.

The advantage of syndication to reduce the diversification benefit dilemma is based on three aspects: 1) the investment manager can share transaction costs and increase total investment amount in proportion to fund size, 2) the portfolio can be diversified over a broader set of companies, and 3) the fund benefits from greater experience and a wider scope, by adding complementary resources into the deal.



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## CONCLUSION

Markowitz's [1952] original concept of the efficient portfolio focused on public equity without explicitly considering transaction costs. However, in VC and PE portfolios, due diligence and transaction costs are relatively high because of market opacity and information asymmetries. Sufficient diversification is thus limited.

The application and limitations of the diversification benefits to VC and PE portfolios is the key research aspect of this study. We examined and answered the following three questions:

1. PE and VC funds can generate sufficient diversification in a market prone to opacity and illiquidity by using syndication to overcome transaction constraints.
2. Larger fund sizes can be beneficial for diversification because they have less need for syndication.
3. PE and VC funds can create efficient portfolios even at high levels of information asymmetries (e.g., early stage, VC, or low levels of experience) by using syndication to benefit from risk-sharing and lower transaction costs.

Furthermore, our results confirm those of Lerner [1994], and Lockett and Wright [2000].

We performed our empirical analyses on a comprehensive dataset merged from Venture Economics and Cepres. The details of the dataset and the precision of measurement extend previous studies on diversification and syndication of VC and PE investments. Our sample enables us to calculate precise cash flow-based returns on investments, and helps to identify risk-related proxies for correlation quotients between VC/PE investments and to quantify the diversification benefits. Future studies might use further empirical findings to examine the fixed and variable transaction costs in more detail.

One implication of these findings is that investors who evaluate a commitment to a smaller VC fund should analyze the syndication networks of the fund managers with other VC funds. If a fund management has better relationships to other VC funds, it should enable an improved deal flow and syndication opportunity. Another implication of these findings is that early stage companies which are looking for funding should prepare their financing round from the outset for a syndicated investment of several small VC funds. The probability of obtaining capital from a consortium might be higher than from just one small VC fund. And the third implication of these results is that VC fund managers should keep good relationships with other VC funds—co-optition instead of simple competition—because they might need each other in future syndicated financings.

## ENDNOTES

The authors would like to thank CEPRES (Center for Private Equity Research) in Frankfurt and Venture Economics for generous access to their data. Helpful comments were provided by Thorsten Klonus and Isabell Welpe. All errors are our own.

[1]For this analysis, we split the dataset into two subsamples: early stage (including seed and start-ups), and non-early stage (including later-stage, expansion, buyouts, public to private, mezzanines, and turnaround deals).

[2]For this analysis, we split the data set into two subsamples: investments of VC funds (629) versus non-VC deals (including 186 buyout deals, 178 mezzanine financings, and 18 investments from funds classified as generalist). The inherent risks of the non-VC investments seem comparable.

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## Performance Measurement



## Asset Allocation





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