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DIVERSIFICATION IN PRIVATE EQUITY FUNDS: ON KNOWLEDGE-SHARING, RISK-AVERSION AND LIMITED-ATTENTION

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Diversification in Private Equity Funds: On knowledge-sharing, risk-aversion and limited-attention

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Abstract

This paper examines diversification as a source of value creation and destruction in private equity. The literature has focused on the 'diversification discount' in corporations. It has not analyzed diversification in PE-funds, where diversification might increase value by ameliorating managerial risk aversion and by facilitating knowledge sharing. Thus, I examine a sample of 1505 PE-funds to show that industry and geographic diversification increases PE-fund returns on average, this is likely due to knowledge-sharing/learning, and is not due to mere risk-reduction or endogeneity. Diversification can also destroy value if it spreads staff too thinly across industries/regions or is motivated by risk-aversion over performance bonuses.

Keywords: Diversification; Private Equity; Venture Capital

1 Introduction

Diversification can destroy value in some, but not all, corporations. Diversification can increase firm-size and entrench managers. This can facilitate shirking and empire-building (Amihud and Lev, 1999; Aron, 1988). Empirical evidence supports this prediction. However, diversification might increase value in some companies by reducing agency conflicts of managerial risk aversion and by facilitating knowledge-transfers between divisions. This should particularly benefit PE-funds since they invest in high risk companies and generate value by sharing knowledge and expertise. Prior literature has not examined the value-implications of diversification in PE-funds.

The main contributions of this paper are to examine diversification in PE funds and to show: (1) diversification increases PE funds' returns; and, (2) this may be because diversification facilitates learning and knowledge transfers. (3) Risk-reduction may increase PE-funds' returns, but this does not drive the relation between diversification and returns. (4) Endogeneity does not drive the return/diversification relation. (5) Diversification reduces returns if it spreads staff too thinly across industries or regions. (6) Diversification appears to reduce value if the motivation is risk-aversion over obtaining a performance bonus. (7) Returns decrease with the number of investment rounds in which the fund participates. This partially supports the theory in Guler (2007) that institutional pressures can induce sub-optimal investments in later investment-states.

Prior empirical literature has focused on 'corporations', rather than 'PE funds', and has found that diversification reduces firm value. Denis, Denis, and Yost (2002) show that industrial and geographic diversification reduce

firm-value. Eckbo and Thorburn (2000) and Chaterjee and Aw (2004) show that the market reacts negatively to cross-border acquisitions. Moeller and Schlingemann (2005) find that the market reacts significantly negatively to takeovers that diversify across region or industry and that this reflects a lower post-takeover operating performance.[1] Chakrabarti, Singh, and Mahmood (2007) show that the negative relation between diversification and performance is robust to country and the level of economic development. Analogously, the literature suggests that firms can generate value by refocusing and divesting non-core assets (see Berger and Ofek, 1999; Haynes, Thompson, and Wright, 2002; Matsusaka and Nanda, 2002). However, there are several reasons to believe that this result might not hold for PE funds.

Diversification might benefit PE-funds. PE funds are both investment vehicles and corporations. They are investment vehicles in that they invest in portfolio of companies. They are corporations in that PE-fund managers actively engage in the corporate management and strategy of the portfolio company. Diversification might benefit both aspects of a PE-fund.

From a portfolio management perspective, PE-funds invest in risky assets with a high failure rate (Dimov and De Clercq, 2006). This might induce agency conflicts of managerial risk aversion. Diversification can 'average-out' this risk; and thus, might ameliorate these agency conflicts.

From a corporate perspective, syndication and connections between PE-funds can create value (Hochberg, Ljungqvist, and Lu, 2007). Diversification might amplify these connections. This diversification might also facilitate knowledge-transfers between portfolio-companies, and might expose man-

[1] This event-study approach largely addresses the endogeneity concerns raised in Campa and Kedia (2002).

agers to a wide-range of skills (Lin and Lee, 2009). Further, given that the regulatory environment can influence PE-fund returns (Cumming and Walz, 2010), international diversification might facilitate regulatory arbitrage. Seed or start-up companies should especially benefit from this due to their reliance on PE-funds for managerial and technological expertise.

There is limited empirical evidence on the impact of diversification in the PE sector. Ljungqvist and Richardson (2003) examine diversification in 73 funds between 1981 and 1993. The data-set comprises the funds in which their source (one limited partner) considered investing. They find no significant relation between IRRs and the number of industries in the fund's portfolio or the number or the percentage invested in the dominant industry. Nonetheless, this might reflect self-selection on the part of the data source (the investor) to focus upon PE funds in which it might want to invest. Lossen (2006) examines 100 European funds and finds some weak evidence that diversification across industries increases returns. However, the sample is limited to 100 PE-funds in Europe and the sign and significance of the result varies across model specification. Knill (2009) finds a positive relation between diversification and 'growth' (defined as the change in the fund's capital under management). But this definition of 'growth' is not the same as returns for it may merely reflect the ability to raise capital rather than to convert capital into value. Humphery-Jenner (2011b) shows a positive relation between diversification and returns, but does not test the driver of this relation.

The limited empirical evidence suggests that further examination of diversification in the PE industry is warranted. I use a sample of 1505 PE-funds from 1980 to 2007 raised in the US. I examine whether and why in-

dustry/geographic diversification influences returns. I focus on whether any positive diversification/returns relation is due to knowledge-sharing/learning between portfolio companies, or merely reflects endogeneity or risk-reduction. I also examine whether diversification destroys value by spreading staff to thinly and limiting the attention they can pay to individual regions/industries, or by facilitating managerial risk-aversion with respect to performance bonuses.

The results show that diversification may increase returns by facilitating knowledge-sharing between portfolio companies. The results show that diversification increases returns on average. It especially does so seed-funds, which might particularly benefit from knowledge-sharing and learning between diverse portfolio companies. Further, diversification in funds previously raised by the current fund's management firm increases returns, implying that prior diversification may create skills that the present fund can use to increase returns. Mere risk-reduction and endogeneity do not drive the results. Overall, this suggests that learning and knowledge sharing may explain why diversification increases returns in PE funds.

I find that risk-reduction may increase returns; however, does not explain the relation between industry/geographic diversification and returns. Increasing the number of portfolio companies in a fund reduces the fund's exposure to idiosyncratic (or company-specific) risk. I find that returns increase with the number of portfolio companies. An explanation is that some reduction in risk reduces managerial risk aversion and encourages managers to invest in companies that are more risky. Nonetheless, industry and geographic diversification still increase returns after controlling for this effect.

Diversification can reduce value in some cases. Diversification reduces

value if it reduces the staff-to-region or staff-to-industry ratio, suggesting that diversification destroys value if spreads staff too thin. Diversification also appears to destroy value if the motivation is managerial risk aversion of performance bonuses.

The paper proceeds as follows. Section 2 details the prior literature and hypotheses. Section 3 describes the sample, variables and methodology. Section 4 contains the results and Section 5 concludes.

2 Literature Review and Hypothesis Development

This section outlines the hypotheses. The overarching idea is to test (1) whether diversification influences IRRs, and (2) if so, why it influences IRRs. Thus, I test seven main hypotheses and an eighth mosaic hypothesis. The eighth hypothesis ties together the preceding seven hypotheses to posit when learning might explain the relation between diversification and returns.

2.1 Diversification and learning: On seed funds and diversification in prior funds

Diversification might increase value for PE-funds in general, and seed-focused PE-funds in especial. A key explanation relates to knowledge-sharing and learning.

2.1.1 Diversification in general and in seed funds

Diversification might improve the PE-manager's skill-set and industry connections. PE managers add value by providing managerial, financial, and technical expertise (Ivanov and Xie, 2010; McDougall, Robinson, and DeNisi, 1992). Some technical skills are industry specific. However, in an innovation-intensive environment, managers can expand their knowledge-base by engaging in diverse, but tangentially related, fields (Hurry, Miller, and Bowman, 1992; Lin and Lee, 2009; Siegel, Siegel, and MacMillan, 1988). Additionally, Hochberg, Ljungqvist, and Lu (2007) highlight the financial importance of wide-ranging industry networks to PE funds. These networks rely on interactions between industries. Further, for seed-funds, which are difficult to value; and thus, difficult to finance. Connections should help the fund raise capital.

Diversification might enable the PE-fund to facilitate knowledge spillovers. Knowledge transfers from PE-managers to portfolio companies, and from portfolio companies to other portfolio companies are a key way to create value (Hochberg, Ljungqvist, and Lu, 2007). In corporations, this is especially true for diversification across similar knowledge-based industries (following Hansen, 2002; Miller, 2006; Schilling and Phelps, 2007; Tanriverdi and Venkatraman, 2005; Teece, 1980, 1982). Further, knowledge transfers are important to innovation generation (Ahuja, 2000; Tsai, 2001). Seed investments especially benefit from this since they rely on knowledge sharing and managerial expertise to generate value.

This theoretical basis induces prediction that diversification increase PE-fund returns, especially if the fund invests in start-ups. Hypothesis 1 and

Hypothesis 2 summarize these predictions.

Hypothesis 1 *PE-fund returns increase with the number of industry-segments and geographic regions in which the fund invests.*

Hypothesis 2 *PE-funds who make 'seed' of 'start-up' investments benefit more from diversification than do other PE-funds.*

2.1.2 Returns and prior-fund diversification

The learning hypothesis also implies that if (a) a fund's management firm has raised prior funds, and (b) there is some communication or personnel overlap between the funds, and (c) diversification induces learning and knowledge-sharing, then the level of diversification in the previous fund should increase IRRs in the present fund. In short, diversification in prior funds raised by the same management firm should increase returns in the present fund. I focus on the level of diversification in the last fund raised before the present fund. Hypothesis 3 summarizes this.

Hypothesis 3 *The level of diversification in the fund that (a) was raised by the present fund's management firm, and (b) was raised before the present fund, should increase returns in the present fund.*

2.2 Diversification and risk reduction

Risk reduction may explain any relation between diversification and returns. This is for two key reasons.

First, diversification might create value by ameliorating agency conflicts of managerial risk aversion. One source of agency conflict is excess managerial risk aversion. Managers invest more personal capital in their companies than do shareholders. Thus, managers have greater firm (or fund) specific risk exposure. Thus, managers might prefer investments that are safer than is optimal for shareholders. This is especially problematic in PE funds because (1) most of the manager's income comes from a performance bonus (called 'carry') (Phalippou and Gottschalg, 2009), and (2) PE funds are risky and have highly skewed returns (Chiampou and Kallett, 1989; Cochrane, 2005; Gompers and Lerner, 1998; Humphery-Jenner, 2011a; Korteweg and Sorensen, 2010). One way to solve this is to reduce the fund's overall level of risk. Portfolio theory suggests that diversification can reduce the fund's exposure industry-specific and region-specific risks. This might encourage managers to invest in riskier companies and might align managers' incentives with those of shareholders.

Second, diversification might reduce the fund's exposure to industry/region specific risk; and thus, increase returns. This rests on two premises. (1) Diversification across industry, region, or both is likely to reduce the fund's exposure to firm/investment-specific risk. (2) Reducing risk might ameliorate the skewness in VCPE investments, which drives-down returns (Humphery-Jenner, 2011a). Thus, a possibility is that mere risk reduction drives any diversification/return relationship. If risk-reduction drives the results, then diversification (a) should not influence returns after controlling for the fund's portfolio size (on grounds that the portfolio size represents the ability to reduce risk), and (b) should not influence risk-adjusted IRRs. This induces Hypothesis 4.

Hypothesis 4 *Diversification influences returns because it reduces the fund's riskiness. Thus, diversification should not influence risk-adjusted IRRs and should not influence IRRs after controlling for the fund's portfolio size (which is a proxy for the fund's reduction in investment-specific/idiosyncratic risk). Further, returns should increase with the number of portfolio companies in which the fund invests.*

2.3 Diversification and limited attention

The limited attention hypothesis argues that diversification reduces returns if it spreads staff too thin. This is especially important in the VCPE sector, where funds typically feature relatively few staff (Metrick and Yasuda, 2010). Cumming and Dai (2011) suggest that larger PE funds might earn lower returns because the ratio of investments-to-staff increases. Thus, the VCPE-staff devote less time to each investment. Similar reasoning suggests that increasing diversification forces managers to monitor multiple industries/regions. Thus, if the ratio of industries/regions-to-staff increases, then staff devote less time to each region/industry. This might reduce returns. This induces Hypothesis 5.

Hypothesis 5 *PE-fund returns decrease with the industries (or geographies) to PE professionals.*

2.4 Fees and diversification

The fee structure might influence the fund's returns. PE funds obtain funding from investors (limited partners). The investors contract with the fund

to invest the money. The management contract stipulates the nature of the PE fund's compensation. The compensation typically comprises both (a) a management fee charged on capital under management, and (b) a performance bonus (carry) that is generally payable only if the fund's return exceeds a specific level (Kandel, Leshchinskii, and Yuklea, 2011; Metrick and Yasuda, 2010).

The structure of the fees might influence the reason the fund diversifies and this might influence returns. A key problem is that the carry is payable only if the fund's overall return exceeds the threshold. This might induce risk-aversion with respect to exceeding the threshold (Humphery-Jenner, 2011c). This risk aversion might induce PE managers to diversify the fund simply to reduce the risk of failing to reach the performance-bonus-threshold. Such risk-reduction-diversification might reduce value (following Amihud and Lev, 1999; Aron, 1988). Thus, I predict that the returns-to-diversification decrease with the ratio of carry-to-management fee. Hypothesis 6 summarizes this.

Hypothesis 6 *The returns-to-diversification decrease with the ratio of carry-to-management fee. That is, returns are negatively related to the interaction of (a) Carry fees/Management fees and (b) diversification.*

2.5 Joint industry and geography diversification

The interaction of industry and geographic diversification might influence PE-funds' returns. Hitt, Hoskisson, and Kim (1997) find that corporate returns increase (and then decrease) if firms jointly increase geographic and

industrial diversification. This is largely based upon (a) the creation of economies of scale and scope (Kogut, 1984), (b) the transfer of core business capabilities between industry and geographic units (see Hamel, 1991), and (c) taking advantages of market discrepancies, such as wage differences (Kogut, 1985).

PE-funds may similarly gain from joint-diversification; however, excess joint-diversification might reduce returns. This is for two key reasons. First, Jones and Hill (1988) and Hitt, Hoskisson, and Ireland (1994) suggest that increasing diversification can increase transaction costs. For PE-funds, these involve fund-raising costs and marketing costs, including management and logistics costs. Second, the joint-diversification, and subsequent reduction in any specialized regional or industrial knowledge, will likely increase the information-processing costs acknowledged in Hitt, Hoskisson, and Ireland (1994); Hitt, Hoskisson, and Kim (1997); Jones and Hill (1988). This is especially important for PE-funds due to the importance of knowledge sharing. This induces Hypothesis 7.

Hypothesis 7 *Diversification across both industry and geographic region initially increases returns, but significant joint-diversification reduces returns.*

2.6 Endogeneity and self-selection

The diversification literature has documented self-selection and endogeneity issues (for example Campa and Kedia, 2002; Villalonga, 2004). Prior studies focus on whether the the negative relation between firm value and diversifi-

cation (the 'diversification discount') is due to endogeneity. The situation in VCPE is different. Here, I hypothesize a positive relation between diversification and IRRs. Thus, the potential endogeneity is that high quality funds both (a) are more capable of managing the complexities of diversification, so are more likely to diversify, and (b) earn higher returns due to their latent skill and quality. This implies Hypothesis 8.

Hypothesis 8 *Endogeneity drives the diversification/return relation.*

2.7 Mosaic learning/knowledge-sharing hypothesis

The mosaic hypothesis joins some of the sub-hypotheses to examine whether any diversification-benefit reflects learning and knowledge sharing. A hypothesized reason for diversification to create value is that it may facilitate knowledge sharing and learning. Indirect support for this hypothesis arises if (a) the funds that are most likely to benefit from knowledge sharing/learning benefit from diversification, and (b) there is not another obvious reason for this diversification benefit, and (c) diversification in prior funds increases returns in the present fund.

A mosaic approach facilitates an indirect test of the learning/knowledge-sharing hypotheses. As suggested above, seed funds could benefit from knowledge-sharing/ learning, but may also benefit from risk reduction. This implies that there is some support for the learning/knowledge-sharing hypothesis if: (a) diversification creates value on average, (b) diversification especially benefits seed-funds, (c) this does not merely reflect risk-reduction, (d) it is not due to endogeneity/self-selection issues, and (e) diversification

in the prior fund raised by the fund's management firm increases returns in the present fund. This induces Hypothesis 9.

Hypothesis 9 *Knowledge-sharing/learning can (at least partially) explain any positive relation between returns and diversification.*

3 Methods

This section contains the methodology. First, I detail the sample. Second, I discuss the variables. Third, I combine these together to provide a fully detailed empirical strategy. Table 1 summarizes the empirical predictions and empirical testing strategy.

3.1 Sample

The sample derives from a Preqin, Thomson VentureXpert, and Execucomp. The sample contains 1505 funds that raised capital between 1980 and 2007.[2] Each observation represents a separate fund. There is only one observation per fund. The data is not panel data. Some private equity corporations manage several funds.[3] Each fund is a discrete corporate entity with a seperate legal identity.

These datasets provide data on (a) returns, (b) diversification, and (c) control variables that might influence returns. The sample excludes funds

[2]The study excludes observations from before 1980 due to the argued unreliability of Thomson VentureXpert before 1980. The results hold in a larger sample that includes funds raised before 1980.

[3]For example, Welsh, Carson, Anderson & Stowe have nine separate funds in the sample.

that lack return, diversification, or control-variable data. The study does not directly distinguish between 'venture' and 'private equity' funds. This is because there is no 'bright-line' distinction between the types of funds. Instead it uses control variables to examine the characteristics of these funds.

The variables are in three categories: (1) dependent (return) variables, (2) diversification variables, and (3) control variables that might influence returns; and thus, might explain any relationship between returns and diversification.

3.2 Dependent variable: IRRs and Risk-adjusted IRRs

The dependent variables measure the fund's performance. First, I focus on the fund's IRR.[4] I note the following.

These returns are net returns. I focus on net returns (gross returns less fees) because (1) Preqin provides net returns but not gross returns or the specific timing of cash flows; and thus, and inferring gross returns involves making potentially inaccurate assumptions about the fund's life and cash flows, and (2) net returns are more relevant because they are the returns that the investor receives from the fund.

The returns represent the returns for the latest year that the fund existed. Thus, if the fund is liquidated, then the IRR is based on all realized cash flows to date less the fees and carry. However, if the fund has not been liquidated, then the IRR is based on all realized cash flows and the esti-

[4]The results are robust to using another measure of the fund's return, its exit multiple (the final value of the fund divided by the amount of capital raised). I suppress these results for brevity.

mated value of unrealized assets. The estimated value is based on Preqin's internal estimates, and data that Preqin obtains from the investors (LPs) and/or the fund.

Second, I analyze the fund's risk-adjusted IRR in order to test Hypothesis 4, which predicts that diversification has no (or less) impact on risk-adjusted IRRs. I do this by subtracting the average return for all funds earned of the given fund's type and vintage. This benchmark return maximally reduces idiosyncratic risk; and thus, provides a way to test whether diversification influences risk-adjusted returns.

3.3 Hypothesized variables: Industry and Geographic diversification

The diversification variables are 'Num Inds' and 'Num Geos', which are respectively the number of industry-sectors[5] and number of geographic-regions[6] in which the fund invests.[7] The data is from Preqin.

I also examine diversification in prior funds raised by the given fund's

[5]Preqin indicates if the fund invests in companies in the following 48 fields: Business services, communications, computer services, consumer products, consumer services, media, education, engineering, environmental services, financial services, gaming, healthcare, security, manufacturing, clean technology, energy (general), energy (renewable), food, hardware, software, retail, utilities, biotechnology, medical devices, medical instruments, medical technology, entertainment, chemicals, aerospace, insurance, internet focused, marketing, leisure, environmental services.

[6]A geographic region is a 'country' (such as Australia) with two key exceptions: (1) north, east, south, west and central US count as separate regions, and (2) countries in the pacific rim count as one region.

[7]The results in Figure 1 show a linear relationship between IRRs and both industry-diversification and geographic-diversification. This suggests against including non-linear industry-diversification or geographic-diversification terms. While some studies show a curvilinear relationship between diversification and performance, (see Hoskisson, Hitt, and Hill, 1991; Palich, Cardinal, and Miller, 2000; Qian, Khoury, Peng, and Qian, 2010), these studies focus on pure corporate diversification as opposed to diversification in PE-funds.

management firm. A management firm can raise many funds. There may be some staffing over-lap between funds. Thus, if there is some overlap in personnel between funds and diversification does facilitate learning, then diversification in the prior fund should increase returns in the present fund. Thus, I examine models that replace 'Num Inds' and 'Num Geos' with the number of industries and/or regions invested in by the fund that (a) was raised immediately prior to the present fund, and (b) was raised by the present fund's management firm. These models drop observations for which there was no 'prior fund'. This reduces the sample size to 753 observations.

3.4 Hypothesized intermediating and moderator variables

Seed Fund: The variable 'Seed Fund' is an indicator that equals one if the fund invests in seed or start-up companies and prefers to invest in seed investments. A 'Seed Fund' can invest in non-seed investments; however, a 'Non Seed Fund' does not invest in seed investments.[8] Prior literature shows that start-up investments have a high failure rate (see for example Dimov and De Clercq, 2006; Roure and Maidique, 1986; Zacharakis and Meyer, 2000). Thus, the prediction is that smaller investments experience lower returns, on average. The investment size data is from VentureXpert the seed-investment data is from Preqin.

Number of people: The variable 'Num People' is the number of investment professionals in the fund. I obtain this from Preqin's Fund Managers database. The professionals are people who manage investments (and do

[8]Preqin only reports whether the fund makes seed investments. It does not report the dollar-value of the investments deemed to be seed investments. Thus, 'Seed' is a dummy variable rather than a continuous variable.

not include general and administrative staff). I use this to test Hypothesis 5 by analyzing the interaction terms 'Num Geos / Num People' and 'Num Inds / Num People'.

Carry/Flat: The variable 'Carry/Flat' is the ratio of the performance fees to the flat management fees. The 'carry' is the performance fee that is payable if the fund meets a certain benchmark return.[9] The management fee is typically around 1.5% to 2.5% of the funds under management. The goal is to test Hypothesis 6 by examining whether the interaction between industry/geographic diversification and 'Carry/Flat' reduces returns. I note that (1) there is no publicly available data on the fees charged by investors (LPs) to individual funds, but (2) there is little variation in fees when the funds are sorted into size-groups[10] and fund-types (Kandel, Leshchinskii, and Yuklea, 2011; Metrick and Yasuda, 2010). Thus, I use use the average carry and average flat-fee for fund's of the given fund's type and size (as suggested in Humphery-Jenner, 2011b).

Number of portfolio companies: The regressions control for the number of portfolio companies ('Num Port Cos'). I predict that increasing the number of portfolio companies should increase returns because it is likely to reduce the fund's exposure to idiosyncratic risk; and thus, should increase the the fund's risk-adjusted return. This addresses the possibility that risk reduction drives the relation between returns and industry/geographic diversification.

[9]Interviews with VCPE professionals, and data from Preqin, indicates that a typical bench mark is 8%.

[10]The fund size-groups are 0-50m, 50-100m, 100-250m, 250m-500m, 500m-1000m, 1000m-2000m, 2000m or greater. They are based on capital under management

3.5 Control variables

The control variables are factors that might influence the fund's returns; and thus, might explain the relationship between diversification and returns.

Fund size: Large funds might earn lower returns. The models control for the natural log of the fund's capitalization (denoted, 'ln(Fund Size)'). This captures the possibility that large size might entrench the fund-managers; and thus, might reduce fund-returns (consistent with Humphery-Jenner, 2011b; Humphery-Jenner and Powell, 2011; Moeller, Schlingemann, and Stulz, 2004, 2005). The fund size data is from VentureXpert.

Average investment size: Investments in smaller companies might earn lower returns. The variable 'ln(Investment Size)' is the natural log of the average size of the fund's investments. This data is from Thomson VentureXpert.

Number of rounds: I control for the number of investment rounds (stages) in which the fund participates ('Num Rounds'). This addresses the finding in Guler (2007) that institutional pressures might cause funds to make sub-optimal investments in subsequent investment stages. This data is from Thomson VentureXpert.

Claimed expertise: Funds that claim high levels of expertise should earn higher returns. VC and PE funds claim to generate value by contributing knowledge and skills to their portfolio companies (Ivanov and Xie, 2010). Preqin reports whether the fund manager claims to have expertise in (a) particular industries, (b) technology, (c) management, (d) operations, (e) marketing, (f) human resources (g) recruiting, (h) networking, or (i) strat-

egy. The models include the variable 'Expertise' that represents the number of fields in which the fund claims expertise. This data is self-reported as part of Preqin's data collection process. [11] Thus, 'expertise' is bound between zero and seven. The expertise data is from Preqin.

Connections: Industry and financial connections should increase returns. PE-funds can create value by facilitating knowledge-transfers (Powell, Koput, Bowie, and Smith-Doerr, 2002; Weber and Weber, 2007) or by obtaining better financing terms. Connections can facilitate better financing terms, and knowledge sharing (following Demiroglu and James, 2010; Hochberg, Ljungqvist, and Lu, 2007). A fund is more connected if its employees serve (or have served) in other PE-funds and/or on the board of publicly listed companies. Thus, for a given fund, the variable 'Connections' is the number of board-positions, or other PE-fund-roles, that its employees have had. The board-of-directors data is from Execucomp and the PE-fund-position data is from Preqin.

Reliance on own funding: A fund might experience lower returns if it must rely on its own funds to finance its investments. PE-funds usually obtain capital from limited partners ('LPs'). Thus, if a fund uses its own capital to fund its investments then it could signal either (a) that the fund is especially confident about its investments and wants to maintain a greater share of the profits; or, (b) the fund cannot raise enough capital from LPs. The former suggests a positive correlation between self-investment and returns; the later suggests a negative correlation. To capture the dominant

[11] I note that these figures are self-reported; and thus, are subject to some bias. However, such self-reported variables have seen use in similar corporate applications (see for example Campello, Graham, and Harvey, 2008; Lins, Servaes, and Rufano, 2010; Onega, Tümer-Alkan, and Vermeer, 2011).

effect, the models include 'Self Invests', an indicator that equals one if Preqin states that the fund has relied on its own capital.

Share ownership and board representation: PE-funds might improve returns by obtaining management control of their portfolio companies. Information asymmetry exists between PE-funds and the companies in which they invest (Trester, 1998). The PE-fund can ameliorate this by obtaining control rights in the portfolio company (following Berglöf, 1994; Chan, Siegel, and Thakor, 1990). Two sources of control rights are (1) a controlling shareholding and (2) representation on the board of directors. Thus, the indicator 'Prefers Controlling' equals one if the PE-fund requires a controlling shareholding, and the indicator 'Rep Required' equals one if the fund requires a position on the board of directors of its investee companies. Preqin provides the data on the fund's requirement (or lack thereof) for board representation and shareholdings.[12]

Average management and carry fees: Management fees are an expense that should reduce PE-fund returns. High fees might also induce high free cash flows within the fund, which might create Jensen (1986) type agency conflicts. Data on the fees that individual PE-funds charge is not publicly available. However, Preqin reports anonymous PE-fee data matched by year, which it sources directly from the funds' Private Placement Memorandums. Thus, the models control for the average management fee and average performance fee (carry) of the fund's type and size group. The anonymous fee data is from Preqin's fund terms database.

[12]The variables 'Prefer Control Shares' and 'Rep Required' are significantly positively correlated; however, the key results are qualitatively unchanged in models that omit either or both of these variables.

Syndication: Syndication should increase returns. The rationale is that syndicates can share expertise and exploit each-other's competitive advantages (Bygrave, 1987). For example, a syndicate might include members who are differently skilled at financing, technical-aspects, and trade-sales. Thus, a failure to syndicate might reduce returns. Thus, the models include an indicator ('Solo Investor') that equals one if Preqin reports that the PE-fund prefers to not invest in a syndicate.

VCPE conditions and Market returns: I control for the environment in which the fund raises capital. The rationale is that a strong general-market-performance might induce investors to invest substantial capital in the PE-fund industry. This over-investment might destroy value by (a) inducing large cash-holdings and causing Harford (1999) type agency conflicts; (b) creating a situation where funds have more capital than they have profitable investments; and thus, invest in companies with diminishing returns-to-investment (Diller and Kaserer, 2009; Gompers and Lerner, 2000); and (c) inspiring over-crowding in the PE-industry, which might reduce returns (following Zhang, 2007). Thus, I control for (1) an indicator that equals one if the return on the CRSP equally weighted index in the fund's vintage-year exceeds that in the prior year ('Strong Equity Market'); and (2) the number of fund's of the given fund's type[13] that exist in the fund's vintage year scaled by the total number of VCPE funds in that vintage year ('VCPE Sector Activity').

[13]The 'types' are: balanced, buyout, co-investment, subsidiary, distressed, early stage, seed, start-up, expansion, fund-of-funds, infrastructure, late stage, mezzanine, resources, real estate, secondaries, 'special situation', venture, and venture-debt.

3.6 Method of analysis

The goal is to test the hypotheses. I use multivariate regressions. The regression specification is in Equation (1). I examine both industry and geographic diversification. I also examine models that replace 'Num Inds' and 'Num Geos' with the level of diversification in the fund that was raised by the present fund's management firm and was raised immediately prior to the present fund.

The modeling technique is as follows: The main models models use OLS, include vintage dummies, and cluster standard errors by both vintage and by the fund's family or overarching management firm. I analyze Hypothesis 4 both by controlling for the number of companies in the fund's portfolio and by replacing the IRR with the risk adjusted IRR ('Adj IRR'). I analyze Hypothesis 8 by using GMM models. The GMM models instrument the variables 'Num Inds' and 'Num Geos'. Due to the lack of quality instruments I run separate regressions for each of industry and geographic diversification. The four instruments are (a) the number of funds that the management firm had previously raised, (b) an indicator that the management firm is a member of a venture capital organization, and indicators that the management firm prefers to invest across (c) a diverse range of industries, and (d) a diverse range of regions.[14] To test the validity of the instruments, I report Hansen J tests for overidentification and Kleibergen-Paap tests for underidentification. The general regression model is below:

[14] I deem a fund to prefer diverse industries/ regions if Thomson VentureXpert states that the fund has no preference over regions/industries or prefers diverse regions/industries. All instruments are from Thomson VenureXpert.

$$\text{Return} = f\,(\text{Num Inds}, \text{Num Geos}, \quad (1)$$
$$\text{Intermediating Term(s)}, \text{Controls})$$

Here, 'Return' is the return variable, which is either the fund's IRR or the risk-adjusted IRR ('Adj IRR'). 'Controls' represents the control variables. 'Intermediating Term(s)' represents the terms used to test the various hypotheses. Section 3.4 details the terms.[15]

4 Results

This section contains the results. First, present a sample description. Second, I present multivariate regression results. Third, I summarize and consolidate the results. Overall, I find that diversification increases returns. The most likely explanation is that diversification facilitates learning and knowledge-sharing. I base this on (a) the result that diversification especially increases returns for seed funds, (b) the positive relation between returns in the present fund and diversification in prior funds raised by the fund's management firm, and (c) the finding no other explanation appears to explain the relation between diversification and returns.

[15] In summary, they are: (Num Inds × Num Geos), (Num Inds × Num Geos)^2, Num Inds/ Num People, Num Geos/Num People, Num Inds × Carry/Flat, Num Geos × Carry/Flat, Num Port cos, Seed Fund.

4.1 Sample Description

Table 2 contains the sample description. Column 1 examines all PE-funds in the sample. Columns 2-5 partition the sample into geographic diversification quartiles, where geographic diversification is the number of countries in which the fund invests. Columns 6-9 partition the sample into industry diversification quartiles, where industry diversification is the number of industries in which the fund invests. All numbers are sample means.

The key univariate result is that IRRs and multiples increase with industry and geographic diversification. In both cases, funds whose industry, or geographic, diversification is in the top quartile of the sample have higher IRRs and multiples. Other interesting results are: First, industry diversification and geographic diversification appear to increase together; that is, funds that diversify across industries are more likely to diversify across countries. Second, diversified firms appear to establish more connections, emphasizing the importance of connections to operating across geographic and industry environments. Third, diversified funds are more likely to invest in 'seed' investments. This is likely because seed investments are risky; and thus, funds diversify in order to risk-manage.

4.2 Do diversified funds earn higher returns?

The results support the hypothesis that diversification across industry or geography, but not both, increases returns. The main regression results are in Table 3. The coefficients on 'Num Inds' and 'Num Geos' are positive and significant in all model specifications. This suggests that returns increase

with diversification.[16]

The coefficients on the interaction terms lend little support for Hypothesis 7 . The coefficient on (Num Inds $\times$ Num Geos)^2 is negative and statistically significant; however, is small in magnitude and is not economically significant. Further, the statistical significance appears to be due to a small number of high-diversification funds. For example, the interaction term (Num Inds $\times$ Num Geos)^2 is insignificant in a sample that excludes funds int he top 95% in terms of geographic diversification.

Figure 1 supports the results. It plots the fitted values from Equation (1) when there are no intermediating variables. That is, it shows the relation between (a) IRRs and Num Inds, and (b) IRRs and Num Geos. It illustrates the positive relationship between returns and both industry-diversification and geographic-diversification. In particular, Panel (a) suggests a monotonic relationship between industry diversification and IRRs. By contrast, some prior studies document a non-linear relationship between IRRs and diversification (see Hoskisson, Hitt, and Hill, 1991; Palich, Cardinal, and Miller, 2000; Qian, Khoury, Peng, and Qian, 2010). However, these studies focus on corporate diversification rather than PE-fund diversification.

The control variables yield some interesting results. Large funds, as proxied by 'ln(Fund Size)', earn significantly lower returns (at 1% significance in all models). This suggests diseconomies of scale in private equity. PE-funds that invest in large companies earn higher returns on average (the

[16]Unreported regressions find no evidence of a quadratic relationship between returns and 'Num Inds' or 'Num Geos'. That is, the coefficients on 'Num Inds^2' and 'Num Geos^2' are insignificant. Unreported regressions also examine the natural log of the level of industry and geographic diversification. These variables ('LnNumInds' and 'LnNumGeos') are positively and significantly related to returns; the results are qualitatively similar to those in the reported regressions.

coefficient on 'ln(Investment Size)' is positive and significant at 1% in all models). This may reflect skewness in the returns on small PE-investments.

PE-funds that are more connected earn higher returns (the coefficient on 'Connected' is significant at 5%). This quadrates with findings that connections are important to forming syndicates, facilitating knowledge-spillovers, and financing deals (see Hochberg, Ljungqvist, and Lu, 2007).

Funds that use their own money in the investment process earn lower returns (the coefficient on 'Self Invests' being negative and significant in most models). This may be because funds self-invest if investors are unwilling to invest in the fund. Thus unwillingness may derive from the belief that the fund lacks profitable investment opportunities.

The coefficient on 'Num Port Cos' is informative. The coefficient on 'Num Port Cos' is positive and significant. This implies that returns increase with the number of companies in the fund's portfolio. A possible explanation is that increasing the number of portfolio companies decreases the fund's exposure to company-specific (idiosyncratic) risk. This might improve the fund's risk/return relationship and ameliorate agency conflicts of managerial risk aversion.

Returns appear to decrease with the number of financing rounds ('Num Rounds'). Guler (2007) suggests that institutional/political pressures may induce sub-optimal investments in subsequent investment rounds. The negative coefficient on 'Num Rounds' provides some support for this hypothesis, indicating that returns decrease if the fund undertakes many investment rounds.

The coefficients on 'VCPE Sector Activity' and 'Strong Equity Market' are interesting. First, 'VCPE Sector Activity' is negative and significant in most models. This quadrates with the 'money chasing deals' hypothesis that excess VCPE activity creates over-crowding and forces funds to invest in companies that have diminishing returns-to-investment (Diller and Kaserer, 2009, see). Second, 'Strong Equity Market' is insignificant and is usually negative. The negative coefficient quadrates with the 'money chasing deals' hypothesis. The insignificance suggests that the activity in the VCPE sector is more relevant than the activity in the general market.

The overall finding is that diversification increases returns. The issue is then whether diversification especially benefits funds that invest in start-ups.

4.3 Does diversification especially assist PE-funds that make seed investments?

The results support the seed-fund hypothesis (Hypothesis 2). The prediction is that diversification is especially beneficial to funds that invest in seed companies. The regression results are in Panel A of Table 4. I suppress control variables for brevity (the results for the control variables quadrate with those in Table 3). The main findings are (1) 'Num Geos × Seed' is postive and significant in all models, and (2) 'Num Inds × Seed Fund' is positive and significant in most models that do not control for 'Num Geos × Seed Fund'. This implies that geographic diversification is more useful for seed funds than is industry diversification.

4.4 Returns and prior fund diversification

The results indicated that diversification in previous funds increases IRRs. The learning hypothesis suggests that knowledge learned in prior funds can filter through into subsequent funds raised by a management firm. Thus, if (a) a management firm/ family raises multiple funds, and (b) there is some overlap in personnel (or at least communication) between the funds, and (c) diversification improves fund-managers' skills, then then diversification in prior funds should increase IRRs in subsequent funds.

The results are in Panel B of Table 4. The key result is that the coefficient on 'Num Inds (Prior Fund)' is positive and significant in all models and 'Num Geos (Prior Fund)' is positive and significant in most models. This suggests that diversification in prior funds improves IRRs in subsequent funds. This implies some support for the hypothesis that diversification improves returns by facilitating learning and knowledge-sharing.

4.5 Diversification and limited attention

There is support for the limited attention hypothesis. Panel C of Table 4 contains the 'limited attention' regressions. They test the hypothesis that diversification reduces returns if it spreads staff across more industries or regions. The coefficients on the term 'Num Inds/Num People' is negative and significant in all specifications (Columns 1-6). The term 'Num Geos/Num People' is negative and significant in regressions that do not control for 'Num Inds/Num People' (Columns 1,2,4,5). This implies that while both forms of diversification can reduce value by spreading staff, industry diversification

is more harmful in this respect.

4.6 Diversification and Fees

There is some support for the prediction that high levels of carry can create risk aversion, which can motivate managers to diversify to reduce risk; and thus, can reduce returns. The regression results are in Panel D of Table 4. They key finding is that both interactions term ('Carry/Flat × Num Geos' and 'Carry/Flat × Num Inds') are negative and significant across all models. This implies that performance-based compensation can reduce returns by encouraging value destroying diversification (likely designed to reduce the risk of failing to earn a performance bonus).

4.7 Endogeneity

Endogeneity does not drive the relation between diversification and IRRs. The GMM results are in Table 5. The key that 'Num Inds' and 'Num Geos' remain positive and significant in both models (albeit at a lower level of statistical significance). Importantly, the Hansen J statistic suggests that I cannot reject the null of over-identification and the Kleibergen-Paap statistics suggest that I can reject the null of under-identification. This implies that the instruments are valid.

4.8 Summary of results

The mosaic of results suggests that diversification creates value on average and that this may be because it may facilitate knowledge-sharing. No individual result shows this. The key results are (1) diversification creates value on average and there is limited evidence; (2) diversification is not per se quadratically related to returns (except for some very high diversification funds); (3) diversification especially creates value for seed-funds, which are the funds for whom diversification would convey the most knowledge-sharing benefits; (4) diversification in prior funds raised by a management firm increases IRRs in subsequent funds, which implies learning from prior funds' diversification-based experiences; (5) endogeneity does not appear to drive the relation between returns and diversification; and (6) risk-reduction does not drive the diversification/return relation. Overall, this suggests that diversification can create value by encouraging knowledge-sharing and learning.

There is some support for the theory that risk-reduction increases IRRs; however, this does not solely drive the relation between diversification and returns. This is because (1) returns increase with the total number of companies in the funds' portfolio, implying that reducing the exposure to company-specific risk increases returns; but, (2) industry/geographic diversification still increases returns after controlling for the number of portfolio companies, and industry/geographic diversification increase risk-adjusted IRRs.

Diversification can destroy value in some circumstances. It can destroy value if it spreads staff over more industries or regions (i.e. lowers the staff-to-industry or staff-to-region ratios). There is also some evidence that di-

versification coupled with a high carry/flat ratio reduces returns, suggesting risk-reduction motivated diversification.

5 Conclusion

This paper analyzes the benefits and disbenefits of diversification in PE-funds. The corporate finance literature has focused on diversification as an avenue of value destruction. The literature shows that diversified firms have lower market values and make worse investment decisions (see for example Moeller and Schlingemann, 2005). However, diversification might improve returns for corporations that make risky investments, lack agency conflicts, and benefit from knowledge-spillovers. PE-funds are a key example of such corporations.

The empirical results show that diversification benefits PE-funds on average. The combined weight of evidence suggests that knowledge sharing and learning drive the results. The key support is that: First, diversification especially increases returns for seed funds, which invest in high-tech companies that particularly benefit from knowledge-sharing and learning. Second, returns are positively related to diversification in prior funds raised by the fund's management firm. Thus, if there is some communication between funds, or there is some personnel overlap, then this implies knowledge sharing and learning from prior diversification. Third, risk-reduction and endogeneity do not appear to explain the relation between diversification and returns.

The results also suggest that diversification can destroy value. diversi-

fication destroys value if it spreads staff to thinly; that is, if it lowers the ratio of staff-to-industries or staff-to regions. Diversification may also destroy value if it couples with an emphasis on performance fees, suggesting that agency conflicts of managerial risk aversion drive such diversification.

Additional contributions are that increasing the number of portfolio companies increases returns. This implies that reducing the overall exposure to idiosyncratic risk benefits fund returns. Further, I find some support for the theory in Guler (2007) that political and institutional pressure can induce sub-optimal investments in subsequent investment rounds. Specifically, returns are negatively related to the number of investment rounds in which the fund partakes.

These results make a key contribution to the private equity, venture capital, and management literature. The results show that PE-funds and VC-funds can create investor-value by diversifying across industries and across geographies. From a management perspective, the results show that diversification does not always destroy value, and can create value for some firms. The results suggest that future literature can examine other types of corporation that might benefit from diversification.

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6 Tables

Table 1: Empirical Predictions

Hypothesis	Prediction	Empirical Test/Implication
Hypothesis 1	Diversification increases returns.	The diversification variables 'Num Inds' and 'Num Geos' are positively related to returns.
Hypothesis 2	Diversification especially increases returns for seed funds.	The interactions 'Seed × Num Inds' and 'Seed × Num Geos' are positively related to returns.
Hypothesis 3	Diversification in the last fund that was raised by the present fund's management firm should increase returns in the present fund.	The variables 'Num Inds (Prior Fund)' and 'Num Geos (Prior Fund)' are positively related to returns.
Hypothesis 4	Diversification has no (or limited) impact on risk-adjusted returns.	The variables 'Num Inds' and 'Num Geos' are not significantly related to the risk-adjusted returns 'Adj IRR', and do not influence returns after controlling for general portfolio diversification (as proxied by number of portfolio companies).
Hypothesis 5	Diversification reduces returns if it spreads the staff across more industries.	The interaction term (Diversification/Number of Staff) is negatively related to returns.
Hypothesis 6	Diversification reduces returns in funds that rely more on performance bonuses than on management fees (because diversification is merely to reduce fund-risk).	Returns are negatively related to the term (Carry/Management) × Diversification.
Hypothesis 7	There is a quadratic type relationship between returns and joint industry-geographic diversification.	(Industry Diversification × Geographic Diversification) increases returns whereas (Industry Diversification × Geographic Diversification)^2 decreases returns.

Hypothesis 8	The relation between diversification and returns merely reflects endogeneity.	Diversification does not influence returns in GMM regressions that instrument 'Num Inds' or 'Num Geos'.
Hypothesis 9	Knowledge-sharing/learning at least partially explains the relation between diversification and value-creation.	Diversification increases returns on average, this especially holds for seed funds, is not due to mere risk-reduction and is not due to endogeneity/ self-selection.

Table 2: Univariate Results

Table 2 contains the univariate statistics for the sample of 1505 PE-funds. Column 1 contains means for all the funds. Columns 2-5 focus on geographic diversification. Geographic diversification is the number of countries in which the fund invests. Columns 2, 3, 4, and 5 contain averages for funds whose geographic diversification is in the 1^{st}, 2^{nd}, 3^{rd} or 4^{th} quartile, respectively. Columns 6-9 focus on industry diversification. Industry diversification is the number of industries in hwich the fund invests. Columns 2, 3, 4, and 5 contain averages for funds whose geographic diversification is in the 1^{st}, 2^{nd}, 3^{rd} or 4^{th} quartile, respectively.

	All Funds	**Geographies**				**Industries**			
		Quartile 1	Quartile 2	Quartile 3	Quartile 4	Quartile 1	Quartile 2	Quartile 3	Quartile 4
IRR (%)	8.912	6.502	8.259	10.778	12.895	4.481	6.965	10.951	13.958
Adj IRR (%)	3.204	0.991	3.150	5.026	6.500	-1.159	2.233	5.062	7.311
Multiple	1.590	1.489	1.578	1.641	1.768	1.409	1.539	1.669	1.769
Num Inds	12.378	10.337	12.764	13.706	15.381	4.542	9.480	14.529	22.589
Num Geos	5.638	2.747	4.000	5.478	12.460	4.688	4.331	6.343	7.381
ln(Fund Size)	5.516	5.294	5.439	5.506	6.014	5.170	5.528	5.586	5.843
ln(Investment Size)	9.047	8.889	9.170	8.926	9.385	8.812	9.044	9.066	9.316
Seed Fund	0.071	0.065	0.037	0.075	0.099	0.046	0.088	0.072	0.081
Expertise	3.690	3.398	3.974	3.776	4.074	2.898	3.621	3.793	4.619
Connections	2.450	2.340	1.377	3.263	2.668	1.729	2.189	2.685	3.336
Self Invests	0.085	0.016	0.079	0.059	0.247	0.039	0.085	0.147	0.063
Rep Required	0.386	0.387	0.340	0.435	0.373	0.344	0.376	0.361	0.480
Prefers Control Shares	0.128	0.124	0.110	0.110	0.159	0.082	0.128	0.110	0.210
Solo Investor	0.179	0.169	0.099	0.286	0.167	0.094	0.157	0.245	0.225
Num Rounds	34.938	30.777	30.037	48.281	36.633	26.348	28.142	36.196	51.649
Num Port cos	15.609	14.404	12.275	19.422	17.172	11.276	12.649	17.838	21.432
Num People	9.065	6.967	7.778	9.956	13.444	6.366	7.668	10.005	12.770
Ave Flat	2.219	2.214	2.186	2.238	2.232	2.256	2.231	2.212	2.166

Ave Carry	20.500	20.176	20.401	20.323	21.345	20.413	20.530	20.414	20.683
Carry/Flat	9.445	9.240	9.532	9.234	9.970	9.229	9.393	9.409	9.820
Num Inds/ Num people	1.787	1.839	2.115	1.806	1.489	1.036	1.609	1.970	2.682
Num Geos/ Num People	0.791	0.584	0.676	0.851	1.237	0.985	0.702	0.755	0.698
VCPE Sector Activity	0.168	0.165	0.171	0.177	0.167	0.142	0.153	0.189	0.191
Strong Equity Market	0.482	0.475	0.524	0.486	0.470	0.459	0.490	0.484	0.497

Table 3: Diversification and returns

Table 3 contains the regression results. The dependent variable for Columns 1-3 is the fund's IRR. The dependent variable for Columns 4-6 is the fund's benchmark adjusted IRR. Brackets contain p-values based upon robust standard errors clustered by vintage. Superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent Variable	IRR (1)	IRR (2)	IRR (3)	Adj IRR (4)	Adj IRR (5)	Adj IRR (6)
Num Inds	0.294***	0.541***	0.205	0.260***	0.489***	0.15
	[0.004]	[0.000]	[0.212]	[0.006]	[0.000]	[0.319]
Num Geos	0.029	0.737***	0.275	0.048	0.704***	0.24
	[0.853]	[0.010]	[0.340]	[0.734]	[0.004]	[0.320]
Num Rounds	-0.072**	-0.069**	-0.067**	-0.056*	-0.053*	-0.051*
	[0.020]	[0.027]	[0.031]	[0.051]	[0.065]	[0.076]
Num Port Cos	0.182**	0.179**	0.168*	0.198**	0.196**	0.185**
	[0.041]	[0.044]	[0.057]	[0.015]	[0.016]	[0.022]
Num People	0.384***	0.462***	0.461***	0.348***	0.421***	0.419***
	[0.005]	[0.001]	[0.001]	[0.006]	[0.001]	[0.001]
Num Inds × Num Geos		-0.045***	0.037		-0.042***	0.041
		[0.001]	[0.221]		[0.001]	[0.123]
(Num Inds × Num Geos)^2			-0.001***			-0.001***
			[0.002]			[0.001]
ln(Fund Size)	-2.535***	-2.727***	-2.843***	-2.735***	-2.914***	-3.028***
	[0.002]	[0.001]	[0.001]	[0.000]	[0.000]	[0.000]
ln(Investment Size)	2.090***	2.114***	2.303***	1.840***	1.862***	2.051***
	[0.003]	[0.002]	[0.001]	[0.004]	[0.003]	[0.001]
Seed Fund	8.168**	8.032**	7.333**	8.823***	8.701***	8.002***
	[0.017]	[0.018]	[0.028]	[0.005]	[0.005]	[0.009]
Expertise	0.502*	0.48	0.458	0.501*	0.480*	0.458*
	[0.088]	[0.102]	[0.119]	[0.063]	[0.074]	[0.088]

Connections	0.194**	0.181*	0.177*	0.168**	0.156*	0.152*
	[0.039]	[0.056]	[0.062]	[0.041]	[0.060]	[0.068]
Self Invests	-3.390*	-3.884**	-4.924**	-3.256*	-3.714**	-4.765**
	[0.067]	[0.036]	[0.012]	[0.067]	[0.036]	[0.011]
Rep Required	0.763	0.295	0.776	0.633	0.2	0.683
	[0.574]	[0.829]	[0.561]	[0.618]	[0.876]	[0.585]
Prefer Control Shares	-1.418	-0.733	-0.579	-2.35	-1.718	-1.567
	[0.380]	[0.651]	[0.720]	[0.122]	[0.258]	[0.301]
Ave Mgt Fee	-3.337**	-3.597**	-3.191**	-1.463	-1.706	-1.291
	[0.034]	[0.020]	[0.037]	[0.342]	[0.261]	[0.386]
Ave Carry	0.756**	0.680**	0.677**	0.37	0.3	0.297
	[0.014]	[0.026]	[0.025]	[0.188]	[0.286]	[0.285]
Solo Investor	0.991	1.093	1.759	0.794	0.89	1.566
	[0.512]	[0.466]	[0.245]	[0.569]	[0.520]	[0.261]
VCPE Sector Activity	-11.170**	-10.793**	-10.917**	-8.148	-7.829	-7.901
	[0.040]	[0.048]	[0.045]	[0.118]	[0.134]	[0.130]
Strong Equity Market	6.174	6.529	7.22	-9.59	-9.469	-8.479
	[0.590]	[0.580]	[0.531]	[0.333]	[0.358]	[0.392]
Constant	-11.224	-13.287	-15.022	-9.014	-10.746	-13.236
	[0.399]	[0.326]	[0.254]	[0.480]	[0.408]	[0.296]
Observations	1,505	1,505	1,505	1,501	1,501	1,501
R-squared	28.50%	28.90%	29.30%	10.40%	10.80%	11.40%

Figure 1: Fitted IRRs by Industry Diversification and Geographic Diversification

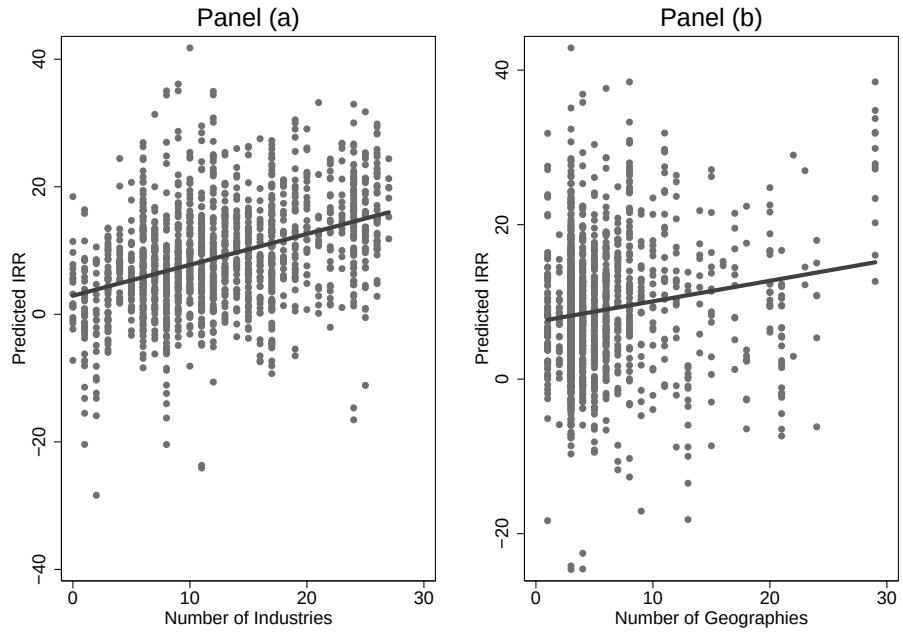

Figure 1 plots 'predicted IRRs' by industry and geographic diversification. For Panel (a), the 'predicted IRRs' are the fitted values from an estimation of Equation (1) that only includes 'NumInds' and the controls; for Panel (b), the 'predicted IRRs' are the fitted values from an estimation Equation (1) that only includes 'NumGeos' and the controls. The vertical axis is the fund's percentage IRR. The horizontal axis in Panel (a) is the number of industries in which the fund invests; and for Panel (b) is the number of geographic regions in which the fund invests.

Table 4: Seed Funds, Number of People, and Fees

Dependent Variable	IRR	IRR	IRR	Adj IRR	Adj IRR	Adj IRR
Panel A: Seed Funds						
NumInds	0.193**	0.268***	0.207**	0.183**	0.231**	0.198**
	[0.044]	[0.007]	[0.030]	[0.040]	[0.013]	[0.026]
NumGeos	0.017	-0.087	-0.068	0.039	-0.068	-0.058
	[0.916]	[0.570]	[0.658]	[0.785]	[0.623]	[0.677]
Num People	0.402***	0.413***	0.418***	0.362***	0.377***	0.380***
	[0.003]	[0.002]	[0.002]	[0.004]	[0.003]	[0.003]
Seed × Num Inds	1.154**		0.762	0.874*		0.414
	[0.037]		[0.200]	[0.077]		[0.435]
Seed × Num Geos		2.687**	2.053*		2.754***	2.403**
		[0.010]	[0.071]		[0.004]	[0.022]
Constant	-9.645	-12.544	-11.191	-7.77	-10.114	-9.385
	[0.468]	[0.342]	[0.396]	[0.549]	[0.431]	[0.467]
Observations	1,505	1,505	1,505	1,501	1,501	1,501
R-squared	0.291	0.293	0.295	10.90%	11.50%	11.60%
Panel B: Prior Fund Diversification						
Num Inds (Prior Fund)	0.308*		0.308*	0.338**		0.338**
	[0.053]		[0.053]	[0.013]		[0.013]
Num Inds (Prior Fund)	0.394*	0.462**	0.394*	0.202	0.277*	0.202
	[0.051]	[0.020]	[0.051]	[0.214]	[0.088]	[0.214]
Constant	-0.633	4.47	-0.633	1.485	7.076	1.485
	[0.953]	[0.660]	[0.953]	[0.874]	[0.421]	[0.874]
Observations	753	753	753	753	753	753

R-squared	13.90%	13.30%	13.90%	10.10%	9.20%	10.10%
Panel C: Number of People						
NumInds	0.512***	0.299***	0.500***	0.476***	0.264***	0.472***
	[0.000]	[0.003]	[0.001]	[0.000]	[0.005]	[0.000]
NumGeos	0.065	0.238	0.098	0.084	0.242	0.097
	[0.671]	[0.221]	[0.640]	[0.546]	[0.181]	[0.617]
Num People	0.108	0.219	0.097	0.074	0.195	0.07
	[0.514]	[0.170]	[0.572]	[0.632]	[0.192]	[0.664]
Num Inds/ Num People	-1.319***		-1.243**	-1.310***		-1.279**
	[0.003]		[0.023]	[0.003]		[0.017]
Num Geos /Num People		-1.784*	-0.297		-1.650*	-0.118
		[0.052]	[0.798]		[0.067]	[0.916]
LnFundSize	-2.659***	-2.521***	-2.649***	-2.858***	-2.721***	-2.854***
	[0.001]	[0.002]	[0.001]	[0.000]	[0.000]	[0.000]
Constant	-10.428	-8.813	-10.072	-8.33	-6.964	-8.199
	[0.433]	[0.508]	[0.451]	[0.511]	[0.587]	[0.520]
Observations	1,505	1,505	1,505	1,501	1,501	1,501
R-squared	28.80%	28.60%	28.80%	10.80%	10.50%	10.80%
Panel D: Fees						
NumInds	1.164***	0.284***	1.038***	0.800***	0.255***	0.692**
	[0.000]	[0.006]	[0.001]	[0.006]	[0.007]	[0.021]
NumGeos	0.047	0.843**	0.615	0.057	0.676*	0.544
	[0.764]	[0.030]	[0.100]	[0.691]	[0.056]	[0.127]
Num People	0.403***	0.397***	0.404***	0.357***	0.354***	0.358***
	[0.004]	[0.004]	[0.004]	[0.006]	[0.006]	[0.006]
Carry/Flat	-0.93	-0.797	0.39	0.414	0.856	1.547
	[0.832]	[0.856]	[0.930]	[0.919]	[0.834]	[0.706]

Carry/Flat × Num Inds	-0.092***		-0.079***	-0.057**		-0.046*
	[0.001]		[0.004]	[0.029]		[0.087]
Carry/Flat × Num Geos		-0.081**	-0.057*		-0.063**	-0.049
		[0.012]	[0.062]		[0.031]	[0.101]
Constant	-10.003	-9.602	-20.583	-14.71	-17.472	-23.833
	[0.755]	[0.765]	[0.525]	[0.626]	[0.561]	[0.433]
Observations	1,505	1,505	1,505	1,501	1,501	1,501
R-squared	28.80%	28.70%	28.90%	10.50%	10.50%	10.60%

Table 5: GMM Regressions

Table 5 contains GMM-based regression results. The dependent variable is the fund's IRR. Brackets contain p-values based upon robust standard errors. All models include vintage dummies. The instrumented variables are 'Num Inds' and 'Num Geos'. The four instruments are: the number of funds that the management firm had previously raised, an indicator that the management firm is a member of a venture capital association, and indicators that the management firm prefers to invest across a diverse range of industries or regions. Superscripts ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Dependent Variable	IRR (1)	IRR (2)
Num Inds	1.691**	
	[0.040]	
Num Geos		1.804*
		[0.067]
Num Rounds	-0.082**	-0.071**
	[0.011]	[0.027]
Num Port Cos	0.099	0.234***
	[0.347]	[0.010]
Num People	-0.226	-0.174
	[0.581]	[0.692]
ln(Fund Size)	-2.359***	-2.545***
	[0.005]	[0.004]
ln(Investment Size)	2.504***	2.301***
	[0.001]	[0.002]
Seed Fund	7.070**	7.986**
	[0.028]	[0.014]
Expertise	-0.093	0.518*
	[0.840]	[0.082]
Connections	0.182*	0.279***
	[0.080]	[0.009]
Self Invests	-6.247**	-13.299**
	[0.012]	[0.034]
Rep Required	0.567	0.855
	[0.692]	[0.533]
Prefer Control Shares	-2.04	-1.886
	[0.227]	[0.270]
Ave Mgt Fee	-2.192	-4.203**
	[0.260]	[0.020]
Ave Carry	1.024***	-0.194
	[0.005]	[0.754]
Solo Investor	-0.57	1.53
	[0.711]	[0.341]
VCPE Sector Activity	-21.167**	-6.213
	[0.014]	[0.268]
Strong Equity Market	-2.61	-3.944
	[0.321]	[0.116]

Constant	-46.806***	-9.247
	[0.001]	[0.407]
Observations	1,505	1,505
R-squared	18.50%	21.90%
Hansen J overidentification statistic	5.005	5.446
	[0.172]	[0.142]
Kleibergen-Paap LM underidentification statistic	17.86***	25.62***
	[0.001]	[0.000]
Kleibergen-Paap Wald underidentification statistic	18.97***	28.82***
	[0.001]	[0.000]