Department of Industrial Engineering and Management

Understanding Private Equity Fund Returns

**Access as the Determinant of Differences
between Limited Partners' Private Equity Returns**

Otso Manninen

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Abstract

Top quartile of private equity funds produce superior returns compared to lower quartile funds or to most other asset classes (the difference in internal rate of return to first quartile funds compared to fourth quartile funds can be over 50 percentage units). Some limited partners continuously invest in the top quartile funds while others have very few investments to such funds. Given the nature of the private equity industry, and the information available to limited partners at the time of the investment decision, such results are puzzling.

In this dissertation, utilizing a unique dataset I compiled for this dissertation, I show that large pension funds as limited partners are not statistically different in their ability to pick better private equity funds for their investments when prior returns to these funds' general partners are controlled for. Given that the access to invest in private equity funds is limited, and limited partners' prior investments are the main determinant of their access, the prior returns to limited partners are the main determinant of their future returns.

Utilizing a simulation model I have developed based on the findings of the empirical analyses conducted in this dissertation and prior knowledge of private equity industry, I show that when general partners consider some of the limited partners to be better investors, there will be systematical differences between returns realized by different types of limited partners.

Altogether the results of this dissertation help to explain several empirical findings in the prior private equity research: why systematic differences exist between limited partners? Why access is more important determinant of returns than selection skills? And how transparency of the private equity industry affects the return dynamics? Furthermore, the results of the empirical analysis show the importance – and one example method – of controlling for prior returns when analyzing the future returns in private equity.

Tiivistelmä

Tuotoiltaan parhaimman neljänneksen pääomarahastot tuottavat huomattavasti parempia tuottoja sijoittajilleen verrattuna alempien neljänneksien rahastoihin tai suurimpaan osaan muista sijoitusluokista (ensimmäisen ja neljännen kvartaalin rahastojen välillä IRR-tuottojen ero voi olla jopa yli 50 prosenttiyksikköä). Osa sijoittajista onnistuu jatkuvasti sijoittamaan parhaimpiin rahastoihin, kun taas osalla sijoittajista ei ole montaakaan tällaista sijoitusta. Ottaen huomioon pääomasijoitusten luonteen ja sijoittajalla käytettävissä olevan informaation sijoituspäätöstä tehtäessä, nämä tulokset herättävät kysymyksiä.

Hyödyntäen kokoamaani aineistoa, osoitan tässä väitöskirjassa, että suuret eläkerahastot pääomarahastosijoittajina ovat tilastollisesti yhtä hyviä valitsemaan sijoituskohteitaan, kunhan näiden rahastojen hallinnointiyhtiöiden aikaisemmat tuotot otetaan huomioon. Koska mahdollisuus sijoittaa parhaimpiin rahastoihin on rajoitettu, ja koska sijoittajan aikaisemmat sijoitukset ovat keskeinen määrittäjä sijoitusmahdollisuuksille, niin aikaisemmat tuotot ovet keskeinen määrittelevä tekijä pääomasijoittajan tuleville tuotoille.

Hyödyntäen empiirisen aineiston ja aikaisemman pääomasijoitustutkimuksen pohjalta kehittämääni simulaatiomallia, pystyn myös osoittamaan, että kun huomioimme pääomarahastojen hallinnointiyhtiöiden suosivan tietynlaisia sijoittajia, tuottoerot tietyntyyppisten sijoittajien välillä tulevat olemaan pysyviä.

Kaiken kaikkiaan väitöskirjani auttaa vastaamaan moniin aikaisemman tutkimuksen avoimeksi jättämiin kysymyksiin: Miksi pysyviä tuottoeroja esiintyy erityyppisten sijoittajien välillä? Miksi pääsy sijoittamaan parhaimpiin rahastoihin vaikuttaa tuottoihin enemmän kuin valinta näiden rahastojen välillä? Ja miten avoimuus vaikuttaa tuottojen käyttäytymiseen? Väitöskirjani tulokset osoittavat myös miten huomioida ja miksi on tärkeää huomioida aikaisemmat tuotot silloin kuin tarkastellaan pääomarahastojen sijoittajien saamia tuottoja.

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Contents

1. Introduction

What can the institutional investors investing in private equity do to increase their investment returns? While private equity returns have been studied to some extent over the past decade (see, e.g., Cochrane 2005; Kaplan & Schoar 2005; Phalippou & Gottschalg 2009), prior research has mainly focused on the descriptive analysis of average returns to private equity investors – these prior studies have typically excluded the analysis of the drivers for the institutional investors' realized returns (for a few exceptions, see Lerner *et al.* 2007; Sensoy *et al.* 2013). So far, the effect of access and the effect of selection skills on the subsequent returns are not explicitly known (again for an exception, see Sensoy *et al.* 2013). Access refers to which funds the limited partner is able to invest in while selection is about how well the limited partner can choose from within the funds in which he/she is able to invest in. Professionals working in the private equity industry have acknowledged the importance of the two factors (e.g., Meyer & Mathonet 2005).

Private equity funds have been fairly popular among institutional investors during the past decades with the assets under management reaching staggering USD 2.5 trillion in 2008 (Kaplan & Strömberg 2009; Preqin 2009). Major part of this capital has been invested by institutional investors, including banks, pension funds, insurance companies, and endowments. This highlights the need for better understanding of the investment returns.

Private equity funds are typically structured as limited partnerships (e.g., Sahlman 1990) where the investors act as limited partners (LP) and a general partner (GP) acts as the fund manager (e.g., Sahlman 1990; Lerner & Schoar 2004). In the limited partnership fund structure, the limited partners typically invest major part of the capital but are restricted from taking part in the daily management of the fund in exchange for limited liability and tax benefits (Sahlman 1990; Lerner & Schoar 2004). Once committed to invest in a fund, the limited partner is effectively forced to remain as an investor for the duration of the fund's lifetime, which can be over ten years (Meyer & Mathonet 2005).

With no public and open market for investment opportunities, the limited partners must be able to invest in a fund in addition to knowing about the fund's existence. Not all limited partners are able to invest in all of the funds they know of, and therefore, unlike in many other asset classes (e.g., exchange traded stocks and most bonds), access to investment opportunities affects the subsequent returns realized by the institutional investors investing in private

equity funds. Thus, selection of investment targets, which is the dominant problem in most other asset classes, is not the only determinant of returns to private equity funds. Another difference between private equity and most other asset classes is the strictly limited number of investors in a single private equity fund.

The importance of a limited partner's investment decisions is highlighted by the illiquidity of investments, long investment durations, and large individual investments (in capital terms). The role of the investment decisions is affected by the fact that the difference in returns to the first quartile funds and to the third quartile funds is significant. Kaplan & Schoar (2005) report that the returns to 25th percentile have IRR of 0.17 as compared to IRR of -0.31 for the 75th percentile of funds. Limited partners try to invest in those general partners with highest prior returns because returns to a general partner's subsequent funds tend to be persistent and because prior fund returns is the best public indicator of future returns (Kaplan & Schoar 2005; Sørensen 2007; Phalippou & Gottschalg 2009). Not every limited partner is able to invest in the highest return general partners, so access to new private equity funds established by general partners with high prior returns makes it more likely for a limited partner to have higher portfolio returns also in the future (Meyer & Mathonet 2005; Mathonet & Meyer 2007; Sensoy *et al.* 2013). The role of access is further intensified by the fact that general partners with high returns can often choose their investors (Lerner & Schoar 2004) and they prefer investors who have invested in the general partner's prior funds and/or investors with high overall investment returns. Despite the evident relevance of access as a determinant of returns, the effect of access on the limited partners' investment returns has received relatively little academic attention and mostly the academic research so far has downplayed the importance of access (see Lerner *et al.* 2007; Sensoy *et al.* 2013). The role of access, on the other hand, has been highly recognized among the private equity professionals even if the academics have been more hesitant about it (Meyer & Mathonet 2005; Fraser-Sampson 2007; Mathonet & Meyer 2007).[1]

Because general partners with high returns to their previous funds can typically choose their investors for new funds (Kaplan & Schoar 2005; Diller & Kaserer 2009), being able to invest in such a fund often means that: i) the limited partner has invested in a prior fund managed by the same general partner (Lerner & Schoar 2004; Hochberg *et al.* 2010), ii) the fund is set up by a general partner that does not have many prior funds, or iii) that the general partner has poor returns to some of its prior funds. While the first option is preferable, very few limited partners are in such a position to choose their new investments exclusively from within this group. In the second case, there are very few pieces of information that can help, ex ante, limited partners to choose a novel general partner whose funds will turn out to be high performers. Factors such as funds' diversification across portfolio companies (Lossen 2006), fund type (Ljungqvist & Richardson 2003), and general fund inflow to

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[1] A private equity professional at a Finnish institutional investor said in an interview that: "During the last years… so called access [to high return general partners' funds] has been difficult to achieve".

all private equity funds during the year in question (Gompers & Lerner 2000; Diller & Kaserer 2009) are of no use in discriminating between two similar alternatives in a given year. The main predictor of a fund's performance is the performance of the previous funds set up by the same general partner (Kaplan & Schoar 2005; Sørensen 2007; Phalippou & Gottschalg 2009). While the performance proxy serves as a warning sign in the case of low-performing funds, it is unavailable for new funds. Therefore limited partners need to use also other proxies to complement and supplement this information (Meyer & Mathonet 2005; Groh & Liechtenstein 2009).

Due to the return persistence on the general partner level (Kaplan & Schoar 2005; Sørensen 2007; Phalippou & Gottschalg 2009), differences between general partners' returns may pass on to the limited partner level and as such investing in high-return general partners is crucial for the limited partner to gain high returns. Therefore, access and selection are the two determinants of limited partners' private equity fund investment returns. Still, very little is known about which of the two drivers, access or selection, is the more important determinant of the limited partners' subsequent returns. Lerner *et al.* (2007) suggest that there are systematic differences in the returns that different types of limited partners are able to attain even when access is controlled for. However, in their study on reinvestment decisions, Lerner *et al.* (2007) do not explicitly take into account the funds available to different investors and the general partners' track records. Sensoy *et al.* (2013) found that in the early years of private equity (1990's) access was critical factor but after that it has become less important.

The contribution of this dissertation is threefold. First, I will show that selection skills as the main determinant of systematic differences between limited partners' private equity returns is a theoretically problematic explanation. This is because the information that is available to (sophisticated) investors at the time of investment decision is practically identical, i.e., all investors have the same information available when making the investment decisions. Furthermore, if someone would be able to select better investment targets than others, then that investment strategy could likely be imitated by other investors rather quickly, therefore eradicating the return difference in future investments and thus there should be no systematic long-term return differences. Given the amount of capital invested in private equity by the large pension funds, the lower-return limited partners would benefit from paying significant amount of money to hire professionals from high return limited partners to learn their investment strategy. But this seems not to be the case; the differences between limited partners' returns tend to be persistent. Access, understood as an organization-level phenomenon instead of personal-level property, would not be subject to similar shortcomings. As a matter of fact, access can explain the persistent differences between limited partners' returns, but it can also help to explain why reinvestment rates are as high as they are in the private equity investing – over 50% of surveyed limited partners had accepted all reinvestment requests in 2005 and close to 20% still in 2009, as reported in Coller Capital (2009). In addition, to losing access to the focal general partner, not

reinvesting in that general partner's fund could also hurt the limited partners' reputation within the private equity community, thus reducing future access also to other more successful general partners.

Second, I show that by adequately taking into account limited partners' prior returns, selection skills can be shown to have no statistically significant effect on the limited partners' investment returns (as also suggested by Sensoy *et al.* 2013). This second contribution is based on an empirical analysis of almost 1,485 reinvestment decisions made by 156 large European institutional investors. This dataset is unique in the sense that it combines funds with their general partners, and general partners' previous funds, but it is also the largest set of reinvestment decisions made by pension funds used in research so far (for example, the data contains practically twice as many pension funds' reinvestment decisions as Lerner *et al.* 2007 and for pension funds similar size data as is used by Sensoy *et al.* 2013, but my data is on European investors as compared to the US data used in these two articles).

This result demonstrates that access is a more consequential explanation for the systematic return differences among limited partners than selection skills.[2] These findings imply that when access to funds and general partners' track records are controlled for, limited partners on whole are not systematically able to select better funds for their reinvestments than the funds in which they choose not to reinvest. When taking into account both the limited partner's access to funds established by certain general partners and these general partners' previous funds' returns, there are no systematic and statistically significant differences between the returns attained by different limited partners on the funds in which they chose to invest. Using a sample of reinvestments made by large institutional investors, I am able to control for limited partners' access and thus have strong support to rule out the selection skills of limited partners as the main driver of return differences among different limited partners. Therefore, instead of limited partners' selection skills, the findings suggest that access to different funds is a more important determinant of limited partners' private equity fund investment returns (cf., Lerner *et al.* 2007). This part of the results also help to explain why some limited partners invest in general partners that do not have track record – this investment helps them to gain access to (potential) future top quartile general partners.

This part of the dissertation also advances the line of research developed by Lerner *et al.* (2007): instead of just focusing on reinvestment decisions to control for access, I am limiting the analysis to reinvestment decisions with explicitly modeling the previous funds' performances in the analyses. Whereas Lerner *et al.* (2007) and Sensoy *et al.* (2013) focused on performance differences between different types of limited partners, this dissertation limits the unobserved heterogeneity between limited partners by focusing on one major type of limited partners (pension funds) in one geographic area (Europe). Although the sample in this dissertation is different from that of the two previ-

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[2] For the difference to be systematic I require it to have two properties: 1) It must exist over time, and 2) it must be statistically significant for the averages of all the funds.

ous studies, focusing on only one part of that large set of potential limited partners will make the analyzes clearer and easier to interpret.

As the third contribution of this dissertation, I show how access formation can be explained with a reputation-based dynamism. So far none of the research on the role of access in private equity fund investing has discussed how access is created. In terms of understanding the investment process, this is a significant shortcoming in any explanation of the limited partners' returns. This proposed dynamic of access advances the literature on institutional investors' private equity investing, and furthermore it stresses the importance of understanding the process as well as its outcome.

Using a simulation model, I show that under a very broad set of assumptions, limited partners' prior returns can be used as a proxy of their access. In this model, limited partners with better reputation are favored by the general partners, and one of the key elements of the limited partners' reputation is their prior returns. Since general partners' own quality is not fully known to limited partners, limited partners assess the general partners also based on their other investors. Knowing this, general partners seek limited partners with high reputation to signal their own quality to other investors with high reputation. Therefore, high prior returns enables a limited partner to invest in better general partners, while low prior returns have the opposite effect. This dynamism maintains the difference between limited partners' returns (i.e., systematic differences are emergent property of the system). Together with the results of the statistical analysis the simulation model shows how the systematic return differences between different types of limited partners can be explained (c.f., Lerner *et al.* 2007). Just taking into account that certain types of limited partners are more preferred investors by the general partners, these preferred limited partners are able to attain higher returns and the systematic return differences between different types of limited partners can be explained.

All in all, the aim of this dissertation is to examine how limited partners' private equity fund investment returns are driven by their access to funds raised by general partners with higher returns. Access, on the other hand, is driven by the limited partners' prior investments: the better the prior returns, the better the future general partners accessible as investment opportunities. Since general partners' returns tend to be persistent and since access is restricted, limited partners' subsequent returns are also persistent. Therefore, differences between limited partners' returns tend to continue over time.

1.1 Research Questions

Why do systematic differences between limited partners' private equity fund returns exist? This simple, yet profound, question has been raised several times before in research, but so far no thorough attempts at answering it exist. Understanding this phenomenon would not only enable higher returns in general from the private equity asset class, but it could also help to attract more capital to private equity investments.

To answer this major question I have set three research questions for this dissertation. The first two research questions are integrally linked to each other while the third one builds on the first two. Other findings of this dissertation are corollary to answering these questions. The three research questions of this dissertation are as follows:

- **Research Question 1a**: *Is access more important determinant of limited partners' returns to their private equity fund investments than their selection skills?*
- **Research Question 1b**: *If access is more important determinant, what would explain this finding given that previous research suggests otherwise?*
- **Research Question 2**: *Given the nature of the private equity industry, what could explain the systematic differences between different types of limited partners' private equity returns as observed by the previous research?*

These research questions are not only theoretically interesting but they have significant practical importance as well.

1.2   Contents of This Dissertation

The rest of this dissertation is organized as follows. Section 2 describes the private equity asset class and its typical characteristics. The point of this background information is to focus on those characteristics most closely related to the analysis made in this dissertation. In this section I will provide description on the typical fund structure as well as on the cash flows between the funds and their investors. Section 2 also covers private equity funds as investments and mainly deals with the returns that the limited partners are able to attain on their investments. So far, majority of the previous research has not emphasized the returns that the limited partners are able to attain but that of the funds themselves. I will show why limited partners' selection skills are theoretically problematic explanation for the observable return differences between limited partners' realized returns.

Section 3 covers the issue of whether limited partners' access to funds or the investors' selection skills is the main determinant of investment returns. Advancing previous research settings, I will show in this section that access to better funds is the only explanation to systematic differences between limited partners private equity fund investment returns. This section also details the empirical dataset used in this dissertation as well as the statistical methods used to examine the relations in the data.

Section 4 examines the question of how access to funds is created and gives an explanation for the dynamics of such process. The offered explanation, that access is created through the signal of limited partners' previous returns, is then shown to produce results similar to what are observed in real world data. This is done using a simulation model specifically developed in this dissertation. This section also details the simulation model along with the assumptions behind that.

Section 5 discusses the results of the individual analyses and how they together form a coherent explanation for how the limited partners' private equity returns come to be. This section also explains how the results relate and extend the existing literature on private equity. Section 5 also concludes the dissertation with discussion on this research's implications for practitioners and potential questions for future research.

2. Private Equity Returns

This second section describes private equity asset class and its characteristics. The focus here is on private equity returns and the factors that affect them. This section describes why access to funds and fund selection are the most important determinants of the limited partners' private equity fund returns. Furthermore, this section motivates why understanding these factors affecting the private equity returns is important whereas discussing about the average private equity returns is less so.

Private equity is a broad term with no universal and exact meaning. The term has a different meaning in the US and in Europe, and even within these regions the exact content of the term is not precise. In the US, private equity is most often used to define venture capital and buyouts, although it can include many other types of investments ranging from mezzanine and turn-around financing to funds focusing on natural resources and real estate (for one of the most common definitions of private equity, see Sahlman 1990). In this dissertation, private equity is used to define buyouts, venture capital, and various types of short term financing, like mezzanine and turn-around financing. Real estate, natural resources, and any other type of financing not directly linked to companies are not included in this dissertation.[3] This is because these excluded types of investments can have significantly different investment logic and legal framework,[4] and therefore only some of the findings are generalizable to these other investment types.

An institutional investor can invest in private equity either directly or through private equity funds in, which case it's the funds that make the direct investments and the institutional investor invests in these funds.[5] The scope of this dissertation will only be on the institutional investors' investments in private equity funds (see Figure 1). This is because the two types of investments (investing through funds or directly) are completely different with different dynamics in how the investments are made and how the returns are realized. Investing in private equity funds is more similar across the spectrum of differ-

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[3] Many times the definition of private equity is left unspecified, which can prove out to be problematic in terms of generalizing the findings. In this dissertation, I have chosen to include only those types of private equity investments that are closely related to financing companies (in order to increase their value).

[4] There is much variation even within the included types of investments, but these differences are small enough that often these types of investments are treated as similar in relevant aspects in studies.

[5] In case of funds of funds, the funds of funds invest in private equity funds which then invest directly, but investing in these funds of funds is similar to investing in funds.

ent types of funds than the spectrum of direct investments and therefore by focusing on investments in funds enables focusing on commonalities instead of having to deal with the differences as would be the case with focusing on the direct investments.
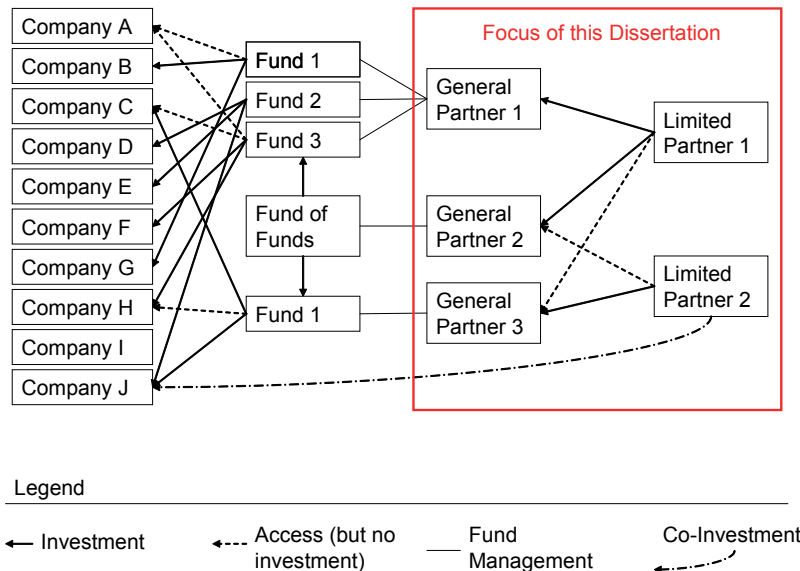
Figure 1. The Focus and the Context of the Dissertation. This Figure illustrates the focus of this dissertation in relation to the private equity investment in general. The focus will be on the investments and access of limited partners to general partners and their funds. How general partners and their funds do their investments is not the scope of this dissertation. While this figure is simplification it serves as a guide for those not familiar with the private equity. Note: while the limited partner's access is to funds (and not specifically to general partners) in most cases in this dissertation I will treat access to a fund as access to that general partner. I will discuss the implications of this later in this dissertation but suffice it to say, this simplification has little effect on the analysis and/or results posed in this dissertation.

2.1   Limited Partnership as the Typical Fund Structure

This section details the typical private equity fund structure and the basic characteristics that follow from this. Furthermore, a brief discussion about investing in private equity funds is presented here.

Limited partnership is the most common legal structure for private equity funds in most western countries (Sahlman 1990; Gompers 1996; Gompers & Lerner 1999b; Lerner & Schoar 2004). This is because of the legal and financial benefits that this legal structure gives to investors. In the limited partnership model, institutional investors act as limited partners providing majority of the fund's capital while foregoing chances to take part in the daily management of the fund in exchange for limited liability and tax benefits (e.g., Sahlman 1990; Gompers 1996; Gompers & Lerner 1999b; Lerner & Schoar 2004). The fund itself is set up and managed by a general partner company which provides minimal amount of the capital, usually only 1-2 percentages of

the total capital (Mathonet & Meyer 2007). Deviations from this norm are rare as this form has become close to an industry standard.

Typical lifetime of a private equity fund (formed as a limited partnership) is around 10 years (Meyer & Mathonet 2005), with predetermined conditions upon which the fund's lifetime can be extended by a couple of years in order to maximize the profits. During the first years, the fund's management spends its time on finding investment targets and making initial investments, while the latter years it spends its time on committing to follow-up investments and exiting the invested companies (Sahlman 1990; Jeng & Wells 2000).[6] The types of investments that a fund can make are restricted by the fund's set up contract, known as private placement memorandum, or PPM for short (Gompers 1996; Gompers & Lerner 1999b; Meyer & Mathonet 2005; Fraser-Sampson 2007). The PPM also contains all other relevant legal aspects of the fund and its relationship with the limited partners and the general partner.

Private equity funds' fee-structure is typically similar across all funds structured as limited partnerships (Gompers & Lerner 1999a), although there are some characteristics in which they differ (for more discussion on these differences, see Litvak 2004). However, these differences are usually small and concern more about the timing of cash flows rather than their size.[7] A typical fund has a fixed management fee of 1.5-3% of the committed capital along with 20% carried interest taken from the profits (Sahlman 1990; Gompers & Lerner 1999a). Management fee may vary during the life cycle of a fund so that most of the management fee is paid to the general partner when the fund is most active, i.e., during the first years, and smaller management fee is paid during the latter years (Gompers & Lerner 1999a).

The traditional view in private equity industry has been that the general partners fee percentages do not vary according to the (previous) returns that the general partner has managed to attain on its previous funds (Gompers & Lerner 1999a). The explanation to this curious puzzle is that although it would seem rational for the best general partners to increase their fees until they have just the amount of potential investors (i.e. to screen investors by raising fees) they are not actually able to do so (Ljungqvist *et al.* 2009). This is because if the existing investors would not invest in the new fund by the general partner, then outside investors would not do so either as they would expect that the existing investors do not invest due to some insider information (Ljungqvist *et al.* 2009). Therefore, trying to raise management fees after a successful fund in most cases would only hurt the general partner. This type of feedback levels the negotiation power between limited partners (who all want

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[6] Exits can be, for example, initial public offerings, trade sales to other companies or private equity investors, or liquidations. How much profit the fund is able to gain from any of these methods depends on a number of factors which are not the topic of this discussion. For more information on various exit strategies, see, e.g., Manigart *et al.* (2002).

[7] So far studies have not shown that the timing of the cash flows would have significant impact on the returns. This is because the timing of the cash flows is restricted by the fund's legal terms and there are typically only some weeks of adjustment period for transferring the cash. This is too short a time for the timing to have a large effect on the returns.

to invest in the best general partners) and the best general partners (who maximize their own profits by not increasing their fees).

General partners typically raise new funds every three to five years partly because of the fee structure (Gompers & Lerner 1996; Gompers 1996). However, general partners with low prior returns often find it difficult to raise new funds (Gompers 1996; Kaplan & Schoar 2005). On the other hand, general partners' that are able to raise subsequent funds tend to raise larger funds than their previous funds (Kaplan & Schoar 2005). And although the fee percentages do not change according to the prior performance (see Gompers & Lerner 1999a; Robinson & Sensoy 2012), as fund size increases with each subsequent fund, even with fixed fee percentages, the total compensation of a general partner increases as a function of prior performance (Metrick & Yasuda 2010). As subsequent funds become larger, and if the fund management won't adjust its strategy to suit the larger size of the new funds, then the fund returns may become lower for future funds (Humphery-Jenner 2011).

A new general partner has no proven track record of prior performance, and young general partners do not have solid track records as the final returns to their fund are not known accurately until later (Ljungqvist & Richardson 2003). Therefore, the new general partners (and general partners who believe that their previous fund may have low returns) may have incentive to 'grandstand', i.e. to make their short term performance better at the expense of their long term returns (Gompers 1996; Cumming & Walz 2010; Brown *et al.* 2013). While the grandstanding can have reputational costs for the general partner, in some instances these costs might be lower than the potential gain from grandstanding (Cumming & Walz 2010). If they are able to raise a new fund before the returns on the prior fund are fully realized they have another chance of getting high returns (c.f., Chung *et al.* 2010; Robinson & Sensoy 2012). Although the evidence suggests that this grandstanding does not help the general partners to raise the next fund (Brown *et al.* 2013), this grandstanding explains partially why many limited partners claim not to invest in general partners without proven track records (Coller Capital 2009).

Not investing in funds set up by new general partners is not necessarily beneficial for limited partners because investors in a general partner's prior funds often have privilege to invest in that general partner's new funds because of the informational hold-up explained above (Ljungqvist *et al.* 2009). This is because agency conflict is not that high in reinvestments (Freiburg & Grichnik 2012), and because general partners favor limited partners that seek long term partnerships, (Lerner & Schoar 2004). Therefore, after a general partner's fund has turned out to have high returns, limited partners not investing in that fund may not be able to invest in that general partner's new funds (Lerner & Schoar 2004). General partners with high returns to their funds do not want new limited partners and limited partners investing in high return general partners' funds do not want to quit investing in those general partners. Therefore, being able to invest in a general partner's new fund – without having invested in its prior funds – may indicate that the general partner's funds do not have very high actual returns and will also not have them in the future.

Or it could be that the fund terms are not good for the limited partners, or some other critical problem. As such, investing in funds set up by new general partners may be the only way to be able to invest in the future high return funds – but even then it is conditional on being able to initially invest in those general partners who later on turn out to get highest returns on their funds.

Once committed to invest in a fund, the limited partners usually have only few predetermined conditions under which they can terminate the limited partnership (Mathonet & Meyer 2007). The underdeveloped secondary market for private equity fund investments, and the nature of private equity as an asset class, makes it difficult for a limited partner to find a buyer for its share in the fund given that this buyer should also be willing to pay the price that the limited partner would like to receive. These factors explain the illiquidity of private equity fund investments (Fraser-Sampson 2007). As this is the case, investing initially in the best opportunities is much more important with private equity than in some other asset classes.

2.2 Investing in Private Equity Funds

This subsection describes the limited partners' investment process when investing into private equity funds. The limited partners' investment process is still a black box but this section describes the process also from practitioner's point of view in order to understand what is not so far known to academic research.

Relatively little academic research has been conducted on the limited partners' investment processes (for one of the few exceptions, see, Groh & Liechtenstein 2009; Zwart *et al.* 2010), but there are some practitioner-written books about them (e.g., Grabenwarter & Weidig 2005; Meyer & Mathonet 2005; Fraser-Sampson 2007; Mathonet & Meyer 2007). While the stages and central issues of a typical investment process can be read from one the practitioner-oriented books, in this dissertation I will focus on two critical aspects of the investment process: 1) access to funds, and 2) selection of funds in which to invest. These two are the factors, which determine (the majority of) the private equity fund investment returns to the limited partners (I will come back to the returns in Section 2.3).

While the role of access to better funds has been recognized as one determinant of institutional investors' returns to private equity fund investments (Meyer & Mathonet 2005; Fraser-Sampson 2007), the extent of this role has been questioned in the recent academic research (Lerner *et al.* 2007 and to some extent in Sensoy *et al.* 2013). However, no study so far has explicitly tried to understand the dynamics of access, even though access has received significant attention from the professionals in the private equity industry. For example, it is known that some limited partners try to gain access to better funds by investing in fund of funds (Weidig *et al.* 2005; Preqin 2010). If they do not believe that access truly matters then this kind of behavior would be puzzling since there are additional costs in dealing with funds of funds – and

these costs may exceed the benefits of diversification given by the funds of funds.

The investment criteria used by the limited partners in selecting their private equity fund investments are fairly simple (for more on this, see Groh & Liechtenstein 2009),[8] but how these criteria are used is unknown (for one example of fund assessment, see Meyer & Mathonet 2005).[9] Similarly, the investment target evaluation has received some attention in the research in recent years (Grabenwarter & Weidig 2005; Meyer & Mathonet 2005), but in research the exact selection process is still considered mainly as a black box (one attempt to understand this black box is presented in Da Rin & Phalippou 2011). Due to the emphasis placed on a general partner's track record in fund assessment, many limited partners claim they are unwilling to invest in funds set up by general partners without proven track record (Coller Capital 2009).[10] The emergence of new general partners that are able to raise funds proves that at least some limited partners are willing to invest in a fund set up by the new general partners (a rationale for such investments was already presented in Section 2.1). However, how a limited partner chooses funds raised by the new general partners is even more of a puzzle than how they choose their normal investments.

Apart from monitoring fund performances and determining which general partners to reinvest based on the fund performances, limited partners have very limited control over their committed capital in private equity funds (Lerner & Schoar 2004). Therefore, in order to solve the apparent agency conflict present in private equity funds, the contract terms have usually several typical characteristics that aim to deal with these agency issues. By forcing the funds to operate with high leverage in relation to the expected cash flow from the investment, the limited partners not only decrease their own capital at stake in relation to the total capital but also control the actions of the general partners by forcing them to obey the terms of their debt and subject them to the oversee of the debtors (Axelson *et al.* 2009). This maneuver transfers some of the monitoring burden to debtors while at the same time the increased leverage increases returns of successful investments.[11] Furthermore, the reputation of a general partner has direct impact on that general partner's future possibilities

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[8] Groh & Liechtenstein (2009) surveyed 75 limited partners and looked at the criteria that these investors use for assessing the funds available to them. The criteria used by these limited partners were similar across the spectrum and represented the fact that there is not much information available to investors when they need to make their investment decisions.

[9] In their book, Meyer & Mathonet (2005) show one model for assessing the investment opportunities and discuss about how one could use that model for assessing private equity funds. The model is based on making numerical assessment of several criteria about the fund, its legal terms, its management, management's track record, and so on.

[10] Here the proven track record refers to the track record of the general partner organization, not that of the professionals working there. Although it is important to note the difference, I leave this out of consideration in this dissertation since monitoring of changes in key professionals working in each organization would be very difficult.

[11] Since the debt is placed on the balance sheet of the target companies and not the funds, a poor investment costs the fund only at maximum what the fund invested in that target company. Therefore, when the increase in returns to successful investments is high enough to offset the marginal increase in the target company's bankruptcy probability, this is beneficial to the limited partners. This is the case, ex ante, in almost all private equity investments.

in operating in the private equity industry (Chung *et al.* 2010; Demiroglu & James 2010; Atanasov *et al.* 2012). Similarly, direct personal ties between the limited partners and the general partner lowers this agency conflict, which also helps to explain why the limited partners favor investing in those general partners in which they have invested previously (Freiburg & Grichnik 2012).

Still, it is puzzling why limited partners are content with having such limited control over their investments in private equity funds. It is even more puzzling considering that only until recently, limited partners have been willing to reinvest almost automatically (Coller Capital 2009) thus negating this inhibitor of the agency problem. While this reinvestment trend has decreased rapidly since 2005, the fluctuation in the reinvestment rate might be caused by industry cycles and not only by changes in the limited partners' behavior.[12] If limited partners willingly do not exercise their best way of controlling the actions of the general partners, then what is it that they do to control their invested capital?

Considering that most of the capital invested in the private equity comes from institutional investors (Sahlman 1990), very little attention has so far been given to the institutional investors investing in private equity (again for a few exceptions, see, e.g., Lerner *et al.* 2007; Groh & Liechtenstein 2009; Cumming *et al.* 2011; Da Rin & Phalippou 2011; Sensoy *et al.* 2013).

2.3 Determinants of Private Equity Returns

This subsection explicitly discusses private equity returns to limited partners investing in private equity funds. The focus is much on the problem of measuring private equity returns in an objective and timely manner.

For the past few decades, the debate has been heated on whether private equity offers, on average, superior risk-adjusted returns compared to other asset classes, such as stocks and bonds. Measuring the private equity returns is a problematic task with no clear guidelines and therefore the returns are affected by how they are calculated. No single measure of returns is optimal and this central problem with the commonly used return measures stresses the importance of understanding the process of how the returns are realized.[13]

Measuring private equity returns in an objective manner is a difficult task due to illiquidity of the asset class, long holding periods and lack of available data (Wright & Robbie 1998; Ljungqvist & Richardson 2003; Harris *et al.* 2012). These three reasons together mean that all the return measures are only estimates until the end of the investment, which can be more than 10 years from the time of the investment decision. Therefore, as limited partners need to assess their investments at a much faster pace they need to rely on estimates – of their own returns but even more so on the returns of other (potential) private equity investments. This also makes it difficult to compare private eq-

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[12] While this is an intriguing question, unfortunately no new study has tackled the issue.

[13] In this dissertation, I will use two different measures for returns to avoid any bias stemming from the calculation of the returns. With similar results using two different variables for returns the validity of the conclusions is much higher.

uity returns to other asset classes. Another, but related, question is about the "average returns", which are of course used for the return comparisons. This problem is more evident in private equity than in the case of traditional asset classes like stocks and bonds as the returns to private equity funds are highly skewed (cf., Fraser-Sampson 2007; Phalippou & Gottschalg 2009). It is worth to note here that these problems are not tied to the used measure of returns but they exist independently of the measure used. One could even argue that the whole term private equity returns in general is not well-defined (Harris *et al.* 2012).

The previous research on whether private equity returns are higher than the returns to other asset classes has found that the private equity risk-returns are either: 1) above the returns of public stocks (e.g., Lamm & Ghaleb-Harter 2001; Ljungqvist & Richardson 2003; Groh & Liechtenstein 2009), 2) below the returns of public stocks (e.g., Chen *et al.* 2002; Nielsen 2006; Schmidt 2006; Phalippou & Gottschalg 2009), or 3) they have been inconclusive (e.g., Cochrane 2005; Ick 2005; Diller & Kaserer 2009). These mixed results high-light the fact that without proper understanding and definition of what is the used return measure, determining anything in relation to the return compari-son is questionable. Understanding how private equity returns are realized is the first step in getting to measure these returns more accurately.

Private equity fund returns are typically negative for the first four to six years as the fund makes its investments in the first years and only after that it begins exiting these investments and the cash flow turns positive (Meyer & Mathonet 2005). For the cumulative cash flow (i.e., the fund returns) to become positive it might take more time. Some studies even suggest that it might take several more years for the average returns to turn positive (Ljungqvist & Richardson 2003). Returns to a private equity fund are mainly driven by its few highly successful investments (Fraser-Sampson 2007). This, combined with the fact that the investments have 3-7 years average duration (Cumming & MacIntosh 2001), helps to explain the large variance in the timing of when the average fund turns to have positive returns. The most profitable investments the fund exits through IPOs or tradesales (Bygrave & Timmons 1992; Gompers 1995; Das *et al.* 2003; Torstila & Laine 2003; Cochrane 2005) while the remaining ones it can sell to third parties, they may remain as "living deads", or they may be liquidated (Ruhnka & Young 1991; Cumming & MacIntosh 2003). How much cash flow these various exits produce and the variance in the timing of these cash flows increase the variance in the returns that the private equity funds have. While the variation in returns on deal level is high, the return vari-ation of funds is smaller as the funds are pools of such deals, and then on the limited partner level the return variation is even smaller as limited partners are basically pools of funds (Weidig & Mathonet 2004; Weidig *et al.* 2005). Thus, at the level of limited partners the average return is a much more mean-ingful measure than on the level of investments made by the funds but it still has problems as has been discussed above.

The private equity fund return variation is significant with the best quartile funds producing fairly high double digit positive internal rate of returns (IRR)

while the lowest quartile funds produce negative IRRs (Emery 2003; Meerkatt *et al.* 2008). Because the fund returns to a general partner tend to be persistent and a general partner's prior fund performance seems to be the best indicator of future returns to that general partner's new funds (Kaplan & Schoar 2005; Phalippou & Gottschalg 2009; Sørensen 2007; Meerkatt *et al.* 2008), fund returns are often interpreted as an indicator of general partner's skills (therefore explaining why general partners with low returns find it difficult to raise new funds, as was discussed in Section 2.1). A general partner with first quartile returns for one fund is more likely to achieve that also with the next fund (Meerkatt *et al.* 2008). Similarly, a general partner with fourth quartile returns is more likely to have last quartile returns in the following funds. The extent of this return persistence is still under debate (cf., Phalippou 2009a; Humphery-Jenner 2011; Harris *et al.* 2013).

Returns to private equity funds and returns to these funds' investors, namely the limited partners, are not the same due to the fund fees and timing of cash flows (Phalippou & Gottschalg 2009; Harris *et al.* 2013). Still, there seems to be a systematic difference in the returns to funds invested by different types of limited partners, even when considering reinvestments only (Lerner *et al.* 2007 and to some extent also in Sensoy *et al.* 2013). This difference is likely not to be a consequence of some investors having alternative motives for their investments (see, e.g., Hellmann *et al.* 2004; Lerner *et al.* 2007). In their article, Lerner *et al.* (2007) attribute this difference to some limited partners being better in selecting their investments. As Lerner *et al.* (2007) do not control for the prior performance their conclusions may be unwarranted as the difference in returns can perhaps be equally well explained with the quality of general partners to which different limited partners can invest in (as suggested by Sensoy *et al.* 2013). In any case, these findings are rather remarkable. And as such, it would be interesting and important to better understand whether these findings are due to some alternative explanations or not.

A private equity fund has some optimal number of investments that maximizes its returns (e.g., Jääskeläinen *et al.* 2006; Cumming & Dai 2011). This is because after certain number of simultaneous investments the fund management becomes too taxed and can not help the target companies to achieve their maximum potential (Lopez-de-Silanes *et al.* 2008). On the other hand, too few investments mean that the managers are probably overcompensated for their effort. Also, as limited partners need to have the committed capital available should the general partner ask for it after the fund has been raised, this capital must be available in short term (and therefore likely low return) assets. If the general partner does not draw all that capital, the overall returns to the investment are lower (c.f., for more discussion on this issue Zwart *et al.* 2010). By working together with other general partners, which is by syndicating, the optimal number of investments can be increased (Jääskeläinen *et al.* 2006). But by syndicating the investments, the fund returns become correlated. As syndication networks can be large, private equity funds' returns are not independent of each other.

Private equity returns are not independent of general macro-economical fluctuations either, and the returns tend to move in cycles where periods of high returns are followed by periods of lower returns (Gompers & Lerner 2000; Lerner & Schoar 2004; Kaplan & Strömberg 2009; Robinson & Sensoy 2012). Kaplan & Strömberg (2009) explain this phenomenon with the credit market during the boom times. They argue that credit markets have a key role in investment decisions made by the funds; during boom times credit is more readily available and therefore more risky projects get financed (Kaplan & Strömberg 2009). Robinson & Sensoy (2012) argue that during boom times the general partners are able to negotiate better contract terms for them, which then leads to lower returns to limited partners. Overall, the returns to private equity might correlate with the returns to general financial markets, but this question is still without a definite answer.

There is an ongoing disagreement on whether private equity offers diversification benefits to an institutional investor's overall portfolio of investments (Chen *et al.* 2002; Quigley & Woodward 2002; Emery 2003; Grabenwarter & Weidig 2005; Franzoni *et al.* 2012). Views on this question are mixed due to not having objective and universal return variable either for the private equity or the asset classes to which the returns are compared to. Intuitively it would seem logical to assume that the correlation between private equity and stocks, for example, is low for the previously mentioned reasons. But without more accurate information, it can also be argued that the boom and bust cycles in private equity are linked to booms and busts in the general economy as well and therefore the correlation between private equity and stocks is high. This view is favored by those who believe that most of the liquidity in private equity industry is constrained by the same factors as liquidity in other asset classes, i.e., bad liquidity in general financial markets means that private equity industry is also constrained by liquidity (Franzoni *et al.* 2012).

Diversification benefits in private equity are also a matter that has been studied with mixed results. Diversification can occur at the fund level with the fund investing in a diverse set of target companies or at the investor level with the institutional investor investing in a diverse selection of specialized funds – or at both levels. But as typically private equity fund does not invest all committed capital (Ljungqvist & Richardson 2003), this makes diversification of a private equity fund portfolio more difficult. Because of syndication at the fund level, institutional investors are not as diversified as they think they are (Checkley 2009). This is because the seemingly independent funds might have invested in the same companies through syndication networks. This whole diversification issue is even more complicated considering that the limited partners can invest in private equity fund of funds to get diversification across different funds at a lower total amount of investments (Fraser-Sampson 2007; Preqin 2010). Whether or not this actually helps the diversification is subject to debate but the returns to funds of funds are likely to correlate highly with the returns to funds in which the funds of funds have invested in (Lai 2005).

2.3.1 Alternative Views on Private Equity Returns

This subsection extends the line of reasoning presented in 2.3. Here, the key is to show that the way how private equity returns are measured in different articles has some effect on what is the result of those articles. This section will act as a motivation for why we need to better understand the process of how private equity returns come to be before we can have any meaningful discussion about what is the average return to private equity fund investments.

The process of how private equity returns come to be is not well understood. To see this acute problem more clearly, I have listed a set of articles on private equity returns (see Table I). These articles do not form a comprehensive coverage on the issue but they provide an insight into the private equity return research conducted since 2000. The articles provide an illustrative example on the problem of not being able to make sense of the private equity returns without understanding the process in which the private equity returns are formed.

Panel A of Table I shows that three articles suggest private equity to be superior to stocks in terms of their risk-adjusted returns, three articles show them to be similar in the same terms, and five articles show that private equity is inferior in the risk-return terms. It seems that the results are mixed even if we take into account whether the article analyzes venture capital or private equity, where the investments are located, or what time period is chosen. Therefore, it seems fair to assume that the different results are not only due to the different samples used in the studies but are also driven by differences in measuring the returns. Based on Panel A of Table I it is clear that the period of time or the location of the data do not determine the results of the risk-return analysis. The longer/shorter and the older/younger periods of time are mixed in the results. Similarly one cannot distinguish whether the data is from US or EU just based on the findings. Thus, the differences in results are due to different measures of risk and return and how they are calculated.

The reason for such controversy among the previous research stems from the fact that in all the studies, what is meant by the term "returns" is different. In order to understand the results we must turn to look at how the returns are actually measured in each article. It is important now to turn attention to the tenth column in Table I. This column details the exact methods of calculation and I will discuss it in the following paragraphsI will now explain how the used methods of measuring returns in the papers have contributed to the results, starting first with the group of articles that found private equity to underperform public equity. Having only liquidated funds or deals is often the most apparent way to decrease the returns. There is some value in non-liquidated private equity investments, whereas liquidation most often means bankrupt and only rarely IPO or acquisition (which would lead to high returns). This is even more apparent since the deals are venture capital deals in which case one highly successful investment could offset tens of bad investments. Very few of such cases exist in the two articles. Especially Schmidt (2006) proves this point, since the average is lower than the median – which is completely opposite to what is typical in the venture capital deals.

Another way to diminish returns is to adjust NAVs. This always decreases some part of funds returns and with relatively young funds (e.g., in Nielsen 2006) this issue might not be warranted – at least to the extent it is done. In the Phalippou & Gottschalg (2009) article the NAV adjustment includes effects from leverage, fees, etc., which all lower returns significantly (without these adjustments the private equity would clearly outperform).

Table I
Articles Comparing Private Equity Risk-adjusted Returns to Stock Returns and Articles Discussing Average Private Equity Returns

The first column in Panel A shows the author's and the year, while the second column shows where the article was published. More detailed references to these articles can be found in the Reference section at the end of this dissertation. Third column shows whether the article discusses private equity in general (not always clear what is included in their definition of private equity) and/or venture capital. Fifth column shows the region where the investments are located while sixth column shows the vintage years included in the deal (this should be observed keeping in mind the year when the article itself was published). Seventh column shows the source of data. Eight column shows the return measure used to analyze the returns and ninth column shows the average returns for private equity in that article. Eleventh column shows the risk measure against which these returns are compared. 12th column shows the results of the analysis while tenth column shows how the data is treated for the analysis. The columns in Panel B are similar except that now there is no risk-return analysis in the sample used in the article (assumed if no explicit analysis of persistence but discussion about it in the article). 12th column now contains the articles'

Panel A: Articles comparing private equity risk-adjusted returns to that of public markets

Article	Journal	Sample	Type	Region	Period	Source of Data	Performance measure	Average return	How data is treated	Risk measure	Result of risk vs. return analysis
Lamm & Ghaleb-Harter, 2001	Journal of Private Equity	71 funds	PE + VC	US (?)	1986-2000	Thomson Venture Economics, Datastream	IRR	23.9% IRR	No special treatment	Std of IRR & Sharpe Ratio	PE outperforms
Ljungqvist & Richardson, 2003	Working Paper	73 funds	PE + VC	US	1981-2001	1 Large US LP	IRR	18.13% IRR	Exact timing of cash flow & no NAV	Std of IRR	PE outperforms
Groh & Gottschalg, 2006	Working Paper	133 deals	PE	US	1984-2004	A set of large GPs and LPs	IRR	50.08% RR*	Corrected for selection bias, only liquidated	Std of IRR	PE outperforms
Cochrane, 2005	Journal of Financial Economics	16,000 deals	VC	US	1987-2000	VentureOne + SDC	Log return	15.9% log return	Corrected for selection bias	Std of log returns	Non-conclusive
Ick, 2005	Working Paper	5,991 deals	PE + VC	EU+US	1975-2003	CEPRES	IRR & PME	46% IRR / 1.05 PME	NAVs included	Several measures	Non-conclusive
Kaserer & Diller, 2009	European Financial Management	200 funds	PE + VC	EU	1980-2003	Thomson Venture Economics	IRR & PME	12.7% IRR / 0.96 PME	Exact timing of cash flow s, NAVs adjusted	Std of IRR	Non-conclusive
Chen et al., 2002	Journal of Portfolio Management	148 funds	VC	US	1960-1999	Thomson Venture Economics	IRR	45% IRR	Only liquidated funds	Std of IRR	PE risk-return is lower
Moskow itz & Vissing-Jørgensen, 2002	American Economic Review	Household deals	VC	US	1989-1998	SCF-survey, Flow of funds accounts, National income and product accounts	Return index	12.3% Geom. Average**	NAVs adjusted	Std of returns	PE risk-return is lower
Nielsen, 2007	Working Paper	Danish PE deals	PE + VC	Denmark	1995-2004	All Danish pension funds	Annual return (%)	4.67% annual return	Exact timing of cash flow s, NAVs adjusted	CAPM	PE risk-return is lower
Phalippou & Gottschalg, 2009	Review of Financial Studies	852 funds	PE + VC	EU + US	1980-2003	Thomson Venture Economics	Profitability index	0.92 PI	Exact timing of cash flow & NAVs adjusted	CAPM	PE risk-return is lower
Schmidt, 2006	Journal of Alternative Investments	642 deals	VC	US	1980-2002	CEPRES	IRR	36.49% IRR	Only liquidated deals	Benchmarking	Non-conclusive

* The authors acknow ledge that this is biased and they use various corrections each how ering the average by close to 20-40%
** The authors use a number of different measures for returns but all of them show similar returns of over 10%

Panel B: Other articles discussing private equity returns

Article	Journal	Sample	Type	Region	Period	Source of Data	Performance measure	Average return	How data is treated	Persistence	Result of risk vs. return analysis / other
Cumming & Walz, 2010	Journal of International Business Studie	221 funds	PE + VC	Global	1971-2003	Center for Private Equity Research	IRR	68.18% IRR	Only liquidated funds	-	Legislation affects mis-reporting by GPs
Lossen, 2006	Working paper	100 funds	PE + VC	EU + US	2000-2005	A European fund-of-funds, Thomson Venture Economics	IRR, MIRR, PME	50% IRR / 19.9 MIRR / 3.08 PME	Only funds with small NAVs, net of fees	Yes	Diversification across countries has no effect on performance
Lerner et al., 2007	Journal of Finance	838 funds	PE + VC	US	1991-1998	Asset Alternatives, Preqin, 20 LPs	IRR, multiple	23.9% IRR	Net of fees & carried interest	Yes (assumed)	Various types of LPs have different returns
Emery 2003	Journal of Private Equity	1459 funds	PE + VC	US	1986-2001	Thomson Venture Economics	IRR	18% IRR	NAVs adjusted	-	PE outperforms public market
Harris et al., 2013	Working paper	1469 funds	PE + VC	US	1984-2008	Burgiss dataset	IRR & PME	15.5-17.8% IRR / 1.26-1.40 PME	NAVs included	Yes/no	PE outperforms public market
Harris et al., 2014	Journal of Finance	1373 funds	PE + VC	US	1984-2008	Burgiss dataset	IRR, multiple, PME	14.2-16.8% IRR / 1.97-2.34 multiple / 1.23-1.36 PME	Exact timing of cash flow s, net of fees, NAVs included	-	Buyout performance exceeds that of public markets, VC funds outperform in 1990's, underperform in 2000's
Lopez-de-Silanes et al., 2008	Working paper	4848 deals	PE	Global	1873-2002	LPs, Thomson Venture Economics, Capital IQ	IRR, multiple	17% IRR / 2.6 multiple	Fees not included, correction for selection bias	Yes	The total number of PE investments during a vintage affect all returns of that vintage
Kaplan & Schoar, 2005	Journal of Finance	746 funds	PE + VC	US	1980-2001	Thomson Venture Economics	IRR & PME	17% IRR / 0.96 PME	Only liquidated funds	Yes	PE has low er returns
Hochberg et al., 2007	Journal of Finance	188 funds	VC	US	1980-1999	Thomson Venture Economics, SDC	IRR	15% IRR	Only liquidated funds	Yes	Strong persistence in fund returns / More central GPs have higher returns
Brown et al., 2013	Working paper	2071 Funds	PE + VC	US	1984-2011	Burgiss dataset	IRR, TVPI & PME	13.63% IRR / 1.72 TVPI / 1.27 PME	NAVs included	Yes (limited analysis)	PE outperforms public market
Meerkatt et al., 2008	BCG report / working paper	218 funds	PE	Global	1979-2002	Preqin, BCG-IESE own database	IRR	13% IRR (size weighted)	Only funds with small NAVs	Yes	PE has same risk-adjusted returns as public market
Sensoy et al., 2013	Journal of Financial Economics	1250 funds	PE + VC	US	1990-2006	VentureXpert (SDC), Capital IQ, Preqin	IRR, multiple, PME	11.2% IRR / 1.62 multiple / 1.28 PME	NAVs included	Yes/no (assumed)	PE outperforms public market / Persistence varies over time
Humphery-Jenner, 2012	Review of Finance	1222 funds	PE + VC	US	1985-2007	VentureXpert, Preqin	IRR & multiple	10% IRR / 1.68 multiple	Only liquidated funds	-	Investment size affects the returns to a limited partner
Caselli, 2012	Journal of Financial Intermediation	834 deals	PE + VC	Italy	1999-2005	MPS Venture SGR	IRR	9.40% IRR	Only liquidated deals	-	The number of covenants correlates with the returns
Robinson & Sensoy, 2012	Working paper	837 funds	PE + VC	US	1984-2009	A large LP	PME	1.18 PME	Exact timing of cash flow s, net of fees, only liquidated funds	-	Contracts in PE are inefficient
Phalippou 2009a	Journal of Banking & Finance	348 funds	VC	Global	1980-2003	Thomson Venture Economics	PME	1.00 PME	Exact timing of cash flow s, NAVs adjusted	No	Non-conclusive about PE vs public returns / No performance persistency
Franzoni et al., 2012	Journal of Finance	4403 deals	PE	Global	1975-2006	CEPRES, Capital IQ	Modified IRR	0.19 MFR	Only liquidated deals	-	PE returns influenced by liquidity
Das et al., 2003	Journal of Investment Management	52,322 investment rounds	PE + VC	US	1980-2000	VentureXpert	Multiple	2-20 multiple*	Mostly liquidated deals, timing of cash flow s	-	Return depends on the stage of financing

* Multiple depends on how the authors treat their data, but multiple close to 2 is for companies that exit through IPO while multiple close to 20 is for companies that exit through IPO or when adjusting for various factors

What about the non-conclusive articles then? Two of them have adjustments for NAVs, which could play a role (Ick 2005; Diller & Kaserer 2009). Diller & Kaserer (2009) article at first hand still seems to be in wrong group since the effect of having exact timing of cash flows is significant. However, what is most likely to have an effect here is that the sample is on European funds (European venture capital funds have the most horrific return histories – it is an industry still struggling to take its first highly successful steps as it has done in the US – the negative effect of having European private equity funds in general is quite apparent in the Panel A of Table I). Cochrane (2005) article corrects for selection bias, which should (intuitively) lead to poorer performance. Cochrane instead found that in terms of risk-return characteristics venture capital is close to small NASDAQ stocks. Therefore this article is not subject to typical comparison as the small cap stocks are so close to venture capital – the article does not discuss the relationship between the risk-returns of venture capital and some large cap stocks.

In the same sense, the anomaly with the selection bias correction is present in the Groh & Liechtenstein (2009) – and here also the inclusion of only the liquidated deals should point to the same direction. However, what makes the difference in this article is that the authors take into account the leverage of the private equity deals and not the leverage of stocks, i.e. an investor to such private equity deals can offset his/her own risk to debtors. The cost of such insurance is moderate compared to the decrease in risk. Ljungqvist & Richardson (2003) article is a prime example of the effect of exact timing of cash flows; it can offset even the effect of not having NAVs (NAVs are more important in the case of venture capital – only few buyout investments are not liquidated within the normal time periods whereas venture capital investments can turn into 'living deads' – term used to refer to companies that are not bankrupt but that can not be liquidated in any profitable way).

Thus, adjusting NAVs (or not including them), having only liquidated funds and correcting for selection bias all decrease returns to private equity. Exact timing of cash flows on the other hand increases the returns significantly. Considering buyouts increases the returns, so does US data, as opposed to venture capital and European data, which have lower returns.

Another dimension worth mentioning is the comparison group. In some articles the comparison is done plainly to some stock index (most often S&P 500) but in others the comparison is to some adjusted index, which is made to look like private equity investments (leverage taken into account, for example). When compared to an adjusted index PE typically underperforms. Compared to S&P 500 PE typically outperforms. However, all these comparisons are dependent on the exact timings of cash flows and the comparison groups.

Panel B of Table I show a larger set of articles discussing the private equity returns. Now the focus should be on the ninth column which shows the average private equity returns in each article (same also goes for the Panel A of Table I). The average internal rates of return for private equity investment returns run from over 50% IRRs to single digit IRRs, with the majority of IRRs between 10% and 20%. Similar variation is true for also the other measures of

returns. The significant variation in the returns between the articles illustrates the need for better understanding of the underlying process for return dynamics. Discussing the exact value for average private equity investment return shouldn't be the first priority for private equity research since the value is dependent on so many factors about how the returns are measured. The first priority should thus be in better understanding the underlying factors and how they impact the subsequent returns.

The problem of measuring private equity returns should always be kept in mind when talking about the returns in general. However, a better way of advancing this line of research is to focus on the dynamics of private equity returns and to try to understand the process in which the institutional investors can influence their private equity returns. By understanding the process in which the return is realized the discussion on average private equity returns becomes more meaningful. In the next sections of this dissertation, I will analyze the effects of access and selection on the limited partners' returns. Understanding the effects of these two determinants of limited partners' returns poses important implications for those who want to understand how the returns come to be.

2.3.2 The Role of Selection Skills for Limited Partners' Returns

This subsection argues that limited partners' selection skills are not likely the explanation for systematic differences between limited partners' private equity fund returns.

Simplifying to some extent, limited partners' returns come from the returns that the general partners are able to attain on their (that is the fund's) direct investments, minus the fees that the general partners charge. I have already showed previously that these returns are not the same, and a fund which is able to get high returns on its direct investments might not be a good investment itself for the limited partners. This can be due to contractual issues and/or fee arrangements, which either makes the returns too low or the associated risks too high. Nonetheless, whichever the return measure used, systematic differences between limited partners returns tend to exist. So far, the most prominent explanation for the systematic differences between limited partners' private equity returns has been that the limited partners are different in terms of their skills in choosing better funds for investment.

If the limited partners' selection skills would be the determinant of their returns (as is suggested, e.g., by Lerner *et al.* 2007 and to some extent also by Da Rin & Phalippou 2011), then on what information would these selections be based on? As described already before, the previous studies have found only a few ex-ante known factors that can help to predict a fund's future returns (e.g., Kaplan & Schoar 2005). All such predictors found in the academic studies are public information known to all, and should any of that information provide accurate forecasts, it would be used to the extent that it would not help to explain differences between the investors' returns.

Furthermore, if some limited partner would be superior in selecting better investment opportunities, then how can the return differences between limited

partners be systematic? Private equity investing is mainly done in small teams (Da Rin & Phalippou 2011), and if any of these teams would actually be superior, others could easily buy them out. With such high differences in returns between good and bad investments (see, e.g., Emery 2003), and taking into account the amount of capital required for these investments, buying out better teams would be obvious way for limited partners to increase their returns on private equity investments. Such phenomenon seems not to exist supporting the conclusion that the differences between selection skills are highly limited.[14,15]

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[14] In my interviews with limited partners, it was acknowledged that the movement of professionals between limited partner organizations is rare.

[15] It should be noted here that Sensoy *et al.* (2013) and Harris *et al.* (2013) suggest that this systematic difference might no longer exist (and thus would not be systematic). However, several other analyses, including the one in this dissertation, do not provide support for the view that the differences are not systematic.

3. The Question of Access versus Selection

In the previous Section 2.3.2 I showed why it was unlikely that selection skill could be the explanation for the systematic differences in returns between different limited partners. In this section I will present a more detailed regression analysis that, unlike the previous research on this issue, takes adequately into account the previous returns to general partners and the limited partners' access to funds.

As I have shown in the previous section, limited partners' different selection skills might not be an adequate explanation for the systematic differences between limited partners' private equity fund investment returns. I have also shown several problems in the current line of research advancing the idea that some limited partners would be better in selecting investment targets for their reinvestments to private equity funds. Given the nature of private equity and the information available at the time of investing, that line of reasoning is problematic. I have argued that the alternative, access as the main determinant of the limited partners' investment returns, is a much more plausible explanation. In this section, I will show that the selection skills are not the explanation for the return difference between different limited partners. I will then argue that as selection skills are not the explanation for these differences, then the access to better funds must be the explanation.

This dissertation differs from the previous studies on the issue on two critical aspects: 1) I will focus solely on the reinvestment decision made by the limited partners, and 2) I will explicitly control for the general partners' prior returns. These two relevant additions to previous models will produce different results but as is evident based on the nature of private equity, these additions are necessary to be included in the model. As I will show later, with simple analysis I will be able to partially replicate the previous results. However, when these additions are taken into account the results will be slightly contradictory. While the additions will place some restrictions on the available data, the sample size used in the following analysis is not different to sample sizes used in the previous studies.

3.1 Data

The data used in this analysis cover 1,485 private equity investment decisions made by more than 156 among the largest European pension funds and pen-

sion insurance companies. The data used in this part of the dissertation were obtained from Private Equity Intelligence database (Preqin[16]), which is the largest and most comprehensive database on limited partners' investments in private equity funds. Using Preqin as the data source instead of using data directly from the limited partners minimizes the risk of having biased data and it covers much broader investor base than would be possible to use had I tried to use data obtained directly from the limited partners themselves. However, the cost of using the Preqin database is that it does not have investments made by all the largest investors. However, as Preqin collects data from both the funds and the limited partners, this process makes it difficult for either of the parties to misreport the returns. And as the limited partners announce their investments before the true returns are known, it makes it more difficult to report only the successful investments (as it is not known whether the investment will turn out to be successful). And finally, given that I will compare re-invested fund returns to not-reinvested fund returns, there should be no systematic bias from certain limited partners not reporting any of their returns.

While Preqin has recently been used in some other studies on private equity (e.g., Lerner *et al.* 2007; Hobohm 2008; Ljungqvist *et al.* 2009), my dataset is unique in two ways. First, by combining information on LPs' actual investments with information on all of the funds that were available to the market, I was able to build a dataset that covers funds in which the limited partners chose to invest as well as the funds in which they chose not to invest (this approach is similar in Sensoy *et al.* 2013). Second, I concentrated solely on the limited partners' reinvestment decisions. Because limited partners are practically always able to reinvest in new funds raised by a general partner in whose fund(s) they have invested before (Lerner *et al.* 2007), limiting the sample to reinvestment decisions effectively and accurately takes into account the availability of investment opportunities (i.e., access to funds). Accordingly, this dataset represents the accessible investment opportunities limited partners' face when making investment decisions. This dataset has a significant advantage to previously used datasets in that my dataset includes not only the investments but also the funds in which the limited partners chose not to invest, whereas previous studies on the issue have only contained investments made by the limited partners.

3.1.1   Sample Construction

The sample was constructed by first identifying several hundred of Europe's largest pension funds and insurance companies.[17] This identification was made

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[16] The Preqin database is accessible at www.preqin.com. Preqin collects its data from both limited partners and general partners, as well as from different news sources and official filings. Based on my discussion with private equity professionals at pension funds, Preqin is often used by the pension funds themselves, thus presenting the minimum information that can be assumed to be available to professionals at pension funds when they make their investment decisions.

[17] The size of the pension fund was measured as the total assets under management. There is no single comprehensive database for the largest such institutions in Europe, so it is difficult to assess the comprehensiveness of our data. Compared to a Pension Funds Online list of the Top 100 European Pension

based on searching for information on company websites, company annual reports, and national and European-wide information sources (including Organization for Economic Co-operation and Development, European Union, and a number of publications on pension funds and insurance companies). The purpose of screening these companies by size was to ensure that they all were sophisticated institutional investors and to maximize the likelihood that they had invested in private equity funds.[18] Since this step did not directly involve any information on actual amount of private equity investments made by these institutional investors, this stage should pose no bias on the results.

Next, I matched this list of the largest European pension funds with the limited partners that had their investments listed on the Preqin database. Then, using this list of investments, I collected information on these funds' general partners, and all of the other funds listed on Preqin that these general partners had set up. To ensure that this sample consisted of funds with similar characteristics, I included only funds listed on Preqin that belong to one of the following types: balanced, buyout, CLO/CDO/senior loan,[19] co-investment, distressed debt, early stage, early stage: start-up, expansion, fund of funds, mezzanine, secondaries, turnaround, and venture (general).[20]

With all of the limited partners and funds known, I then created a data matrix in which all of the limited partners were on one axis, and all of the private equity funds set up by the general partners were on the other. A binary variable was created for each cell to indicate whether the focal limited partner had invested in the focal fund (1 was used for investments and 0 was coded for those observations where no investment took place). From this matrix, I excluded limited partners with no known investments to focal funds and funds for which I did not have adequate information (i.e., with no vintage, type, location, or general partner known).

In the final step, I restricted the dataset to only those observations where the focal limited partner had already invested in at least one of the focal general partner's prior funds. This restriction was chosen to specifically study the reinvestment decisions. Ultimately, this process yielded a dataset of 1,485 reinvestment decisions, 501 in which investment took place and 964 in which it did not. These investment decisions were made by 156 limited partners in 390 funds set up by 137 general partners. Because I did not have complete data on all variables on all observations, some of the analysis is based on a smaller subset of this dataset (thus, sample sizes are reported separately for each analysis).

Funds, our sample contains 64 of these 100 funds, with varying information on them. The pension funds in my sample mainly come from the UK, France, Germany, the Netherlands and the Nordic countries.

[18] Sophistication here means only that the institutional investor has enough resources available to be able to access the same information as others about investment opportunities available to it, i.e., it can benchmark the funds it has invested in against other similar funds.

[19] CLO refers to collateralized loan obligation while CDO refers to collateralized debt obligation.

[20] Effectively, I excluded funds such as infrastructure, natural resources, and real estate funds. Based on my discussions with private equity investment teams at pension funds, these investments are not typically managed by the institutional investors' private equity teams due to differences in dynamics and operating logic.

3.1.2 Description of Variables

In this subsection, I will describe all the variables used in the analysis as well as all the relevant issues with the variables:

Fund Returns. The dependent variable in the following analysis was the focal fund's return, and in order to avoid any problems with measuring these returns I used two complementary measures of returns. The first measure is the internal rate of return (IRR, or more precisely, natural logarithm of it). These IRRs were obtained directly from the Preqin database, which collects this data from both the GPs and the LPs. While IRR is the most commonly used measure of private equity returns taking into account both the returns and their timings, the Preqin database does not report the IRRs for all funds. To both account for recent concerns regarding the IRR as a measure of private equity fund performance (see previous sections and, e.g., Phalippou 2008 for more discussion on this) and to use a measure that is available for a larger sample of funds, I also used the return multiple (or again more precisely the natural logarithm of it) as another dependent variable in our analysis. While multiples do not take into account the timing of cash flows, they provide a somewhat alternative view on the returns than the IRR; a small return over a short time period may lead to a high IRR while being low in the scale of multiples. Also, the opposite is true for high returns over a long period of time, and thus to better assess the true returns, both measures should be taken into account. Finally, to ensure that the lack of observations on IRR data did not lead to biased estimates due to systematically different reporting of high and low return funds, I used a Heckman selection model to correct for potential sample selection bias.

Prior Fund Returns. Previous studies have shown a strong persistency in the general partners' fund returns (Kaplan & Schoar 2005; Phalippou & Gottschalg 2009). High returns in a general partner's one fund tend to lead to high returns in that general partner's subsequent funds. Therefore I controlled for this persistency by identifying the previous funds of the general partner and using either the IRR or the multiples (that is the natural logarithms of them) of the previous fund corresponding to the dependent variable. Since determining the actual previous fund is difficult for several reasons,[21] I determined the previous fund to be the fund immediately preceding the focal fund and being of the same type of private equity fund as the focal fund.

Because the fund returns and multiples reported in Preqin are from the summer of 2008, the performance data for previous funds are closer to the final outcome than the data that are available to limited partners at the time of a re-investment decision. In the data, the difference in vintage years between the focal fund and its predecessor fund is, on average, slightly less than 3 years. This could lead to a bias if funds were to systematically misreport their short-term performance data, for example, to "grandstand" (cf., Gompers

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[21] Two consecutive funds can be raised almost simultaneously, so that the previous fund to which they are actually compared to could be the same. Also, large general partners might raise several European buyout funds so determining which is following which fund is difficult. Related to this is the problem that the professionals at the general partner might change between two funds and how well prior performance then correlates with the future performance might be different due to these personnel changes.

1996; Brown *et al.* 2013). To rule out this bias and to test the robustness of our results against potential differences regarding available information on the returns of the prior funds, I repeated the same analyses using fund returns from the funds preceding the immediate predecessor. Between a fund and its predecessor's predecessor fund, there is an average of 5 years between the two funds. Previous studies have found that this is a sufficient length of time to produce fund return estimates that are highly correlated with the final returns (Kaplan & Schoar 2005). The results from these robustness analyses were qualitatively identical to estimates using the performance of the immediate predecessor.

Re-Investment Decision (Re-Ups). A key independent variable in this study is a binary variable indicating whether the focal limited partner reinvested or not into the focal general partner's new fund. I treated an observation as a re-investment decision if the focal limited partner had invested in any of the focal general partner's previous funds of the same type.[22] The variable was coded 0 for observations where the limited partner did not reinvest and 1 where he/she did reinvest. This approach enabled me to analyze also those investment decisions where no investment was made rather than focusing solely on positive investment decision, as in earlier studies (cf. Lerner *et al.* 2007). By analyzing the returns to limited partners' investments while taking into account the returns to funds not invested in by those limited partners, I was better able to rule out alternative explanations for the differences in the returns to different limited partners. This approach also explains why the results from this study contradict the results in the previous studies, which do not take into account the non-investment decisions.

I acknowledge that one of the main reasons for why limited partners might refuse to reinvest despite a general partner's previous funds' high returns are changes to the personnel at either the general partner or the limited partner level (Coller Capital 2008). The reasons for refusing to reinvest in such case may be due to the fact that the limited partner associates the performance of a fund to certain key individuals at the general partner organization or that personnel turnover may indicate internal conflicts at the general partner organization. While this data are on the level of organizations, I also ran analyses with limited timeframes to control for the effects of personnel turnover. No differences in the results were found with limited time frames.[23]

LP Experience/GP Experience. I measured limited partner's experience by counting the number of the same type of funds in which the focal limited partner had invested prior to the year of the focal investment decision. This is not only a proxy of the limited partner's experience but also controls for the number of available opportunities the limited partner is likely to have: general

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[22] This means that in order for an observation to be considered as reinvestment decision the following two conditions had to be met: 1) the LP had to have invested in a fund set up by that same GP in any year prior to the year of the observation, and 2) that previously invested fund had to be of the same type as the fund in the observation.

[23] I ran two robustness analyses in which I restricted the time between a fund and its predecessor to less than 3 and 5 years respectively. Although the datasets were smaller producing some troubles in the analysis, the results were effectively similar.

partners are fairly constant in the pace in which they set up new funds, thus, a limited partner with more prior investments is more likely to have more opportunities for reinvesting each year. Similarly, I measured a general partner's experience by counting the focal general partner's funds that are of the same type as the focal fund and that have their vintage year before the focal fund's vintage year.

LP-GP Relationship. I measured the strength of a relationship between a limited partner and a general partner by counting the number of the focal general partner's similar funds in previous years in which the limited partner had invested. The strength of the relationship also indicates how much work is required from the limited partner during the due diligence. Therefore, this is also a measure of inertia as reinvesting in a general partner's new funds is easier the more times the limited partner has invested into that general partner's prior funds.

Control variables. In the analyses, I used four control variables to rule out potential alternative explanations. First, I controlled for the vintage to ensure that the data were valid for returns (cf., Gompers & Lerner 2000; Kaplan & Schoar 2005). I included vintages between 1991 and 2005. Second, I controlled for fund size, because it correlates with fund returns (see, e.g., Kaplan & Schoar 2005).

Third, I controlled for the fund type, because it has also been shown to affect fund returns (e.g., Ljungqvist & Richardson 2003). Fund types were modeled as follows: one dummy variable is for buyouts (listed as buyouts in the Preqin database), another is for mezzanine funds (mezzanine in Preqin), a third dummy is for funds-of-funds (Fund of Funds), while a fourth dummy is for venture capital funds (consisting of funds listed on Preqin with any of the following codes: venture (general), expansion, early stage, early stage: seed, or start-up). The base case was all of the other funds (i.e., funds that are listed on Preqin as balanced, CLO/CDO/senior loan, co-investment, distressed debt, secondaries, or turnaround).

Fourth, I controlled for the fund location using dummy variables for funds listed in the US and Europe, with the base case being the funds located in the rest of the world. This was used to control for any systematic differences in the fund returns across geographic regions that might stem from regulation, available opportunities, etc.

3.2 Multilevel Mixed-effects Model

To analyze the returns to funds in which limited partners have reinvested and in which they have not I used a multilevel mixed-effects linear regression model (for more information, see, e.g., Baltagi *et al.* 2001; Rabe-Hesketh & Skrondal 2005). With the multilevel model it is possible to control for the fact that observations are not independent but they are clustered around higher-level variable, i.e., that a general partner's fund returns are clustered as the general partners' returns are persistent. Similarly, on the higher level general partners might be clustered as limited partners of certain type might be more

able to invest in certain types of general partners. All this can be controlled with the multilevel models. With the mixed-effect models, one can control for the random-intercept and random-coefficient that are due to higher level variables. This means, for example, that it is possible to control for the GP-level effect on the fund returns. I did not use ordinary least squares (OLS) regression since the investment returns are likely not independent from each other and/or explanatory variables. Therefore, OLS regression could not have been used in the analysis. The downside of using multilevel mixed-effects model is the degrees of freedom that are limited by the used model. However, since the sample used in this study is in several hundreds at minimum in each analysis, the degrees of freedom are fairly high in each analysis.

In the models that are used in this dissertation, limited partners are modeled on the highest level (identifier k), the general partners are modeled on the second-highest level (identifier j) and nested within the first level, and the funds are modeled on the lowest level (identifier i). Each general partner and fund is further treated as unique identities, despite them being nested under different limited partners. This type of setup is used to control for LP- and GP-specific differences (in a similar way to Hochberg *et al.* 2010). This reflects the assumption that all limited partners in a certain fund have the same kind of contract and cash flows. This assumption is rarely challenged in the context of private equity funds, and therefore this is the proper method to deal with the issue. With the above-stated assumptions, the model can be expressed as follows:

$$r_{ijk} = \beta_1 + X\beta + \zeta_j + \zeta_k + \varepsilon_{ijk}, \tag{1}$$

where r_{ijk} is the return variable for the observation ijk, β_1 is a constant, matrix X consists of the independent variables, ζ_k represents random effects due to LP (constant for limited partner k in all observations), ζ_j represents random effects due to GP (constant for general partner j in all observations), and ε_{ijk} is the error term associated with the observation ijk. Therefore, the statistical significance of either of the ζ_s indicates that there are systematic differences in the returns at that level (with s being either j or k).

In the analysis, I used the default convergence criteria in STATA version 11, except that I disabled the use of the Hessian-scaled gradient because I could not achieve convergence when the Hessian-based convergence criterion was used. This is likely due to the fact that I have a large number of funds in which I had only one investor, leading to the method being unable to differentiate between random effects at various levels and the error term.

In the robustness analysis section of the results, I ran the same regression analyses using Heckman-like sample selection correction method to avoid incidental truncation (for more information, see, e.g., Greene 2000). With this type of correction, the regressions are done in two successive steps, where in the first step a regression model is used to determine how likely the observation is to be included in the sample. The second step regression is then similar to the original models without the sample correction except that the likelihood of including an observation in the sample is used as an additional independent variable. This method helps to overcome potential reporting bias in the data,

which could be an issue if, for example, the more successful funds were more likely to report their returns. If the inclusion variable is statistically non-significant, the potential bias is not acute (as is the case in the analyses in this dissertation).

For the analyses, I used all of the funds for which I had information on all of the required variables. Ultimately, I used five models with slightly different variables included in each of them. In Models 1 and 2 I use IRRs for fund returns while in Models 3-5 I use return multiples. The measure for previous fund's returns used in each model is the same as the dependent variable in each model.

In Models 1 and 2, in which the IRR is used as the return variable, no control is included for the vintage. This is to avoid over-controlling the model, and should pose no significant bias for the results as IRR is a measure that takes into account the timing of the returns. Models 3-5 use multiples as their dependent variable and include vintage years as control. This is because otherwise the multiples would not be comparable across years.

3.3 Results of Reinvestment Decisions

This section presents the results in the order of going from the simple analysis to more complex. The purpose of this "narrative" is to show how one could first think that the limited partners would be different in their skills of selecting investment targets but that there are more plausible explanations when other factors are properly considered.

3.3.1 Descriptive Statistics

Panel A of Table II reports the descriptive statistics for the sample of all observations between 1991 and 2005 with IRR data on both the focal fund and its prior fund. Panel A has two components: columns 1-4 are for observations in which the limited partners chose to reinvest, and columns 5-8 are for those observations in which the limited partners chose not to reinvest. In the reinvested sample the sample size is 147 observations, whereas in the non-reinvested sample there are 273 observations. Column 9 shows the comparison between the means of the two samples using a standard t-test for the difference in means. According to the test, the difference in the returns is statistically significant at the 5% level.[24] Because the funds in which the limited partners reinvested are a bit older, the small difference in returns may be explained with the vintages alone. I will come back to this issue later with a more detailed analysis.

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[24] A Kolmogorov-Smirnov test also showed that the two samples do not have similar returns at the 5% level.

Table II
Entire Sample Summary Statistics

The first four columns show descriptive statistics for the sample of reinvestment decisions, where the limited partner (LP) has decided to invest in the fund, while columns 5-8 show the same statistics calculated for those observations where no reinvestment took place. LP experience is measured as the number of similar private equity funds in which the focal LP has invested over the prior years. Total number of funds set up by the focal general partner (GP) is represented by the GP experience. Vintage is the year when the fund started its operations. Fund size is a logarithm of the fund size measured in USD million. The LP-GP relationship tells how many of the focal GP's funds the LP invested in prior years. Fund returns (IRR) is the logarithm of the fund internal rate of return (IRR, but calculated as 1+IRR) as reported in the Preqin database in summer 2008. Prior fund returns (IRR) is the logarithm of the GP's previous fund's IRR (1+IRR) as reported in the Preqin database. Similarly, for funds with multiple information sources, the fund returns (multiple) is the logarithm of the return multiple reported in the Preqin database for the observation. Fund locations indicate the locations of funds as measured by the dummy variables. Similarly, fund type dummies indicate the fund types. Column 9 reports the difference in the means between the two populations, along with the significance level of a t-test for the difference. The sample size for reinvested funds with IRR information is 147 and for non-reinvested funds is 273. The sample size for observations with information on return multiples is 253 reinvested and 450 not reinvested. * denotes statistical significance at the 5% level, ** at the 1% level, and *** at the 0.% level.

Panel A: Observations with Fund Returns in IRR								
	Reinvested Funds				Not Reinvested Funds			Difference
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	
Fund return (IRR)	0.182	0.144	-0.14	0.61	0.150	0.150	-0.27	0.86	0.03*
Prior fund return (IRR)	0.175	0.171	-0.29	0.86	0.170	0.174	-0.27	0.99	0.01
LP experience	10.810	11.333	1	52	9.205	10.180	1	52	1.60
LP-GP relationship	2.170	1.776	1	11	1.553	1.137	1	9	0.62***
Fund size	7.174	1.375	3.22	9.16	6.468	1.594	2.64	9.16	0.71***
GP experience	5.476	6.040	1	25	7.136	6.918	1	25	-1.66*
Vintage	2001	3.437	1991	2005	2001	3.612	1991	2005	-0.60
Fund location: US	0.272	0.447	0	1	0.359	0.481	0	1	-0.09
Fund location: Europe	0.714	0.453	0	1	0.634	0.483	0	1	0.08
Fund location: RoW	0.014	0.116	0	1	0.007	0.085	0	1	0.01
Fund type: Buyouts	0.558	0.498	0	1	0.484	0.501	0	1	0.07
Fund type: Mezzanine	0.163	0.371	0	1	0.216	0.412	0	1	-0.05
Fund type: Fund-of-funds	0.170	0.377	0	1	0.231	0.422	0	1	-0.06
Fund type: Venture capital	0.007	0.082	0	1	0.022	0.147	0	1	-0.02
Fund type: Other	0.102	0.304	0	1	0.048	0.213	0	1	0.05*
Panel B: Observations with Fund Returns in Multiples								
	Reinvested Funds				Not Reinvested Funds			Difference
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	
Fund return (multiple)	0.910	0.252	0.34	1.79	0.890	0.261	0.25	2.42	0.02
Prior fund return (multiple)	1.006	0.265	0.15	1.79	0.965	0.271	0.25	2.42	0.04*
2nd previous fund's return	1.028	0.299	0.15	1.98	1.050	0.334	0.25	2.68	-0.02
LP experience	10.277	10.255	1	52	8.560	9.724	1	52	1.72*
LP-GP relationship	2.308	1.714	1	13	1.420	0.919	1	10	0.89***
Fund size	6.882	1.452	1.79	9.12	6.482	1.489	2.64	9.12	0.40***
GP experience	5.387	5.073	2	25	5.153	4.350	2	22	0.23
Vintage	2001	3.278	1992	2005	2001	3.409	1991	2005	-0.46
Fund location: US	0.142	0.350	0	1	0.236	0.425	0	1	-0.09**
Fund location: Europe	0.854	0.354	0	1	0.758	0.429	0	1	0.10**
Fund location: RoW	0.004	0.063	0	1	0.007	0.081	0	1	0.00
Fund type: Buyouts	0.652	0.477	0	1	0.562	0.497	0	1	0.09*
Fund type: Mezzanine	0.138	0.346	0	1	0.176	0.381	0	1	-0.04
Fund type: Fund-of-funds	0.126	0.333	0	1	0.216	0.412	0	1	-0.09**
Fund type: Venture capital	0.012	0.108	0	1	0.020	0.140	0	1	-0.01
Fund type: Other	0.071	0.258	0	1	0.027	0.161	0	1	0.04**

Funds in which the limited partners have reinvested tend to be larger than funds in which they chose not to reinvest. Limited partners also tended to re-invest more often in funds when there are more prior investments made by the limited partner to the general partner's prior funds. This may be explained with less resource-consuming due diligence in these cases where the limited partner and the general partner already are familiar with each other. In the reinvested sample, the general partners tend to have fewer prior funds. This might result from the fact that it usually takes a few funds until the general partner's quality becomes apparent, and limited partners need to reinvest at least once to a new general partner's funds to be able to determine that general partner's true quality. Thus the limited partner may not be able to choose not to reinvest in a fund by a new general partner, because if that general partner later turns out to be highly skilled, the limited partner might not anymore be able to invest in that general partner's subsequent funds.

Panel B of Table II shows the same statistics for observations that have in-formation on the focal fund's returns measured in multiples, previous fund's return multiple, and second previous fund's return multiple. Here the rein-vestment sample consists of 253 observations, whereas the non-reinvested sample contains 450 observations. Based on multiples, no difference in re-turns exists between the two samples. Again, we note that reinvestments tended to be larger and that the limited partners tended to be more familiar with the general partner. US funds are less likely to be reinvested, while Euro-

pean funds are more likely to be. This is a puzzling result: One would think it would be less difficult for these limited partners to find new funds in Europe than in the US because our sample consists of limited partners that are European. Thus, the difference is contradictory to what could be expected. These results could be explained with a home bias and larger risk aversion with further away investments. Limited partners favor deals closer to home since they (think they) are better aware of the risks involved with the local investments as compared to the investments in other geographical regions.

3.3.2 Analysis of Return Differences between Limited Partners

A central requirement for the argument is that there are actually systematic differences between limited partners' private equity fund investment returns. Based on the histogram of limited partners' average returns to their investments, this is evident in this sample (see Figure 2).[25] This analysis was restricted to funds with vintage years prior to 2005, and to limited partners that invested in at least three such funds. Similar results are attainable with practically any restrictions, so the results are not sensitive to these restrictions.
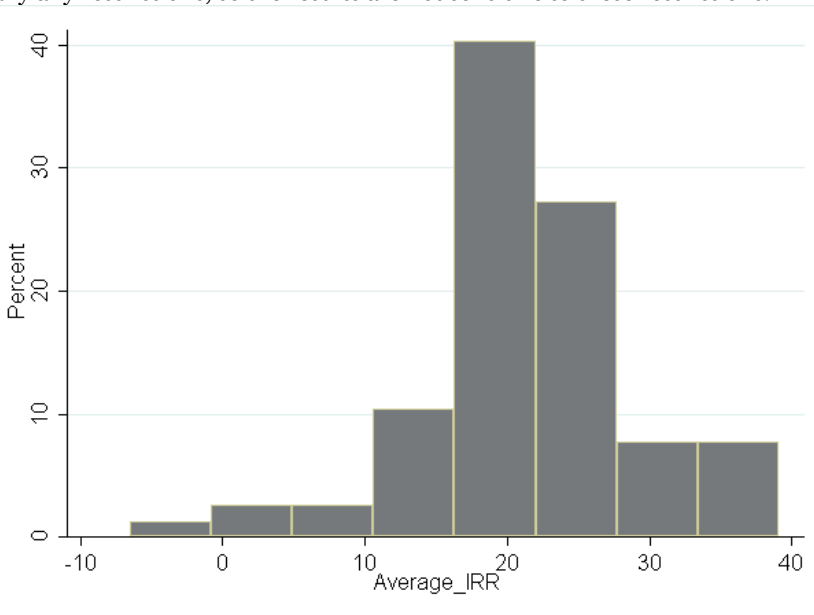
Figure 2. Histogram of the Limited Partners' Average Returns. Plots histogram of limited partners' average returns measured in internal rate of return (IRR). Funds were included in the calculation if their vintage year is before 2005, and limited partners were included if they had at least three funds in their portfolio.

The descriptive statistics also provide support for the argument that there are differences in the fund returns between funds in which the limited partners chose to reinvest and those in which they chose not to reinvest. The difference

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[25] This result is evident also based on my several informal discussions with various professionals at several limited partner organization. Also, various studies have reported similar results (see, e.g., Lerner *et al.* 2007).

in IRRs was deemed statistically significant at the 5% level (see Panel A of Table II). However, the slight difference in multiples was not statistically significant (see Panel B of Table II). While this simple analysis provides support for the previous research claiming that the selection skills matter, later in this dissertation I will come to show that when taking into account the previous funds' returns this difference becomes non-existent.

Differences in limited partners' returns, however, do not mean that some limited partners would be better in selecting funds with high returns. To analyze this issue I analyzed the difference in returns to reinvested and not reinvested funds. Assuming the limited partners, on average, would be able to choose better funds for reinvesting then the sample of reinvested funds should have higher return than the not reinvested funds. Table III shows the IRRs of reinvested and not reinvested averaged annually to rule out possibility that the results would be biased by different vintage years. Only a few of these annual differences are statistically significant. Additionally, the total difference in returns between the two groups is 0.032 in IRR (difference is 0.033 in multiples), indicating that limited partners would be able to select better funds when reinvesting. This difference is, however, not statistically significant.

Table III
t-test for Differences in Annual Returns from Reinvested vs. Not Reinvested Funds

This table reports average returns for all reinvestments and not reinvested observations. The comparison was done annually to control for the timing of the vintages because there are a different number of observations in reinvested and non-reinvested groups in different years. The returns are averaged over all limited partners. N indicates the number of observations in each category, and mean and Std. Dev. are calculated for the natural logarithms of the returns in observations. Difference is the difference in the means of the two populations. The last row is just for illustration, and it shows the average multiple in the two populations in the entire sample without a year control. In the IRR, we must note that the highly statistically significant differences during the first few years are simply the result of having few observations and very little variation between them. Apart from that, t-tests clearly indicate that the reinvestments do not have higher multiples than observations with no reinvestment. * denotes statistical significance at the 5% level, ** at the 1% level, and *** at the 0.1% level.

Vintage	Reinvestment	Fund Returns in IRR				Fund Returns in Multiples			
		Mean	Std. Dev.	N	Difference	Mean	Std. Dev.	N	Difference
1991	Not reinvested	0.225	0.001	5	0.002***	1.239	0.120	14	0.101**
	Reinvested	0.226	0.000	3		1.340	0.151	9	
1992	Not reinvested	0.236	0.072	10	0.172***	1.273	0.333	20	-0.028
	Reinvested	0.408	0.166	2		1.246	0.278	3	
1993	Not reinvested	-	-	0	-	1.278	0.171	3	-0.495**
	Reinvested	-	-	0		0.783	0.238	6	
1994	Not reinvested	0.331	0.152	2	-0.073	1.329	0.397	16	-0.060
	Reinvested	0.257	0.138	4		1.268	0.207	9	
1995	Not reinvested	0.168	0.033	4	0.179***	1.108	0.477	25	0.241
	Reinvested	0.347	0.020	2		1.349	0.632	13	
1996	Not reinvested	0.110	0.082	4	-0.006	1.009	0.170	8	-0.032
	Reinvested	0.104	0.000	4		0.977	0.150	10	
1997	Not reinvested	0.183	0.218	6	0.124	0.937	0.282	50	0.035
	Reinvested	0.306	0.231	7		0.972	0.196	30	
1998	Not reinvested	0.080	0.149	14	0.032	0.775	0.315	47	0.105
	Reinvested	0.112	0.050	7		0.880	0.196	27	
1999	Not reinvested	0.047	0.160	16	0.063	0.846	0.335	60	-0.021
	Reinvested	0.111	0.135	9		0.825	0.200	38	
2000	Not reinvested	0.143	0.099	27	-0.013	0.914	0.244	72	-0.005
	Reinvested	0.130	0.130	20		0.908	0.299	45	
2001	Not reinvested	0.211	0.138	23	-0.043	0.931	0.209	100	-0.029
	Reinvested	0.168	0.125	23		0.902	0.183	61	
2002	Not reinvested	0.123	0.157	25	0.120*	0.881	0.191	110	0.051
	Reinvested	0.243	0.124	9		0.932	0.195	45	
2003	Not reinvested	0.201	0.131	31	-0.054	0.851	0.132	110	0.006
	Reinvested	0.147	0.070	15		0.857	0.118	43	
2004	Not reinvested	0.171	0.112	23	0.068	0.883	0.205	123	0.037
	Reinvested	0.239	0.189	11		0.921	0.243	63	
2005	Not reinvested	0.130	0.171	83	0.055	0.746	0.132	226	0.065
	Reinvested	0.186	0.152	31		0.812	0.176	99	
Total	Not reinvested	0.150	0.150	273	0.032	0.880	0.256	984	0.033

Table III also shows a similar analysis done with the fund return multiples. The results show that only two years during which the difference is statistically significant, with one of the differences being positive and another negative (the significance is again a likely result of having relatively few observations during

those years). A total of seven out of the 15 annual differences are negative, with eight being positive, suggesting that there is no difference in the returns between those funds in which the limited partners chose to reinvest and those in which they chose not to reinvest.

Thus, Table III provides support for the conclusion that limited partners, at least as a whole, are not able to select better-performing new funds among the opportunities that they have. I have controlled for access by focusing on reinvestment decisions and found no evidence that there are any differences between the returns that limited partners are able to attain for the funds in which they invest and those in which they chose not to invest. This implies that there is no statistically significant difference between different limited partners' returns and that, as whole, they are not able to reinvest in better funds.

3.3.3 Return Differences on the Limited Partner Level

To see if individual limited partners have different returns on funds in which they chose to reinvest versus funds in which they chose not to reinvest, I also analyzed the returns to reinvestments versus non reinvestments for each individual limited partner to determine whether the results are driven by few extreme limited partners. To do so, I conducted a limited partner specific test on whether the limited partners had higher returns on the funds in which they chose to reinvest or in which they chose not to reinvest. The results of this analysis are presented in Table IV.

Table IV shows that there are only a few limited partners that have a statistically significant difference in the returns to reinvested versus not reinvested funds, and even fewer when looking at both return variables at the same time. In only one case a statistically significant difference in one return variable co-existed with statistically significant difference in the other return variable also. The most clearly significant coefficients were negative suggesting that these limited partners actually chose funds with lower returns for their reinvestments. These results again highlight the importance of utilizing at least two different return variables when analyzing private equity returns. Results obtained with one return variable might not be confirmed with another return variable, and therefore any conclusion drawn from the results on analyzing only one return variable might not be found when using the other return variable. This presents a challenge for any research on private equity returns. As stated previously, I have tried to overcome this problem in this dissertation by using two different measures for returns.

Another point to note in Table IV is that the limited partners with a statistically significant (and positive) return difference (i.e., those limited partners that have reinvested in better funds than those in which they have not reinvested) are not the ones with the most investments. More precisely, although this notion is not statistically significant in any of the cases, limited partners with the highest number of reinvestments and non-reinvestments also tend to have lower returns for the funds in which they reinvested. These results suggest that the limited partners, as a whole, are unable to select better funds to reinvest and that the individual limited partners are also unable to do this.

Table IV

t-test for LP-Specific Differences in Returns from Reinvested vs. not Reinvested Funds

The table reports LP-specific calculations for the differences in the limited partner's (LPs) returns to funds in which he/she has reinvested as opposed to funds in which he/she has chosen not to reinvest. In order for an LP to qualify for this comparison, we required that he/she has at least two reinvestments and two non-reinvestments between 1991 and 2005 in observations for which we have return information. The first four columns are for fund returns in IRR, and the next four columns are for fund returns in multiples. With multiples, we did not control for vintage, so there may be some bias due to LPs' reinvestments being from a different year than the non-reinvestments. Due to slight variation in the available information, some LPs might be included only in the other comparison. The fund returns are the logarithm of the corresponding return, as reported on the Preqin database. LP reinvested indicates whether the statistics are calculated for the reinvestments or non reinvestments. Difference is for the difference in means for the LP in the two populations. Stars indicate the statistical significance of a simple t-test for the difference in means. The lowest two rows indicate averages over populations and their standard deviations (where each LP is treated as a single observation). Neither of the population-level averages is different from zero with standard significance levels. * denotes statistical significance at the 5% level, ** at the 1% level, and *** at the 0.1% level.

	Reinvestment	Fund Returns in IRR				Fund Returns in Multiples			
		Mean	Std. Dev.	N	Difference	Mean	Std. Dev.	N	Difference
LP1	Not reinvested	0.108	0.098	20	0.021	0.819	0.209	33	0.002
	Reinvested	0.130	0.081	5		0.821	0.066	9	
LP2	Not reinvested	0.110	0.061	8	0.121*	0.811	0.130	11	0.022
	Reinvested	0.231	0.186	13		0.833	0.245	24	
LP3	Not reinvested	0.121	0.318	7	0.028	0.809	0.500	16	-0.012
	Reinvested	0.149	0.157	4		0.796	0.247	10	
LP4	Not reinvested	0.120	0.081	5	-0.008	0.754	0.245	11	0.039
	Reinvested	0.112	0.054	4		0.793	0.049	4	
LP5	Not reinvested	0.244	0.114	2	0.027	0.938	0.294	4	0.175
	Reinvested	0.271	0.113	3		1.113	0.096	3	
LP6	Not reinvested	0.080	0.022	2	0.085	0.776	0.063	11	-0.081
	Reinvested	0.166	0.229	2		0.695	0.254	5	
LP7	Not reinvested	0.229	0.191	7	-0.101	0.801	0.198	13	0.068
	Reinvested	0.128	0.115	4		0.869	0.271	9	
LP8	Not reinvested	0.181	0.122	6	-0.035	0.857	0.289	10	0.124
	Reinvested	0.146	0.135	2		0.981	0.345	4	
LP9	Not reinvested	-	-	-	-	0.766	0.084	12	0.316*
	Reinvested	-	-	-		1.082	0.241	5	
LP10	Not reinvested	-	-	-	-	0.788	0.100	2	0.051
	Reinvested	-	-	-		0.840	0.085	2	
LP11	Not reinvested	0.170	0.146	3	0.184	0.790	0.166	8	0.027
	Reinvested	0.354	0.063	2		0.817	0.099	4	
LP12	Not reinvested	-	-	-	-	0.680	0.147	2	-0.004
	Reinvested	-	-	-		0.676	0.222	2	
LP13	Not reinvested	-	-	-	-	0.736	0.107	5	0.448
	Reinvested	-	-	-		1.184	0.254	2	
LP14	Not reinvested	0.140	0.106	15	0.080	0.896	0.206	26	0.479
	Reinvested	0.219	0.116	3		1.375	0.442	3	
LP15	Not reinvested	0.142	0.171	31	0.004	0.824	0.177	46	0.112
	Reinvested	0.146	0.109	9		0.936	0.237	10	
LP16	Not reinvested	0.071	0.124	9	0.141*	0.787	0.283	12	0.074
	Reinvested	0.212	0.145	10		0.861	0.214	23	
LP17	Not reinvested	0.126	0.179	19	0.100	0.860	0.224	41	0.152*
	Reinvested	0.226	0.124	19		1.012	0.382	47	
LP18	Not reinvested	0.195	0.224	5	0.051	1.225	0.456	5	-0.269
	Reinvested	0.246	0.246	4		0.956	0.231	4	
LP19	Not reinvested	0.129	0.140	20	0.078	0.826	0.209	34	0.129
	Reinvested	0.208	0.141	9		0.955	0.170	10	
LP20	Not reinvested	0.153	0.132	6	0.012	0.839	0.318	12	0.197
	Reinvested	0.164	0.176	8		1.036	0.392	11	
LP21	Not reinvested	0.101	0.080	5	-0.031	0.786	0.209	5	-0.120
	Reinvested	0.070	0.284	5		0.665	0.079	4	
LP22	Not reinvested	0.205	0.210	27	0.024	0.972	0.318	36	-0.084
	Reinvested	0.229	0.165	16		0.889	0.275	37	
LP23	Not reinvested	0.155	0.136	9	0.125	0.791	0.103	10	0.369*
	Reinvested	0.280	0.168	2		1.160	0.197	4	
LP24	Not reinvested	-	-	-	-	0.788	0.100	2	-0.014
	Reinvested	-	-	-		0.774	0.091	4	
LP25	Not reinvested	0.048	0.157	4	0.160	0.831	0.161	11	0.029
	Reinvested	0.207	0.186	5		0.860	0.183	13	
LP26	Not reinvested	-	-	-	-	1.047	0.376	11	-0.562***
	Reinvested	-	-	-		0.485	0.013	2	
LP27	Not reinvested	-	-	-	-	0.788	0.100	2	-0.014
	Reinvested	-	-	-		0.774	0.091	4	
LP28	Not reinvested	0.419	0.317	4	-0.295	1.036	0.263	8	-0.046
	Reinvested	0.124	0.044	2		0.990	0.334	3	
LP29	Not reinvested	0.196	0.093	6	-0.072	0.818	0.016	5	-0.026
	Reinvested	0.124	0.056	4		0.792	0.060	3	
LP30	Not reinvested	0.176	0.182	54	0.023	0.945	0.269	75	0.092
	Reinvested	0.199	0.143	13		1.036	0.364	18	
LP31	Not reinvested	-	-	-	-	0.867	0.121	4	0.077
	Reinvested	-	-	-		0.944	0.169	4	
LP32	Not reinvested	-	-	-	-	0.552	0.128	5	0.236*
	Reinvested	-	-	-		0.788	0.131	6	

(*Continued*)

Table IV—*Continued*

LP33	Not reinvested	-	-	-	-	0.980	0.223	11	-0.008
	Reinvested	-	-	-		0.973	0.008	2	
LP34	Not reinvested	0.067	0.133	8	0.096	0.765	0.090	8	0.072
	Reinvested	0.163	0.007	2		0.837	0.006	2	
LP35	Not reinvested	0.215	0.090	5	-0.323**	0.797	0.053	6	-0.270
	Reinvested	-0.108	0.049	2		0.527	0.171	3	
LP36	Not reinvested	-	-	-	-	0.719	0.088	13	0.306
	Reinvested	-	-	-		1.025	0.328	3	
LP37	Not reinvested	-	-	-	-	0.748	0.047	5	-0.004
	Reinvested	-	-	-		0.744	0.030	2	
LP38	Not reinvested	0.128	0.115	6	-0.014	-	-	-	-
	Reinvested	0.114	0.070	2		-	-	-	
LP39	Not reinvested	0.125	0.154	17	0.071	0.834	0.247	24	0.195*
	Reinvested	0.196	0.143	7		1.028	0.168	7	
LP40	Not reinvested	-	-	-	-	0.731	0.075	4	0.048
	Reinvested	-	-	-		0.779	0.133	3	
LP41	Not reinvested	0.109	0.222	10	0.188*	0.819	0.282	15	0.182*
	Reinvested	0.297	0.194	15		1.001	0.173	18	
LP42	Not reinvested	0.116	0.126	13	0.042	0.970	0.330	14	-0.131
	Reinvested	0.157	0.117	3		0.839	0.255	8	
LP43	Not reinvested	0.071	0.045	5	0.068	0.753	0.085	9	0.015
	Reinvested	0.139	0.073	2		0.768	0.084	3	
LP44	Not reinvested	0.100	0.122	4	0.242*	0.950	0.277	7	0.094
	Reinvested	0.342	0.066	3		1.044	0.054	3	
LP45	Not reinvested	0.240	0.217	20	-0.179	0.983	0.342	23	-0.078
	Reinvested	0.060	0.063	2		0.905	0.161	14	
LP46	Not reinvested	0.091	0.183	5	-0.006	0.882	0.204	14	-0.097
	Reinvested	0.085	0.034	2		0.785	0.069	5	
LP47	Not reinvested	-	-	-	-	0.798	0.101	9	0.009
	Reinvested	-	-	-		0.807	0.204	2	
LP48	Not reinvested	0.155	0.114	6	-0.001	0.888	0.377	8	0.087
	Reinvested	0.155	0.123	2		0.975	0.356	2	
LP49	Not reinvested	0.090	0.062	6	0.096	0.779	0.192	13	0.194
	Reinvested	0.186	0.194	3		0.973	0.263	6	
LP50	Not reinvested	0.168	0.189	47	-0.025	0.911	0.252	66	-0.002
	Reinvested	0.143	0.164	45		0.909	0.260	62	
LP51	Not reinvested	-	-	-	-	0.860	0.178	3	-0.098
	Reinvested	-	-	-		0.762	0.048	3	
LP52	Not reinvested	0.182	0.268	6	0.037	0.874	0.192	7	-0.007
	Reinvested	0.219	0.112	8		0.866	0.162	12	

3.3.4 Regression Model without Sample Selection

Next, I will utilize multilevel mixed-effects regression model (introduced in Section 3.2) to study the limited partner's returns more accurately. With this model I can control for other factors that might affect the limited partners' returns. In Model 1 in Table V, I did not control for the general partner's prior fund performance. There is a positive coefficient on the 'LP reinvested' variable, although this coefficient is significant only at 10% level. This model suggests that limited partners could be able to select better-performing funds and invest in them as suggested by previous research (e.g., Lerner *et al.* 2007). The model suggests that the funds in which the limited partner re-invests into have 1.9 percentage points higher IRR. However, in Model 2, where I specifically controlled for prior performance, the 'LP reinvested' variable becomes statistically insignificant. Thus, it seems that the correlation between previous fund's returns and focal fund's returns makes the variable insignificant. This indicates that limited partners tend to reinvest in funds that are established by those general partners whose previous fund has had high returns. Therefore, limited partners would not be able to pick better funds – instead they just seem to pick funds with the highest returns in their predecessor fund.

When the previous returns are controlled for, the limited partners are not able to choose better funds for reinvesting among all of the funds in which they could reinvest into. One should also note that fund size becomes insignificant when the previous fund's performance is controlled, thus supporting the find-

ings in previous research stating that better-performing general partners tend to raise larger funds (Kaplan & Schoar 2005). This finding also gives support to my research setting by confirming the previous findings and therefore providing support that the method used here is correct.

Table V
Multilevel Mixed-Effects Regression without Correction for Sample Selection

Table V shows the estimates for multilevel mixed-effects regression model on fund returns reported in Private Equity Intelligence database (Preqin), measured as the logarithm of internal rate of returns (IRRs) in Models 1 and 2, and in the logarithm of multiples in Models 3-5. LP reinvested is a dummy variable indicating whether the limited partner (LP) reinvested (indicated by 1) or not (0) to the fund in the observation. Prior fund return is the natural logarithm of the focal general partner's (GP) previous fund's return (again in the logarithm of IRRs in Models 1 and 2 and in multiples in Models 3-5). Second previous fund's return indicates focal GPs second previous funds' return measured in multiples (no such IRR model is available due to the IRR sample being too small). GP experience is the number of the same type of funds the GP has set up during previous years. Fund size is the logarithm of fund size in USD million as reported on Preqin. The LP-GP relationship is the number of the GPs similar funds in which the focal LP has invested during previous years. LP experience is the overall number of same type of private equity funds in which the LP has invested during previous years. Fund type is the dummy variable for fund types, while category labeled 'other funds' is the default. Fund locations are dummy variables indicating fund locations, with the category "Rest of the World" being the default. In Models 1 and 3, we did not control for previous performance, whereas in Models 2 and 4, we did. In Model 5, we also controlled for the second previous fund's returns. In Models 3-5 we have controls for vintages from 1992 to 2005 (1991 being default), but these are not included in the Table. † denotes statistical significance at the 10% level, * at the 5% level, ** at the 1% level, and *** at the 0.1% level.

	Dependent variable				
	IRR		Multiple		
Fixed Effects	Model 1	Model 2	Model 3	Model 4	Model 5
LP reinvested	0.019†	0.017	0.004	-0.007	0.002
	(0.011)	(0.014)	(0.011)	(0.011)	(0.012)
Prior fund returns (IRR)	-	0.046	-	-	-
	-	(0.038)	-	-	-
Prior fund return (multiple)	-	-	-	-0.011	-0.022
	-	-	-	(0.024)	(0.039)
2nd previous fund's returns (multiple)	-	-	-	-	0.149***
	-	-	-	-	(0.030)
LP experience	0.000	0.000	0.000	0.000	0.009†
	(0.000)	(0.001)	(0.001)	(0.001)	(0.005)
LP-GP relationship	-0.007†	-0.005	-0.002	0.006	0.000
	(0.003)	(0.005)	(0.003)	(0.004)	(0.001)
GP experience	-0.002	0.000	0.000	-0.001	0.005
	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)
Fund size	0.012*	0.006	0.015**	-0.003	-0.069***
	(0.005)	(0.007)	(0.006)	(0.007)	(0.010)
Fund location: US	-0.093	-0.182*	-0.019	-0.042	0.127
	(0.088)	(0.086)	(0.112)	(0.122)	(0.149)
Fund location: Europe	-0.075	-0.157†	-0.012	-0.026	0.091
	(0.088)	(0.085)	(0.111)	(0.121)	(0.150)
Fund type: Buyout	0.110***	0.071*	0.079***	0.102**	0.157*
	(0.026)	(0.035)	(0.025)	(0.035)	(0.064)
Fund type: Mezzanine	-0.006	-0.049	-0.147***	-0.174***	-0.224***
	(0.028)	(0.039)	(0.028)	(0.035)	(0.067)
Fund type: Fund-of-funds	0.040	0.006	-0.052	0.007	-0.156†
	(0.036)	(0.046)	(0.033)	(0.046)	(0.086)
Fund type: Venture capital	-0.036	-0.014	-0.039	-0.058	-0.030
	(0.049)	(0.059)	(0.047)	(0.052)	(0.071)
Random Effects	Model 1	Model 2	Model 3	Model 4	Model 5
LP	0.001	0.000	0.004	0.003	0.001
	(0.005)	(0.028)	(0.004)	-	(0.005)
GP	0.096	0.070	0.136	0.146	0.177
	(0.010)	(0.011)	(0.011)	-	(0.019)
Residual	0.129	0.123	0.164	0.152	0.131
	(0.003)	(0.005)	(0.003)	-	(0.004)
N	902	420	1485	1075	703

Furthermore, the statistically significant random coefficient on the general partner identifier variable in the random-effect part of the regression indicates that there are certain general partners that are able to systematically outperform others. In contrast, the limited partner level indicator is insignificant,

suggesting that any systematic difference in the returns of limited partners eventually boils down to differences at the general partner level. This supports the findings in the previous research noting the general partners' persistency in the returns that they are able to attain on their funds (e.g., Kaplan & Schoar 2005).

In Models 3-5 in Table V, I ran the regression model with the returns measured in multiples. In addition to these models' different measure of investment performance, I had more data on multiples and thus was able to use larger sample sizes with multiples. However, using multiples, I needed to control for the fund vintages, because the fund multiple increases with time passed since the fund's vintage (unlike IRR). In Model 3, I did not control for a general partner's prior performance. In Model 4, I controlled for the previous fund's performance, and in Model 5, I controlled both the previous and the second previous funds' returns. Because the average time between a fund and its preceding fund was only 2.5 years in this sample, the fund returns may not be accurate when the LP has to consider investing into the next fund. The second previous fund in our sample was 4.5 years old at that time and thus gives a more accurate prediction on the prior fund performance.

In Model 3 in Table V, I did not control for prior fund returns and found that fund size was statistically significant. This is likely because the fund size has a high correlation with prior fund performance. In addition, several of the fund vintages and a few fund types are statistically significant. Model 4 in Table V shows estimates for a model where the general partner's previous fund's returns are controlled. The results are similar to the results in Model 3, except fund size is no longer statistically significant, suggesting – as already stated – that fund size correlates with the prior fund's returns. Finally, in Model 5 in Table V, I controlled for both the general partner's previous fund's and the second previous fund's returns. Fund size is again significant (increase of fund size from 10 to 11 million means that the focal fund's multiple is 0.0066 units lower), but the previous fund's return is not. When I ran a similar regression without the fund size, the previous fund's returns became negative (coefficient -0.15) and statistically significant at the 0.1% level. This indicates that the differentiation between fund size and the previous fund's returns is not a simple task. Despite this difficulty, one must acknowledge that including one of the variables in the analysis without controlling for the other will produce biased estimates.

In Model 5 in Table V, the LP experience is statistically significant at 10% level, with no significance in Models 3 and 4 (in model 5, 1 more investment into similar fund by the limited partner increases the focal fund's multiple by 0.009). It is also interesting to note that the previous fund's returns are not statistically significant, whereas the second previous fund's returns are. An increase of 1 multiple in the second previous fund's returns increases the focal funds returns by multiple of 0.16. Why second previous fund's returns are statistically significant and the previous fund's returns are not is likely because the previous fund is, on average, less than three years old at the time of investment, and fund returns at that age are not accurate in determining the

future returns. Second previous funds' returns are much more accurate, but there are fewer funds whose second previous returns are known compared to those with only the most previous funds returns known.

To ensure the robustness of these results, I also estimated Models 1 and 2 in Table V with funds that have vintages between 1993 and 2002 to ensure that the results are not driven by funds established between 2003 and 2005.[26] This robustness test also controls for the duration of the ties between limited partners and general partners. This ensures that the results are not be driven by ties between general partners and limited partners that initiated long ago and might have thereafter actually disappeared. The results are similar with this setup. Similarly, when I included only observations where the time between a fund and its predecessor fund is more than five years, the results are similar. The shortcoming of this analysis, however, is that the sample size is less than half of the original model, which may have lead to all of the coefficients being statistically insignificant at typical confidence levels.

To see how my results relate to the findings of Sensoy *et al.* (2013) who noted that there is a paradigm change in the private equity between 1991-1998 and 1999-2006, I run the regression Models 2 and 4 with only the years 1991-1998 and with 1999-2006 to see if there is a difference in the results between the years.[27] For Model 2 the results for period 1991-1998 are insignificant since there are only 74 observations but re-investment decision is positive and significant while in the latter period 1999-2006 there are 350 observations but the re-investment is non-significant. While this result may support the findings in Sensoy *et al.* (2013), my result could also be driven by the fact that in the latter period the funds' returns are not yet realized to any significant extent by the time the data is gathered. For Model 4 these robustness results are non-significant for both periods. Thus, this robustness analysis is inconclusive in terms of whether there has been a change in the dynamics between the two time periods as suggested by Sensoy *et al.* (2013).

Respectively, Table V shows that while all the limited partners are similar to each other in terms of the systematic returns they attain on their investment decisions, the general partners are systematically different. When I controlled for the prior fund returns (which effectively measures general partners' quality), the limited partners were unable to select better funds when deciding re-investments. This indicates that the relevant information available to the limited partners at the time of the reinvestment decision is contained in the general partners' prior funds' returns.

3.3.5 Regression Model with Sample Selection

To further validate the results presented in the Section 3.3.4, and to avoid potential selection bias I ran the same regressions using a Heckman-like correc-

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[26] I do not report these results here because they contain very little new information in addition to what is reported in the text. Numerical estimates are similar as well as the statistical significances, taking into account the smaller sample sizes.

[27] These results are not reported here either for they contain very little statistically significant information apart from what is detailed in this report.

tion for the potential selection bias. This was done by regressing the selection likelihood (lambda) for every observation with a Probit regression model (see the results in Table VI). In the selection model, I controlled for the following factors: vintage, fund type, fund location, fund size, previous fund's returns reported (dichotomous variable, which is valued 1 when the general partner reported returns on its previous fund, 0 otherwise), number of known investors in the fund (counted as the number of limited partners that have reported investing in that fund), and whether the general partner raised subsequent funds after the focal fund (dichotomous variable with the value of 1 if the general partner was able to raise following funds even after 2005 but before summer 2008 when the data was collected).

Table VI
Sample Selection Regression Model

The Table VI shows estimates for the Probit estimation of the selection model for both return variables. These estimates are used for the calculation of lambdas in Table V. Fund size represents fund size in billion USD. GPs previous fund's performance is a binary variable indicating whether the General partner's (GP) previous fund's return is reported in the Preqin database. Number of LPs in the fund indicates the number of limited partners (LP) in our sample that invested in the focal fund. Subsequent fund raised by the GP is a binary variable indicating whether the general partner raised any following funds after the focal fund. Fund location: US controls for funds located in the US, while Fund location: Europe controls for funds located in Europe. The base case is funds located in the rest of the world. Fund type control variables control for the respective types of funds with the remaining types of funds being included in the base case. Additionally, vintages were controlled for in the estimation, although these coefficients are not reported in the table. † denotes statistical significance at the 10% level, * at the 5% level, ** at the 1% level, and *** at the 0.1% level.

	Dependent variable	
	IRR reported	Multiple reported
Fund size	0.330***	0.188**
	(0.058)	(0.059)
GP's previous fund's returns reported	1.065***	1.116***
	(0.079)	(0.079)
Number of LPs in the fund	0.041*	0.226***
	(0.020)	(0.027)
Subsequent fund raised by the GP	0.017	0.029
	(0.106)	(0.103)
Fund location: US	0.281†	0.212
	(0.164)	(0.165)
Fund location: Europe	-0.465**	-0.365*
	(0.168)	(0.167)
Fund type: Buyout	0.324**	0.065
	(0.122)	(0.123)
Fund type: Mezzanine	0.257	0.090
	(0.188)	(0.186)
Fund type: Fund-of-funds	0.005	-0.050
	(0.136)	(0.137)
Fund type: Venture capital	0.089	-0.039
	(0.124)	(0.123)
N	1691	1691

Utilizing the selection regression, I calculated the lambda and then redid the analysis presented in the previous section with the lambda as an additional independent variable to ensure that sample selection did not bias the results. The results of these analyses are presented in Table VII. As noted, the regression coefficients are similar compared to Table V.

Table VII

Multilevel Mixed-Effects Regression with Correction for Sample Selection

The Table VII shows the estimates for multilevel mixed-effects regression model on fund returns reported in Private Equity Intelligence database (Preqin), measured as the logarithm of internal rate of returns (IRRs) in Models 1 and 2, and in the logarithm of multiples in Models 3-5. The model incorporates Heckman-like correction for sample selection. LP reinvested is a dummy variable indicating whether the limited partner (LP) reinvested (indicated by 1) or not (0) to the fund in the observation. Prior fund return is the natural logarithm of the focal general partner's (GP) previous fund's return (again in the logarithm of IRRs in Models 1 and 2 and in multiples in Models 3-5). Second previous fund's return indicates focal GPs second previous funds' return measured in multiples (no such IRR model is available due to the IRR sample being too small). GP experience is the number of the same type of funds the GP has set up during previous years. Fund size is the logarithm of fund size in USD million as reported on Preqin. The LP-GP relationship is the number of the GPs similar funds in which the focal LP has invested during previous years. Lambda is calculated for each observation based on the selection regression model presented in Table VI and effectively gives the likelihood for such an observation to be included in the analysis. LP experience is the overall number of same type of private equity funds in which the LP has invested during previous years. Fund type is the dummy variable for fund types, while category labeled 'other funds' is the default. Fund locations are dummy variables indicating fund locations, with the category "Rest of the World" being the default. In Models 1 and 3, we did not control for previous performance, whereas in Models 2 and 4, we did. In Model 5, we also controlled for the second previous fund's returns. In Models 3-5 we have controls for vintages from 1992 to 2005 (1991 being default), but these are not included in the Table. † denotes statistical significance at the 10% level, * at the 5% level, ** at the 1% level, and *** at the 0.1% level.

	Dependent variable				
	IRR		Multiple		
Fixed Effects	Model 1	Model 2	Model 3	Model 4	Model 5
LP reinvested	0.017†	0.011	0.003	-0.000	0.004
	(0.011)	(0.015)	(0.011)	(0.011)	(0.013)
Prior fund returns (IRR)	-	0.047	-	-	-
	-	(0.038)	-	-	-
Prior fund return (multiple)	-	-	-	0.001	-0.017
	-	-	-	(0.025)	(0.040)
2nd previous fund's returns (multiple)	-	-	-	-	0.149***
	-	-	-	-	(0.030)
LP experience	0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
LP-GP relationship	-0.007*	-0.005	-0.002	0.005	0.008†
	(0.003)	(0.005)	(0.003)	(0.004)	(0.005)
GP experience	-0.001	0.001	0.000	-0.001	0.004
	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)
Lambda (from selection model)	-0.027†	-0.059*	-0.009	0.134*	0.061
	(0.015)	(0.024)	(0.019)	(0.054)	(0.064)
Fund size	0.008	-0.002	0.013*	0.009	-0.062***
	(0.001)	(0.007)	(0.007)	(0.008)	(.0.011)
Fund location: US	-0.093	-0.187*	-0.018	-0.033	0.128
	(0.088)	(0.084)	(0.111)	(0.120)	(0.147)
Fund location: Europe	-0.065	-0.143†	-0.012	-0.020	0.091
	(0.088)	(0.084)	(0.111)	(0.120)	(0.147)
Fund type: Buyout	0.103***	0.056	0.079**	0.098**	0.154*
	(0.026)	(0.035)	(0.025)	(0.035)	(0.063)
Fund type: Mezzanine	-0.010	-0.058	-0.149***	-0.179***	-0.223**
	(0.028)	(0.039)	(0.028)	(0.035)	(0.067)
Fund type: Fund-of-funds	0.035	-0.001	-0.053	0.000	-0.154†
	(0.036)	(0.035)	(0.033)	(0.046)	(0.085)
Fund type: Venture capital	-0.053	-0.039	-0.040	-0.071	-0.038
	(0.050)	(0.059)	(0.047)	(0.052)	(0.072)
Random Effects	Model 1	Model 2	Model 3	Model 4	Model 5
LP	0.001	0.000	0.004	0.002	0.001
	-	(0.021)	-	(0.005)	-
GP	0.095	0.068	0.136	0.144	0.174
	-	(0.011)	-	(0.013)	-
Residual	0.129	0.123	0.164	0.152	0.131
	-	(0.005)	-	(0.003)	-
N	902	420	1485	1075	703

Again in Model 1 in Table VII the LP reinvested is statistically significant at 10% level. This means that limited partners would get about 1.7 percentage points higher IRR for funds in which they chose to reinvest as compared to funds in which they chose not to. In other models this variable is statistically insignificant.

The most important result presented in the Table VII is that the lambda coefficient is positive and significant in only one of the models (and negative and significant in one other), while being insignificant in all others. This indicates

that selection bias is not evident in the overall data. Therefore, the results attained in this section are not driven by different reporting by different limited partners, but the results are due to the reasons stated in the text.

Some caution is advised in interpreting the results presented in Table VII, because the variables included in both the selection model and the final model are not directly interpretable. This is because a variable present in both regression models can have effect either through a selection parameter or through itself in the real regression model (or most likely it will have some effect through both). One should also be cautious as the data did not allow for the random effects to be calculated for all the models. The estimates are not biased but they are not efficient either – this inefficiency is not an issue in models 2 and 4 so the lack of statistical significance is not the result of model problems.

4. Access Formation

In the Section 3, I showed that limited partners were similar in their ability to select better funds for their reinvestments and that the limited partners were not able to pick only the winners. Thus, the systematic differences in returns between various limited partners were due to the fact that these limited partners had access to different funds. In this section I will show how such observation can lead to systematic differences in the returns between different types of limited partners.

How can there be systematic differences in the returns that different types of limited partners are able to attain? In the previous section I showed that while limited partners were, on average, similar in their ability to select reinvestments they were different in the returns that they attained due to them having different access. In this section I will utilize a simulation model to show how these systematic differences in the returns to limited partners can extend to systematic differences between different types of limited partners.

Little is known about how access is formed between the limited partners and the general partners. No previous study has focused on understanding how the limited partners are able to invest in some general partners but not in others. I will utilize a simulation model to show how a certain set of dynamics (derived from the findings in the previous section) can produce private equity market similar to reality. These dynamics will then explain how access is formed between the limited partners and the general partners. To study returns to various types of investors I will now extend the setting in previous sections by also focusing on other types of limited partners in addition to just focusing on pension funds alone.

4.1 Model Settings

This simulation model is deeply rooted in the real-world private equity investing.[28] The parameters and dynamics in this model are chosen to closely mimic the observed empirics. The dynamics are taken from the real investment process, and the parameter values are decided according to what is reported in research or what can be calculated from the data (whenever such parameter values are available).

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[28] This section is mostly based on Section 2, but also to the extensive discussions I had with the various professionals at several limited partner organizations.

Actors in the model are of two types: general partners and limited partners. Not taking into account the investors/investments, in other regards each general partner is identical to each other in every respect other than the returns that they produce to investors (see general partner returns in the next section for more discussion), while each limited partner is similar to every other limited partner in every way other than in their reputation due to the investor type (see limited partner type-reputation in the next section for more discussion).

In this section of the dissertation, I will assume that the limited partners will not only have access to the general partners in which they have previously invested in (as was assumed in Section 3), but also to other general partners. Access to those general partners in which the limited partner has invested in previously is an often used simplification (e.g., as in Lerner *et al.* 2007) as it is fairly common that the limited partners reinvest in a general partner's new funds when they have invested in that general partner's previous funds. Typical limited partners will reinvest into 75% of the general partners that the limited partner has invested into previously (Coller Capital 2011b). The reason for such behavior is that the due diligence is less resource-consuming and that this way the limited partner maintains its access to the potential future high-return funds of those general partners (Meyer & Mathonet 2005). This extension from the basic simple assumption to more complex concept of access will enable more accurate and more generalizable findings. Still, this does not mean that all general partners are available to all limited partners.

There are several ways to narrow the group of general partners available to limited partners, but I will only focus on one that is based on the limited partners' reputation.[29] Limited partners with high reputation have better access to those general partners with the high returns, and vice versa. A limited partner's reputation might consist of such factors as the returns that the limited partner has attained previously, how much it has invested in private equity, how long it has invested in private equity, how it has conducted its businesses within the private equity community, etc. In this model, there is no need to know the exact composition of the variable, all I am assuming at this point is that such a variable can be formed. In this model the exact variable is calculated as follows:

$$LPR = \beta * LPTR + (1 - \beta) * LPIPR, \qquad (2)$$

where beta indicates the tradeoff between limited partners achieved returns and its reputation due to its type. In this equation LPR is limited partner reputation, LPTR is limited partner type-reputations, and LPIPR is limited partner investment portfolio returns. I will discuss these parameters in more detail in the next subsection but at this point it is important to note that the beta-coefficient tells about how much the type of the investor is valued over the actual returns that the limited partner has.

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[29] In my informal discussions with several limited partners, reputational issues were often cited as a reason for many investments. All actions taken by limited partners and general partners will affect their reputation within the private equity community, and as such, how others perceive these actors within the community.

It is generally thought that certain types of investors, e.g., funds-of-funds, are not as highly appreciated as investors as some other types of investors. For example, funds-of-funds are seen as short-term investors and therefore not as good investors for a private equity fund. This is because when the investors in the fund-of-funds want to take their money away the fund-of-funds may become less likely to reinvest with the general partner, or in the worst case, they may want to try to default on their commitments. Such actions cost time and money for the general partner, and it diminishes the other limited partners view of the general partner – an unstable investor base in a certain general partner's funds is a risk for limited partners. Similarly, general partners have ranking for other types of limited partners as well, whether it is implicit or explicit. All these rankings are modeled into the simulation.

In addition, I will take into account that the general partners' returns cannot be known accurately beforehand. To do this, I will utilize a "transparency" variable to measure how well the limited partners can assess the true quality of general partners and how much they have to rely on other measures - the other measures being in this case the reputation of limited partners investing in the general partners' other funds. The exact variable used in this simulation is calculated as follows:

$$GPQ = \alpha * GPR + (1 - \alpha) * GPIPR, \qquad (3)$$

where alpha indicates the tradeoff between real and the perceived quality of a GP, GPQ is the general partner quality, GPR is the general partner returns, and GPIPR is the general partner investor portfolio reputation. Equation 3 shows that the alpha parameter depicts how well the limited partners are able to assess the general partners' true returns. With alpha being close to one they are able to correctly tell how good the general partner is, while with low alphas the limited partners need to rely on a proxy – which in this case is the quality of the investor base in that general partner's funds. It is also evident based on the Equation 3 that the reputation of a limited partner is also clouded by the "transparency" variable.

By interpreting the general partners' quality as a combination of the returns that they are able to produce and the quality of their investors represents the difficulty that the limited partners have in not being able to accurately assess the quality of the general partners (similar idea is presented in Chung *et al.* 2010). The returns to a general partner may be driven by (good or bad) luck, creative accounting, or any such factor that does not actually represent the quality of the investment team within the general partner. Or it could be that the general partner is so new that their returns are not yet known and thus their quality cannot be assessed based on the returns. Therefore, limited partners, to some extent, use other investors in the general partner's previous funds as a proxy of that general partner's quality – the better the investor base, the better the quality of the general partner.

The simulation is turn-based with a fixed set of actions taking place each turn. During each turn, the limited partners invest in general partners and the general partners take investments from the limited partners. The purpose of

the limited partners is to gain maximum returns to their investments, and the purpose of the general partners is to increase their perceived quality.

As the simulation proceeds to subsequent turns, each limited partner invests to a number of general partners (see Limited partner investment portfolio size in the next subsection for more discussion) and gains the returns based on this portfolio (see limited partner portfolio returns in the next subsection for more discussion). While limited partners favor general partners in whom they have prior investments (see Limited partner investment portfolio in the next subsection for more discussion), they also may invest in those general partners in which they have not invested previously. However, while the limited partner's returns are determined by the invested general partner's returns, they choose new investments based on their perception of how qualified the general partner is (see general partner quality in the next subsection for more discussion).

Similarly, each general partner takes in a number of limited partners as investors (see General partner investor portfolio size in the next subsection for more discussion). The general partner favors limited partners which have already invested in the general partner (see General partner investor portfolio in the next subsection for more discussion), and limited partners with high reputation.

To introduce dynamics to this system I have included several conditions under which the limited partner might terminate its relationship with a general partner. I will now present these conditions and how they are included in this model: The fact that limited partners may seemingly randomly (that is random to an outside observer) terminate their investment relations to general partners, is a simplification.[30] Such reasons for a limited partner to end its investment relationship with a general partner could include a key person leaving the general partner (closely related issue is presented in Freiburg & Grichnik 2012 where they find that social ties between limited partners and general partners are a significant contributor to limited partners' investment decisions), in which case the limited partner may consider that the general partner organization has lost its ability to attain similar profits in its future funds as it has with its previous funds. Also, the focus of the new fund could be different than the focus of the previous fund (this is true often when two consecutive funds are significantly different in size) and the limited partner does not want to invest in a fund with that new focus. Third, and also relatively common reason, is that contract terms between the general partner's two consecutive funds may be different (for more such reasons, see, e.g., Coller Capital 2011a, 2012). Thus, even though the general partner has had high prior returns, the contract terms in the new fund might be such that the limited partner does not want to continue in the next fund. One most simplistic example of this is that the general partners with high prior returns might want to increase their fees.

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[30] Blackstone, one of the most famous and highest returns general partner organizations says 84% of its limited partner base has invested in a successive fund. This means that for some reason, few limited partners choose not to reinvest even though they are very unlike to get better returns from elsewhere – meaning that the reason for not reinvesting is not the returns. (Source for the percentage is Blackstone website, accessed Feb 19th, 2013. http://www.blackstone.com/limited-partners/our-approach)

Thus, the reasons why some limited partners might terminate their partnership with any of the general partners are many, but to an outside observer the real reason is rarely obvious. This is because such reasons are not necessarily due to any visible changes in either the limited partner or the general partner (or the prior fund performance) and therefore these terminations are occurring fairly constantly across all limited partners and general partners (no studies have reported, for example, different termination rates between different types of limited partners). As these terminations are not due to other events and as they are equally likely in all relationships between limited partners and general partners, they can be treated as randomly occurring events in this simulation without biasing the results.

To simulate that the general partners with the lowest returns have difficulties in raising new funds as limited partners are not willing to invest in them is done by eliminating the general partners with lowest returns after each turn. It is commonly found in the empirical research that general partners with low returns are not able to raise new funds and must seize their operations. Such occurrences in reality rarely mean that the limited partner would decrease investments to private equity funds altogether, but just that the limited partners naturally must find new general partners to invest in their new funds. This all is also taken into account in the simulation by forcing the limited partners to find new investments for each general partner that cease to exist.

4.2 Model Parameters and Variables

This section describes the variables that are used in the Model. In this section, the term parameter is used to describe variables that are specified prior to running the simulation while the term variable is used specifically for those variables that calculated during the simulation (i.e., for those that are endogenous). Some of the parameters were introduced already in the previous subsection, but here they will be discussed in greater detail.

In the base-case simulations, three parameters, alpha, beta, and LP/GP-ratio are central variables that will be changed between simulations to see the effect of the hypothesized concepts. In the robustness analysis section also the other parameters vary. Alpha measures how well the limited partners are able to distinguish the general partners' true returns (beforehand) and how much they have to rely on looking at the other investors in those general partners' fund. Similarly, beta measures how much certain types of limited partners are valued by the general partners because of their type and how much because of their previous investment returns. LP/GP-ratio will tell how many limited partners there are for each general partner.

General partner returns. The general partner returns is an endogenous variable that describes how large returns the focal general partner's investors receive. This variable is ordinal in the beginning and thus it only gives the returns relative to other general partners (new general partners are created randomly along the spectrum). Furthermore, this variable is hidden so that it is not known to investors, although it is used in determining the limited partner's

portfolio return variable. This variable lists all general partners in order according to their returns (high means better). Thus, a general partner with return ranking equal to 1 has the lowest returns. By using just the sequential order, all variables are commensurable without any assumptions on their distributions. This variable can be thought of as IRRs or multiples without significant effect on the results. The choice of return variable has effect only through how fast the model converges to a some kind of equilibrium but it does not affect whether such exists (at least as long as the variations of the return distributions are small enough).

General partner investor portfolio. This endogenous variable tracks which limited partners are currently investors of the focal general partner. Itself this variable is not interesting but it is used in calculating other endogenous variables in the model. The focal general partner favors these limited partners when deciding new investors in the following turns. This favoring means that in any given turn, the limited partner can always invest into a fund set up by a general partner in whose fund the limited partner has invested in the previous turn.

General partner investor portfolio size. This is a parameter that describes how many investors each general partner has at any time. This parameter is the same for each general partner and it does not vary in time either. For various reasons discussed in the section 2, there is little correlation between a fund's returns and the number of investors in that fund. General partner investor portfolio size is set to 10. For the sake of simplicity, this value is set to be the same as the limited partner investment portfolio size.

General partner investor portfolio reputation. This endogenous variable tells the order of general partners according to the reputation of their General partner investor portfolio. This variable is calculated in each period to determine the combined reputation of each general partner's investor portfolios. It is the sum of all limited partner reputations of all limited partners in the focal general partner investor portfolio.

General partner quality. This endogenous variable describes the order of general partners according to their quality. The quality is a function of general partner returns and general partner investor portfolio reputation.[31] The quality is a linear combination of the two, and can be represented as follows:

$$GPQ = \alpha * GPR + (1 - \alpha) * GPIPR, \qquad\qquad (3)$$

where alpha indicates the tradeoff between real and the perceived quality of a GP, GPQ is General partner quality, GPR is General partner returns, and GPIPR is General partner investor portfolio reputation. Alpha will have one of the following values: 0.1, 0.5, or 0.9. These values will represent various scenarios where the information about the general partners is either transparent (i.e., they are valued only by their true returns, alpha equals one), or nontransparent.

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[31] In my discussions with the private equity professionals, it was often said that the limited partners in a general partner's fund tell something about the quality of that general partner. This is because "better" limited partners were known to do their due diligence thoroughly and they had a reputation of being able to invest in funds set up by better general partners. In case one feels that the parameter is not completely accurate, I will run the model with the parameter value set so that the general partner is not measured.

Limited partner investment portfolio. This endogenous variable describes for each limited partner the general partners in which the focal limited partner has invested. The focal limited partner favors these general partners when deciding investments in the following turns. The limited partner will continue investing in each of these general partners unless it has access to better opportunity or it decides (for some unspecified reason) to quit partnership with a specific general partner. This parameter is key to introducing real-world like momentum in the investments and to keep track of the access that the limited partners have.

Limited partner investment portfolio size. This is a parameter that describes how many investments each limited partner has at any time. This parameter is the same for each limited partner and it does not vary in time either. While this is a simplification, at least in a few years perspective, the limited partners seem to want to do the same number of investments each year. Also, whether the portfolio size would be different for some of the limited partners does not effect the results since it can be modeled into this simulation by using limited partner type-reputation (more on this will follow) and by looking at those limited partners with suitable returns (the number of investments does not play role, so high returns from one fund is the same as lower returns from two funds, for example). For the base-case, the limited partner investment portfolio size is set to 10. This enables enough changes on the overall level, and is somewhat balanced with the number of general partners.

Limited partner investment portfolio returns. This endogenous variable describes the combined returns for each limited partner. It gives out the order of limited partners according to their portfolio returns. This variable is calculated by summing up all general partner qualities in the focal limited partner investment portfolio.

Limited partner type-reputation. In this model, there are several types of investors in the model, all of which are identical in every sense except one – the limited partner type-reputation parameter is used to describe how attractive investor the limited partner's type is considered to be by the general partners.[32] The higher the reputation the more likely it is for the limited partner to be able to invest in those funds that it wants to invest in. Limited partner type-reputation parameter has four potential values: highly attractive (++), attractive (+), neutral (0), and unattractive (-). The respective values used in the analysis are 3 (for ++ category), 2 (for +), 1 (for 0), and 0 (for – category). For simplicity, I will divide the limited partners equally to each of the four categories with each category having 25% of the limited partners. In the real world this would represent the fact that all else being equal, the general partner would choose any limited partner with higher type-reputation over others with

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[32] As was discussed already earlier, certain types of limited partners are seen as better investors than other types of investors. For example, it is fairly common belief that politically motivated limited partners will invest in poorer general partners if it is otherwise according to their strategy. Therefore, any general partner with such politically motivated limited partners will signal that it might not be top quality – and as will be allowed in this model this signaling might or might not be true. Similarly, funds-of-funds are seen as poor investors as they are affected by their own cash flows. And on the other end are so called flagship investors that are large and prestigious organizations and/or investors that have reputation for making solid investment choices.

lower type reputation. Together with beta value these will give the tradeoff of how much lower returns can a higher type-reputation limited partner have to still be considered as better alternative than a lower type-reputation limited partner with higher returns. All limited partners within respective category will be given the same value. In the base-case, this value does not affect the simulation as beta will be set to zero.

Limited partner reputation. This variable describes the order of the limited partners according to their perceived reputation. The perceived reputation is calculated using the following equation:

$$LPR = \beta * LPTR + (1 - \beta) * LPIPR, \qquad (2)$$

where beta indicates the tradeoff between limited partners achieved returns and its reputation due to its type, LPR is limited partner reputation, LPTR is limited partner type-reputations, and LPIPR is limited partner investment portfolio returns. Beta will have value of 0.00 in the base case and values between 0.00 and 1.00 at intervals of 0.05 in the beta analysis. These values will represent various scenarios where the information about the limited partner is either transparent (i.e., they are valued only by their true investment returns, beta equals zero), or nontransparent.

General partner regeneration. This parameter is used to determine how many of the general partners with the lowest General partner quality are replaced by new general partners in each turn. As in the real world, those general partners with the lowest returns will find it difficult to raise new funds and they cease their operations. New general partners will emerge to try to raise capital and as in the real world, their quality can be at any level of the return spectrum. The number of replaceable general partners is the same in each period and does not vary according to time. General partner regeneration is set to 0.1, meaning that in every turn, the 10% of general partners with the lowest quality will be dropped out.

Investor-base regeneration. This parameter describes the chance of any limited partner not investing in any turn in some general partner despite prior investment to that general partner. Not all limited partners continue reinvesting in all the general partners and the reasons for this are numerous but nontransparent to an outside observer (so the not reinvesting seems like a random, and is actually treated as a random in this simulation model). It is thus used in every period for every limited partner in case of every general partner in the focal limited partner's limited partner investment portfolio. Investor-base regeneration will be set to 0.1. Studies show that true non-reinvestment rates are between one third and one half, and combined with the fact that some of the non-reinvestments are classified here as general partners being replaced this value comes fairly close to reality.

LP/GP-ratio. A central parameter in the simulation is the limited partners to general partners –ratio, which tells how many limited partners there are for each general partner. With high ratio there is much more competition among the limited partners and the general partners are better able to choose their investors. With the ratio being opposite it is the investors who are able to choose their investments. LP/GP-ratio will have one of the following values:

1.0, or 0.9. This ratio will tell how many limited partners there are for each general partner. Together with the limited partner portfolio size and the general partner investor portfolio size they decide how many investments and investment opportunities there are altogether either made or available at any given time. The various values will affect how many limited partners are competing for the same investment opportunities, but also together with the general partner regeneration this will affect the level of changes in the system between the turns. Values higher than one are not interesting as there rarely are situations where there would be more investors than investment opportunities. Values much lower than 0.9 would only result there being more and more redundant general partners. This would mean that no one would invest in the general partners with the lowest returns and the average of all would increase while the dynamics would become smaller and changes more difficult to observe. Number of limited partners in the model is limited to 25 so the number of general partners is either 25 or 28 depending on the ratio. Any larger number does not add any new insight into the analysis, but on the other hand, it is large enough to eliminate results being driven by few externalities.

The number of turns in a simulation round, n, will be set to 25. If each turn represents a new fund by the general partners, which in reality is in cycles of 2 to 3 years, then this is long enough period to represent reality.

The number of iterations for a set of parameters, N, will be set to 10. This is enough to cancel out externalities in randomization while low enough not to even out all variation (the variables of interest are averages over all the iterations so with large number of iterations the model becomes almost deterministic).

A brief listing of all the parameters/variables is presented in Table VIII.

Table VIII
Model Parameters and Variables

The Table VIII describes the parameters and variables and their values used in the model. The first column shows the name of the parameters / variables. The second column gives out brief description of the variables. Third column details potential range of values for the variables. Fourth column details values used for the base case (endogenous tells that the variable is calculated during the simulation). Other values list all the other parameter values that are used in the other simulations to study the characteristics of the model.

Parameter / variable name	Variable Description	Potential variable value range	Base-case values	Other values
General partner returns	Describes the returns to a general partner.	Positive integer	Positive integer [1-25]	Positive integer [1-25]
General partner investor portfolio	Lists all limited partners currently investing into the funds set up by the focal general partner.	List of identification numbers	-	-
General partner investor portfolio size	The number of limited partners that can invest into a general partner.	Positive integer	10	5
General partner investor portfolio reputation	Tells how good reputation the general partner's investors have. This is calculated as the sum of all limited partner reputations of all limited partners investing into the general partner.	Positive real number	Endogenous	Endogenous
General partner quality	Describes the perceived quality of the general partner. Calculated as the weighted average of general partner returns and general partner investor portfolio reputation. Alpha describes the weight.	Positive real number	Endogenous	Endogenous
Limited partner investment portfolio	Lists all general partners in which the limited partner has currently invested in.	List of identification numbers	-	-
Limited partner investment portfolio size	The number of general partners in which the limited partner can invest in within one turn.	Positive integer	10	5
Limited partner investment portfolio returns	Variable describing the returns to the limited partner's portfolio. Calculated as the sum of the returns of all general partners in the limited partner's portfolio.	Positive real number	Endogenous Positive integer [10-250]	Endogenous Positive integer Depends on the portfolio size
Limited partner type-reputation	Lists limited partner types in the order in which they are preferred by the general partners.	Either 0,1,2 or 3	No effect (beta 0)	0,1,2,3
Limited partner reputation	Describes the perceived reputation of the limited partner. Calculated as the weighted average of limited partner type reputation and the limited partner portfolio returns. Beta describes the weight.	Positive real number	Endogenous	Endogenous
General partner regeneration	How many of the lowest return general partners are replaced by new general partners each turn.	Interval [0,1]	0.1	-
Investor-base regeneration	How many of the relationships between general partners and limited partners are terminated each turn.	Interval [0,1]	0.1	-
Alpha	The extent to which the general partners are measured based on their returns and not their investor base	Interval [0,1]	0.5	0.1 and 0.9
Beta	The extent to which the limited partners are measured based on their type and not on their returns	Interval [0,1]	0	[0,1] at 0.05 intervals
LP-GP-ratio	Ratio of limited partners to general partners.	Positive real number	1	0.9
Number of general partners	The number of general partners in the model. Together with the LP-GP-ratio tells also the number of limited partners.	Positive integer	25	28

4.3 Model Dynamics

In the model, all parameter values apart from LP/GP-ratio, alpha, and beta are fixed and remain the same throughout the simulation. These fixed parameter values are decided prior to running the simulation. LP/GP-ratio, alpha, and beta are parameters that vary between rounds. The number of rounds (M) is determined by the combination of suitable parameter values for LP/GP-ratio, alpha, and beta. Each round is calculated using the same values for these parameters, and each round consists of N such repetitions. Each of these N repetitions consists of n turns. Therefore, the simulation consists of M*N*n turns.

4.3.1 Contents of a Simulation Round

Each simulation round consists of a number of repetitions (N). Each of these repetitions during one round for a set of parameters is similar in all other aspects except the initial setup (more detailed description of this follows). From this it follows that for a given set of parameter values, the (potential) difference in results is mostly due to differences in the initial setup.

For each round, with the unique combination of values for GP/LP-ratio, alpha, and beta, specified number of limited partners and general partners are created (their ratio corresponding to the GP/LP-ratio of the current round). The limited partners are then assigned values for Limited partner type-reputation, with 25 percent of limited partners belonging to each group. For the general partners, values for General partner returns are drawn.

4.3.2 Initial Setup (Turn 0)

Each simulation during one round begins with a random assignment of investments, so that each limited partner will invest randomly to general partners so that both the Limited partner investment portfolio size and the General partner investor portfolio size are met. Based on these investments, a value for Limited partner investment portfolio returns is calculated for each limited partner. Using the Limited partner investment portfolio returns, a value also for Limited partner reputation is determined, as well as values for General partner investor portfolio reputation and General partner quality.

At the end of this step, general partners with the lowest values for General partner quality are dropped out (the amount is determined by General partner regeneration parameter). The same number of new general partners is created with each having random value for their General partner returns parameter. Also, for each investment made by all the limited partners, it is randomly determined whether the investment relation ceases to exist (the chance is given by the Investor-base regeneration parameter). All investment relationships that do not cease to exist continue.

4.3.2 Subsequent Simulation Turns (Turns 1 to n)

Each subsequent turn in the simulation is identical in terms of actions that occur within the turn. These actions can be divided into four steps. During the

first step, all limited partners are categorized in order according to their Limited partner reputation. Similarly, all general partners are ranked according to their General partner quality.

During the second step, all limited partners – in the order of their Limited partner reputation will choose to invest in the best general partners (ranked according to their General partner quality) so that their investment quota is full (i.e., their Limited partner investment portfolio size is met). Also, the limited partners can not invest in general partners whose investor portfolio is already full (this is given by General partner investor portfolio size).

During the third step, when all investments have been made, a new value is calculated for each limited partner and for each general partner for Limited partner investment portfolio returns, Limited partner reputation as well as for General partner investor portfolio reputation and General partner quality.

Finally, in the fourth step, general partners with the lowest values for General partner quality are dropped out and the same number of new general partners is introduced. The General partner returns-parameter values for each of these new general partners are randomly determined. Also, for each limited partner – general partner relation it is randomly determined whether the relation continues in the following turns.

4.3.3 Simulation Round Ending

Each simulation round ends when the number of repetitions is reached. During the round of simulations, the values for each simulation's each turn's results are stored: Limited partner investment portfolio returns, Limited partner reputation, General partner investor portfolio reputation, and General partner quality. At the end of the simulation round, averages of all the relevant values are calculated. Several graphs are drawn to show the development of returns as a function of prior returns. These turn-specific values also enable the determination of how fast the convergence is, if such a relationship is determined in the first place.

Following the end of a single simulation round, the simulation will continue to next round with new combination of GP/LP-ratio, alpha, and beta values. With the results of multiple rounds, it is possible to determine the sensitivity of prior-returns to returns relationship to these parameters.

4.4 Simulation Results

The simulation contains a base-case analysis, which introduces the simulation model and discusses the behavior of it with a certain set of parameter values. The base case is run with the best estimates for the parameters (based on previous research and the data used in this dissertation).

Following the base-case analysis is an analysis of the effect of the beta-coefficient. This subsection will discuss what happens when certain (types of) limited partners are treated as preferred investors by the general partners. This section most closely mimics the reality of private equity investing.
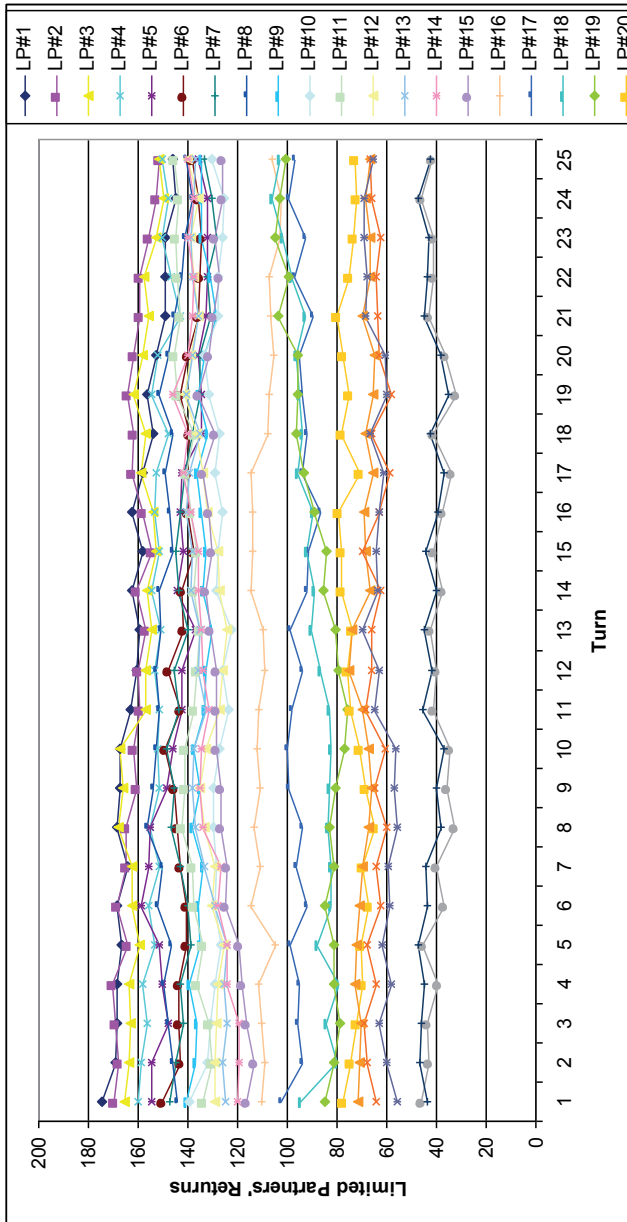
Finally the results will deal with a robustness analysis subsection, which shows the effect of various parameters on the simulation dynamics and results. These robustness cases are mostly run with parameter values that vary slightly from the base-case to see how robust the results are for parameter values close to the base case and to see whether the change in the results is in line with what is expected. While I ran a large number of robustness cases only few are reported here. This is because the chosen cases are enough to show the effect of each parameter on the simulation results. Furthermore, including additional simulation reports does not give any new significant information in addition to the results reported already in this dissertation.

4.4.1 Base-case Analysis

The most basic case of the simulation model is as follows: 1) the limited partner type does not have any effect (beta will have value of zero), 2) there is the same number of limited partners as there are general partners (LP/GP-ratio is set to 1), and 3) the true returns are not completely transparent and the general partner's true returns are as important as is its investor base in determining how good returns the limited partners expect to get from investing in the focal general partner (alpha is 0.5). All other cases will be compared to this one. The results of the base case are presented in the Figure 3. For simplicity, only the 20 highest returning limited partners are included, so that LP1 is the limited partner with the highest portfolio returns in the first turn, and then the rest are ranked accordingly.

Reporting only 20 of the highest returning limited partners is also due to the fact that the limited partners with the lowest returns may not be able to invest their full quota. This is because they will be the last ones to invest and all the other limited partners have preferred not to invest in the poorest general partners and consequently, during some turns, the lowest-return limited partners will only be able to invest in a general partner in which they have already invested once in that period. As only one investment at maximum in a certain general partner is allowed for each limited partner, the limited partners with the lowest returns may not have their full quota of investments fulfilled each turn and their portfolio returns are low during that turn. In the next turn, similar issue is more likely to happen to these limited partners and these low returns will continue in the following rounds also. As such, including the limited partners with the lowest returns would make the results more difficult to compare and would produce results not seen in reality.

In reality, the lowest-return limited partners would most likely stop investing in private equity as they could attain better returns from other asset classes. The lowest returns to private equity are much lower than the average returns to other asset classes and therefore moving out from the private equity investing is a rational choice for such limited partners. Since the limited partners are a fixed set in this model, the results of the simulation are not accurate for the lowest returning limited partners. This shortcoming does not, however, bias the results for the other limited partners.

Figure 3. Average Returns to Limited Partners in the Base-case Simulation. The figure plots average returns (in units, the higher the better) to limited partners over 10 iterations. The figure includes only top-20 limited partners. The figure shows that the initial returns (turn 1) significantly determine the future returns (for all subsequent turns). The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0, number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

Reporting only 20 of the highest returning limited partners is also due to the fact that the limited partners with the lowest returns may not be able to invest their full quota. This is because they will be the last ones to invest and all the other limited partners have preferred not to invest in the poorest general partners and consequently, during some turns, the lowest-return limited partners will only be able to invest in a general partner in which they have already invested once in that period. As only one investment at maximum in a certain general partner is allowed for each limited partner, the limited partners with the lowest returns may not have their full quota of investments fulfilled each

turn and their portfolio returns are low during that turn. In the next turn, similar issue is more likely to happen to these limited partners and these low returns will continue in the following rounds also. As such, including the limited partners with the lowest returns would make the results more difficult to compare and would produce results not seen in reality.

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What is evident based on Figure 3, is that in this base case, the initial returns that the limited partners are able to attain determine, to a significant extent, also their future returns. However, as is evident, there are some limited partners that are able to change their relative position significantly. This too, should be expected based on the data from the real world. Observing such results in this base-case model validate the basic assumptions behind the model dynamics.

Therefore, the base case seems to be fairly accurate description of the reality and the results observed in the empirics in the Section 3, but more discussion on this will follow in the Section 5. While the base case (and all subsequent extensions of it) is a simplification of the reality and the most important part of this simulation model is to study the effects of various parameters, the results of the base case still allow generalizations and insight into the real world.

Turning next to the return variance in the 10 different runs of the simulation, Figure 4 shows the return intervals for 5 limited partners with different returns (the highest return LP, 6th highest LP, 11th LP, 16th LP, and 20th highest return LP). The chosen limited partners represent the whole spectrum of returns so that every fifth of the limited partners is chosen, according to their return ranking. The upper limit for the return intervals are calculated by adding one standard deviation to the mean, while the lower limit is calculated by subtracting that one standard deviation from the mean. The results are similar for any set of limited partners, i.e., what is the starting point for the limited partners makes no difference (so as if the limited partners are 2nd, 7th, 12th, 17th and 21st , is not significantly different from what is presented in Figure 4).
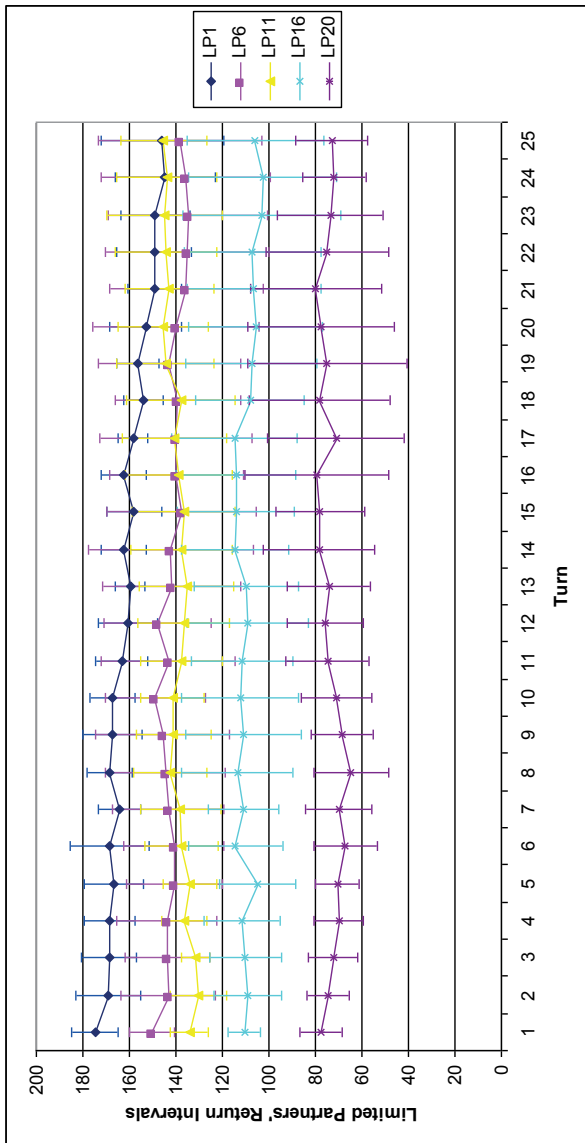
Figure 4. Return Intervals for Limited Partners in the Base-case Simulation. The figure plots average returns (in units, the higher the better) to limited partners with one standard deviation intervals to both directions from this average. These are calculated over 10 iterations. The figure includes only top-20 limited partners. These results show that the variation in the average returns increases when moving away from the top representing the fact that the rest are more dependent on the options left after the higher ranked limited partners have made their choices. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

The results in Figure 4 show that the variances for the limited partners with the highest returns are relatively smaller than for the limited partners in the middle and at the bottom of the return rankings. This is explained by the fact that the limited partners in the high end of the return spectrum are better able to pick the best alternatives while the others are more dependent on what is left. Limited partners with the highest return general partners already in their portfolio (most often) can only invest in lower return general partners when they have to choose new investment targets. Limited partners on the low end of the return spectrum (excluding the extremely worst ones), on the other hand, can sometimes be able to invest in the better general partners thus increasing their portfolio returns. Therefore the variance for the lowest returns varies the most as the lowest ones are left with the option that the others did

not take – it can be ok but it can be terrible in terms of returns. Also there is still practically no tendency for the returns to regress to the mean in the long run, as only rarely do the limited partners dramatically change their position in the return rankings. Again, this seems to be what the observations from the real world suggest. Those limited partners in the middle of the return spectrum have either the possibility of gaining access to higher general partners or, in the opposite case, be left with the lower return general partners. Therefore we see that their variance is much higher than that of the top limited partners.

What can be seen in Figure 3 and in Figure 4 is that the tendency for limited partners as whole to be stable in the return ranking does not hold for individual limited partners. We can see that certain limited partners, thanks to a few good investments, can quickly become one of the top limited partners. Similarly, the limited partner can also fall quickly in the rankings. However, the large changes tend to come in early periods in the simulation and the rankings seem to change less after that. This is again as would be expected since the limited partners with many good investments tend to be able to loose the bad ones and replace them with the good ones. The opposite is true of course for the limited partners with many bad investments, i.e., they are left with investing in the low return general partners whom the better limited partners have abandoned.

Now, after having looked at the basic results in this base-case it is worth to take a closer look at the model. Based on the Figure 3 it seems as though the limited partners' returns are clustered and there are groups of limited partners with similar returns and that these clusters seem not to overlap. To analyze this I will run a cluster analysis on the limited partners' portfolio returns. I will use equal weights in weighted average linkage model with Euclidean distance as the distance measure. This method is the best since: 1) I do not want to predetermine the number of clusters, 2) I want to allow significantly different sizes for clusters, and 3) all variables included in the calculation of the distance are about the same scale. I will use the portfolio returns to rounds 21-25 to calculate the distance to avoid any bias stemming from effects of one round. For this base-case the cluster analysis dendrogram is presented in the Figure 5.
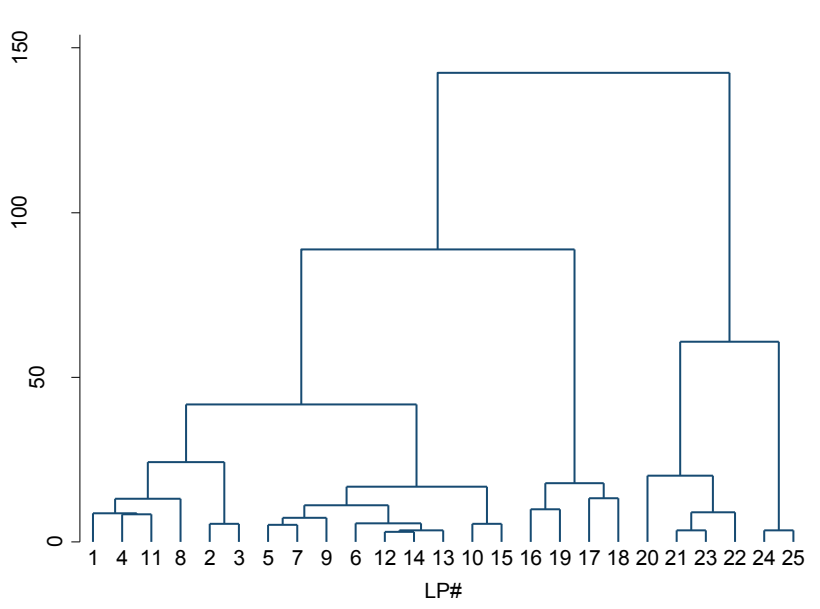
Figure 5. Base-case Cluster Analysis Dendrogram. This figure shows the clustering of limited partners according to the weighted average linkage of their portfolio returns in turns 21-25. The weights are equal. The portfolio returns are averages of 10 simulations. With a cutoff distance of 50 the cluster analysis groups the limited partners to four different groups.

Figure 5 shows that there indeed is clustering among the limited partners. To allow for some clustering but not too much I chose cutoff distance for further analysis to be 50. The figure above shows that then the limited partners are clustered to four clusters.

To be better able to analyze whether this emergence of clustering is only due to chance or whether it is an inherent property of the model, I repeated the base-case simulation for total of 10 times. The clustering for these 10 runs is presented in Table IX.

Table IX confirms that the clustering of limited partners according to their portfolio returns is indeed an inherent property of the simulation model. Given that the general partners favor limited partners with high returns, there is a tendency for such limited partners to be able to invest in those general partners with high returns. As such there is a persistency in the returns the limited partners are able to attain and therefore they are clustered to various numbers of clusters. Limited partners in one cluster are highly unlikely to move to another cluster. Since the averages between clusters in most cases are highly different and the standard deviations relatively small, these clusters have statistically different returns. Such emergent differences between limited partners are an interesting finding and may help to explain why there are systematic differences in returns between the various types of limited partners. I will discuss these findings more in the Discussion section of this dissertation.

Table IX
Clustering of Observations in 10 Base-case Simulations

The Table IX shows cluster analysis for 10 different simulations (cases) using Base-case parameter values. The clustering is calculated using equal weights on weighted average linkage distance measure. The measure used is Euclidean distance on the portfolio returns in turns 21-25. This method enables cluster numbers to be non-predetermined and the cluster sizes that can vary significantly. The portfolio returns are averages over 10 iterations. The cutoff distance for clusters is 50. Obs in the table tell the number of observations in each cluster, while average tells the average portfolio returns in that cluster and std. dev. shows the standard deviation.

|		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Case1	Obs	15	4	4	2	-
	Average	140.02	101.65	67.98	42.00	-
	Std. Dev.	7.68	3.71	3.40	0.28	-
Case2	Obs	6	11	3	5	-
	Average	153.43	129.97	92.57	48.04	-
	Std. Dev.	8.07	8.24	11.13	13.59	-
Case3	Obs	7	9	5	1	3
	Average	148.85	123.89	92.78	71.40	44.07
	Std. Dev.	7.70	5.51	10.45	0.00	3.41
Case4	Obs	1	13	5	2	4
	Average	166.50	136.45	112.58	83.30	46.58
	Std. Dev.	0.00	9.10	6.51	6.79	10.19
Case5	Obs	16	4	1	4	-
	Average	134.28	106.45	74.00	47.60	-
	Std. Dev.	12.28	5.08	0.00	3.79	-
Case6	Obs	17	4	4	-	-
	Average	137.16	98.28	37.88	-	-
	Std. Dev.	9.40	10.07	4.50	-	-
Case7	Obs	15	5	5	-	-
	Average	136.05	108.08	50.76	-	-
	Std. Dev.	9.69	5.96	10.75	-	-
Case8	Obs	1	16	2	2	4
	Average	161.90	133.93	108.25	76.85	44.45
	Std. Dev.	0.00	7.15	9.26	3.04	4.75
Case9	Obs	4	13	5	3	-
	Average	154.10	130.04	87.36	38.60	-
	Std. Dev.	7.82	9.09	11.67	3.21	-
Case10	Obs	14	7	4	-	-
	Average	139.61	97.83	49.83	-	-
	Std. Dev.	9.00	11.49	10.04	-	-

4.4.2 Beta Analysis

In the previous subsection I was able to show that the systematic differences between the limited partner groups can be an emergent property resulting from the fact that those limited partners with high returns are more likely to be able to invest in the high return general partners in the future. However, this might not help to explain why these systematic differences exist between various limited partner types.

To try to explain the systematic differences in the returns that different types of limited partners are able to attain, I will make a simple assumption: all limited partner types are not equally attractive investors. That means that certain types of limited partners are preferred if all else is equal.

To begin with I will go back to the base-case analysis presented in Figure 3. As each limited partner had a type (but this did not have any role in the base

case) I counted the average returns to each investor type. This was done by taking all type 1 investors and calculating their average return over all of those types of investors in all iterations for turn 1, turn 2, and so forth. Similarly for all other types of investors and we get the following average returns (see Figure 6).
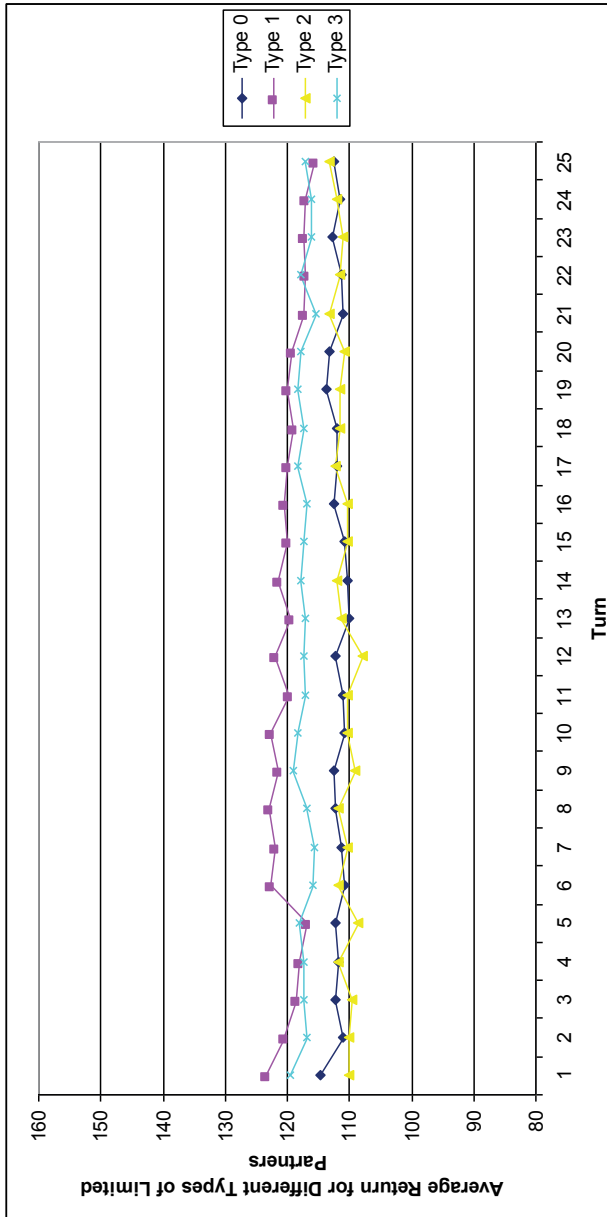
Figure 6. Average Returns to Limited Partner Types in the Base-case Simulation. The figure plots average returns (in units, the higher the better) to limited partner averaged over their types over 10 iterations. The figure includes all limited partners. The figure shows that there is no significant impact for the limited partner type in the base case as should be the case since there was no preference over certain types of limited partners. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor base regeneration is 0.1 also. Type tells which limited partners are more attractive investors with type 0 being the least attractive and type 3 the most attractive (plays no role in the base case but for comparison). Turns represent stages where the portfolio composition is potentially subject to change.

Based on Figure 6 it is evident that when beta has value 0 the investor type plays no role in determining the limited partner returns (as should be the case as beta zero means that the type of investors has no effect in the calculations). The averages of different types of investors are in random order and they fluc-

tuate slightly over all turns. Still, changes in relative positions are few and changes in absolute terms are minimal too. This is because even though there is some fluctuation within the types of investors and some persistency in the returns, the changes are averaged out when observing all investors. This too suggests that the base-case values are chosen accurately and that the simulation model is valid in terms that it produces results that are intuitive given the dynamics and initial starting values.

It now should be noted that with the predetermined investor types have no effect on the clustering in the case of zero beta. This is because the investor type had no effect on the returns and the clustering is done according to the returns so the different types of limited partners are clustered seemingly randomly and as such their average returns are close to each other (see Figure 6).

To evaluate the effect of beta-coefficient I then analyzed a case with higher beta, 0.98 to be exact. As limited partner type values range from 0 to 3, while portfolio return values range from 40 to 180 a relatively high beta is needed for the effect to show (high beta sort of standardizes the two and makes their scale similar). All other parameter values are the same as in the base case. These results are presented in Figure 7.

Results in Figure 7 show that despite the initial portfolio returns in the period 1, if the general partners prefer certain investor types, then even those limited partners with high returns are affected in their ability to maintain high returns. This is to say that depending on the level of preference, the role of prior returns in determining who gets to invest in the best new options is smaller. When general partners prefer certain types of investors over others, then the average returns converge according to the investor types. The more emphasis is placed on the investor type, the faster the convergence. Even with significantly low betas, the convergence is seen in longer time periods (50 turn simulation results not reported here since the effect is seen already in the first 25 rounds and the additional 25 rounds provide no further information).
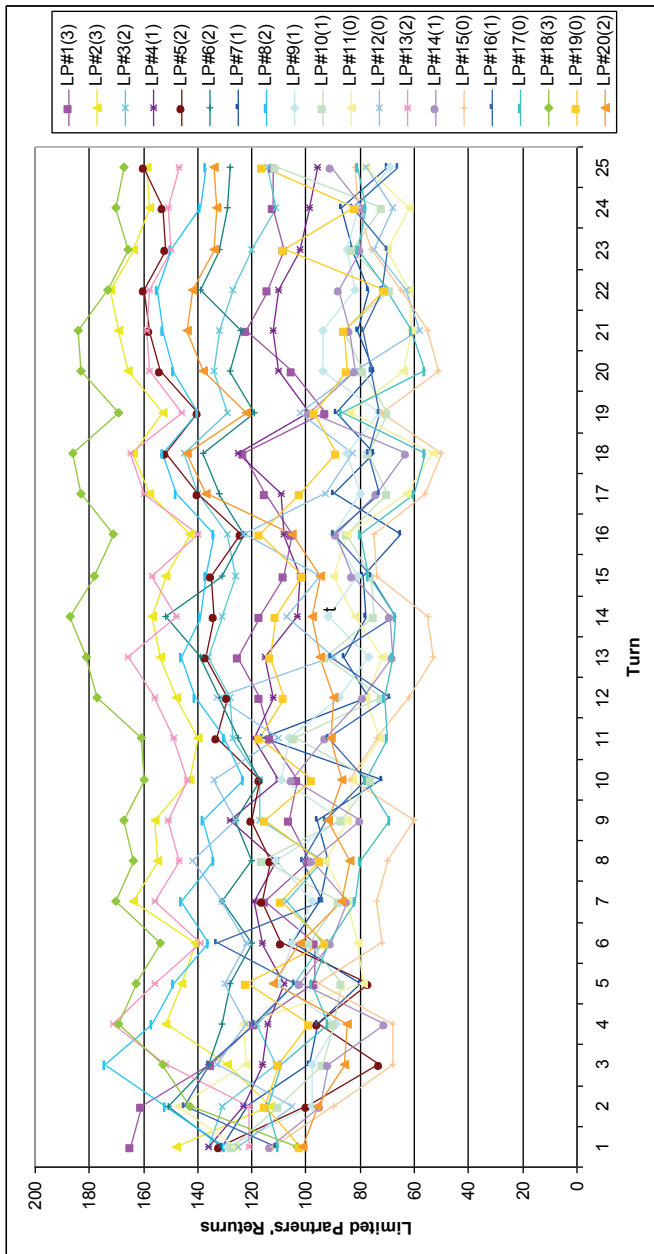
Figure 7. Returns for Limited Partners in the Base-case Simulation with Certain Limited Partner Types Being More Attractive Investors. The figure plots returns (in units, the higher the better) to limited partners. These are taken from single iteration only since otherwise there would be complications with the type and initial portfolio returns. The figure includes only top-20 limited partners. The figure shows that with the limited partner type making certain limited partners more attractive than others, the initial portfolio returns are less significant in determining the future returns. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0.98, number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

To further study the effect of investor type, we can again observe the returns to various types of limited partners by averaging over all of that certain types of investors (similar to Figure 6). These results are presented in Figure 8. Figure 8 shows that with emphasis on the investor type in the dynamics of the investor selection make systematic differences between various types of investors (as was evident based on the previous research). The initial return rankings change rapidly to represent the ranking of how attractive as investors the limited partner types are, despite their initial portfolio.
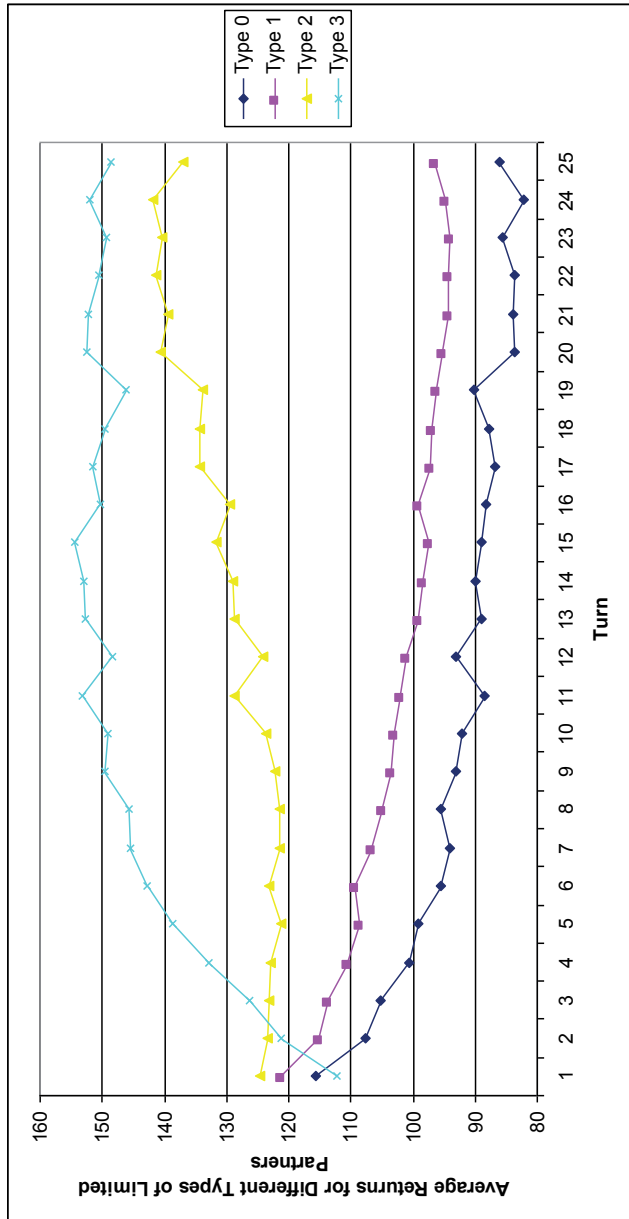
Figure 8. Average Returns to Limited Partner Types in the Base-case Simulation with Certain Limited Partner Types Being More Attractive Investors. The figure plots average returns (in units, the higher the better) to limited partner averaged over their types over 10 iterations. The figure includes all limited partners. This figure shows that when certain types of limited partners are more attractive investors than others, there will be systematic differences in the returns attained by different limited partner types. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0.98, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. Type tells which limited partners are more attractive investors with type 0 being the least attractive and type 3 the most attractive. Turns represent stages where the portfolio composition is potentially subject to change.

Altogether, Figure 6, Figure 7, and Figure 8 show that beta affects the development of the limited partners' portfolio returns, but the initial portfolio returns still play some role in determining the future returns (see especially Figure 7). However, to further analyze the effect of beta-coefficient I run the simulation with various beta-coefficients and focused on the return difference between Type 0 and Type 3 limited partners. In this analysis I let the beta take values from zero to 1 at 0.05 intervals. To ensure that differences are noticed I

ran this simulation over 50 turns. The results of this analysis are presented in Figure 9.
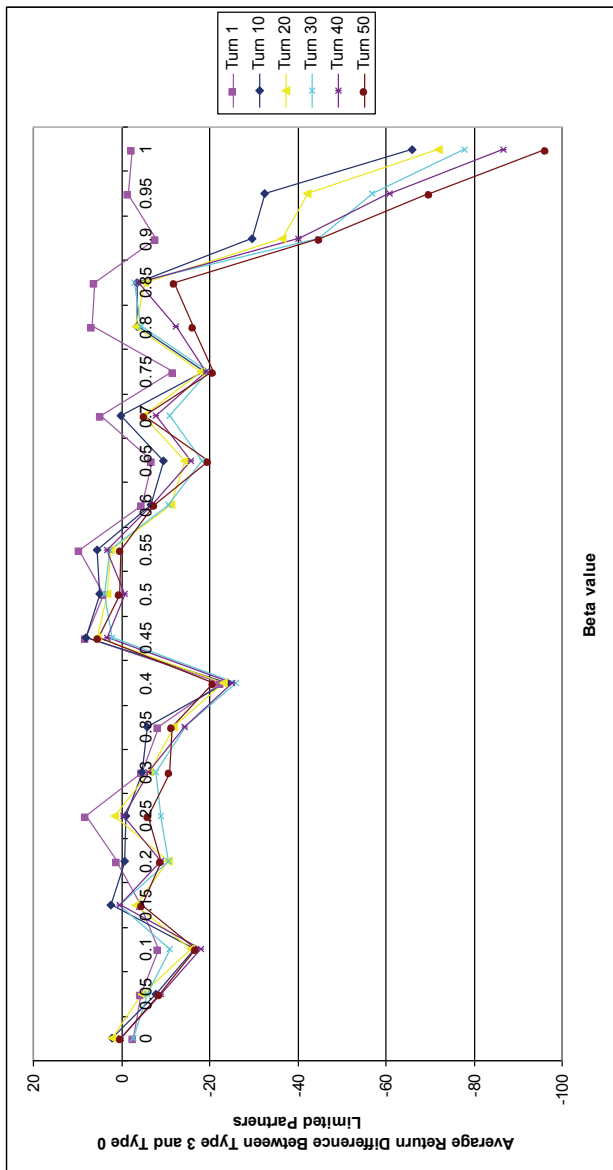
Figure 9. Return Difference Between Most Preferred Investor Types and the Least Preferred Investor Types as a Function of Preference. The figure plots the difference in average returns (in units) between limited partners of types 3 and type 0. The averages are calculated over 10 iterations. Negative number indicates that the more preferred investor is able to get better returns. The figure includes all 25 limited partners. This figure shows that as certain types of investors are preferred more they will get better returns. Furthermore, the smaller the preference the more the initial portfolio returns determine the future returns whereas with higher preference levels the initial portfolio return has only miniscule role in determining the returns at later stage. The parameters used in this simulation are as follows: alpha equals 0.5, beta is from 0.00 to 1.00 at 0.05 intervals, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. Turns represent stages where the portfolio composition is potentially subject to change. Unlike in most other analysis, 50 turns are included to see the effect at slightly lower beta values.

Figure 9 Shows that at small beta values the differences are small, either positive or negative, and that the difference stays the same throughout the turns. This represents the fact that the investor type has only a little role in determining who gets to invest in the best available general partners. Thus, in terms of observing the returns as averages to the investor types, the difference seems random at low beta values. However, with the higher beta values it becomes evident that the difference starts to show and that it becomes larger as turns go. This means that when certain types of limited partners are preferred, no

matter their initial portfolio returns, in the long run their returns become higher than that of other types of limited partners. This important finding will explain how the results in the previous section are actually well aligned with the previous findings, i.e., how similar selection skills will lead to systematic differences between the returns to different types of limited partners. More discussion on this will follow in the Discussion section of this dissertation.

4.4.3 Additional Robustness Checks

While the base case shows that the simulation dynamics are closely mimicking reality, it is important to see whether this is the case if the parameters change a bit. First I will change alpha to see the effect of prior returns on the model: the higher the alpha the larger the role of returns. Basically, larger alpha values imply that the limited partners are better able to assess the quality of the general partners without having to rely on using other limited partners in the general partners' previous funds as a proxy for the general partners' quality. It is common knowledge among the private equity professionals that certain "flagship" investors do their due-diligence properly and (often) try to invest in only the top general partners so other limited partners may have incentive to follow them. However, it should be noted that this does not necessarily mean that these flagship investors are able to attain higher returns, or that all other limited partners would be able (or even had the chance) to invest in the same opportunities. Since all limited partners do their own due diligence it is difficult to objectively estimate the actual significance of flagship investors.

Since these robustness checks mostly affect the dynamics of the system and not the end results, I will not report all the analysis in this section. Instead I will report only those figures that will show how the results change with various parameter values. From these figures it will be easy to see how the end results might be different if they are different at all.

Since the system is not highly sensitive to small changes in alpha, to assess the effect of alpha parameter for the model, in the next simulation an alpha value of 0.9 is used. The results of the base-case analysis with alpha set to 0.9 are presented in figure 10.

Figure 10 shows that when the role of general partners' returns is increased, limited partners with high initial returns stand out more than in the case where the role is weaker. This is because now the limited partners are better able to asses the true quality (and the subsequent returns) of the general partners and therefore the better limited partners are more likely to be able to pick the better general partners for their investments. Subsequently, the limited partners with low returns are now more likely not to be able to pick winners and their rankings are less likely to improve.

Therefore, what is evident based on Figure 10 is that the dynamism of the limited partner returns rankings is less intense, and the limited partner' rankings remain fairly constant after the few first periods that it takes for the model to stabilize. Based on the existing knowledge on the private equity industry, we can conclude that the true value of alpha in reality is high since there are systematic return differences between limited partners. However, since there are

a number of limited partners (for example in the data used in the analysis in the previous section) that are able to improve their positions alpha is not very close to one either.
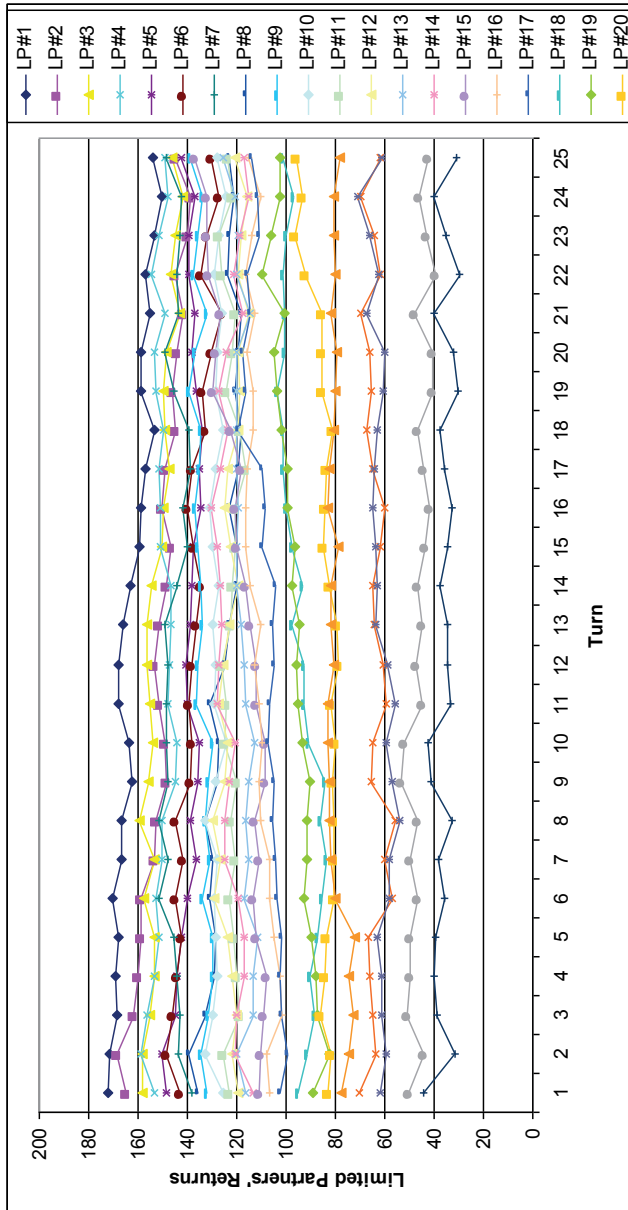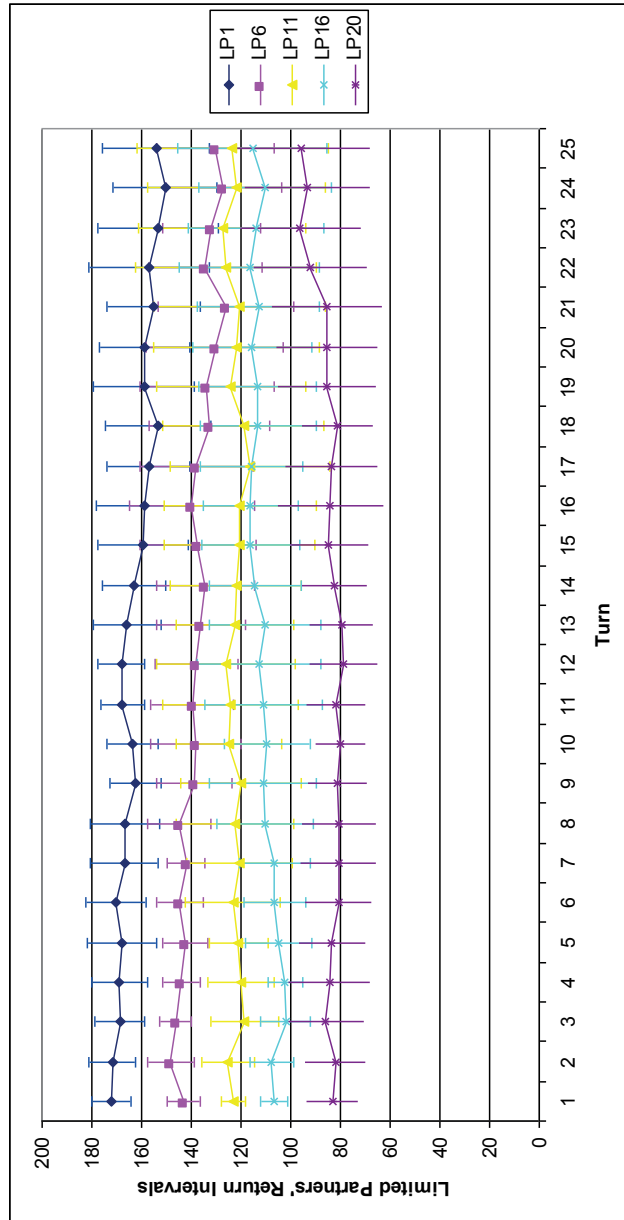

Figure 10. Average Returns to Limited Partners in the Base-case Simulation with Higher Role for General Partners' True Returns. The figure plots average returns (in units, the higher the better) to limited partners over 10 iterations. The figure includes only top-20 limited partners. The results show that when limited partners' previous returns have more effect on their ability to invest in better general partners, then the return rankings are more stable and there are more systematic differences in the returns over longer periods of time. The parameters used in this simulation are as follows: alpha equals 0.9, beta is 0, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

When observing the variation in this high alpha analysis (presented in Figure 11), it becomes evident that now there is less variation for the middle return limited partners and the averages are closer to each other. This is most likely because the smaller the return difference between two limited partners, the more sensitive the system is now to the other parameters. With relatively small portfolios (10 new investments each round) a change in one investment can

have drastic effect on the portfolio returns in either direction but with more emphasis on the previous returns makes the averages more stable as the new investments are more likely to have returns that are close to previous returns.
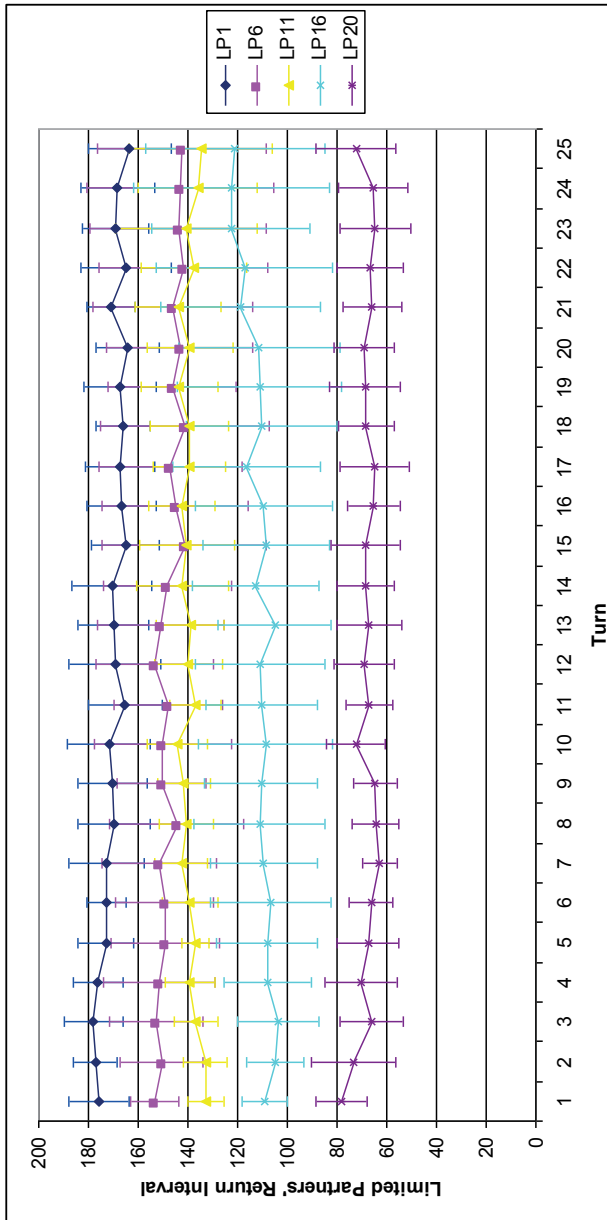

Figure 11. Return Intervals for Limited Partners in Base-case Simulation with Higher Role for General Partners' True Returns. The figure plots average returns (in units, the higher the better) to limited partners with one standard deviation intervals to both directions from this average. These are calculated over 10 iterations. The figure includes only top-20 limited partners. This figure shows that when prior returns have more effect on the selection the variance is smaller for the middle return limited partners than in the Figure 3. The parameters used in this simulation are as follows: alpha equals 0.9, beta is 0, number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

In this simulation with higher alpha the beta is again equal to zero so the investor type has no effect on the returns. Therefore the plot would be similar to Figure 6 and I have chosen not to report it here. Same is true for the next analysis with lower alpha. I will not include the figures of these analyses here either as these figures contain no information beyond what is written here.

To test that the opposite change in alpha will lead to opposite change in the stability of rankings the next simulation of base-case is run with lower than the initial alpha. In the same line of reasoning as in the previous case, low alpha would now mean that the general partners' investor-base has higher role in determining their perceived quality in the eyes of limited partners. This also means that the observed returns have lower role in determining the perceived quality. Again, to see the effect clearly I have chosen alpha to be 0.1. These results are presented in Figure 12.
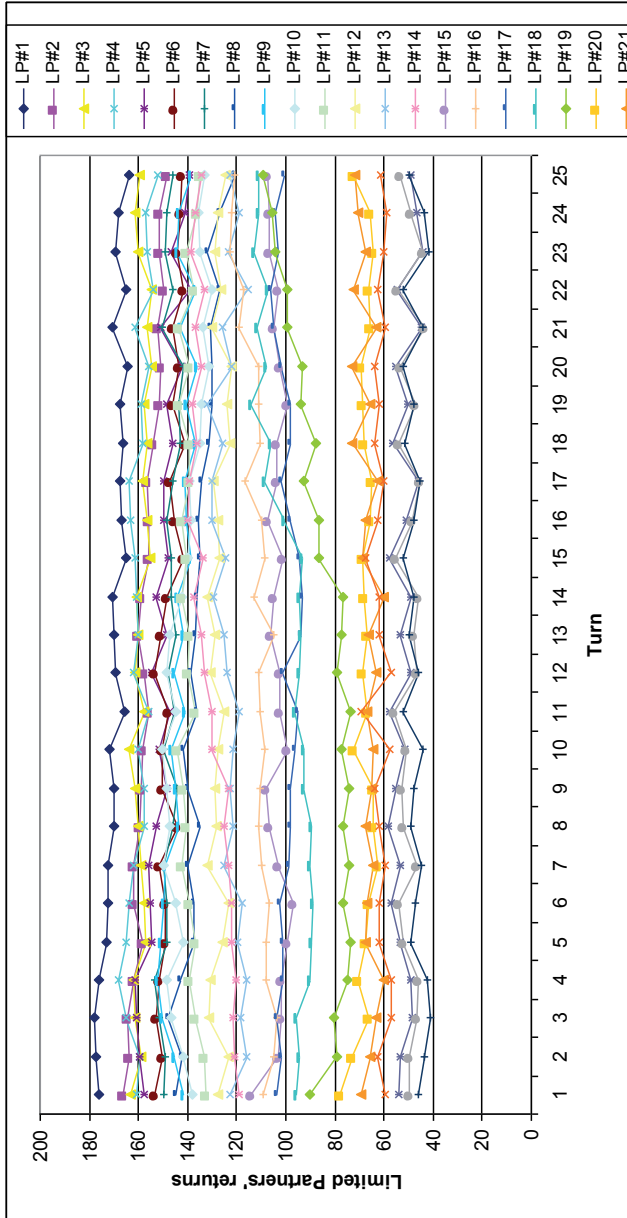
Figure 12. Average Returns to Limited Partners in the Base-case Simulation with Smaller Role for General Partners' True Returns. The figure plots average returns (in units, the higher the better) to limited partners over 10 iterations. The figure includes only top-20 limited partners. Compared to the two previous cases, now there is more dynamics in the rankings but with low rate of change in the portfolios changes in the rankings are not fast. The parameters used in this simulation are as follows: alpha equals 0.1, beta is 0, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

The results shown in Figure 12 are as expected. With very little role for the returns, all limited partners are equally bad in assessing the general partners' quality and thus even the limited partners with low returns are more likely to be able to invest with the better general partners. However, the low rate of change in the total portfolio makes the changes happen slowly and thus in so short a simulation the results are not very clear. (I have not reported here but with longer than 25 turns and/or with higher turnover rate for GP or Investor base regeneration the results are clearer). This setting produces more "regression to the mean", where the differences between limited partners with different prior returns become smaller each turn.

Turning to the variances (presented in Figure 13), the limited partners return intervals seem similar across the return spectrum. This is as expected as there is only very little difference now between the limited partners with different returns and therefore their chances of being able to invest with the better general partners is more similar. Consequently, their return variances become similar.

Figure 13 also show that, compared to the initial values (Figure 4) or high alpha (Figure 11), with low alpha the variances tend to be closer to each other across the limited partners' return rankings. The explanation is that with investor-base emphasized in the quality estimation, the limited partners tend to invest in those funds with the highest investor base. Consequently, little attention is paid to the observed returns and the limited partners do not adjust their portfolios as much. After all, it is highly unlikely for the investor base to lose a member (there is the random chance for such happening), which could potentially result in many other limited partners also changing their investment targets. With the other models where returns are a more significant factor, the changes are more likely. Therefore, the variation is smaller in this case than in the other cases of higher alphas.

Figure 13. Return Intervals for Limited Partners in the Base-case Simulation with Smaller Role for the General Partners' True Returns. The figure plots average returns (in units, the higher the better) to limited partners with one standard deviation intervals to both directions from this average. These are calculated over 10 iterations. The figure includes only top-20 limited partners. The parameters used in this simulation are as follows: alpha equals 0.1, beta is 0, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

To study the effect of portfolio size I did the simulation with the limited partner investment portfolio size and general partner investor portfolio size set to 5. Again, I chose significantly smaller portfolio size to explicitly show its effect on the results. The smaller these parameter values are the more sensitive the analysis is to the random changes in the portfolio composition, so having portfolio size of only few (less than 5) would make the results more random and therefore more difficult to interpret. The results of this analysis are presented in Figure 14. Note that the returns are not comparable to the other analyses because the absolute return levels are different. This is because the number of investments in one period is only half of what it was in the previous analysis

and as a consequence, the absolute return levels are only about half of what they were in the previous analysis. What is important here is the dynamism of the respective rankings.
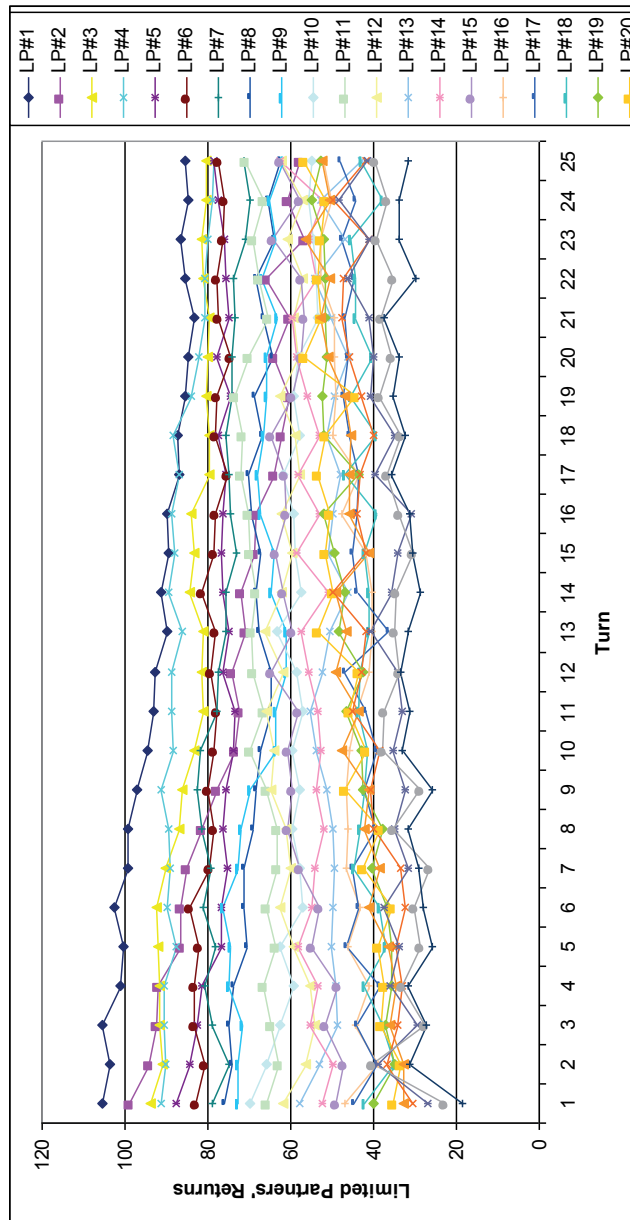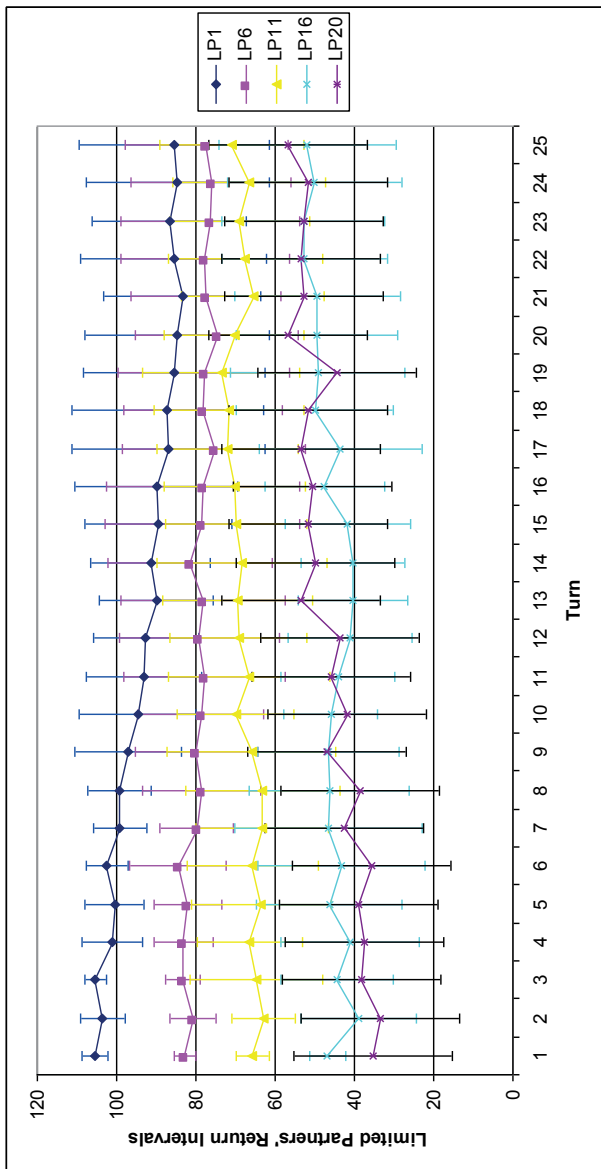

Figure 14. Returns for Limited Partners in the Robustness Simulation with Smaller Portfolio Sizes. The figure plots average returns (in units, the higher the better) to limited partners over 10 iterations. The figure includes only top-20 limited partners. This figure shows that with smaller portfolio sizes the rankings are more dynamic as changes affect the average returns more than in the base case with larger portfolios. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 5, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

As predicted, Figure 14 shows that the returns of different limited partners are much more dynamic and the rankings change more constantly. Still, on the level of whole population of limited partners the results are similar to the base-case. The rankings change over longer period of time (over more turns) than previously but a good investment portfolio in the beginning means that the

limited partner is more likely to be better off also later. And the opposite is true for the limited partners with low returns for initial investments.

These findings are confirmed by observing the return intervals for the different limited partners (see Figure 15). The variances are larger (relatively compared to the base-case) for all limited partners and there does not seem to be a clear link between the variance and the initial portfolio returns. This is not what was observed in some cases for the base-case results. The explanation is that now a single termination of relationship will significantly increase the limited partner's portfolio variance. Since these terminations can happen to limited partners with high return portfolio as well as to limited partners with low return portfolio, the variance is high for all.

Figure 15. Return Intervals for Limited Partners in the Robustness Simulation with Smaller Portfolio Sizes. The figure plots average returns (in units, the higher the better) to limited partners with one standard deviation intervals to both directions from this average. These are calculated over 10 iterations. The figure includes only top-20 limited partners. This figure shows that with smaller portfolio size the variance is higher than with larger portfolios since now change in one investment will have more significant effect on the average. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0, the number of limited partners and the number of general partners are both equal to 25, limited partners' portfolio size and general partner investor base are both limited to 5, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

Finally, I show how the ratio of general partners to limited partners will affect the results. With more general partners than limited partners the limited partners will have opportunities to better choose general partners that they like. However, should the number of general partners be too high in comparison to the number of limited partners then some of the general partners become obsolete. This is because they do not get enough investors in the first stage and they do not have enough quality so they do not get new investors either. While this again mimics the reality it means that there is no point in trying to choose too high a number.

For this purpose I have chosen general partners to outnumber limited partners by 28 (GPs) to 25 (LPs) in the simulation. The results of this analysis are presented in Figure 16. What is evident based on these results is that the importance of the initial portfolio becomes more significant. Now the changes in the rankings happen during the very few first turns. Compared to the basecase, the difference between the high return limited partners and the low return limited partners is more significant. This is because there are more good funds available in the first turns and the best limited partners get to pick first. Therefore, they will take the best investments and the low return limited partners are left with the even worse opportunities (by increasing the number of general partners but keeping their return variable random the number of high return general partners as well as the number of low return general partners increases).
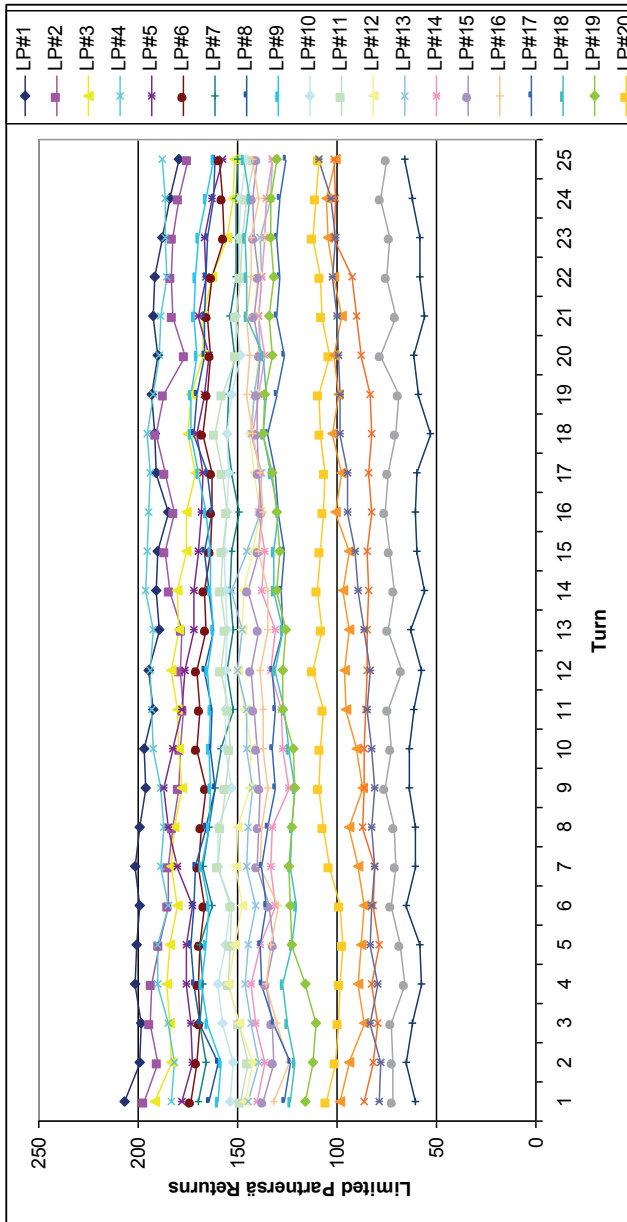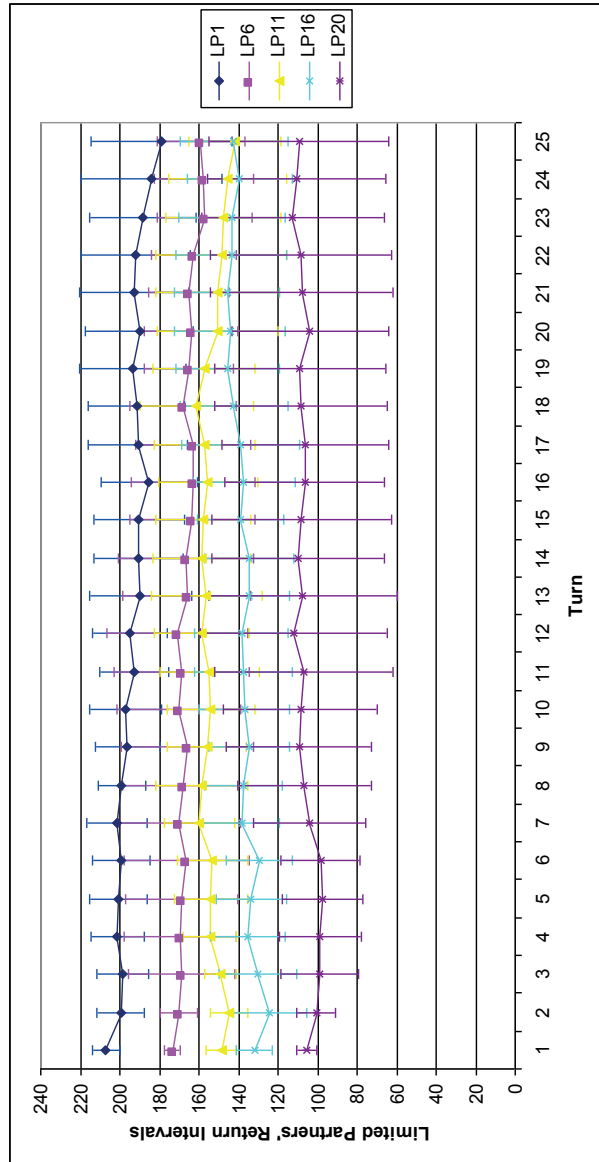
Figure 16. Returns for Limited Partners in the Robustness Simulation with More General Partners than Limited Partners. The figure plots average returns (in units, the higher the better) to limited partners over 10 iterations. The figure includes only top-20 limited partners. This figure shows that when there are more general partners than limited partners, the limited partners have more to choose from and there is more dynamics in the rankings. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0, number of limited partners is equal to 25 and the number of general partners is 28, limited partners' portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

Looking at the variance in limited partners' average returns in this case produces expected observations (see Figure 17). Limited partners with the high initial portfolio returns can choose high return general partners and therefore their variance is not high. However, now the low return general partners have a set of opportunities from which to choose from and consequently, their variance is much higher than the variance of the high return limited partners' returns.

Another significant difference to the base case is that now the lowest included limited partner (with 20th highest returns) has much more meaningful interpretation since there is a smaller risk of that limited partner not being

able to fill its investment quota. One should be cautious here when comparing this figure to the previous similar figures as now the average of the 25 best general partners is higher than in the previous case. This means that the average of all limited partners is likely higher in each of the iterations. This will also impact the dynamism too, but the basic comparisons can be made keeping in mind that instead of actually thinking about 28 GPs we are practically talking about only the best 25 in here (this line of reasoning is good especially if one wants to compare the results to those of the base case).

Figure 17. Return Intervals for Limited Partners Robustness Simulation with More General Partners than Limited Partners. The figure plots average returns (in units, the higher the better) to limited partners with one standard deviation intervals to both directions from this average. These are calculated over 10 iterations. The figure includes only top-20 limited partners. The figure shows that with more general partners than limited partners the variance becomes higher as there are more options from which to choose from and as they are randomly distributed, the variation is, on aveege, higher. The parameters used in this simulation are as follows: alpha equals 0.5, beta is 0, the number of limited partners is equal to 25 and the number of general partners is 28, limited partners portfolio size and general partner investor base are both limited to 10, general partner regeneration is 0.1, and investor-base regeneration is 0.1 also. LP# tells the ranking of the focal limited partner's portfolio returns in turn 1. Turns represent stages where the portfolio composition is potentially subject to change.

If the number of general partners in relation to the number of limited partners is too high, the simulation becomes stable in the sense that the limited part-

ners with high returns will always be at the top as they can always find the new funds into which they can invest. This is because there are so many open investor positions in the low return general partners' funds that they struggle in getting their investor base high. As a consequence, the investors in these low return general partners often are left with investing in the low return funds.

This dynamism explains why there are not too many funds coming to the market. Rational general partners know that if the market is saturated with funds, the outcome for the general partners and their investors is poor. This happens in the reality also. Furthermore, this dynamism explains why after the boom cycle in private equity a bust cycle follows – the investor base is not enough to fund all available opportunities and markets are filled with funds that do not have adequate amount of capital, i.e., they have too few investors. Of course, as discussed in the Section 2, the boom-bust cycle is also due to the fact that the funds themselves are fighting each other over investment opportunities but as shown by this simulation model, this might not be the complete explanation.

Situation where limited partners outnumber general partners produces uninteresting results. This is because there will be very little dynamism as all opportunities are taken as soon as they become available and the limited partners do not get to choose. For them it is better to take any investment than none so they will take them. Again this is what would happen in the real life – if a limited partner has decided to commit a certain amount of capital to the private equity funds it will likely invest also in the low return general partners if no better alternatives are available.

5. Discussion of the Results

In this dissertation, first I showed that there are two potential determinants for systematic differences in limited partners' private equity fund investment returns between limited partners: access to funds or selection of the funds. Out of the two determinants, selection of the funds has so far received more attention in the research even though it is theoretically less convincing explanation. This is because of the nature of private equity and the fact that an investment decision must be made based on the information available at the time of the investment while the investment returns are realized over the next decade. Furthermore, there is only limited information available to limited partners and all limited partners have basically the same information available. As such, it is not likely that this setting could produce systematic return differences due to the limited partners' different selection skills.

Using a large dataset I showed that access is the main determinant of systematic return differences between limited partners. The model I used was similar to those used in the prior studies on the same issue but I included past returns as one of the independent variables. Controlling for prior returns explains why my research showed access as the more important determinant unlike the previous studies, which highlight the role of selection skill. My results were robust to changes in the timeframe of the sample and to various other factors potentially affecting the returns.

I also showed that systematic differences between different types of limited partners can also be explained without any differences in the selection skills of various types of investors. This can either be an emergent phenomenon resulting from the fact that limited partners with high returns are preferred investors among high return producing general partners. If certain types of limited partners had initially higher returns (resulting, for example, from their longer history with the private equity asset class) then these systematic differences would be explained. In addition, all that is required is to assume that certain types of limited partners are not equally attractive investors to general partners and that the general partners, given the choice, would select those types of investors that they prefer the most. The fact that certain types of investors are not equally attractive is a generally held belief in the industry (and was confirmed also by professionals interviewed for this dissertation). Thus, using the simulation model developed in this dissertation and the results obtained from the data analysis in this dissertation, I am able to show how equally good selection skills of limited partners will produce systematically different returns

(as a result of their different access) and how various levels of attractiveness between the types of limited partners will mean systematically different returns across types of limited partners.

The findings in this dissertation relate to many open questions in the prior private equity research presented in Section 2. Results in Section 3 answer to Research Question 1a, and together with the discussion following in this section they will answer also to Research Question 1b. Taken together, the statistical analysis in Section 3 and the simulation model in Section 4 help to explain why there are systematic differences between limited partners' returns – thus answering also Research Question 2. The next subsections discuss the findings more closely and how this dissertation relates to the existing and future research on private equity.

5.1 Discussion about the Access versus Selection Puzzle

The findings imply that when both the access to funds and the general partners' track records are controlled for, limited partners are not systematically able to choose better funds for their reinvestments as compared to funds in which they chose not to reinvest. Furthermore, there seems to be no indication that some limited partners are more skilled in selecting better performing funds for their reinvestments than others. Given that there are differences in the limited partner's returns (as is evident based on the Fig. 1, and as suggested by Lerner *et al.* 2007) and that these differences are nonexistent when the access and prior fund returns are controlled for, the results suggest that the systematic differences in fund returns between different limited partners must be due to limited partners having systematically different access to better-performing funds and their general partners (as was also suggested by Sensoy *et al.* 2013).

Because my results also show that limited partners are not able to increase their private equity fund portfolio returns by mere reinvestment decisions alone, I feel safe in arguing that building access, either by investing in funds with no proven track record or otherwise proactively building relationships with other limited partners and general partners, is a crucial determinant of limited partners' overall private equity returns. This suggests that instead of focusing too much on the reinvestment decisions, limited partners should focus on finding new general partners to invest in.

The findings of this empirical study also shed light on the puzzle of why would any limited partner invest in a general partner without a proven track record even though such an investment has higher risks. The results imply that such an investment could help the limited partner to secure access to the best future funds because being an investor in prior funds is the best way to gain access to subsequent funds (e.g. Lerner *et al.* 2007). In the case of successful general partners, this could be the only way for most limited partners to gain access to such a general partner's new funds. Therefore, the simplest and most certain way for a limited partner to gain access to top tier general partner's funds is by being an investor in that general partner's first funds.

As such, the focus of private equity research and private equity practitioners should be on building access. While due diligence and contract terms are still important, out of the potentially suitable investment targets the reinvestment decisions on most occasions can be made based on performance (if no other criteria stands against such investment). Building access to a new general partner or finding suitable first time funds is a much more difficult task for the limited partners (this difficulty is evident in Sensoy *et al.* 2013 where they show that limited partners are equally good/bad in choosing their investments to first funds). In cases where no track record is yet available, the investment decision is more difficult but, at the same time, has a more substantial impact on the limited partners' portfolio returns (cf. Da Rin & Phalippou 2011 where they argue why larger limited partner organizations might be better in choosing the better first time funds). In cases where access needs to be made to funds with a top quartile general partner, it requires contacts and communication, often along with one or more recommendations from within the private equity sector.

Furthermore, my results suggest that there is no significant institutional learning on either the general partner or on the limited partner levels in terms of being able to attain higher returns; the more funds that the limited partner has previously invested in or the more the funds raised by the GP do not help the limited partners to achieve higher returns. Because the number of prior funds in which the limited partner has invested in also serves as a proxy of how many opportunities the limited partner has from which to choose his/her investments (at least if we assume that there is no difference in how often the general partners raise new funds), the portfolio size may have a positive effect on returns. However, even then, the effect is only due to limited partners being better able to choose funds with high prior returns (this line of reasoning is partly supported by Sensoy *et al.* 2013). This further supports the argument that limited partners are only able to get reinvestment returns that are, on average, close to the portfolio average.

Because limited partners with different portfolio sizes make approximately the same number of investments each year, if we would assume that some of the limited partners are more skilled in selecting better opportunities (within a homogenous set of general partners), the limited partners with most previous investments should be able to choose better investments and thus have higher overall returns. However, this is not the case further suggesting that the limited partners are not systematically able to choose better investments.

Phalippou (2009b) argues that with a sophisticated investor base, there is no persistence in fund returns.[33] However, based on these analyses of sophisticated investors, there clearly exists performance persistence, and prior performance is an important determinant of future performance (as is suggested by Phalippou & Gottschalg 2009). Although I used only a proxy of the prior fund performance, the random effect on general partners was also statistically

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[33] Phalippou & Gottschalg (2009b) assumes that funds with higher returns are backed by more skilled investors, argument also suggested by Da Rin & Phalippou (2011). Our paper uses the term sophistication for all investors that have enough investments. While these definitions are not the same, we feel that our results do not fully support the previous findings.

significant. If this is to be interpreted as the skill of the general partner, it can be safely claimed that general partners' skill (manifested most commonly in the prior fund performance) is an important determinant of future fund returns. Apart from prior fund returns, though, other determinants of fund returns are difficult to identify. If it were not difficult, one would expect to see better performance with the reinvested funds than with the non-reinvested funds.

These findings also relate to prior research in a third way. In their paper, Kaplan & Schoar (2005) claim that better-performing general partners are more likely to raise follow-on funds and larger funds. This sounds rational, given the high persistence in fund returns. The results indicate that the causality here could be that better-performing general partners are better able to lure existing investor limited partners to reinvest in the next fund, and these investors are willing to invest more capital, thus enabling the general partner to raise larger new funds (and perhaps even more often). The limited partners want to invest their capital in a way they expect to maximize their profits and this means that they want to invest as much as possible to highest return general partners.[34]

5.2 Discussion about the Access Creation

The results of the simulation show a further support for the empirical findings discussed previously. This kind of return-based dynamics would explain why limited partners' private equity returns are persistent. The base case model, although fairly simple, is among the first attempts to understand the dynamics of private equity investing. And despite the simplicity, the results mimic reality to a striking degree.

The most important finding of this simulation analysis is to understand that even if all limited partners were assumed to be equally good in selecting investment targets, the systematic differences between the limited partner types can be explained by two different ways: 1) the systematic return differences can be emergent resulting from the fact that investors with higher returns are preferred investors in the eyes of general partners and therefore those limited partners with the high returns are more likely to be able to invest in the high return general partners also in the future, or 2) that the general partners prefer certain types of limited partners over other types of limited partners.

In the analysis I showed that the limited partners' portfolio returns are persistent and the limited partners form several clusters according to their returns. This is because the high return limited partners are able to invest to the high return general partners and the low return limited partners are likely to be forced to invest into the low return general partners. Therefore the limited partners form clusters where in each cluster the returns are similar and the

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[34] LPs' dependence on prior fund returns might explain the anomaly in everyday private equity fund investing in which there seems to be, at least in the marketing materials, only first-quartile (or upper-half) funds. This is because GPs know of the luring effect that a high prior fund performance has among the potential investors, and the GPs aim to find a measure according to which they can claim to be top fund managers.

returns between clusters are different. By observing these returns we would note systematic differences between limited partners. If we assume that certain types of limited partners would have been able to achieve initially better returns (for example, by starting to invest in private equity asset class earlier) then this could explain why there are systematic differences in returns between different types of limited partners (as suggested by, e.g., Lerner *et al.* 2007). There is at least some anecdotal evidence to support this view (i.e., endowments that have the highest returns typically have longer history in private equity than other types of investors), but it may not be the full explanation.

The simulation model also showed that when we assumed that certain types of limited partners are more preferred investors than others, then these limited partners are able to systematically outperform all other investors. With low level of preference, the initial portfolio is the most significant determinant of future returns. At higher levels of preference, the initial portfolio returns become less and less important determinant. It is commonly held view among private equity professionals that certain types of limited partners are more preferable investors than others. Therefore, preference is plausible explanation for the observed systematic return differences between different types of limited partners. And it is a more convincing explanation than considering some of the limited partners to be better in selecting their investments than others.

The analysis also reveals that limited partners with a small portfolio (i.e., only few partner general partners) are much more vulnerable to the continuity of their partnership with the best returning general partners. Their future returns are not only hurt by the loss of high returning general partner from their portfolio but also because that makes them less able to invest in other high return general partners. In the same way, after reaching a certain level of investments, the returns are not significantly impacted by the number of previous investments, a result also found in the empirical observations of real investment returns.

The results of the simulation model show also support for the results presented in Lerner *et al.* (2007). When some limited partners are seen as more attractive investors by the general partners, i.e., with high enough values for the limited partner type in the simulation model, the returns of different types of limited partners do not converge. This dynamism helps to explain why there are systematic differences between private equity fund returns of different types of limited partners (see also Sensoy *et al.* 2013; Da Rin & Phalippou 2011). If general partners have at least a moderate preference for certain types of investors than these general partners are willing to disregard the lower returns that these preferred limited partners have attained. Therefore, the access that limited partners face is determined by their perceived type and not by the returns. The level of preference moderates the tradeoff between the two parameters.

The simulation results further suggest that the boom and bust cycles in the private equity industry are not entirely driven by the fund level competition for investment targets but also at the limited partner level competition for good general partners in which to invest (cf. Gompers & Lerner 2000; Lerner &

Schoar 2004; Kaplan & Strömberg 2009; Robinson & Sensoy 2012). This, combined with the abundance of available opportunities, means that many of the general partners set up their funds with too few investors, i.e., they are likely unable to raise the amount of capital they need. Continuing with the suboptimal capital available means that the general partner is likely to fail in attaining the returns it has hoped for. This will mean that it will likely soon be forced out of the industry being unable to raise subsequent funds.

The simulation model is highly robust to parameter values. Furthermore, the assumptions behind the simulation's dynamics are justifiable and general. Therefore, the model is highly reliable. The results from the simulation model are aligned with the empirical data on private equity investing, and explain several empirical findings reported in the previous articles and working papers.

One potential shortcoming, in terms of the simulation model, is that it does not exactly represent reality. For instance, there is no multi-staged negotiation in the model although it is how the real fund raising process is. In reality, the limited partner would meet several general partners, some of them several times, and then it would choose the best one(s). Several problems would be present with this approach. First, very little research has been conducted on the negotiation process and the little understanding there is on it tends to say that every process is different. Various individual facts can decide the process alone, but the decision can also be based on a combination of them. Second, in light of the parameters included in the simulation there is no difference whether the decision is made over time or not. Thus, although it could be beneficial to make the simulation model using more complex negotiation dynamics, it would require quite a significant amount of new data on the negotiation process and still it would not be certain that the results would be any closer to reality. However, it is almost a norm in the industry that unless the general partner's results are exceptionally poor or the contract terms between the two consecutive funds are different, then the existing investors will invest in the new fund also. By eliminating poorest general partners in our model at each step and then terminating some of the remaining partnerships between a general partner and limited partners, the model is able to fairly accurately take this into account. By modeling the limited partner reputation as one factor in general partner's attractiveness the model is able to capture the role of flagship investors that make the general partner's new funds more attractive in the eyes of other investors. While a flagship investor in reality can be one with high returns, a large limited partner with reputation for thorough due diligence can also be considered as one even if it does not have superior returns. Therefore, modeling flagship investors through reputation is more accurate than just considering the returns. Thus, the most significant issue with the model is the fact that it does not treat the termination as a function of the limited partner's average general partner return compared to the focal general partner's returns. However, for the very same reasons detailed previously, this is not likely to lead to significant problems in terms of the correspondence between the model and reality.

Second important simplification in the model is that all existing general partners raise new funds at the same intervals. In reality, the time between a general partner's two consecutive funds differs between general partners and at different times. Still, the process of raising a fund is a long one and limited partners have fairly accurate picture of the funds that the general partners are setting up in the next year or so. Thus, although two funds are not raised simultaneously, the limited partner has to consider the funds at the same time when considering investing in one of them. And as the limited partners make typically about the same number of new commitments each year, the simplified approach used in this simulation does not bias the results.

5.3 Limitations and Future Research

An important question that remains is what determines the returns to general partners' first funds. Because these are the ones where the limited partners have to make their decisions and (due to the reinvestment process) this return can be persistent, it is crucial to understand what differentiates a top-performing new general partner from low performers. One explanation for the first funds returns is presented by Zarutskie (2010), who suggests that fund managers' human capital (measured as experience in the fund's target industry and in the venture capital industry, education, etc.) is one determinant of the successful exit rates of venture capital funds (cf. Cumming & Dai 2011). Still, other factors are also at play here, and how they relate to this human capital aspect is unknown.

Similarly, future research could focus on more carefully analyzing the fund sequence and how this affects the fund returns / re-investment behavior of the limited partners. This could also shed light to the question of how grandstanding affects the investors in the funds (cf. Cumming & Walz, 2010). Since grandstanding is closely tied to the legislative framework in the countries of the general partners (Cumming & Walz, 2010), a more detailed analysis of general partner locations and limited partner locations could increase our understanding of the behavior of these actors depending on the legal environment within various countries (Cumming & Walz, 2010; Nahata *et al.* 2013). Similarly, a more careful understanding of locations could help to understand how these financial organizations use their ties to gain new ties (cf. Jääskeläinen & Maula 2013).

Other potential questions for future research could be to differentiate the institutional level skills of general partners and limited partners from the skills of their professionals and observe the investment return at the level of individual professionals. This issue is also briefly discussed in Zarutskie (2010), where the role of general partners' human capital is analyzed, and the importance of this is highlighted by Freiburg & Grichnik (2012) who analyze how social ties affect the limited partners decisions to which general partners' funds they will invest in. This aspect still requires more careful analysis to be understood fully. By observing the investment behavior of certain individuals before and after changing their workplace from one limited partner to another

and then by observing the returns that their investments have, we could answer two important questions. First, we could answer how personalized the access to funds is, i.e., whether we can even treat access as institutional-level concept if we do not control for the people working at the limited partner. Second, it would help us to answer how much of the limited partner returns is due to the skills of individuals working at the limited partner versus these peoples' access to better general partners. Furthermore, taking this individual professional approach to the general partner level as well would enable an even more accurate explanation for the reinvestment decisions and their outcomes, and it could even help to explain the initial return differences between limited partners.

5.4   Implications for Practice

This dissertation poses several implications for private equity professionals. First, the findings suggest that first investments to general partners are the ones where the limited partners have the most to gain – and the most to lose. Reinvestment decisions can practically be based only on the prior general partner returns and the contract terms, but even the returns are not necessarily known at the time of the investment decision.

The findings also stress the importance of prior returns as a way for the limited partner to gain access to new, high-return general partners. This kind of backward-loop in the return process makes investing in high return general partners even more beneficial. In the same way, investing in poor general partners makes future good investments harder to invest in. This implies that investors with poor history in the private equity might benefit greatly by focusing on the first time funds and others that do not have yet a proven track record.

Finally, the results show why it is difficult for any limited partner to be able to change (positively) its portfolio returns quickly. There is high persistence in the returns and because of the reputation based dynamics in access formation, significantly better investment opportunities are not necessarily within the reach of the limited partners.

5.5   Conclusions

Previous research and my data show that certain limited partners are systematically able to attain higher than average returns for their investments to private equity funds. Previous research has suggested that certain limited partners are better in selecting their investment targets than others, although given the nature of private equity industry and the available information at the time of the investment decision this is somewhat puzzling.

In this dissertation, I show that by controlling for prior performance of the general partners no selection differences are detected between different limited partners. Therefore, the systematic differences in the returns that limited

partners are able to attain are determined to a great extent by their prior returns.

By utilizing a simulation model I am able to show that given the restricted size of limited partners' investment portfolios, the initial differences between the limited partners can be an outcome from chance alone. Furthermore, by taking into account that not all limited partners are seen by the general partners as good investors as some other limited partners, the systematic return differences between different types of limited partners can be explained by the investment process alone. Therefore, to explain the systematic differences between different limited partners we do not need to assume superior selection skills for some type of limited partners.

The results and improvements to current research methods employed in the research on private equity presented in this dissertation are important for extending the understanding of private equity fund investing. This dissertation helps to explain previous findings in the private equity literature with theoretically simpler explanations than the previous research. The results presented in this dissertation participate in the recent dialogue in the literature on the role of access in the determination of limited partners' returns, and is thus essential and timely for anyone interested on the issue. Finally, Table X summarizes this dissertation and its findings.

Table X

Research Questions, Their Context, and The Answers Proposed in This Dissertation

Table X shows the research questions posed in this dissertation, their context in terms of prior research and private equity in general, as well as the answers proposed in this dissertation. This table contains only very brief illustrations of each of these and for any reader interested in the questions it is advised to look through the dissertation for more information.

#	Research Question	Context	Answer
1a	Is access more important determinant of limited partners' returns to their private equity fund investments than their selection skills?	There are two potential determinants for limited partners private equity fund investment returns: access and selection. The debate is about which of the two is more important.	Using a large dataset I was able to show that when access is controlled for, limited partners are statistically equally good in picking better performing funds for their reinvestments. Thus, selection is not enough to offset the role of access in determining the returns and therefore access is more important determinant of returns.
1b	If access is more important determinant, what would explain this finding given that previous research suggests otherwise?	Given that prior research has suggested that selection skill would be the crucial determinant of limited partners private equity fund returns, I have shown that this is not the case. However, it is important to understand why my findings are contradictory to the previous findings.	Prior research has not given enough emphasis on the limited partners' previous returns and therefore prior research has overlooked the importance of access.
2	Given the nature of the private equity industry, what could explain the systematic differences between different types of limited partners' private equity returns as observed by the previous research?	In the light of the findings for the two first research question, it is puzzling why there would be systematic differences in returns between different types of limited partners. All prior suggest that these differences are an anomaly.	If we assume that limited partners with high returns are preferred investors, then systematic differences would exist according to the initial portfolio returns. Furthermore, if we assume that certain types of limited partners are more preferable investors than other types of limited partners, then systematic differences between different types of limited partners would be to be expected.

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