Essays in Private Equity



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To Amanda,
for always being there.

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Abstract

This dissertation presents three empirical analyses on private equity (PE) investments. The first chapter, *The accuracy of net asset values in private equity: Evidence from the secondary market*, examines pricing in the secondary market for PE fund stakes. The average transaction occurs at a discount, which is commonly attributed to compensation for liquidity provision. As a quarter of bids come in at a par or a premium, this cannot be the full explanation. I document that cross-sectional variation in discounts predicts future fund returns. The second chapter explores *The dynamics of pay-for-performance sensitivity in private equity funds* arising from carried interest. As carried interest is conditional on beating a hurdle rate, pay-for-performance sensitivity is increasing in fund performance, and increasingly so as the fund matures. I document that within-fund variation in pay-for-performance sensitivity is positively related to growth in portfolio companies acquired in buyouts. The effect is stronger when the importance of the direct component is high relative to the indirect component of pay for performance. To rule out confounding factors, I utilize public market movements to generate exogenous variation in the measure. My findings provide evidence of the importance of incentives for value creation. The third chapter, *Managerial ownership and operational improvements in buyouts*, investigates the relevance of CEO ownership stakes in companies acquired in buyouts. I find that post-buyout CEO equity ownership stakes are positively associated with profitability improvements. Consistent with an effect of incentives, the results are stronger when the ownership stake increases, and are driven entirely by the subsample in which the CEO is retained. Taken together, these three studies contribute to the growing body of work on private equity investments and the impact of private equity ownership on companies acquired in buyouts. They open the door to further theoretical and empirical research in the field.

Contents

1 Introduction **1**

References **20**

2 Literature Review **25**

1 Investing in Private Equity 27

2 The Structure of Private Equity Funds 31

3 The Economic Impact of Buyouts 33

References **40**

3 The Accuracy of Net Asset Values in Private Equity: Evidence from the Secondary Market **46**

1 Introduction 46

2 Institutional Setup 51

2.1 Evolution of the Secondary Market 52

3 Data 52

3.1 Descriptive Statistics 53

4 Research Design 57

4.1 Determinants of Bid Levels 57

4.2 Informativeness of Bids 58

4.3 Bids, not Transactions 60

5 Results 62

5.1 Determinants of Bids 62

5.2 Returns Post Bidding 65

6 Conclusions 69

Appendix 83

A Appendix Figures and Tables 83

B Variable Definitions 87

References **90**

4 The Dynamics of Pay-for-Performance Sensitivity in Private Equity Funds 92
1 Introduction . . . 92
2 Theoretical Framework . . . 97
2.1 Institutional Setting . . . 97
2.1.1 Hypotheses development . . . 98
2.2 Estimating Explicit Incentives in Private Equity Funds . . . 100
2.2.1 Modelling Expected Carried Interest . . . 100
2.2.2 Estimating the Pay-for-Performance Sensitivity . . . 103
3 Data . . . 105
3.1 Sample Selection . . . 106
3.2 Sample Composition . . . 108
3.3 Accounting Data . . . 110
3.4 Fund cash flow data . . . 112
4 Results . . . 113
4.1 Operational Performance and Pay-for-Performance Sensitivity . . . 113
4.1.1 Impact of reputation . . . 117
4.1.2 Deals made close to fundraising events . . . 119
4.1.3 Public market movements as exogenous shocks . . . 120
4.1.4 Summary . . . 123
5 Conclusion . . . 125
Appendix . . . 139
A Appendix Figures and Tables . . . 139
B Additional Data Description . . . 154
B.1 Sample Construction . . . 154
B.2 Additional Details on the Accounting Data . . . 156
C Details on Monte Carlo Procedure . . . 158
D Variable Definitions . . . 163

References 166

5 Managerial Ownership and Operational Improvements in Buyouts 170
1 Introduction . . . 170
2 Institutional Setting . . . 175
3 Data . . . 177
3.1 Sample Selection . . . 178
3.1.1 Accounting Data . . . 179
3.1.2 Managerial Ownership Data . . . 181
4 Results . . . 183
4.1 Cross-Sectional Variation in Ownership . . . 184

4.1.1 Controlling for industry effects . . . 186
4.2 Interpretation of the Results . . . 188
4.2.1 Changes in ownership stakes . . . 189
4.2.2 The parallel trends assumption . . . 190
4.2.3 Retained or replaced CEO . . . 192
4.3 Sources of Profitability Improvements . . . 195
4.4 Determinants of Post-Buyout CEO Ownership . . . 196
5 Conclusion . . . 198
Appendix . . . 209
A Appendix Tables . . . 209
B Data Description . . . 217
B.1 Sample Construction . . . 217
B.2 Additional Details on the Accounting Data . . . 219
C Comparison PE targets and Matched Peers . . . 222
D Variables in the data set . . . 225

References **227**

6 Conclusion **230**

References **237**

1 | Introduction

> Despite the fact that the global economy and individual investors are increasingly dependent on private capital, much remains poorly understood about these investments. (Jeng and Lerner (2016))

The private equity industry has experienced a tremendous growth since the 1980s. Private equity funds raised approximately $0.8 billion in 1980, $11 billion in 1990, $222 billion in 2000, $450 billion in 2007 prior to the onset of the financial crisis, and $860 billion in 2018, having $4.11 trillion assets under management as of June 2019.[1] The industry growth has been accompanied by increased attention from both academics and policy makers.

Private equity firms act as financial intermediaries, raising private equity funds with capital provided by investors. These funds make investments directly in portfolio companies that are privately held. This differentiates investments by private equity firms from angel investors that invest their own capital.

Private equity encompasses a range of investment strategies, differentiated by the stage of a portfolio company's development at which investments are made. Venture capital (VC) and buyout funds are the most common types of private equity strategies. VC investments are typically staged over multiple rounds in young, innovative companies that have significant growth potential but tend to not yet be profitable. The venture capital investment injects capital in the company, typically in exchange for minority stakes, which is used to support company growth. By contrast, buyout investments are often one-off investments, where the buyout fund acquires a controlling stake from existing shareholders using a mix of equity and debt. Target companies tend to be at a more mature stage, with some level of profitability to support interest payments. This thesis focuses on the buyout segment of private equity, and the terms buyout and private equity are used interchangeably.[2]

Buyouts became an important phenomenon during the 1980s, and Jensen (1989) famously predicted that they would eclipse the public market as the dominant corporate

[1] The numbers for 1980, 1990, 2000, and 2007 are estimated from Preqin data by summing up fund sizes of the relevant vintage years in Preqin. The assets under management figure for 2019 are from the 2020 Preqin Global Private Equity and Venture Capital Report.

[2] For a summary of research on venture capital, see Gompers and Lerner (2001); Metrick and Yasuda (2011); Da Rin et al. (2013), and Tykvová (2018)

organizational form. In his view, the structure of buyouts alleviated several issues present in the public equity market. With private equity firms taking large ownership stakes they have incentives to engage with and monitor the management team, and sufficient control to implement changes deemed necessary. A buyout typically employs significant leverage, which act as a disciplinary mechanism to focus management on generating cash flows (Jensen, 1986). While buyouts have not yet replaced the public equity market as the dominant ownership form, it has grown in prominence over time.

A private equity fund is typically organized as a limited partnership between a group of investors, called limited partners (LPs), and a private equity firm that manages the fund, referred to as the general partner (GP). Investors in private equity funds tend to be institutional investors such as pension funds, endowments, sovereign wealth funds and family offices. When a fund is raised, LPs commit capital to the fund but do not provide it upfront. Instead, the GP has an "investment period" during which the committed capital should be invested. Once an investment is exited, the resulting cash is generally not allowed to be recycled into new investments, but is distributed to LPs. The timing and size of capital calls and distributions are ex ante uncertain, with the GP provided significant discretion about the timing of investments and the exit. The GP is constrained only by contractual terms set out in a limited partnership agreement, stipulating the investment period as well as when the fund should be wounded up; private equity funds have finite lifespans, usually 10–12 years.[3]

The compensation to GPs consist of three parts: a management fee, a carried interest provision which gives GPs a fraction of fund profits, and various fees charged directly to portfolio companies. The management fee can be viewed as the fixed part of compensation. It is usually 2%, with the basis being committed capital during the investment period, and invested capital in the later part of a fund's life. Carried interest typically gives GPs 20% of fund profits, conditional on fund performance exceeding a hurdle rate (normally 8%). There is more variation in other types of fees, and various rebates offered to LPs. Gompers and Lerner (1999) and Metrick and Yasuda (2010) provide detailed descriptions and empirical investigations of common fee arrangements, and how each part contributes to GP revenue, while Phalippou et al. (2018) focus on fees charged to portfolio companies. The fee structure with carried interest and a fixed management fees resembles the fee structure in hedge funds, but there are distinct differences such as the use of high watermarks in hedge funds.

The purpose of carried interest is to provide GPs with a strong pay-for-performance component of pay, aligning incentives of LPs and GPs. Chung et al. (2012) note that in

[3]See Sahlman (1990) for a discussion of the common organizational structure of private equity funds, and Metrick and Yasuda (2010) for a recent overview.

addition to the direct pay for performance provided by carried interest, the finite fund life provides a natural indirect component as GPs regularly have to raise new funds in the market. As documented by Chung et al. (2012), Barber and Yasuda (2017), and Brown et al. (2019), high current fund performance increases the likelihood that a GP raises a new fund and, conditional on successful fundraising, the fund is larger. Typically, new funds are raised between the third and sixth year of the existing fund (Barber and Yasuda, 2017). This ensures that the private equity firm has capital to deploy when promising investment opportunities are found.

A major difference between private equity funds and other actively managed fund structures is the role of the fund manager once an investment is made. While all actively managed funds are responsible for selecting investments, and are evaluated on their performance, not all are as actively involved in running the business. Metrick and Yasuda (2011) view this as the raison d'être of private equity. By taking large, often controlling, stakes, private equity firms have the means to implement any changes deemed necessary to generate value in portfolio companies.

As private equity firms are financial intermediaries, generating value should be interpreted as value for the private equity fund. Private equity is often associated with negative headlines, commonly due to perceptions that private equity extract value from other stakeholders.[4] A theoretical channel is suggested in Shleifer and Summers (1988), where the acquirer is able to transfer wealth by breaking implicit contracts.

Much of the criticism towards private equity are based on specific cases rather than large-scale analysis of the impact of private equity. Analysing large, representative, samples is difficult due to the lack of readily available data, as discussed in Jeng and Lerner (2016). Investments made by private equity funds are privately held, and are consequently often exempted from disclosure requirements facing publicly listed companies. The private equity firms themselves are under no obligation to make their data available. Even information that is basic in other areas, such as fund performance data, is typically only available for subsets of private equity funds. Researchers tend to rely on commercial databases such as Burgiss, Cambridge Associates, Pitchbook and Preqin.[5] An alternative is to use confidential datasets provided by individual investors (e.g. Robinson and Sensoy, 2013) or government agencies (e.g. Cohn et al., 2014).

[4] A recent example of this is a letter sent to Blackstone, KKR, New Mountain Capital and Frazier Healthcare Partners on the 15thof April 2020 by Elizabeth Warren, the US Democratic senator, and Katie Porter, the US Democratic congresswoman. In the letter they criticize that portfolio companies of these PE firm cut doctors' pay and benefits during the ongoing Covid-19 pandemic. In the letter they acknowledge that the healthcare industry is experiencing financial difficulties, while still criticizing the approach taken.

[5] Brown et al. (2015) compare these four commercial databases in terms of coverage and what they say about fund performance. The authors also describe and discuss differences in how the data is sourced.

This thesis combines a variety of databases to advance our knowledge in two areas of the private equity field. The first paper utilizes a confidential dataset containing bids on the secondary market for private equity fund stakes to examine whether bids in that market are informative of the accuracy of net asset values (NAVs). This secondary market was once marginal due to contractual restrictions on transfers (see Lerner and Schoar, 2004), but took off after the financial crisis. The second and third papers contribute to the growing literature on the impact of private equity ownership on the portfolio companies owned. For these papers I assemble a new, representative, dataset with financials on portfolio companies acquired in buyouts. I do this by utilizing the unique UK setting, where all companies are required to submit annual filings to Companies House, the national registrar. The second paper examines the role of direct pay for performance at the fund level, provided to GPs by the carried interest provision. I document how this pay-for-performance sensitivity varies over a fund's life, and establish a positive relationship between portfolio company growth and the sensitivity of pay to performance of the acquiring GP. The third paper shifts focus to the role of managerial ownership stakes in portfolio companies. A salient feature of private equity acquisitions is changes to the ownership stakes of CEOs in the acquired companies (e.g. Cronqvist and Fahlenbrach, 2013; Kaplan and Stein, 1993). I hand-collect data on managerial ownership stakes prior to and following the buyout, and document a positive relationship between increases in CEO ownership stakes and profitability improvements in the acquired company.

Given the distinct nature of each analysis, I review the major findings of each paper separately, highlighting its relevance and contribution to the literature. A detailed survey of the existing body of research related to these topics is presented in Chapter 2.

Paper 1: The accuracy of net asset values in private equity: Evidence from the secondary market

For a long time, one of the distinct characteristics of private equity was the inability of LPs to liquidate their fund stakes prior to the fund itself being liquidated. In other fund structures that restrict the ability of investors to redeem invested capital from the fund, such as closed-end funds and hedge funds, investors are typically able to liquidate their stakes on a secondary market.[6] For a long time, private equity was an exception to this, commonly employing restrictions on the transferability of fund stakes. For example, GPs are typically able to block the sale of a fund stake.

As a consequence, the secondary market for private equity fund (PEF) stakes remained marginal for a long time, having only $2 billion of annual transactions in the early 2000s (Nadauld et al., 2019). These features make investments in private equity illiquid from

[6]Investments in hedge funds can be redeemable, but they often impose lock-up and redemption notice periods (Ramadorai, 2012).

the point of view of LPs. Lerner and Schoar (2004) argue that this illiquidity is an optimal design feature, chosen by GPs to screen for investors with "deep pockets" and long investment horizons. However, the financial crisis exposed a need among investors to be able to liquidate their stakes early, and the secondary market has grown in response, reaching a high of $88 billion in transaction volume in 2019.[7] While there are many reasons for investors to want to liquidate a stake early, two points illustrate why the market was bound to take off eventually.

First, restrictions on transferability of fund stakes may have been feasible when private equity represented small fractions of investors' portfolio. However, the growth of the industry have followed an increased allocation to private equity by individual institutions. The Yale endowment is an extreme example, having an asset allocation target of 38% to buyout funds and venture capital for the fiscal year of 2020, the highest to date.[8]

Second, to reach any desired asset allocation, LPs have to account for the fact that they do not have discretion over the entry and exit decisions of investments. To maintain any desired allocation, commitments have to be made today to replace expected future distributions. To achieve an increase in the allocation, investors face a lag between committing today and achieving the desired increase in invested capital. As distributions are not guaranteed, and capital calls are uncertain ex ante, the total potential exposure to private equity is therefore larger than the value of current investments. Robinson and Sensoy (2016) document that distributions are more cyclical than capital calls, suggesting that an LP's exposure is likely increased in bad times. If adverse shocks reduce the value of the other parts of the portfolio and the availability of liquidity, uncalled commitments may become a burden on liquidity due to the strict contractual obligations to meet capital calls (Metrick and Yasuda, 2010).

The Harvard endowment's exposure during the financial crisis exemplifies this. As of June 2008, the endowment had $11 billion of uncalled capital commitments to private equity and real estate funds, compared to their combined reported value of $15.3 billion, and a total endowment value of $43.0 billion. The endowment shrunk in value during the next fiscal year, and reported a value of $30.9 billion in June 2009. The uncalled committed capital therefore represented a much larger fraction of the endowment. The endowment reduced their uncalled commitments by $3 billion during that year.[9] One way of reducing the amount of committed capital is to sell a fund stake on the secondary market, as the buyer takes over the responsibility to meet future capital calls.

[7] https://www.greenhill.com/en/content/greenhill%E2%80%99s-secondary-market-analysis-record-volume-third-consecutive-year, accessed 2020-05-18.

[8] https://news.yale.edu/2019/09/27/investment-return-57-brings-yale-endowment-value-303-billion, accessed 2020-05-18.

[9] The figures on endowment valuations and uncalled commitments are taken from the financial reports of the Harvard Endowment for the fiscal years 2009 and 2010.

While we might have expected 2009 to be a year with many secondary market transactions, transaction volumes dropped to half of what it was in the years before and after (see Nadauld et al., 2019). One of the reasons for this, as documented by Hege and Nuti (2011), is that sellers and buyers disagreed on the fair price of fund stakes. Sellers anchored their valuations around reported NAVs, while buyers argued that valuations were stale and therefore demanded large discounts.

As the market has grown, substantial capital is now earmarked to purchasing PEF stakes through the secondary market. For instance, secondary funds, focused on such transactions, raised over $160 billion between 2011 and 2016.[10] Even with this influx of capital, Nadauld et al. (2019) show that, on average, transactions occur at a discount to a fund's NAV.[11]

A common explanation for the discounts is one of imperfect liquidity provision: when investors are forced to liquidate their PEF stakes, buyers providing liquidity are able to acquire assets for less than the underlying value of the asset (Hege and Nuti, 2011; Kleymenova et al., 2012; Nadauld et al., 2019). This explanation alone cannot account for all variation in discounts, as we observe a quarter of bids that arrive at par or at a premium to NAVs. If NAVs reflect the underlying value, it is puzzling that most of these bids do not lead to a transaction.

An alternative explanation is that variation in discounts reflect expected future performance, as in the model of closed-end fund discounts by Berk and Stanton (2007). Expected future performance could reflect beliefs about managerial ability. It could also reflect a discrepancy between NAVs and fundamental value, owing to the lack of market valuation of portfolio companies in private equity funds and an aspect of subjectivity when estimating value (Crain and Law, 2018). Secondary market prices may represent more accurate estimates of fund value. Boyer et al. (2019) construct a private equity index based on secondary market transactions, which can be used to examine factor loadings of private equity returns if secondary market prices reflect the market value of fund stakes.[12]

This paper asks whether bids are informative of the accuracy of NAVs. The main findings of the paper is twofold. First, cross-sectional variation in bids predict the future performance of funds, measured from the first NAV after the bid is posted. Funds receiving high bids have high post-bid performance, measured as the public market equivalent (PME) of Kaplan and Schoar (2005). This result does not hold true for variation in

[10] Other buyers include funds-of-funds, which invest in both the primary and secondary market for PEF stakes; and various asset owners (investment banks, hedge funds, endowments, pension funds, sovereign funds), which have their own teams to manage purchases of PEF stakes.

[11] Nadauld et al. (2019) report average discounts ranging from an average of 46% in 2009 to 7% in 2014.

[12] The index of Boyer et al. (2019) is constructed to represent the returns of an investor that both buys and sells through the secondary market, but the extent to which their index is relevant for evaluating factors relevant for returns in private equity overall depend on what discounts reflect.

discounts over time, only when comparing cross-sectional variation in discounts between funds within a given time period. To assess the economic magnitude, we sort funds into quartiles based on the highest bid received during a quarter. Over a three-year period following the bid, funds in the quartile receiving the highest bids report a PME of at least 0.103 above funds receiving the lowest bids. This difference is large when put in relation to an average PME of 1.18 during the entire life of buyout funds, as reported in Harris et al. (2016). These results refer to an ex post measure of performance, measured from the first NAV report after the bid date and three years into the future. Additionally, we find that bids are positively related to performance of funds during the period the bid is posted: bids are higher for funds that report a higher NAV-to-NAV return during the quarter in which the bid is placed. Note that this information is not available at the time of the bid.

Second, we find that the relationship between post-bid fund performance and the bid placed is sufficiently strong to offset the difference in price paid. Investors posting low bids would not achieve higher returns than those posting high bids, had their bids been accepted. The reported gain for those posting low bids is large over short horizons, while it is offset by the reduced fund performance over longer horizons. Again, this result only holds within a given time period, not for variation in discounts over time. Together, these results indicate that investors in the secondary market are able to identify the relative accuracy of funds' NAVs. Time-series variation in discounts may reflect varying liquidity compensation, as suggested by Nadauld et al. (2019).

It may seem as if the results of the paper are obvious. However, the opaque nature of private equity makes it hard to access any information on the portfolio companies that make up the value of a fund. While investors in the fund receive regular updates, potential outside investors do not, complicating any valuation exercise.[13] Despite a rapid growth, the secondary market remains small relative to assets under management of $4.11 trillion (Preqin 2020). In Boyer et al. (2019), the average fund transacts 2.7 times over the period 2006 through 2018, conditional on trading at all. This market is therefore characterised by limited price discovery. The results of the paper therefore suggests a high level of sophistication among participants in the secondary market, echoing findings in Brown et al. (2019) that investors are not tricked by misreported NAVs.

The secondary market is an over-the-counter market intermediated by specialized organizations that match buyers and sellers. The data in this study is a proprietary dataset provided by a London-based sell-side agent for investors wishing to exit via the secondary market. The data provider gave us access to its entire bid book, which is

[13]To highlight the inaccessible nature of the data, it is instructive to consider how our data provider describes the process of selling a fund stake. After an initial interest is found for a given stake, the general partner of the fund has to agree to a set of potential buyers. Bidders then sign non-disclosure agreements and are only allowed access to data in "data rooms" set up to provide access for a limited period of time.

comprehensive and representative of the global market: the average bid in our sample each year is close to the average annual transaction price reported by Greenhill-Cogent. Most of the bids are made at a discount to NAV, and the discounts vary over time as well as cross-sectionally. Our dataset consists of 4,242 bids on 488 buyout funds by 144 bidders.

It is important to understand how well the secondary market functions to evaluate performance in private equity. While buyout funds tend to outperform the public equity market (Harris et al., 2014, 2016; Robinson and Sensoy, 2016), it is not clear whether this reflects an alpha or compensation for bearing the illiquidity of private equity investments. Franzoni et al. (2012) find an alpha of zero when including a liquidity premium, and the theoretical models in Sorensen et al. (2014) and Bollen and Sensoy (2016) suggest that the reported performance may be just enough to break even.

A well-functioning secondary market reduces the illiquidity of investments in private equity, lowering the return required to invest in the primary market. This is shown in the models of Maurin et al. (2020) and Bollen and Sensoy (2016), where the discount from the fair value of the fund directly impacts the required return from investing in a private equity fund. Hence, to understand whether reported returns in private equity are compensating investors for the risk they take, it is essential to know whether the secondary market is efficient. This paper suggests that merely looking at the discount from NAV to gauge the discount from the fair value is simplistic, as cross-sectional variation reflects differences in underlying value.

This is one of few empirical studies of the secondary market for PEF stakes. Like us, Kleymenova et al. (2012) utilize bid-level data. They explore the determinants of bids in auctions of PEF stakes, finding that bids are lower when fewer bidders participate in an auction, and higher if the stake is more liquid. Nadauld et al. (2019) is the first to use transaction data. They document an average discount in the market which increases in bad economic times. They also find that buyers of PEF stakes earn higher return than sellers, a difference they attribute to compensation for liquidity provision. Using the same dataset as employed in this paper, Albuquerque et al. (2018) study liquidity provision in the secondary market by modelling demand for private equity fund stakes. They find evidence of compensation for liquidity provision, as demand moves to where selling pressure is highest. This paper complements existing studies by studying the informativeness of bid levels, providing evidence that cross-sectional variation predicts fund performance. In doing so it also provides empirical evidence in favour of the model of Berk and Stanton (2007), from a setting outside the closed-end fund setting it was initially developed for. In that it contributes to earlier evidence from secondary market for hedge funds provided by Ramadorai (2012).

The paper also contributes to the literature examining the accuracy of NAVs by documenting that secondary market participants are able to spot which NAVs are misvalued, and price it appropriately. Barber and Yasuda (2017) and Brown et al. (2019) show that NAVs are not always accurately priced, particularly around fundraising events. Ang et al. (2018) and Boyer et al. (2019) document significant autocorrelation in private equity return indices, suggesting that NAVs do not fully incorporate recent returns. To the extent that secondary markets become more liquid, it provides a potential avenue to overcome the lack of market valuations.

A limitation of our data is that we work with bids and not transactions. While this enable us to examine valuations of funds that LPs are not willing to sell, a natural concern is that some bids may not be serious, and even if bids are serious they are lower than the price which would lead to a transaction. We take several steps to mitigate this concern.

First, we note that our descriptive statistics closely match those published by Greenhill Cogent and those in Nadauld et al. (2019) that are based on transaction prices from a US-based financial intermediary. This similarity is not surprising given that i) bidders submit the same bid to several intermediaries to maximize the probability of matching a selling interest; and ii) submitting bids is costly both in due diligence and in terms of reputation. A bidder attempting to manipulate the perception of demand, submitting unrealistic bids, or reneging on a submitted bid, would be quickly spotted and excluded from this market by the financial intermediary. Hence, we believe that bids are informative of the bidder's true valuation.

Second, we take steps to mitigate concerns arising from bids being systematically lower than the price a fund would transact at. Let Δ denote this difference. Evidence in Hege and Nuti (2011) suggests that this difference varies over time. All of our analysis therefore include specifications with time fixed effects to soak up this effect. Such time-variation in Δ may explain why we find weaker relationship between discounts and future performance when not controlling for time fixed effects.

Third, while our data is bid-focused it does include a few transactions. For 35 such transactions we observe earlier bids from the investor that eventually buys the stake. The final bid placed prior to the completion of a transaction is on average the same price as the completed transaction. However, we do observe that bids generally increase in the submitted bid sequence, presumably as the bidder is attempting to convince the seller by posting bids closer and closer to the bidder's reservation price. This suggests that the bid sequence correlates negatively with Δ, and we can test the whether our results are sensitive to including this proxy from our specification. The results of the paper are qualitatively unchanged whether we include and exclude this proxy.

Finally, we note that the presence of Δ is likely to work against us finding the results of the paper. When we measure the hypothetical return to bidders, we use the bid placed as an initial investment. An increase in Δ equals a lower bid, leading to a higher return to the investor. But what we find is that higher bids do not perform any worse than lower bids.[14] There is no such mechanical relationship between the bid and funds' future performance, but the presence of Δ is likely to add noise, making it more difficult to find any relationship. We conclude that it is unlikely that our results are driven by the fact that we work with bids rather than transaction prices.

Paper 2: The Dynamics of Pay-for-Performance Sensitivity in Private Equity Funds

The carried interest part of a GP's compensation is intended to provide the GP with a strong pay-for-performance component of pay. It is credited by some as one of the drivers of strong returns in PE (e.g. Jensen, 1989; Kaplan and Strömberg, 2009). A GP's payoff from carried interest functions similarly to a call option, with the hurdle rate acting as its strike price. The sensitivity of pay to performance corresponds to the delta of this option. The hurdle rate is fixed and set at fund inception, leading the delta to vary with fund performance. As with call options, the delta is low (high) when a fund is far out of (in) the money.

A PE fund does not invest all the committed capital at once. Instead, it makes staggered investments during an investment period that normally spans five years. Consequently, when making investments late in the investment period, the delta depends on the success of earlier deals. Proponents of PE claim that they add value to their portfolio companies. Presumably, this takes effort on behalf of the GP, and agency theory predicts that we expect higher effort when the sensitivity of pay to performance is higher (e.g. Holmström, 1979). In this paper, I ask how variation in a GP's pay-for-performance sensitivity relates to operational improvements at the portfolio companies acquired in buyouts.

The main finding of the paper is that there is a positive relationship between the growth rate of companies acquired in buyouts and the delta of the acquiring PE fund. The results suggest that a one standard deviation increase in delta is associated with between 2.7% and 3.5% higher annual revenue growth, measured from the pre-buyout period and up to four years post-buyout. Delta is not related to improved profitability. While estimates suggest a positive relationship, it is statistically insignificant and the economic magnitude is small.

[14] If Δ is an increasing function of the bid placed it would help us find our results. However, this seems unlikely given that the mechanical effect of an increase in Δ is to lower the bid. Note also that we may have several bids targeting a given fund in specific time period, in which case the ones with the highest Δ are the lowest bid and it is certain to work against us.

Earlier studies document that one way PE facilitates growth in portfolio companies is through relaxing credit constraints, allowing for increased investment (e.g. Boucly et al., 2011; Cohn et al., 2020). Interestingly, the observed positive relationship between company growth and delta does not reflect capital spending. There is not only a lack of significant relationship between delta and asset growth in the target company, the point estimates are consistently negative. This suggests that the results likely reflect organic growth.

This study utilizes a dataset of UK companies acquired in a buyout to measure improvements in operational performance. All companies in the UK, public and private, are required to submit filings to Companies House, the UK national registrar, which makes these filings publicly available. This setting provides two distinct advantages for the study at hand. First, a representative dataset containing both pre- and post-buyout financials can be assembled.[15] Second, UK companies submit annual ownership lists, allowing a company to be linked to the acquiring fund. This is crucial as the delta is estimated at the fund level, while transaction databases commonly only list the acquiring PE firm.

To estimate the delta of GP pay I build on the framework developed by Metrick and Yasuda (2010). They provide a model for estimating the expected revenue to a GP, of which carried interest is one part. A PE fund consists of investments in portfolio companies with simulated return paths. Using a set of contractual features, the resulting stream of cash flows is allocated to the fund's investors (limited partners, or LPs) and the GP. In equilibrium, GPs must add value to portfolio companies to compensate LPs for the fees charged, and hence I calibrate the model so that LPs break even. The delta of a GP's compensation is measured as the expected increase in the present value of a GP's payoff from adding $1 extra of value to a portfolio company. To match an additional moment of the data I add leverage to their framework, and calibrate the model to match the empirical default rate in the sample.

To evaluate the dynamics of delta the model is estimated at intermediate points in funds' life, using reported cash flows and NAV valuations from Preqin. I find that the delta is positively related to fund performance, and increasingly so as the fund matures and performance becomes more informative.

The delta captures only the direct pay for performance sensitivity. As documented by Chung et al. (2012), the indirect pay for performance — stemming from improved fundraising prospects — is of at least an equal magnitude to the direct component.

[15] Availability of data on privately held companies is often scarce. Consequently, researchers often utilizes samples containing companies with publicly available financials (e.g. Guo et al., 2011), or samples made available to them by individual investors (e.g. Acharya et al., 2013). Such samples are not necessarily representative. Cohn et al. (2014) document that among public-to-private buyouts, those with publicly available financials perform better than those without. I am not the first to utilize the UK setting for these reasons. Bernstein et al. (2019) examine how PE-backed companies fared during the financial crisis, while Chung (2011) focuses on the impact of PE ownership in private-to-private buyouts.

They show that the relative importance of the direct component increases with GP experience: GPs with a proven track record are less reliant on current fund performance to successfully raise new funds. Their insight provides a cross-sectional prediction: the observed relationship between delta and operational improvements at target companies should be stronger when the direct component of pay is more important to a GP. Consistent with this prediction, the documented positive relationship is driven by highly reputable funds, with estimates suggesting a larger economic effect. A similar argument can be made for deals completed around successful fundraising events. If investors care mostly about the performance of the most recent fund when deciding to participate in future funds, the indirect pay for performance will drop following successful fundraising. Consistent with this prediction, the positive relationship between delta and operational improvements is stronger for deals completed near fundraising events.

So far, I have documented a positive correlation between a GP's pay-for-performance sensitivity and post-buyout growth in portfolio companies. This may reflect an effect of incentives provided by the pay-for-performance compensation. However, factors related to the delta may be directly related to the operational improvements at portfolio companies. For example, an obvious alternative is that the results reflect managerial ability: GPs skilled at improving operations of portfolio companies likely translate that ability into high fund performance, leading to a high delta. Additionally, there is a time-varying mechanical relationship as PE performance closely follow public markets (e.g. Ang et al., 2018): virtually all funds are in the money when equity markets are doing well. To the extent that expected operational improvements are state-dependent, this leads to a correlation unrelated to incentives.

To overcome these issues, the empirical specification includes fund fixed effects and time fixed effects. The inclusion of fund fixed effects absorbs time-invariant differences in GP ability, and implies that the results of the paper correspond to within-fund estimates. The staggered nature of PE investments provides for natural within-fund comparisons. With the amount of investment capital available to a PE fund fixed at inception, there is no concern that capital flows, and diseconomies of scale, offset increases in delta due to good performance as in Berk and Green (2004).

To further strengthen the interpretation I exploit that the valuation of PE funds move with the public market (Ang et al., 2018), and that the delta increases with fund performance. A public market valuation shock is exogenous and common to all PE funds. While the shock is common, the resulting impact on delta varies between funds. The degree to which a market shock impacts a fund's delta largely depends on two factors: the fund's current performance and the degree to which the fund is invested. To illustrate, the value of a fund that has yet to make its first investment is not impacted at all by

market movements, while one that is fully invested will see the value of all its investments impacted. Similarly, a fund far in or out of the money will not be much impacted, while one at the money will experience a big impact. This implies that market shocks can be used to generate exogenous variation in delta.[16]

Extracting the part of delta due to a market shock is done in two steps. First, I estimate what the NAV would have been absent any market movement, using a simple market model. Second, using this counterfactual NAV and the implied counterfactual fund performance, I estimate a delta absent the market shock. The difference between the normal delta and the counterfactual delta is attributable to the market movement.

I confirm the main result of the paper using only the part of delta attributable to market movements. The results suggest that a one standard deviation increase in the market-driven component of delta translates to an increased revenue growth rate of between 1.8% and 3.9%, depending on the model specification. Again, this growth is neither attributable to increased capital expenditure nor does it come at the expense of worsened profitability.

The paper provides insights to the wider question of how pay-for-performance compensation of managers impacts performance. This question has received considerable attention to in the context of CEOs, but is notoriously difficult to give a convincing answer to. Compensation packages are the outcome of a matching and bargaining process, so manager quality is likely related to both the magnitude and structure of compensation. Managers may influence the process in which compensation is set (Bebchuk et al., 2002) or time the delivery of news to the awarding of stock options (Aboody and Kasznik, 2000; Yermack, 1997); compensation packages can be renegotiated ex post (Brenner et al., 2000); and firms design compensation packages to exploit managerial characteristics such as optimism and overconfidence (Humphery-Jenner et al., 2016; Otto, 2014).[17] The private equity setting overcomes many of these issues as compensation terms are fixed at fund inception. This is similar to Agarwal et al. (2009), that examine how the managerial delta in hedge funds relates to fund performance. The PE setting provides additional benefits as it is a natural setting to perform within-fund estimations allowing the econometrician to control for time-invariant managerial ability. As PE funds are always long the equity market, unlike hedge funds, market shocks can be utilized to generate exogenous variation in delta.

[16] This strategy is conceptually similar to that used in Shue and Townsend (2017), where they utilize differences in the sensitivity to industry shocks of the value of options awarded to CEOs under fixed-value versus fixed-number option plans.

[17] Frydman and Jenter (2010) provides a survey of this literature. Notable papers on the efficacy of compensation packages are Jensen and Murphy (1990), showing that CEO compensation is weakly related to the dollar increase in firm value; Hall and Liebman (1998), showing that CEOs compensation is strongly related to the percentage increase in firm value; Yermack (1995), who does not find that stock options appear to be awarded in order to reduce agency costs; and Datta et al. (2001), showing that stronger incentives lead to better acquisitions.

The results of the paper are important for the private equity literature. Carried interest is intended to align the incentives of managers with that of investors, but we lack empirical evidence on the effect of variation in the sensitivity of pay to performance. Hüther et al. (2020) document that VC partnerships with more "GP-friendly" contracts, with carry on a deal-by-deal basis, are associated with higher returns. Robinson and Sensoy (2013) find that funds with higher fees do not deliver lower net-of-fee performance. However, these findings are subject to many of the same endogeneity concerns as the CEO compensation literature, in particular the matching of contract terms and manager quality. In that respect, this study provides additional insights by exploiting within-fund variation in the strength of incentives as well as plausibly exogenous variation.

By examining how the pay-for-performance sensitivity of GPs relate to operational improvements at target companies, the paper contributes to an extensive and growing literature exploring the impact of private equity ownership on the performance of portfolio companies (e.g. Acharya et al., 2013; Bernstein et al., 2019; Bernstein and Sheen, 2016; Boucly et al., 2011; Cohn et al., 2014; Davis et al., 2014, 2019; Guo et al., 2011; Kaplan, 1989).

Paper 3: Managerial Ownership and Operational Improvements in Buyouts

Given the large role that private equity plays in the economy, it is important to understand if and how private equity impacts the performance of portfolio companies. Although the existing literature suggests that private equity generates improvements to portfolio companies' operations, we know little of which actions taken generate these improvements.[18]

Two recent papers give us some insight into what GPs do. Biesinger et al. (2020) examine confidential value creation plans for specific emerging market deals, relating these plans to subsequent success in the deals. Interestingly, they do not find that the ex ante selection of strategy predicts deal success. Instead, they find that successful deals are those in which GPs disclose that their proposed strategy was successfully implemented, which the authors interpret as evidence of the importance of execution of these plans. A complementary paper is that of Gompers et al. (2016), asking 79 private equity firms how they operate. Their survey reveals that private equity firms themselves believe that the two most important sources of value creation, both in expectation and ex post, are increasing revenue and improving incentives of the management team.

Starting with Jensen and Murphy (1990), there has been a long debate over whether the equity ownership of CEOs provides sufficient incentives to generate value for shareholders. A salient feature of private equity acquisitions is that managerial equity ownership increases

[18] Examples of studies documenting operational improvements are Acharya et al. (2013); Bernstein and Sheen (2016); Boucly et al. (2011); Davis et al. (2014, 2019); Guo et al. (2011); and Kaplan (1989).

(e.g. Kaplan and Stein, 1993; Cronqvist and Fahlenbrach, 2013). Increasing the equity ownership stake increases the pay-for-performance sensitivity of the management team, providing stronger incentives to generate value. This paper examines how the change in managerial ownership induced by a buyout is related to portfolio company performance.

This paper utilizes the dataset of portfolio company financials assembled for the second paper of the thesis. Adding to the company-level financials, I utilize an additional filing required to be submitted annually in the UK: a breakdown of the precise ownership of every individual shareholder in the company. I compile these ownership filings by hand to measure managerial ownership before and after the buyout. This data is used to provide new insights into the impact of managerial ownership on the performance of companies acquired in a buyout.

The main finding of the paper is that the post-buyout CEO ownership share is positively correlated with improvements in profitability (EBITDA/Revenue). The results suggest that companies with a 10 percentage points higher CEO equity ownership stake (one standard deviation) improve their profitability margin by 3.1%–3.6% from the unconditional average profitability. The relationship is more pronounced for changes in CEO ownership stakes, where a 10 percentage points increase in the ownership translates to a 4.3%–5.0% increase in profitability.

Clearly, the interpretation of any observed relationship between managerial ownership and operational performance depends on whether the CEO is retained or replaced. Cornelli and Karakas (2015) document that the CEO of a target company is often replaced by the acquiring private equity firm, which is the case in 39% of the buyouts in my sample. Interestingly, the positive relationship between managerial ownership and profitability improvements found in this study is driven entirely by the subsample of buyouts where the CEO is retained. By contrast, the coefficient is statistically insignificant and close to zero when the CEO is replaced. The economic magnitude is up to 60% higher when the CEO is retained compared to the full sample.

The positive relationship between operational performance and increased managerial equity ownership may reflect matching of talented CEOs to companies as in Gabaix and Landier (2008). Higher ability CEOs should be able to bargain for a bigger share, as well as accept compensation packages that are more dependent on performance. The results could also correspond to the outcome of efficient bargaining from managers with inside information (Blanchflower et al., 1996). Additionally, they may capture an effect of incentives provided through the ownership stake. The arrival of private equity almost invariably induces a shock to the managerial ownership share. To the extent managers have limited say over the post-buyout share, the change in ownership level represents a shock to CEO incentives.

The different sample splits help differentiating between these potential explanations. If the positive relationship between managerial ownership and performance reflects attracting talented CEOs, we would expect the results to be stronger when the CEO is replaced as the pool of potential CEOs is larger. Instead, the positive relationship is only observed when the CEO is retained, which casts doubt on this explanation. When a CEO is retained, a change in the ownership stake implies a change in incentives, while CEO ability is held constant. Furthermore, the incentive story suggests that changes in ownership are more relevant than the level of ownership, which is what I find. In contrast, the bargaining story suggests that the relevant metric is the ownership share of the management team.

To further sharpen the interpretation of the results I examine the determinants of CEO equity ownership post-buyout. These results are largely consistent with a desire to provide incentives. There is a negative relationship between ownership stake and initial profitability. Taken together with the main results of the paper, this is consistent with private equity firms setting contracts to maximize value. Providing management with higher equity stakes comes at a cost as it limits the upside of the acquirer. Therefore, we expect higher management stakes in companies where profitability improvements are particularly valuable: those with low initial profitability. Furthermore, the pre-buyout ownership stake is positively related to the post-buyout stake, but only when the CEO is retained. This is consistent with an attempt to increase incentives from pre-buyout levels. Taken together, the results of the paper support the view that improving managerial incentives plays an important part in value creation by private equity firms.

A natural question to ask is how profitability improvements come about. Improved profitability may reflect reduced costs or increased revenues with the existing cost base. The results of the paper indicate that the profitability improvement related to increases in managerial ownership stems from reducing costs rather than increasing productivity. This could indicate that private equity firms provide CEOs with larger stakes when cost cutting is desired. If cost cutting is associated with a high private cost to the CEO, this is consistent with an optimal contracting view.

Any study on private equity portfolio companies has to deal with the fact that companies are not randomly assigned to be buyout targets. Thus, simply comparing buyout targets with non-targeted companies is tricky. Therefore the analysis relies on cross-sectional variation in managerial ownership among buyout targets, rather than comparing buyout targets and other companies. Following Boucly et al. (2011), the analysis includes matched control companies to account for industry-time fixed effects, but the variation in managerial ownership is only among the targets of a buyout.

However, even among buyout targets there is a concern that the optimal compensation package varies with unobserved company characteristics. But this explanation cannot

explain why it is only in the retained CEO subsample that we see positive relationships between managerial ownership and operational performance, and between pre- and post-buyout CEO ownership stakes. Presumably, a high pre-buyout ownership stake would indicate a higher CEO ownership stake in the optimal contract whether the CEO is retained or not.

Finally, distinguishing between the efficient bargaining and the incentive story is problematic as they often give similar predictions. For example, imagine a manager of a division in a conglomerate. Suppose she has private knowledge of an unpleasant action that could improve the division, but does not feel she is currently sufficiently compensated for the cost of taking the action. She may approach a private equity firm with the intention of increasing her ownership stake prior to implementing the necessary improvements. The larger stake provides incentives to take action, but presumably the manager's inside information allows her to bargain for a larger stake. Absent exogenous shocks to the ownership stake provided to CEOs, this paper cannot claim causality, merely offering robust supportive evidence of the idea that higher CEO incentives lead to improved operational performance.

This paper speaks directly to the literature on operational improvements provided by private equity. Early studies by Kaplan (1989), Lichtenberg and Siegel (1990), and Smith (1990), showed that management buyouts are associated with improved operations, and that this generates value for the private equity sponsors. More recently, Guo et al. (2011), and Acharya et al. (2013) document the importance of operational improvements for generating value in buyouts. Boucly et al. (2011), using a sample of French portfolio companies, suggest one important channel through which private equity can help their portfolio companies: relaxing credit constraints to facilitate growth. Davis et al. (2014) and Davis et al. (2019) provide evidence that private equity facilitates reallocation of capital to more productive establishments, generating an overall increase in total factor productivity. This paper adds to this literature by documenting how a specific change induced by a buyout — changes in managerial ownership — relates to operational improvements.

As discussed in Jeng and Lerner (2016), data limitations is always an issue in private equity research, and certainly when studying privately held portfolio companies with limited disclosure requirements. Cohn et al. (2014) directly show how this may impact the interpretation of results, as companies with publicly available financials perform better than those without. Davis et al. (2019) highlight that not all buyouts are the same, with public-to-private buyouts differing markedly from other types of buyouts. This speaks to one of the strengths of this study, as the UK setting allows the inclusion of all types of buyouts, and all companies are required to submit annual reports.

The UK setting also allows for collecting a large-scale sample of managerial ownership both pre- and post-buyout, and linking it to operational performance. This is a significant improvement over the existing large-scale study focusing on managerial ownership of private equity targets by Leslie and Oyer (2009).[19] They utilize a set of public-to-private buyouts to obtain pre-buyout ownership data, while using a different set of companies going public through an IPO to measure managerial ownership levels after a period of private equity ownership. Since these sets are different, the authors are unable to measure changes induced at the time of the buyout. Additionally, the authors lack company financials during the period of private equity ownership.

Beginning with Kaplan and Strömberg (2003), private equity and venture capital have been used to explore optimal governance, examining the choices taken by value-maximizing principals. Cornelli and Karakas (2015) study the role of boards and find that CEO turnover decreases and becomes less contingent on performance when private equity sponsors have higher involvement in the company. Edgerton (2012) shows that private equity sponsors curb excessive usage of corporate jets. Cronqvist and Fahlenbrach (2013) provide a detailed overview how CEO contracts are changed for a set of 20 private equity deals. This paper contributes to this stream of papers by linking how changes in managerial ownership is related to operational performance.

The question of how managerial ownership impacts the value of a company is an important question in the agency literature. Agency theory suggests that if managers can exert costly effort to increase performance, then we expect better performance when the pay of the manager is more tightly linked to performance.[20] Existing studies on managerial ownership in publicly held companies have to overcome multiple issues: compensation packages are the outcome of a matching and bargaining process; managers may influence the process in which compensation is set (Bebchuk et al., 2002) or time the delivery of news to the awarding of stock options (Yermack, 1997; Aboody and Kasznik, 2000); compensation packages can be renegotiated ex post (Brenner et al., 2000); and companies design compensation packages to exploit managerial characteristics such as optimism and overconfidence (Otto, 2014; Humphery-Jenner et al., 2016). To

[19] Cronqvist and Fahlenbrach (2013) also examines CEOs of companies acquired in public-to-private buyouts. They obtain detailed information about the contract offered to CEOs in 20 large deals, offering insights into optimal contracting. While this paper lacks that level of detail, it covers more transactions and combines the ownership data with operational performance data.

[20] Jensen and Meckling (1976), Fama (1980), Fama and Jensen (1983b,a) are examples of this theoretical agency literature. Holmström (1979) and Grossman and Hart (1983) provide models of optimal contracts when effort is unobservable and impacts contractable output with noise. There is some empirical evidence that company value is positively impacted from increased managerial ownership and when compensation is more sensitive to company performance (e.g. Abowd, 1990; McConnell and Servaes, 1990; Mehran, 1995). However, the evidence is mixed. Agrawal and Knoeber (1996) and Demsetz and Villalonga (2001) do not find evidence of a relationship between managerial ownership and company performance.

the extent that a buyout shocks the ownership level of managers, this study provides evidence of the importance of managerial ownership.

The remainder of the thesis is organised as follows. Chapter 2 presents an extensive literature review spanning the three topics above. Chapter 3, Chapter 4 and Chapter 5 correspond to my first paper (titled *The accuracy of net asset values in private equity: Evidence from the secondary market*), second paper (titled *The Dynamics of Pay-for-Performance Sensitivity in Private Equity Funds*), and third paper (titled *Managerial Ownership and Operational Improvements in Buyouts*), respectively. Chapter 6 concludes, highlighting the general implications of this three-paper dissertation and directions for future work.

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2 | Literature Review

Private equity funds today are organized as limited partnerships where investors, as limited partners (LPs), provide capital to a private equity fund that is managed by a private equity firm, acting as a general partner (GP). This structure has its origins in 1958, when the first venture capital limited partnership - Draper, Gaither, and Anderson - was formed, while the first venture capital firm - American Research and Development - was established 12 years earlier (Gompers and Lerner, 2001). Buyout funds, the focus of this dissertation, is a more recent phenomenon. Some of the earliest firms, such as KKR and Thomas H Lee Partners, were formed in the 1970s. In 1978, an important regulatory change increased the potential pool of investors: the clarification of the "prudent man rule" by the US Department of Labor, which allowed pension funds to invest in high-risk assets such as private equity funds. Following that change, leveraged buyouts grew rapidly during the 1980s, and Jensen (1989) famously predicted that the ownership form provided by buyouts would eclipse the public market.

As it turned out, Jensen's prediction came at the end of the first, though not the last, buyout boom. Kaplan and Strömberg (2009) observe that private equity appears to go through recurring boom and bust periods, both in terms of transaction volumes and capital raised in new private equity funds.

Buyouts utilize significant amounts of leverage, and each buyout wave has been accompanied with developments in the debt market. The 1980s wave tapped the junk bond market (Kaplan and Stein, 1993), the 2000s wave was fuelled by growth in collateralized debt obligations (Shivdasani and Wang, 2011), and the growth of the most recent decade has been accompanied by an increase in the usage of covenant-light leveraged loans, loans with weaker enforcement features (Becker and Ivashina, 2016).

Becker and Ivashina (2016) document that 70% of newly-issued leveraged loans were covenant-light in 2015, three times the level in the earlier peak in 2007. The authors provide evidence that this increase is attributable to an increased involvement by non-bank institutions, which increases the cost of coordination among lenders that is required when enforcing covenants. However, the changed investor base cannot explain changes in the strength of restrictions on indebtedness, liens, payments, or asset sales. Loan

terms also depends on the sponsoring GP: Demiroglu and James (2010) and Ivashina and Kovner (2011) show that reputable GPs with good banking relationships are able to obtain more favourable borrowing terms.

Kaplan and Strömberg (2009) hypothesize that private equity firms are able to take advantage of mispricings in the debt and equity markets, by borrowing when interest rates are low. They suggest that one criteria for a private equity boom to occur is that earnings yields (EBITDA/Enterprise Value) exceed the interest rate charged on high-yield rates. Consistent with this hypothesis, Ljungqvist et al. (2020) provide evidence that the investment pace of private equity funds increases when credit spreads are low, and Axelson et al. (2013) document that debt levels in buyouts are largely driven by credit market conditions, while being unrelated to cross-sectional factors suggested by traditional capital structure theories.[1]

Jensen (1989) views leverage as one of the advantages of buyouts. Leverage disciplines management by alleviating the free cash flow problem articulated in Jensen (1986). He further argues that buyouts provide greater incentives to improve value compared to public corporations. The management team of companies acquired in buyouts typically have higher equity ownership stakes than management teams of publicly listed companies (Cronqvist and Fahlenbrach, 2013; Kaplan and Stein, 1993; Leslie and Oyer, 2009). Additionally, the concentrated ownership ensures that the private equity firm has sufficient incentives to monitor and get actively involved in the company when required. Finally, private equity firms' compensation is conditional on performance, both directly through the carried interest provision and indirectly as high performance supports future fundraising (e.g Chung et al., 2012).

The governance model of private equity attracts criticism as well. Investing in private equity funds comes at a cost of illiquidity and loss of discretion over investment timing. Evaluating investments is much less straight-forward than for funds investing in assets with market valuations, and the lack of transparency complicates performance evaluation (e.g. Kaplan and Sensoy, 2015). The private equity firm is an agent relative to the investors in the private equity fund, adding an additional layer of potential agency conflicts (Phalippou, 2009). While proponents point to value gains in portfolio companies, a common critique is that at least part of the value is a gain for the private equity fund at the expense of other stakeholders (e.g. Morris and Phalippou, 2020).

[1] An opposing view is offered by Haddad et al. (2017). They argue that the cyclicality in buyout activity is driven primarily by variations in the equity risk premium rather than credit conditions. Their explanation is based on a simple present value argument: the present value of future performance gains is higher when discount rates are low. Their model framework captures why we would expect high deal leverage at times of high buyout activity, as well as low expected returns of those deals, consistent with the empirical evidence in Axelson et al. (2013).

We can broadly categorize these three areas as issues around investing in private equity; issues regarding the LP-GP interaction and the structure of private equity funds; and the impact of private equity ownership on portfolio companies. The next three sections will review the literature in these areas.

The papers in the dissertation contribute to each of these topics. The first paper examines the secondary market for private equity fund stakes, a market that can alleviate the illiquidity of investing in private equity funds. The second paper focuses on carried interest, the part of GP compensation that is performance-based and is intended to align incentives of GPs and LPs. By linking how variation in pay-for-performance sensitivity relates to operational improvements of portfolio companies, the paper contributes to the literature covered in the final two sections of this literature review. The third paper focuses solely on the impact of private equity ownership on portfolio companies, by examining how changes in CEO ownership stakes relates to operational improvements.

1 Investing in Private Equity

Since private equity funds invest in private companies there are no readily available market prices. Thus, the usual framework to evaluate fund performance is not easily applicable to private equity funds. Instead, once a fund is fully liquidated, the timing and magnitude of cash flows can be used to assess performance. If an investor (or researcher) wishes to evaluate performance prior to liquidation, one has to rely on net asset value (NAV) estimations provided by the GP. As GPs have no requirement to disclose these valuations publicly, many databases relies on voluntary reporting from GPs, source information from LPs, or a mix of both (see Brown et al., 2015, for a comparison of databases).

Performance has historically been evaluated, and still commonly is by practitioners, using internal rate of returns (IRR) and money multiples (TVPI). There are multiple issues with using IRR when comparing investments in general in corporate finance. Since GPs control the decision of when to exit investments, the suitability of IRR is even worse in a private equity context (Phalippou, 2008). Despite these issues, Larocque et al. (2019) find that investors care more about IRRs than TVPIs when deciding whether to invest in follow-up funds. While the TVPI has fewer issues than IRR, it does not account for exposure to movements in the public market.

Kaplan and Schoar (2005) provide an alternative measure which accounts for market movements: the public market equivalent (PME). The PME is defined as the ratio of the present value of distributions to the present value of capital calls. The discount rate used is the realized return on the public market, providing a simple interpretation of the ratio: a value above (below) one indicates that an investor in the private equity fund did

better (worse) than she would have done by replicating the cash flows via investments in the public market. The PME has become the preferred measure to evaluate performance in academic research, and the measure has received theoretical support by Korteweg and Nagel (2016) and Sorensen and Jagannathan (2015).

Early studies using the PME found that, net-of-fees, returns in private equity were equal to or worse than those of the public market (Kaplan and Schoar, 2005; Phalippou and Gottschalg, 2009). However, both studies utilized databases that were later discovered to not provide an accurate picture of the performance of private equity funds. More recent studies by Harris et al. (2014a), Harris et al. (2016), and Robinson and Sensoy (2016) find that buyout funds have outperformed the public market by roughly 3% per year, although performance have not been as impressive for the more recent vintages.

Phalippou (2014) and Stafford (2017) suggest that this outperformance may be an artefact of the type of companies invested in. Compared to investments that more closely resembles typical buyout targets, private equity funds have not generated any additional value to their investors. As noted in Kaplan and Sensoy (2015), the investable market of listed companies with such characteristics is only a fraction of the buyout market. Hence, private equity may offer an efficient way for large institutional investors to get exposure to such companies.

There is some evidence of performance persistence among private equity funds, contrasting evidence among mutual funds (e.g. Carhart, 1997; Fama and French, 2010). Kaplan and Schoar (2005) found evidence of performance persistence among GPs, and Lerner et al. (2007) of heterogeneity in performance among LPs. Persistence in performance may arise due to asymmetric information between investors in the fund and outsiders (Hochberg et al., 2014), or due to heterogeneity among LPs in their ability to absorb liquidity shocks (Maurin et al., 2020). Empirically, persistence appears to have declined over time among GPs (Braun et al., 2017; Harris et al., 2014b) as well as LPs (Sensoy et al., 2014), though it has not disappeared (Korteweg and Sorensen, 2017; Cavagnaro et al., 2019). Evidence of skill is not only found at the institutional level, as Ewens and Rhodes-Kropf (2015) document skill at individual partners in the venture capital context.

Overall, the literature suggests that there is an element of persistent ability in private equity, both among GPs and LPs, and that the performance of private equity funds exceed that of publicly listed markets. The trend over time has been a decline in both, suggesting a maturing of the industry with increased competition.

Even if private equity funds outperform the publicly listed market, it is not immediately obvious that it represents a risk-adjusted outperformance for investors. In particular, private equity investments are much more illiquid than public markets. Theoretical models by Sorensen et al. (2014) and Bollen and Sensoy (2016) suggest that the observed

outperformance is just enough to compensate LPs for the illiquidity of their investments. Ang et al. (2018) and Franzoni et al. (2012) provide empirical evidence that outperformance disappears when controlling for the exposure of private equity returns to a liquidity factor.

Lerner and Schoar (2004) argue that the illiquidity of private equity investments is an optimal design feature, chosen by GPs to screen for investors with "deep pockets" and long investment horizons. The intuition of their model is that investors in the current fund possess information about the quality of the GP. If current investors are unable to provide capital for the next fund due to liquidity constraints, outsiders cannot distinguish this from an active choice to not invest with a GP of low skill. Having investors with deep pockets therefore decrease the future cost of capital for the GP, at the expense of a higher cost of capital in early funds to compensate LPs for the illiquidity.

Lerner and Schoar (2004) model illiquidity as a choice variable for GPs since they observe severe restrictions on the transferability of LPs' fund stakes. For example, GPs are typically able to block the sale of a fund stake. Consequently, the secondary market for private equity fund stakes, where LPs sell their stakes to other investors, was marginal for a long time. But the market has grown rapidly from an annual volume of $2 billion in the early 2000s to a record $88 billion in 2019, presumably because the cost of not allowing LPs the ability to liquidate early became too costly.

The development of a secondary market can potentially spur further growth in fundraising in the primary market, as the cost of illiquidity is reduced. The impact of the secondary market on required returns in the primary market is modelled in Bollen and Sensoy (2016). In their model, the degree to which the secondary market reduces the illiquidity cost of private equity investments depends on the discount from a fund's fair value at which fund stakes transact in the market.

Maurin et al. (2020) further build on the importance of illiquidity in private equity. LPs in their model differ in their resilience to liquidity shocks. With heterogeneity in tolerance for illiquidity among LPs, their model provide an explanation for rigidity in contract terms, return persistence at both the GP and LP level, and why some LPs have preferential access to private equity funds. Their model further suggests that GP performance persistence disappear when a secondary market exist, which could explain why performance persistence has declined among GPs in recent years.

Despite the rapid growth of the secondary market, Nadauld et al. (2019) document that the average transaction occurs at a discount to net asset value (NAV), on average 15% for buyouts though varying over time. They also document that the performance of buyers exceed that of the sellers. They interpret these findings as consistent with buyers being compensated for providing liquidity. Their interpretation of the difference in buyer and seller performance is based on an assumption of constant returns throughout

a private equity fund's life. However, rational buyers should pay at most a price that ensures they earn their required rate of return in expectation, whereas the performance of sellers depends on the fund's performance to date in addition to the transaction price. If sellers opt to sell stakes in poorly performing funds, as evidence in their paper suggests, we would expect buyers to perform better.

Kleymenova et al. (2012) examine how factors related to the liquidity of a fund stake impact the price investors are willing to pay. They define liquidity as having more bidders in an auction, more money bidded, and a smaller dispersion in the bids placed. They find that large buyout funds are the most liquid, and that more liquid funds are sold at smaller discounts. In a paper using the same dataset as employed in the first paper of the thesis, Albuquerque et al. (2018) study liquidity provision in the secondary market by modelling demand for private equity fund stakes. They find that aggregate demand is pro-cyclical, and that demand flows to funds where selling pressure is expected to be high, particularly in bad times. As bids placed for these funds are lower, they interpret this as evidence that bidders require compensation for providing liquidity.

Overall, these papers suggest that liquidity compensation is an important reason for discounts in the secondary market. While one might expect secondary market transactions to be high during distressed times, it is somewhat surprising that volumes where markedly lower in 2009 after the financial crisis (see Nadauld et al., 2019). One potential explanation, provided by Hege and Nuti (2011), is that sellers and buyers disagreed on the value of the fund stakes. Sellers anchored their valuations at reported NAVs, while buyers believed that those valuations were stale and demanded large discounts.

As prices are quoted as a percentage of NAVs, our interpretation of discounts depends on whether reported NAVs are fair estimations of the underlying funds value. Though Jenkinson et al. (2019) find that NAVs are fair on average, evidence in Barber and Yasuda (2017), Bienz et al. (2017), and Brown et al. (2019) suggests that NAVs are sometimes misreported. Ang et al. (2018) and Boyer et al. (2019) document autocorrelation in private equity indices, suggesting that NAVs do not fully incorporate recent returns.

If NAVs are overvalued (undervalued), expected future performance is low (high). In addition to liquidity compensation, we may therefore expect variation in discounts due to expectation of future fund performance, similarly to the model of closed-end fund discounts by Berk and Stanton (2007). The first paper of the thesis contributes to this literature by examining if bids in the secondary market for private equity fund stakes are informative of the future performance of funds for which the bids are placed.

2 The Structure of Private Equity Funds

Private equity funds are typically organized in similar ways, as limited partnerships (Sahlman, 1990). LPs provide ex ante equity financing, providing the GP with significant leeway over when and what to invest in, while deals employ significant amount of leverage. The profit-sharing arrangement from carried interest is typically based on fund profits, but GPs could be compensated on a deal-by-deal basis.

Axelson et al. (2009) provide a model that justifies why buyouts are financed in this way. Their model suggests that providing ex ante financing and compensating GPs on a fund level reduce the incentive of GPs to invest in bad deals. Since carried interest payoffs are similar to call options, deal-by-deal level compensation incentivizes gambling, making even poor investments attractive from the GP's point of view. However, there is an incentive for GPs to spend all the capital towards the end of the investment period, even if no good investments are found. Complementing the ex ante financing with deal-level debt financing provides additional discipline that reduce the amount of bad deals pursued in bad times. The financing structure optimally reduces agency conflicts, although investment still deviates from its first-best level, with overinvestment (underinvestment) in good (bad) times.

Even contracts that are set up optimally ex ante may be incomplete and therefore not ex post optimal in all possible states. For example, GPs may invest in bad deals when they have large amount of unspent committed capital, as the basis of management fees often changes from committed capital to net invested capital after the investment period ends (Metrick and Yasuda, 2010). Consistent with this idea, Arcot et al. (2015) and Degeorge et al. (2016) provide evidence that secondary buyouts undertaken under pressure underperform. Arcot et al. (2015) show that pressured buyers pay higher multiples, syndicate less, and use less leverage, consistent with a desire to spend equity.

Restrictions on GPs are set out in the limited partnership agreement (LPA). Investors cannot get directly involved in running the fund if they wish to retain the status as limited partners. Gompers and Lerner (1996) examine variation in the usage of covenants in LPAs in venture capital funds. They find that covenants are more widely used when more severe agency problems are expected. They also find a supply and demand effect: when there is an abundance of capital available to be invested in funds, GPs are able to negotiate contracts with fewer restrictions.

An important part of the LPA is the fee structure of private equity funds, which constitutes the economics of a private equity fund. While headline fees for buyouts are typically 2% of committed capital and a 20% carried interest, there is more heterogeneity in the details. The basis for management fees is usually changed after the investment

period, but not always, and the fee level itself may change. Similarly, the basis for carried interest could be committed capital or invested capital, determining whether investors receive their fees back before the GP starts earning carry.

Metrick and Yasuda (2010) discuss these and other contract terms in detail, and estimate how these terms impact GPs' expected fee revenue.[2] Litvak (2009) provides a legal perspective to compensation terms in venture capital (VC), extending the analysis of Gompers and Lerner (1996) by considering additional fund terms. In particular, Litvak (2009) emphasizes the importance of the timing of carry payments for its value to GPs.

One of the major findings in Metrick and Yasuda (2010) is that about two-thirds of the expected revenue in private equity funds is attributable to the fixed component of pay that is independent on performance. Their analysis considers the economics of a given fund, and consequently only captures the direct pay from performance. Chung et al. (2012) complements their analysis by considering the indirect pay from performance: the increased ability of a GP to raise additional funds that generate future streams of revenue. They estimate that the magnitude of indirect pay is at least as big as the direct component. Consistent with their learning model, they find that fundraising success is increasingly dependent on performance for younger GPs that lack a strong track record (see also Barber and Yasuda, 2017).

How much this pay-for-performance sensitivity of GP pay incentivizes effort of the partners involved in specific deals is unclear; Ivashina and Lerner (2019) find that the allocation of carry is primarily related to the status of founder of a PE firm, rather than past success. However, there may still be an implicit career concern, as they find that partners depart if they do not get a fair share of profits. Such departures negatively impact the ability of GPs to raise more capital.

GPs additionally charge monitoring and transaction fees directly to portfolio companies, which Metrick and Yasuda (2010) find puzzling as management fees are supposed to cover such costs. Phalippou et al. (2018) collect information about portfolio company fees from SEC filings. They find that these fees amount to about 6% of equity invested by GPs. The authors consider several potential justifications for these fees, such as tax-efficient distributions and ex post adjustments necessary due to incomplete contracting in the LPA, but find it hard to rationalize the fees. They suggest that these fees may reflect GPs extracting value from inattentive LPs. They document that GPs backed by more skilled LPs charge lower fees, and present evidence that LPs learn over time: the amount

[2]Other contract terms they cover are: catch-up clauses in funds with hurdle rates, allowing GPs to earn a higher fraction of profits after beating the hurdle rate to "catch up" to the pre-specified profit-sharing level; early carry, where the GP may receive carry based on unrealized (estimated) profits; early carry is typically associated with a clawback provision, allowing LPs to claw back early carry if the ultimate fund performance does not warrant the amount of carry paid out.

of fees charged by GPs prior to the financial crisis is negatively related to fundraising success in the period after the financial crisis.

Other contract terms discussed in Metrick and Yasuda (2010) can give rise to misalignment in incentives between LPs and GPs. Robinson and Sensoy (2013) document that GPs accelerate distributions when funds enter their "catch-up" region, where GPs earn 100% of profits until reaching the profit-sharing level. The authors interpret the acceleration of distributions in order to enjoy this "waterfall" as likely to lead some investments to be exited too early. They also find evidence consistent with GPs holding onto investments for too long, when doing so allows the GP to keep earning management fees on remaining invested capital.

Two papers examine how variation in fee terms relate to fund performance. Robinson and Sensoy (2013) do not find evidence of lower net-of-fee performance in funds with higher fees or lower managerial ownership. Their results are akin to the equilibrium model of Berk and Green (2004), where high ability GPs extract rents in the form of improved contract terms. Hüther et al. (2020) find that VC funds with "GP-friendly" carry provisions, where carry is paid on a deal-by-deal basis, are associated with higher returns both gross and net of fees.

The second paper of the thesis contributes to this literature by examining the dynamics of the pay-for-performance sensitivity of carried interest *within* a given fund. The paper relates the resulting within-fund variation in pay-for-performance sensitivity to operational improvements at portfolio companies acquired in buyouts.

3 The Economic Impact of Buyouts

While there is debate on whether private equity funds perform well enough to justify the fees charged, the gross returns of private equity deals are substantially above public market returns (e.g. Braun et al., 2017; Brown et al., 2020). An important question is how private equity generate these gains.

Acharya et al. (2013) provide a method that helps us broadly think about the components of private equity returns. Returns are partly driven by exposure to market movements, including multiple expansion (Guo et al., 2011; Jenkinson et al., 2018), partly a result of leverage - providing a tax shield and amplifying returns to equity - and partly through a residual effect. This residual effect could arise due to M&A expertise that allow private equity firms to identify promising targets or successfully grow portfolio companies with add-on acquisitions (Bansraj et al., 2019), or an ability to improve operations of target companies. Given the amount of companies controlled by private equity, the impact of private equity ownership on portfolio companies is an area that has received considerable interest.

Jensen (1989) views buyouts as a way to improve how companies are run by improving governance, incentive schemes, and providing an optimized financial structure. Early studies documented operational improvements, and their importance for value generation, in buyouts (Kaplan, 1989; Lichtenberg and Siegel, 1990; Muscarella and Vetsuypens, 1990; Smith, 1990). Guo et al. (2011) largely confirm the importance of operating gains for deal performance, though on average they find, at best, small improvements in operating performance compared to benchmark companies. On corporate governance, buyouts typically lead to increased managerial equity ownership stakes (Kaplan and Stein, 1993; Cronqvist and Fahlenbrach, 2013), venture capitalists support professionalization of companies (Hellmann and Puri, 2002), and portfolio companies backed by private equity have better management practices (Bloom et al., 2015).

In the absence of regular market valuations of companies held private, some studies use company financials to measure improvements in operational performance. However, private companies in the US are typically not required to make financial statements publicly available. As a consequence, US studies often rely on subsamples of companies with publicly available financials (e.g. Guo et al., 2011), or data made available to them by industry practitioners (e.g. Acharya et al., 2013). There is a concern that such samples are not necessarily representative of a typical buyout.[3] Cohn et al. (2014) use tax data to show a marked difference in operational gains among companies with and without publicly available financials, with the latter displaying significantly worse operational performance. An alternative is to examine countries outside of the US, where data access is more readily available.

Public-to-private buyouts have received the largest amount of attention, presumably due to their size, visibility, and data availability. However, they represent only a small fraction of all buyouts. In Strömberg (2008), 6.7% of all deals are public-to-private buyouts, though they represent 28.2% of enterprise value. Recent studies by Davis et al. (2019) and Cohn et al. (2020) highlight stark differences between different type of buyouts in the impact private equity ownership has on target companies. Davis et al. (2019) find that employment at target companies shrinks in public-to-private buyouts, but expands for privately held companies. Similarly, Cohn et al. (2020) find rapid growth of already private companies, which they attribute to alleviating financing constraints. This interpretation is similar to Boucly et al. (2011) that, examining small French companies acquired in buyouts, provide evidence consistent with the notion that private equity ownership can support growth by relaxing credit constraints. Similar evidence is provided by Chung (2011) for small, private, companies acquired in buyouts in the UK.

[3]Financials are publicly available only if the company has public debt that requires disclosure of financials, or if the company subsequently lists on the public market and in that process provides historical financial statements.

An important change brought about by buyouts is the increase in leverage, a practice that has received considerable criticism as it can lead to an increased risk of bankruptcy. For example, Kaplan and Stein (1993) argue that PE transactions in the second half of the 1980s used excessive amounts of leverage, which they attribute to a "demand push" from the junk bond market. Andrade and Kaplan (1998) estimate the cost of financial distress to be 10 to 20 percent of company value.

As private equity firms are serial investors that commonly utilize high levels of leverage, their experience may make them better able to manage companies in financial distress. Hotchkiss et al. (2014) show that, after controlling for leverage, companies backed by private equity are no more likely to default than other leveraged loan borrowers. When default does occur, PE-backed companies restructure faster, more often restructure out of court, and the company is more likely to remain an independent entity. They also document that the likelihood of a successful restructuring increases when the PE owner injects new capital in the company. Bernstein et al. (2019b) similarly find that having a private equity owner can help companies withstand economic crises. Companies backed by private equity during the financial crisis saw smaller declines in investment, and were more likely to receive equity injections as well as take on new debt. The documented effect is stronger when the PE fund has high amounts of dry powder, supporting an interpretation that private equity owners can support struggling companies by capital injections. More successful resolution of financial distress can be socially valuable, as reorganizing a company result in higher asset utilization than liquidation (Bernstein et al., 2019a). However, the main analysis in these papers compare companies backed by private equity with comparable companies with similar leverage. We do not yet have a complete understanding of the net effect of the initial increase in leverage.[4]

Private equity is often accused of creating job losses, cutting costs, and enriching themselves by focusing on short-term profits at the expense of the long-term investments or by extracting wealth from other stakeholders. The academic evidence is not entirely positive of private equity, though it has refuted many of the accusations aimed at private equity (see e.g. Morris and Phalippou, 2020). Looking at plant level data, Davis et al. (2014) document that private equity firms are active in reallocating capital by exiting less productive establishment while expanding in more productive ones. The net effect of this is a small net job loss, combined with large gross job creation as well as job destruction, and an increase in total factor productivity. In continuing plants, they find

[4]The current economic downturn caused by lockdowns to stem the spread of Covid-19 may provide for an additional stress test of the private equity model with high leverage. However, comparisons between portfolio companies and those not backed by private equity may be problematic as many portfolio companies risk not qualifying for relief packages, at least in Europe (see for example https://www.ft.com/content/46641ba1-fd7d-4718-8f17-262881bf31ef, accessed 2020-05-21).

no evidence of improved productivity relative to peers, similarly to what Bharath et al. (2014) document for public companies transitioning to private ownership.

Examining the claim that short-term profits come at the expense of long-term investments, Lerner et al. (2011) find no evidence that investment in innovation is harmed. Instead, after undergoing a buyout, patents are more cited and become more concentrated areas of high importance for the company. In a similar spirit, Harford and Kolasinski (2014) do not find evidence of short-terminism or the extraction of wealth from debt holders, except in some special situations. Looking at spillover effects on competitors, Bernstein et al. (2017) show that industries in which private equity invests grow more quickly in terms of both employment and total production.

Some studies focus on the impact of private equity ownership on customers. Matsa (2011) finds that companies with high financial leverage degrade their product quality by reducing inventory to preserve cash to service debt, potentially harming consumer loyalty. Fracassi et al. (2019) examine manufacturing companies of consumer goods that are acquired in buyouts. Companies in their sample increase revenue substantially, but they do so via expanding geographically and by introducing new products rather than raising price. Prices on existing products only increase by 1% relative to competitors' products. Biesinger et al. (2020) find similar results, with revenue growth accompanied by declines in price markups. Studying buyouts of supermarket chains in the 1980s, Chevalier (1995) documents price increases (decreases) when competitors are highly leveraged (have low leverage).

Eaton et al. (2019) suggest that private equity ownership is not equally likely to be beneficial for customers in all types of industries. They argue that sectors with intense competition are likely to experience gains for customers, while industries characterized by opaque product quality and substantial government subsidies are likely areas where private equity value comes at the expense of customers. Their study focus on one such sector: higher education. Consistent with their argument, they find that buyouts are associated with an increase in enrolment, tuition costs and student debt, while quality drops. They observe lower graduation rates, lower earnings, and reduced loan repayment rates, while at the same time spending on teaching is reduced and the ratio of faculty to students decreases. Gupta et al. (2019) similarly find that quality decreases in healthcare homes acquired in buyouts.

The theoretical model of Shleifer and Summers (1988) suggests that investor-led acquisitions may transfer value from employees to the investors by breaking implicit contracts. Several papers examine the impact of buyouts on employees. Davis et al. (2019) document a modest net loss of jobs in buyout targets, particularly for public-to-private buyouts. Faccio and Hsu (2017) show that buyouts by politically connected

private equity firms are associated with higher employee growth than other buyouts. The authors interpret this as a quid pro quo arrangement, as this effect is more pronounced around election years and target companies are more likely to receive government contracts and grants.

Focusing on wage growth, Amess and Wright (2007) document that UK buyouts are associated with lower employee wage-growth. Lichtenberg and Siegel (1990) find that employment and compensation of white-collar workers decline, while that of blue-collar workers are unchanged. That not all workers are equally at risk are found in other countries as well. Antoni et al. (2019) show that average earnings decline in German buyouts, with employees that are least likely to find new jobs experiencing the most negative impact. Olsson and Tåg (2017) examine the type of job that is most at risk in Swedish buyouts. They find that workers doing routine tasks, or have jobs that can be offshored, are more likely to be laid off. This result is particularly strong for companies with low pre-buyout productivity relative to peers, suggesting that buyouts may accelerate necessary but unpleasant actions to improve competitiveness.

Agrawal and Tambe (2016) document that buyouts pushing to modernize portfolio companies can yield positive spillover effects on employees. In companies that receive significant IT investment, employees experience improved long-run employability, and higher wages, by gaining valuable human capital in the form of IT skills. Workers may also benefit from other initiatives undertaken under private equity ownership. Cohn et al. (2019) find that both establishment-level workplace injury rates and safety inspection violations decline after public-to-private buyouts.

One obstacle facing research attempting to evaluate the impact of private equity ownership is that targets are not randomly chosen, making it difficult to attribute any observed changes to a causal impact of private equity ownership. Ofek (1994) examines this hypothesis by evaluating the performance of management buyouts that failed despite management supporting it, and find no improvements in operational performance for targets of failed management buyouts. Bernstein and Sheen (2016) provide a detailed study of restaurant chains, utilizing health inspection records. They show that, following a buyout, restaurants become cleaner, safer, and better maintained. Importantly, their setting allows for a natural control group: franchised restaurants. Consistent with a causal interpretation, improvements are larger at chain-owned stores than in franchised ones over which the PE firm has limited control. The value of involvement by venture capitalists is examined by Bernstein et al. (2016). They utilize exogenous variation in the ability of VCs to visit portfolio companies, using newly opened airline routes that reduce travel time. They find that the introduction of a new airline route results in portfolio companies becoming more innovative, and are more likely to be successfully exited.

The second paper of the thesis contributes to the wider literature on operational improvements by examining how variation in the pay-for-performance sensitivity of a GP's payoff relates to operational improvements at portfolio companies. The paper exploits within-fund variation arising due to staggered investments, as well as exogenous, heterogeneous, variation in the pay-for-performance sensitivity arising from public equity market movements.

Most of the evidence discussed above, including the second paper of the thesis, do not link specific actions taken by private equity firms to improvements in operational performance of portfolio companies. Instead, they document an overall impact of private equity ownership.[5] For example, workplace injury rates could decline in Cohn et al. (2019) as a result of reduced short-term pressure from public markets, because the new private equity owners redirects investments to reduce injuries, or for another reason completely. Similarly, low productivity companies in Olsson and Tåg (2017) may increase offshoring because management receives sufficient incentives to take unpleasant actions and lay off workers, the old management team may have been replaced, or another reason unrelated to the management team.

Two recent papers offer insights into what GPs say they do. Biesinger et al. (2020) examine value creation plans prepared for individual deals. They document a significant heterogeneity in strategies, but find that ex ante selection of strategy is not related to deal returns. Instead they document that, somewhat less surprisingly, deals in which the GP claims they successfully executed their strategies have high returns. The authors interpret this as execution being the key to achieve high returns for investors. A complementary analysis is provided by Gompers et al. (2016) that survey GPs and ask what they believe generate value in their deals. The top five expected sources of value creation are, in order, "increase revenue or improve demand", "improve incentives", "follow-on acquisitions", "facilitate a high-value exit", and "improve corporate governance". Clearly, these sources are not mutually exclusive as, for example, follow-on acquisitions increase revenue while improving incentives is likely part of improving governance. The belief that GPs can help increase revenue is consistent with evidence in buyouts of already private companies (e.g. Boucly et al., 2011; Chung, 2011; Cohn et al., 2020).

Private equity firms are often seen as strong principals whose actions can inform us about optimal governance. In this spirit, Kaplan and Strömberg (2003); Kaplan and Strömberg (2004) examine how contracts are designed when VCs provide financing

[5]Some exceptions are Davis et al. (2014) that document the importance of reallocating capital to improve productivity, though again the exact actions that lead to these decisions are not well understood. There is also evidence on the importance of relaxing credit constraints to spur growth and investment provided by Bernstein et al. (2019b), Boucly et al. (2011), Chung (2011), and Cohn et al. (2020).

to entrepreneurs. They document that contracts are generally designed in line with what optimal contracting theory suggests.

Similarly, Cronqvist and Fahlenbrach (2013) study changes in CEO contracts when companies are taken private, looking in detail at the contracts of 20 such transactions. They find an increase in CEO equity ownership stakes, and CEO pay becomes more sensitive to performance. Leslie and Oyer (2009) look at changes in CEO ownership stakes. However, they rely on different sets of companies for pre-buyout and post-buyout stakes, and their post-buyout stakes are after private equity exits through an IPO. They do not observe CEO ownership stakes during the period of private equity ownership, and cannot observe changes in any given company.

Cornelli and Karakas (2015) study the role of boards in companies owned by private equity. While CEOs are often replaced in the acquisition, CEO turnover during private equity ownership is reduced when the private equity firm sits on the board, and is less sensitive to performance. These results suggest that monitoring allows private equity firms to rely less on verifiable performance data. The private equity setting has also been used to examine agency issues in the form of corporate jets as an excessive perk. Edgerton (2012) documents a sharp reduction in the ownership of corporate jets of companies taken private by private equity funds. This is driven by the top 30% of the distribution of corporate jet ownership, suggesting that there is a subset of companies where perks are excessive.

The third paper of thesis contributes to this literature by examining a salient feature of private equity acquisitions: the increase in managerial equity ownership stakes. The paper examines how changes managerial ownership stakes relate to operational improvements at companies acquired in buyouts.

The next three chapters contain the three empirical papers in this dissertation, and Chapter 6 concludes with a summary of what this dissertation contributes to the field of private equity.

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3 | The Accuracy of Net Asset Values in Private Equity

Evidence from the Secondary Market*

We study the demand side of the secondary market for private equity interests using proprietary data from an intermediary in London. Despite a quarter of the bids coming in at a par or a premium to the net asset values (NAVs), few lead to a transaction. If NAVs are reflective of the market value this is puzzling. We find that cross-sectional variation in bids reflects expectations of future fund returns. Not only are bids informative of future returns, the bid levels adjust to the point that the return the bidder would experience if their bid was accepted is unrelated to the bid placed, suggesting a high level of sophistication among bidders.

1 Introduction

Investors in private equity funds commit to locking their investments into the fund, ceding control of cash flow timing to the fund manager. The only option to liquidate their stake early is through the secondary market for private equity fund (PEF) stakes. This market remained marginal for a long time due to contractual restrictions on transfers (see Lerner and Schoar, 2004). The increased allocation to private equity, combined with the financial crisis, exposed an increasing need for liquidity solutions, and the market has grown in response from $2 billion in the early 2000s to $88 billion in 2019.

Substantial capital is now earmarked to purchasing PEF stakes through the secondary market. For instance, secondary funds, focused on such transactions, raised over $160 billion between 2011 and 2016.[1] Even with this influx of capital, Nadauld et al. (2019) show that, on average, transactions occur at a discount to a fund's NAV.[2]

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[1] Other buyers include funds-of-funds, which invest in both the primary and secondary market for PEF stakes; and various asset owners (investment banks, hedge funds, endowments, pension funds, sovereign funds), which have their own teams to manage purchases of PEF stakes.

[2] Nadauld et al. (2019) report average discounts ranging from an average of 46% in 2009 to 7% in 2014.

A common explanation for the discounts is one of imperfect liquidity provision: when investors are forced to liquidate their PEF stakes, buyers providing liquidity are able to acquire assets for less than the underlying value of the asset (Hege and Nuti, 2011; Kleymenova et al., 2012; Nadauld et al., 2019). This explanation alone cannot account for all variation in discounts, as we observe a quarter of bids that arrive at par or at a premium to NAVs. If NAVs reflect the underlying value, it is puzzling that most of these bids do not lead to a transaction.

An alternative explanation is that variation in discounts reflect expected future performance, as in the model of closed-end fund discounts by Berk and Stanton (2007). Expected future performance could reflect beliefs about managerial ability. It could also reflect a discrepancy between NAVs and fundamental value, owing to the lack of market valuation of portfolio companies in private equity funds and an aspect of subjectivity when estimating value (Crain and Law, 2018). Secondary market prices may represent more accurate estimates of fund value. Boyer et al. (2019) construct a private equity index based on secondary market transactions, which can be used to examine factor loadings of private equity returns if secondary market prices reflect the market value of fund stakes.[3]

This paper asks whether bids are informative of the accuracy of NAVs. The main findings of the paper is twofold. First, cross-sectional variation in bids predict the future performance of funds, measured from the first NAV after the bid is posted. Funds receiving high bids have high post-bid performance, measured as the public market equivalent (PME) of Kaplan and Schoar (2005). This result does not hold true for variation in discounts over time, only when comparing cross-sectional variation in discounts between funds within a given time period. To assess the economic magnitude, we sort funds into quartiles based on the highest bid received during a quarter. Over a three-year period following the bid, funds in the quartile receiving the highest bids report a PME of at least 0.103 above funds receiving the lowest bids. This difference is large when put in relation to an average PME of 1.18 during the entire life of buyout funds, as reported in Harris et al. (2016). These results refer to an ex post measure of performance, measured from the first NAV report after the bid date and three years into the future. Additionally, we find that bids are positively related to performance of funds during the period the bid is posted: bids are higher for funds that report a higher NAV-to-NAV return during the quarter in which the bid is placed. Note that this information is not available at the time of the bid.

Second, we find that the relationship between post-bid fund performance and the bid placed is sufficiently strong to offset the difference in price paid. Investors posting low bids would not achieve higher returns than those posting high bids, had their bids

[3]The index of Boyer et al. (2019) is constructed to represent the returns of an investor that both buys and sells through the secondary market, but the extent to which their index is relevant for evaluating factors relevant for returns in private equity overall depend on what discounts reflect.

been accepted. The reported gain for those posting low bids is large over short horizons, while it is offset by the reduced fund performance over longer horizons. Again, this result only holds within a given time period, not for variation in discounts over time. Together, these results indicate that investors in the secondary market are able to identify the relative accuracy of funds' NAVs. Time-series variation in discounts may reflect varying liquidity compensation, as suggested by Nadauld et al. (2019).

It may seem as if the results of the paper are obvious. However, the opaque nature of private equity makes it hard to access any information on the portfolio companies that make up the value of a fund. While investors in the fund receive regular updates, potential outside investors do not, complicating any valuation exercise.[4] Despite a rapid growth, the secondary market remains small relative to assets under management of $4.11 trillion (Preqin 2020). In Boyer et al. (2019), the average fund transacts 2.7 times over the period 2006 through 2018, conditional on trading at all. This market is therefore characterised by limited price discovery. The results of the paper therefore suggests a high level of sophistication among participants in the secondary market, echoing findings in Brown et al. (2019) that investors are not tricked by misreported NAVs.

The secondary market is an over-the-counter market intermediated by specialized organizations that match buyers and sellers. The data in this study is a proprietary dataset provided by a London-based sell-side agent for investors wishing to exit via the secondary market. The data provider gave us access to its entire bid book, which is comprehensive and representative of the global market: the average bid in our sample each year is close to the average annual transaction price reported by Greenhill-Cogent. Most of the bids are made at a discount to NAV, and the discounts vary over time as well as cross-sectionally. Our dataset consists of 4,242 bids on 488 buyout funds by 144 bidders.

It is important to understand how well the secondary market functions to evaluate performance in private equity. While buyout funds tend to outperform the public equity market (Harris et al., 2014, 2016; Robinson and Sensoy, 2016), it is not clear whether this reflects an alpha or compensation for bearing the illiquidity of private equity investments. Franzoni et al. (2012) find an alpha of zero when including a liquidity premium, and the theoretical models in Sorensen et al. (2014) and Bollen and Sensoy (2016) suggest that the reported performance may be just enough to break even.

A well-functioning secondary market reduces the illiquidity of investments in private equity, lowering the return required to invest in the primary market. This is shown in the models of Maurin et al. (2020) and Bollen and Sensoy (2016), where the discount

[4]To highlight the inaccessible nature of the data, it is instructive to consider how our data provider describes the process of selling a fund stake. After an initial interest is found for a given stake, the general partner of the fund has to agree to a set of potential buyers. Bidders then sign non-disclosure agreements and are only allowed access to data in "data rooms" set up to provide access for a limited period of time.

from the fair value of the fund directly impacts the required return from investing in a private equity fund. Hence, to understand whether reported returns in private equity are compensating investors for the risk they take, it is essential to know whether the secondary market is efficient. This paper suggests that merely looking at the discount from an NAV to gauge the discount from the fair value is simplistic, as cross-sectional variation reflects differences in underlying value.

This is one of few empirical studies of the secondary market for PEF stakes. Like us, Kleymenova et al. (2012) utilize bid-level data. They explore the determinants of bids in auctions of PEF stakes, finding that bids are lower when fewer bidders participate in an auction, and higher if the stake is more liquid. Nadauld et al. (2019) is the first to use transaction data. They document an average discount in the market which increases in bad economic times. They also find that buyers of PEF stakes earn higher return than sellers, a difference they attribute to compensation for liquidity provision. Using the same dataset as employed in this paper, Albuquerque et al. (2018) study liquidity provision in the secondary market by modelling demand for private equity fund stakes. They find evidence of compensation for liquidity provision, as demand moves to where selling pressure is highest. This paper complements existing studies by studying the informativeness of bid levels, providing evidence that cross-sectional variation predicts fund performance. In doing so it also provides empirical evidence in favour of the model of Berk and Stanton (2007), from a setting outside the closed-end fund setting it was initially developed for. In that it contributes to earlier evidence from secondary market for hedge funds provided by Ramadorai (2012).

The paper also contributes to the literature examining the accuracy of NAVs by documenting that secondary market participants are able to spot which NAVs are misvalued, and price it appropriately. Barber and Yasuda (2017) and Brown et al. (2019) show that NAVs are not always accurately priced, particularly around fundraising events. Ang et al. (2018) and Boyer et al. (2019) document significant autocorrelation in private equity return indices, suggesting that NAVs do not fully incorporate recent returns. To the extent that secondary markets become more liquid, it provides a potential avenue to overcome the lack of market valuations.

A limitation of our data is that we work with bids and not transactions. While this enable us to examine valuations of funds that LPs are not willing to sell, a natural concern is that some bids may not be serious, and even if bids are serious they are lower than the price which would lead to a transaction. We take several steps to mitigate this concern.

First, we note that our descriptive statistics closely match those published by Greenhill Cogent and those in Nadauld et al. (2019) that are based on transaction prices from a US-based financial intermediary. This similarity is not surprising given that i) bidders

submit the same bid to several intermediaries to maximize the probability of matching a selling interest; and ii) submitting bids is costly both in due diligence and in terms of reputation. A bidder attempting to manipulate the perception of demand, submitting unrealistic bids, or reneging on a submitted bid, would be quickly spotted and excluded from this market by the financial intermediary. Hence, we believe that bids are informative of the bidder's true valuation.

Second, we take steps to mitigate concerns arising from bids being systematically lower than the price a fund would transact at. Let Δ denote this difference. Evidence in Hege and Nuti (2011) suggests that this difference varies over time. All of our analysis therefore include specifications with time fixed effects to soak up this effect. Such time-variation in Δ may explain why we find weaker relationship between discounts and future performance when not controlling for time fixed effects.

Third, while our data is bid-focused it does include a few transactions. For 35 such transactions we observe earlier bids from the investor that eventually buys the stake. The final bid placed prior to the completion of a transaction is on average the same price as the completed transaction. However, we do observe that bids generally increase in the submitted bid sequence, presumably as the bidder is attempting to convince the seller by posting bids closer and closer to the bidder's reservation price. This suggests that the bid sequence correlates negatively with Δ, and we can test the whether our results are sensitive to including this proxy from our specification. The results of the paper are qualitatively unchanged whether we include and exclude this proxy.

Finally, we note that the presence of Δ is likely to work against us finding the results of the paper. When we measure the hypothetical return to bidder we use the bid placed as an initial investment. An increase in Δ equals a lower bid, leading to a higher return to the investor. But what we find is that higher bids do not perform any worse than lower bids.[5] There is no such mechanical relationship between the bid and funds' future performance, but the presence of Δ is likely to add noise, making it less likely that we find the relationships we do find. We conclude that it is unlikely that our results are driven by the fact that we work with bids rather than transaction prices.

The remainder of this paper proceeds as follows. Section 2 discusses the institutional features and provides a brief history of the secondary market. Section 3 describes the dataset and provides descriptive statistics. Section 4 discusses our empirical approach and the predictions of the paper. Section 5 presents our results. Section 6 concludes.

[5]If Δ is an increasing function of the bid placed it would help us find our results. However, this seems unlikely given that the mechanical effect of an increase in Δ is to lower the bid. Note also that we may have several bids targeting a given fund in specific time period, in which case the ones with the highest Δ are the lowest bid and it is certain to work against us.

2 Institutional Setup

A private equity fund is a private partnership between a group of asset owners (pension funds, sovereign wealth funds, family offices) called limited partners (LPs), and a private equity firm (referred to as the general partner, or GP). During the fundraising period, a GP (e.g. KKR) seeks capital for a given private equity fund (e.g. KKR millennium fund). Once a fund has reached its fundraising target, it has its "final close", and the year this occurs is the fund's vintage year. After a fund's final close it is not possible for new investors to invest in the fund, except by purchasing a fund stake from one of the fund's existing LPs on the secondary market. Typically, a sale requires the approval of the GP.

When investors enter a limited partnership agreement, they commit to provide a certain amount of capital to the fund. The aggregate commitments to a fund is the fund's size. No capital is paid other than in connection with fees and the fund making specific investments, at which point the fund "calls" its investors for capital. Such capital calls are ex ante uncertain in terms of quantity, amount and timing. Capital is called project by project. When an investment is exited, the resulting cash is distributed to the LPs, and cannot (usually) be recycled into new investments.

The difference between fund size and the sum of all capital calls at a given point in time is called "dry powder" or "unfunded commitments". The transfer of the limited partnership interest allows LPs to be released from any remaining unfunded obligations to the fund. Sellers on the secondary market, therefore, sell a combination of a set of on-going non-traded investments and the remaining unfunded commitments.

Each quarter, funds self-report an estimate of the value of all on-going investments, the fund's net asset value (NAV). At fund inception, NAV is zero and dry powder is equal to capital committed. As funds have a soft deadline of (usually) 10 years, funds reaching their tenth anniversary typically have an NAV close to zero. Since the end of 2008, FAS 157 requires that NAVs are marked to market in the US, while such requirements were in place from 2006 in Europe (Crain and Law, 2018).

Bids on private equity fund interests are denoted as a percentage of a reference NAV. In general the latest known NAV is used, and the reporting date of that NAV is called the "reference date". Any cash flows occurring between the reference date and the date of a purchase are accounted for when determining the final purchase price: the seller is reimbursed for capital calls, whereas distributions are kept by the seller and reduce the purchase price payable. Any interim valuation changes to the underlying fund interests typically accrue to the benefit - or detriment - of the buyer.

2.1 Evolution of the Secondary Market

The Venture Capital Fund of America was the first fund specializing in buying private equity fund interests on the secondary market; it raised $6 million in 1984. In 2016, Paris-based Ardian raised the largest secondary fund to date with $10.8 billion of committed capital for its ASF VII. We note a strong concentration of capital among secondary funds. From 2011 to mid-2016, the largest 30 fund families raised more than 90% of a total of $164 billion (the top 10 players have raised more than $127 billion between them according to Private Equity International).

Global transaction volumes are estimated by Greenhill Cogent (Global Secondary Market Trends & Outlook 2020). Volumes reported in several of their secondary market reports are gathered in Figure 1. We see an exponential growth in the early 2000s. From 2007 to 2013 volumes were comparable at about $25 billion per year (except for 2009, which stands out, with only $10 billion of transactions). There is an increase in 2014 to about $40 billion, with similar numbers achieved in 2015 and 2016. The last three years are characterised by rapid growth, with transaction volumes reaching a record $88 billion in 2019.

Buyers of private equity fund interests on the secondary market used to be mainly private equity funds specializing in buying through the secondary market, called secondary funds. Over the last ten years, fund-of-funds and asset owners have increased their participation in the market. Setter Capital, in a 2015 report, estimates that there are more than 1,000 potential buyers including "opportunistic" secondary buyers (including pension funds, sovereign wealth funds, asset managers).[6]

3 Data

The secondary market for private equity fund stakes is intermediated by specialized organizations that matches potential buyers and sellers. One such financial intermediary - based in London and operating on that market since September 2009 (its other operations are older) - gave us access to its entire database. Most of the requests it receives are

[6]The first $1 billion secondary transaction occurred in 2000 when Abbey National plc sold $1.3 billion of stakes in 41 private equity funds (and 16 interests in private companies) to Coller Capital, a secondary fund. Bank One sold $1 billion of fund interests to Landmark Partners (2004), Dresdner Bank sold $1.4 billion of fund interests to AIG (2005), Mellon Financial Corporation, following the announcement of Mellon's merger with Bank of New York selling $1.4 billion of fund interests to Goldman Sachs Vintage Funds (2006), Ardian's 2010 acquisition of a $1.9bn portfolio of fund interests from Bank of America comprising 60 fund interests. In the UK, Lloyds Banking Group plc sold 33 fund interests for $730m to Lexington Partners and a $2 billion portfolio to Coller. Even pension funds with a long horizon have sold large portfolios: State of Wisconsin Investment Board sold 12 fund interests managed by six firms for $1 billion. California Public Employees' Retirement System, sold $6 billion of fund interests between 2007 and 2012, while later announcing it is moving to the other side of the trade, with an objective of deploying $600 million a year to purchase fund interests.

from LPs offering to buy fund stakes at an indicative price (the bid). In essence, what we observe is the demand side of the market. Bids are quoted as a fraction of a reference NAV, and often given as a range (e.g. 80%-85%). We use the midpoint of a range as the bid level, though all results presented below are qualitatively unchanged to using the high or low points of the range instead.

Our data provider is viewed as a market leader for individual fund stake transactions (in contrast to transactions on portfolios of fund stakes.) This is an attractive feature because it is problematic to infer the valuation of individual fund stakes from the pricing of a portfolio of fund stakes. Having access to valuations of individual funds allows us to examine whether bid levels are informative of future fund returns.[7]

For each bid received, we observe the name of the fund, but not that of the bidders (only their type and country are provided to us).[8] One third of the bids come from the UK – where our data provider is based. Switzerland is the second largest country in the sample, followed by the US (10% of the bids), France, Germany, Netherlands and Norway. The other countries count for less than 1% of the bids each.

We match the funds in our dataset to two databases provided by Preqin. The first database contains fund characteristics such as size, vintage year, type and geographic focus. It covers 22412 funds and we have matched funds in our dataset using fuzzy lookup algorithms and, for funds we could not match this way, manually searching the database. A manual search is often required due to databases differing in how they record fund names. It is for example common that we observe an abbreviation in one database and the full name in the other. The second Preqin database contains cash flows and NAV valuations up until June 2018. The cash flow database contains significantly fewer funds, so whenever we rely on it our sample size decreases. The upside of using this database is that having access to cash flows and intermediate NAV valuations allow us to compute fund performance at the time a bid is placed, as well as fund performance in the period after a bid is posted.

3.1 Descriptive Statistics

Our initial sample contains 5576 bids made on buyout, venture and some other PE funds (e.g. infrastructure, fund of funds). Figure 2 shows the number of bids on different types of PE funds over time, measured at a monthly frequency. We observe that our sample really starts in October 2009 when we count 35 bids, and that the sample is mainly made up of buyout funds.

[7]The data employed in Nadauld et al. (2019) includes single fund exchanges as well as portfolio transactions.

[8]The funds most represented in our dataset are well-known funds. Those with the highest numbers of bids are: Apax Europe VII, Bain Capital IX, Blackstone V, and Thomas H Lee VI. They received more than 30 bids each.

Buyouts represent the largest sub-type of private equity funds in terms of dollar invested. They also tend to invest in larger companies and we suspect that their reported NAVs is less noisy, making it perhaps easier to trade on a secondary market. 94% of the buyout funds in the sample focus on Western Europe (including Scandinavia and UK) and North America. In order to work with a homogeneous sample, we include in our sample only buyout funds focusing on these geographies.[9]

Our working sample contains 4242 bids from October 2009 to October 2016. Whenever we rely on the Preqin cash flow database, the sample decreases to 2905 bids.[10]

Panel A of Figure 3 plots the average bid per month. We notice that average bid is particularly low in the first few months of the sample (reaching 72% in January 2010). From February 2010 on, the monthly average bid stays in between 76% and 97%.[11]

We expect the bids received by our financial intermediary to represent serious interests and valuations of a given fund stake at that given point in time. Although we can never rule out strategic behavior, it is important to note that submitting bids is costly both in terms of due diligence and in terms of reputation. A bidder attempting to manipulate the perception of demand, submitting unrealistic bids, or reneging on a submitted bid, would be quickly spotted and excluded from this market, as financial intermediaries would ignore future demand or supply emanating from that organization.

In addition, we observe a number of completed transactions and do not find any significant deviation between initial bids and eventual transaction prices. Moreover we compare the time-series of average bids to the time-series of average transaction prices as reported by the US market leader on the secondary market, Greenhill Cogent. Panel B of Figure 3 displays these dynamics, and the correlation between the two time-series is 0.94, with the two averages differing by 1.7 percentage points.[12] The average bid in both samples is low in the early part of the period and displays a slight upward trend at the end of the sample. Similarly, we compare the time-series of yearly averages

[9] Assets of mature businesses should be easier to value than those of venture capital backed companies. In our sample, venture capital funds experience a much larger discount on average. In conversations with practitioners a common explanation is that this reflects the higher volatility in venture returns. However, the significant price difference between buyout and venture prices on the secondary market may disincentivize investors to sell venture funds. In a market where most buyout funds can be sold at small discounts or better, LPs that care about accounting losses would prefer to sell buyout funds and hold on to their venture capital funds.

[10] While the drop in bids from 5576 to 4242 is quite dramatic, the reduction is much smaller (we lose 15% of bids) when we merge with the Preqin cash flow database. Venture capital and other PE funds, as well as funds operating in developing markets, tend to be smaller and are less likely to be included in the Preqin cash flow database.

[11] The large drop in March 2016 is due to our provider only receiving 3 bids on US or Europe buyout funds for that month, and they were unusually low. They have provided no explanation to why that particular month is different, and there does not appear to be any specific news at the time which explain such a drop in activity.

[12] Greenhill Cogent, in its *Secondary Market Trends & Outlook*, reports semi-annual statistics from 2010 to 2013 and annual statistics for 2009, 2014, 2015. The figure averages our bids at the same frequency for ease of comparison.

in our sample to the transaction prices in Nadauld et al. (2019). The correlation is 0.99, and the average discount is the same.

Figure 4 presents the cross-sectional distribution of bids. 11% of bids are made at par (i.e. 100% of NAV) and about 13% are made at a premium to NAV.[13] Additional descriptives are provided in Figure A.1, which summarizes the distribution of bids by fund age, fund value, fraction of committed capital called, and the fraction of fund value distributed. We see that most bids are concentrated on funds in their mid-life, with very few bids targeting funds in their early years or funds more than ten years old. Bidders target funds which have called most of committed capital and with most fund value yet to be distributed.

Table 1 presents key descriptive statistics, with variable definitions provided in Table B.1. In Panel A, the first three columns present statistics when treating all bids as unique. There are 4242 bid observations, with an average (median) bid of 88.2% (90.0%). An alternative approach is to consider all bids received by a fund in a quarter as a single observation. Columns 4-6 presents descriptives taking this approach instead, summarising 2213 fund-quarter observations. Each fund-quarter observation is defined as the average bid the fund has received during the quarter. The average (median) bid of these fund-quarter observations is 89.4% (92.5%). The average time at which a fund receives a bid is 6.6 years after inception. The last three columns of statistics are for the 488 unique funds that receive at least one bid in our sample, taking averages of all bids targeting each fund. The average (median) bid is 88.9% and 91.0%. Noteworthy is that the average fund size is much larger when weighting fund size by the total number of bids, suggesting that larger funds receive far more bids. The sample is weighted towards Europe, with 69% of bids aimed at European funds and 31% at US funds. This reflect the fact that our data provider is based in Europe.

Panel B compare differences in the two samples used in the paper. 488 unique funds receive bids, which we split up by funds that are covered by the Preqin cash flow dataset (255 funds) and those that are not (233 funds). The average bid is very similar at 88.6% of NAV for funds with Preqin cash flow data and 89.2% of NAV for those that are not in the Preqin cash flow data. Funds covered by Preqin are far more likely to be US-based and are much larger, corresponding to the overall bias in Preqin towards large, US-based funds, that arises as Preqin partially sources its data from US pension funds.

For the funds that are covered by Preqin we also provide a comparison between our funds and comparable funds in the Preqin cash flow database. Funds receiving bids are larger on average. It is also more common for bids to target funds of well-established

[13] As some bids are extreme and may drive results we winsorize at 1% and 99%, which correspond to bids at 30% and 120% of NAV.

GPs, those that have raised more funds and whose funds are generally performing better. This likely reflect a desire of potential buyers to gain access to reputable funds.[14]

For this subsample we can formally examine systematic differences between funds receiving bids in our sample against those that do not, as well as when in a fund's life bids are likely to arrive. We define an indicator variable taking the value of 1 if the fund received a bid in a given quarter, and 0 if it did not. The funds that are included in this analysis are the 255 funds in our sample which are covered in Preqin, as well as 287 comparable funds in the Preqin database which do not receive a bid. Table 2 presents results from estimating a logit model that characterizes the likelihood of receiving a bid within a given quarter. The three models we run differ only from the set of fixed effects that are included.

The first result of the table is that better performing funds are more likely to be targeted by bidders, though it is only statistically significant at the 10% level in the model with no fixed effects. The relevance of past performance increases when controlling for quarter fixed effects. As past performance varies from one quarter to the other, this indicates that it is the better performing funds at the time that are more likely to be targeted by bids. We note that this differs from the results in Nadauld et al. (2019), where poorly performing funds are the most likely to be sold. Presumably, this difference arises as their data is seller-initiated whereas ours is buyer-focused. It may reflect a preference of LPs wanting to sell their worst performing funds, while buyers are primarily interested in the better performing funds.

In untabulated results, we find that the effect of performance is driven by a reluctance to target bottom quartile funds in any given quarter, while there is no statistical difference between the other three quartiles.

Consistent with the descriptive statistics and results in Nadauld et al. (2019), larger funds are more likely to receive bids than smaller funds. The effect of fund age is non-linear: it has an inverted U-shape where young and old funds are less likely to receive a bid, again corresponding to the descriptive statistics of fund age distribution. The number of funds available by a GP is negatively related to the likelihood of receiving a bid, though only significant at the 10% level. If investors bid in the secondary market to gain access to a GP, this result could reflect the increased amount potential funds through which a bidder could get access to this GP. As the intermediary providing the dataset is base in London, we find that US funds are less likely to be targeted.

[14]The comparison Preqin funds are restricted to be to be buyout funds focusing on either the US or Europe. Furthermore we require that they have at least one NAV reported at 10% of capital committed during our sample period, and we only include vintages of 2000 or later. This filtering ensures that we do not capture funds that would not have been receiving bids during the sample period.

4 Research Design

This section outlines the methodology employed in the paper and discusses what we expect to find from our analysis.

4.1 Determinants of Bid Levels

We begin with a descriptive analysis of the determinants of the bid level. To that end we will look at correlations between the bid level and fund characteristics, the state of the economy, and characteristics about the bidders. We estimate the following model,

$$\text{Bid}_{f,t,i} = \alpha + \beta X_f + \lambda X_t + \theta X_i + \phi X_{f,t} + \psi X_{f,i} + \gamma X_{t,i} + \xi X_{f,t,i} + \varepsilon_{i,t}, \qquad (1)$$

where $\text{Bid}_{f,t,i}$ is the bid placed by investor i at time t for fund f. $\text{Bid}_{f,t,i}$ is expressed as a percentage of the reference NAV. X_f contains fund characteristics that are constant over time, such as fund size and the geographical focus of the fund. X_t contains time-varying variables shared by all funds. Those examined here are the Price/Earnings Ratio (following Nadauld et al., 2019), the Listed Private Equity Price/NAV and R_m ($t_{NAV} - 1$ year to t_{NAV}).[15] $X_{f,t}$ contains time-varying fund variables such as fund performance, dry powder and fund age. The vectors X_i, $X_{f,i}$, $X_{t,i}$ and $X_{f,t,i}$ similarly contains variables relating to the bidder placing the bid such as type of bidder, number of funds bidded for, which bid in a sequence it is, and the geographical proximity of a bidder to the GP.

The existing literature help us form predictions of what we expect to find. While there is no direct theoretical model on discounts in the secondary market for private equity fund stakes, the model of Berk and Stanton (2007) on closed-end fund discounts is relevant here, as closed-end fund quote prices with discounts from NAVs. Their model predicts that the price is an increasing function of managerial ability. To the extent that the current fund performance is informative of managerial ability, we expect a positive relationship between a fund's current performance and the price a bidder is willing to pay.

There is plenty of evidence that the values of private equity fund investments move together with the stock market (e.g. Jegadeesh et al., 2015; Franzoni et al., 2012; Ang et al., 2018). If private equity funds are slow at incorporating recent movements in their NAV valuations — as the positive autocorrelation in private equity indices documented in Ang et al. (2018) and Boyer et al. (2019) suggests — we expect recent market movements to be positively related to the price a bidder is willing to pay.[16] It is possible that

[15] The Listed Private Equity Price/NAV is measured in the same way as the bid is, using market prices of listed private equity funds. We thank the LPX group for providing us with this data. For the public market return we use regional indices based on the fund location. See Table B.1 for details.

[16] If the public market went up (down) recently and NAVs only slowly incorporates this information, then the NAVs referred to is undervalued (overvalued) and hence the price, as a fraction of NAV, should be higher (lower).

such an effect is picked up by the price/earnings ratio or by the discount on listed private equity funds. Nadauld et al. (2019) document a positive relationship with the price/earnings ratio and the price paid, which they interpreted as transaction costs being higher in worse economic times.

The results of Table 2 suggest that large funds and funds in their mid-life are more likely to receive bids. To the extent that these funds are generally more desirable, bidders may be willing to pay more for them. That would be consistent with the findings of Nadauld et al. (2019). They also note that one reason why there might be a discount for young funds is the the fact that the buyer takes over the responsibility for future capital calls. As capital calls have to be met at par, the effective discount is smaller than the quoted one.

4.2 Informativeness of Bids

The theory of Berk and Stanton (2007) suggests that discounts are a function of managerial ability, as investors are willing to pay a high price when expected future performance is high. Future (reported) performance also depends on the extent to which NAVs are accurate estimations of funds value. Boyer et al. (2019) create a private equity index based on transaction prices on the secondary market, implicitly assuming that market prices in the secondary market correspond to the correct valuation of funds.

Jenkinson et al. (2019) show that NAVs of buyout funds on average reflect the expected discounted future cash flows. Although their evidence suggest that NAVs of buyout funds are correct on average, there may be cross-sectional variation in the accuracy of any given fund's NAV. Similarly, there may be points in time when NAVs are more or less accurate, which would be the case if NAVs are slow in incorporating recent market movements. Evidence in Barber and Yasuda (2017), Bienz et al. (2017), and Brown et al. (2019) suggest that NAVs do not always provide a fair representations of the underlying fund value.

We begin by considering a simple model of the accuracy of NAVs to examine if there are any systematic bias in the accuracy of NAVs, as a function of the state of the economy or fund-characteristics. We use a methodology similar to that employed in Jenkinson et al. (2019), which compares discounted cash flows (DCFs) to reported NAVs. The intuition is that if NAVs are unbiased estimates of fund value, then they should on average equal the future DCF given an appropriate discount rate. For ease of interpretation, we measure discrepancies by dividing the DCF with the reported NAV. We estimate the DCF in the spirit of PME calculations (Kaplan and Schoar, 2005), by discounting future cash flows with realized public market returns.[17]

[17] Jenkinson et al. (2019) use an ex ante discount rate of 11% when estimating DCFs. As private equity cash flows are highly sensitive to overall market movements (e.g. Ang et al., 2018), a PME-type measure takes out some of that expected co-movements. In essence, this captures whether the reported NAV is over- or under-valued relative to the expected cash flows conditional on the realized market movements. If such patterns exist related to for example specific macro-economic conditions, we expect secondary market participants to adjust the prices they are willing to pay relative to reported NAVs.

We specify the following econometric model[18]

$$\frac{DCF_{f,t}}{NAV_{f,t}} = \alpha + \beta X_f + \lambda X_t + \gamma X_{f,t} + \varepsilon_{f,t} \tag{2}$$

where $DCF_{f,t}$ is the discounted future cash flows for fund f in quarter t. The independent variables correspond to those used in Table 3, though bidder-specific variables are not part of this model.

We estimate this model for all fund-quarter observations for buyout funds in the Preqin database that focus on either Europe or North America. Fund-quarters are included from the third quarter of 2009. These filter ensure we estimate the model for a comparative sample to those in our bid dataset. Many of the funds reporting in this time period will not have been liquidated at the end of our Preqin sample (June 2018), and for those we include the final NAV as a liquidating distribution when calculating the DCFs. This is a limitation as we wish to assess how the reported NAVs relate to future cash flows. To mitigate it we require that we have cash flow data until at least the fund's sixth year. A particular NAV is included only if we have at least four quarters of cash flow data after that NAV report; the NAV is at least 10% of capital committed; and the fund is not older than 10 years at the time of the NAV report.[19]

While the previous analysis could potentially help us understand some of the variation in discounts, it is likely to remain a significant amount of unexplained variation. Participants in the secondary market may be able to better assess idiosyncratic variation in the accuracy of NAVs, or the ability of GPs. To the extent they expect competition when bidding for stakes, their information should feed into what they are willing to pay for a fund stake. If that is the case, we expect bid levels to predict future fund performance.

To test this prediction we will estimate a model of the future performance of a fund as a function of the discount in bids placed. The following model is estimated

$$\text{Fund Performance}_{f,t,i} = \alpha + \beta Bid_{f,t,i} + \theta X_{f,t,i} + \varepsilon_{f,t,i} \tag{3}$$

where f, t, i as previously denotes fund f, time t and the bidding investor i. $X_{f,t,i}$ captures the same set controls that was included in the analysis of determinants of the bid price. It is not obvious over which distance one should measure Fund Performance$_{f,t,i}$. In the analysis this will be calculated for several different horizons, from one to three years.

[18]Our specification uses the ratio of the DCF to the reported NAV, while Jenkinson et al. (2019) instead use a log specification, with $\ln DCF$ on the left-hand side and $\ln NAV$ on the right-hand side. We prefer the ratio as it simplifies the interpretation of the coefficients for other variables. We use the alternative log specification in an appendix table to show the robustness of the results.

[19]The choices of minimum NAV and maximum fund age are motivated by Panel A and Panel C in Figure A.1 as very few bids are made for funds older than 10 years or with an NAV of less than 10% of capital committed. In untabulated results we vary these cutoffs on the restrictions and find qualitatively similar results.

Fund performance is defined as the PME of the fund, measured from the closest NAV report following the date of the bid, until a point in time defined by the horizon. For the PME calculation, the first post-bid NAV is accounted for as an initial investment, while the NAV at the end point is accounted for as a liquidating distribution. It therefore reflects a measure of the fund's reported performance, measure in a period strictly after the period in which the bid is placed.

While it is hypothesised that fund performance is positively related to the bid placed, a natural follow-on question is whether the pricing is rational, in the sense that bidders are indifferent to buying a fund at a premium to NAV versus a discount. To evaluate this we can measure a bidder's performance similarly to the fund performance measure, but using the submitted bid value as an initial investment in place of the fund's NAV. As any inaccuracies in NAVs or managerial ability is only likely to be resolved over time, we expect the bid amount to be negatively related to a bidder's performance in short horizons due to (paper) valuation gains. However, if the bids are sufficiently informative of future fund performance, we expect no differences in performance over longer horizons if bids are rational, akin to efficient pricing in the market.

To that end, we estimate the following model,

$$\text{Bidder Performance}_{f,t,i} = \alpha + \beta Bid_{f,t,i} + \theta X_{f,t,i} + \varepsilon_{f,t,i} \tag{4}$$

where $\text{Bidder Performance}_{f,t,i}$ is computed analogously to $\text{Fund Performance}_{f,t,i}$, but using the bidded amount as an initial investment rather than the closest NAV following the bid.[20] In this way it corresponds to the hypothetical return that the bidder would report, had the bid been accepted. We hypothesize that the bid placed will be unrelated to the bidder's performance over longer horizons.

Several bids may be placed for a given fund around the same time, and bids are not evenly distributed over time but arrive in large numbers in certain months. We therefore going to double-cluster the standard errors by the month in which the bid is made, as well as by fund ID. To account for overall time trends in both bids and fund performance we include time fixed effects and vintage fixed effects in some specifications.

4.3 Bids, not Transactions

It is important to discuss one limitation of our dataset: it primarily consists of bids rather than completed transactions. While this enable us to evaluate valuations of funds that LPs are unwilling to sell, a natural concern is that bids are lower than transaction prices

[20]The bidded amount is the reference NAV times the bidded percentage, accounting for any cash flows in between. The seller is reimbursed for capital calls, whereas distributions are kept by the seller and reduce the price payable.

and that this may drive results. While we cannot change the nature of the data, we can think about potential issues that may arise and take steps to mitigate them.

Let $\Delta_{f,t}$ denote the difference between the value at which fund f would transact at time t to the bid placed for the fund at that time. Our analysis is largely focused on cross-sectional variation in bids, which means that the problem is limited if $\Delta_{f,t} = \Delta$, i.e. is constant between funds and over time. This assumption appears rather strict and unlikely to hold. We know from Hege and Nuti (2011) that the divergence between the amount sellers asked and bidders offered increased substantially around the financial crisis compared to both prior to and following the crisis.

If instead $\Delta_{f,t} = \Delta_t$, i.e. varies over time but is a constant across funds, we can account for this difference with the inclusion of time fixed effects. All tables presented therefore include specifications with and without time fixed effects, to examine whether the results are materially different.

Of course, we cannot rule out that it varies not only over time, but between funds and perhaps between bidders as well, if some investors place bids closer to their reservation price than others. When analysing whether bids are informative of funds' future performance, an increase in the difference $\Delta_{f,t}$, all else equal, introduces noise which will work against us finding any statistically significant results. In the case of the analysis on bidders' performance, it would bias our estimates downwards. We provide a more detailed discussion when we present the results of the paper.

We note that our average bid closely matches the average transaction price, and is much higher than the average bid, in Nadauld et al. (2019) for the time period over which the two studies both have data. Panel B of Figure 3 suggests that our descriptive statistics also matches those reported by Greenhill Cogent.

There are 35 transactions for which we observe an earlier bid from an LP that later acquires the fund stake, allowing us to follow the negotiation process. For those cases we identify the last bid prior to the transaction. In 26 cases the transaction price is identical to the amount bidded, in 4 cases the transaction price is higher (on average less than 1 percentage point) and in 5 cases the transaction occurs at a lower value than the prior bid (on average less than 1 percentage point). For cases where we observe multiple prior bids we find that bids generally increase during a bid sequence, which we interpret as the result of a negotiation process. This increase is on average 1 percentage point.

One lesson from this exercise is that it may be worthwhile to explicitly control for where in a bid sequence a bid is placed, as bidders may be increasing their bids in an attempt to convince sellers. We therefore construct a "bid sequence" variable, defined as the number of bids placed by a given investor for a specific fund in a given sequence. As this is expected to capture part of variation in $\Delta_{f,t}$, it acts as a proxy for $\Delta_{f,t}$, allowing us to examine whether our results are significantly altered by including it. Though imperfect, we find that our results remain qualitatively similar whether this proxy is included or excluded.

5 Results

5.1 Determinants of Bids

We begin by examining the determinants of the bid (quoted as a fraction of NAV). Results are presented in Table 3. To make the coefficients easier to interpret, the dependent variable takes the value of 70 to represent a bid of 70% of NAV.

The first column includes fund characteristics and bidder-specific variables. The fund characteristics included are fund age and fund size. Age is represented by three indicator variables denoting if a fund is a young fund (up to 3 years old), middle-aged (between 4 and 7 years old, omitted from the table), or an old fund (8 years or older). Size is split into four categories: small, medium (omitted), large, and very large. The size dummies are suppressed from the table for presentation purposes, as none of the dummies are statistically significant. Larger funds receive more bids, but the price investors are willing to pay does not appear be related to fund size. Young funds command a higher discount compared to middle-aged funds, with the discount being 6 to 8 percentage points higher, depending on specification.[21] Old funds receive bids with a discount of about 2.5 percentage points above middle-aged funds, though the difference is not statistically significant in all models.

We include four bidder-specific variables. Two indicator variables tests for differences in price paid by the type of bidder, classified as being a specialist secondary fund, a fund-of-funds, or an asset owner category that group together pension funds, endowments and other investors. Asset owners tend to place higher bids than the other two investor types, possibly in an attempt to gain access to a particular GP they wish to invest with. To capture negotiation rounds, or attempts by bidders to convince an LP to sell by offering prices closer and closer to their reservation price, we include the log of a bidder's bid sequence, defined as the number of bids placed by a bidder on a specific fund in the past 180 days. As expected, the variable is positively related to the price submitted by the bidder.[22] Finally, to examine whether there is a potential home bias we include an indicator variable for whether the bidding investor and the GP have are based in the

[21] The discount on young funds partly reflects that uncalled capital has to be met fully by the buyer, as noted in Nadauld et al. (2019). In untabulated analysis we calculate the effective discount as the offered dollar discount as a fraction of quoted NAV and uncalled capital. In this specification, young funds are not associated with a significantly different discount. However, note that simply adding dry powder in the model, as in column 5, does not drive out the result on young funds.

[22] As discussed in section 4.3, the variable is expected to be related to the discrepancy between the price at which a transaction would take place and the bidded amount. As such, comparing coefficient estimates of other variables when it is included and excluded can inform us whether having bids rather than transaction prices appear to introduce a bias in the estimates. In untabulated results we find qualitatively similar results for all other variables when omitting the bid sequence variable.

same country. Bids for funds managed by local GPs are approximately one percentage point higher, though the coefficient is not always statistically significant.[23]

In the second column we add monthly fixed effects but keep the same set of explanatory variables. This has little impact on the estimated coefficients, but does increase R^2 from 0.30 to 0.40, suggesting that there is significant time-variation in bid levels. In the third column we replace time fixed effects with macro-variables to examine what this time-variation is driven by. The return on the stock-market over the twelve months running up to the NAV report is strongly positively related to bid. This may be due to a belief that NAVs have not fully incorporated recent market movements. In untabulated results we find that the effect is there for recent market movements over shorter horizons as well. The effect of market movements is not absorbed by the price-earnings ratio of the stock market or the discount on listed private equity, perhaps the closest substitute to secondary market prices. The discount on listed private equity is highly correlated with the price-earnings ratio.[24] All three of these variables are positively related to the bid price, though the listed private equity discount is only statistically significant at the 10% level, and only for the final two specifications.

The specifications in the fourth and fifth columns are estimated on the sample for which we have cash flow data from Preqin available. Column four confirms that the previously documented relationships hold in this subsample. In the fifth column we add fund characteristics gathered in Preqin. We find that bids are higher for funds that have done well, as measured by the to-date PME, consistent with the Berk and Stanton (2007) theory. However, the bid is lower when a higher fraction of that performance is realized (i.e. already distributed), perhaps reflecting a belief that well-performing funds have conservative valuations, as found by Brown et al. (2019), providing the buyer with an upside when investments are exited. Note that dry powder is unexpectedly positively related, even though we expected a negative relationship. Dry powder is highly related to the (young) age dummies, and in untabulated results we find that when age dummies are excluded the coefficient on dry powder takes the expected negative sign.

[23]Home bias among investors is documented in for example French and Poterba (2016) and Coval and Moskowitz (1999). A preference for investing in GPs that are geographically closer could reflect an information advantage. Evidence of informational advantages in investments is provided by Hau (2001), Ivkovic and Weisbenner (2005) and Bae et al. (2008). In the private equity setting, Hochberg and Rauh (2013) document home-state bias of LPs in private equity, which is particularly pronounced for pension funds that underperform with local investments.

[24]In untabulated results we collect a large set of macroeconomic variables and test various permutations of them. The set of macrovariables is the one used in Albuquerque et al. (2018), with some additions. The set includes credit spreads, interest rate measures, various measures of liquidity proposed in the literature, GDP growth, measures of global economic policy uncertainty, and the VIX. In addition to the three presented in the table we find that only the VIX is significantly related to the discount. However, the VIX does not survive a horse-race against the price-earning ratio or the discount of listed private equity funds, and is consequently not presented in the specification.

Having examined factors that drive the discount we turn to the analysis of whether these factors are associated with expected over- and undervalued NAVs, measured as the ratio of the discounted future cashflow to the reported NAV. Table 4 presents the results of this exercise. The variables included are those used in Table 3, excluding the bidder-specific variables. We demean all explanatory variables and subtract 1 from the dependent variable for ease of interpretation of the coefficients. A positive (negative) intercept indicates that NAVs are below (above) the DCF on average. The first column includes only fund-characteristics, while the second to fourth examines the macro-variables in some more detail. The final column includes fund performance, measures of dry powder, and the realized part of performance.

The results on fund characteristics resemble those in Jenkinson et al. (2019), with NAVs being conservative (aggressive) when the fund is young (old), and the largest funds being the most conservative. Large funds tend to be raised by the most successful and reputable GPs, which are shown by Barber and Yasuda (2017) and Brown et al. (2019) to have more conservative valuations. The large coefficient on young funds reflects low NAVs as not all capital has yet been invested, while the average PME of funds in the analysis is positive, resulting in the DCF being much higher than the reported NAV that only reflects investments undertaken to-date. When controlling for dry powder in column (5), the coefficient on young funds decreases though it does not disappear.

The economic variable that best captures divergence of NAVs and future DCF is the listed private equity premium. The listed private equity premium is defined in the same fashion as the bids in our data: price of listed private equity divided by the reported NAV. The positive coefficient suggests that when the price (discount) on listed private equity is high (low), NAVs in private equity are more (less) conservatively valued. This echoes the finding in Jegadeesh et al. (2015), that returns on listed private equity forecasts returns on indices constructed using reported NAVs and cashflows. The return on the public market in the previous year is also positively related to the NAV, albeit statistical significance is diminished when controlling for the listed private equity premium. I therefore provide some weak evidence that NAVs lag in incorporating market returns.[25]

To alleviate concerns that our results are due to the specific modelling choice of the ratio DCF/NAV, we perform a robustness check by using a log-log specification, as in Jenkinson et al. (2019). The results are presented in Table A.1, which confirms the patterns observed in the main specification.

[25]The model is estimated for the same sample period over which the bid data is available, from Q3 2009. This implies that fair value requirements in FAS 157 have been imposed on NAVs (see Crain and Law, 2018). In a previous version of the paper the model was estimated for a longer horizon, comparing the periods prior to and following the implementation of fair value requirements. While the results on fund characteristics were qualitatively similar in that model, NAVs were more conservatively valued prior to the implementation of FAS 157.

Comparing the results of Table 4 to those in Table 3, there are at least three noteworthy observations. First, similarly to Nadauld et al. (2019) we find that bids are higher (lower) in good (bad) times. They interpret this as transaction costs being high in bad times. The results of this paper suggest that there may be a complementary reason: NAVs may not fully incorporate changes in the valuations in a timely fashion, and the secondary market participants adjust their bids accordingly. Second, while better performing funds attract higher bids, there is no evidence here that this is motivated by identifying undervalued NAVs. Third, while young funds receive lower bids, they also have the most conservatively valued NAVs. This largely reflect the effect of uncalled capital: the NAVs are low by construction for young funds as most investments are yet to be made, and as noted by Nadauld et al. (2019), the effective discount is higher than the quoted as capital calls have to be met in full.

5.2 Returns Post Bidding

We now turn to a more direct analysis of how well the bidders separate the wheat from the chaff. To this end we will examine whether bids predict funds' performance post bidding. To ensure that we truly measure performance after the bid is placed we start measuring it from the first NAV report after the date the bid was placed. The results are presented in Table 5. We measure the performance post-bidding over three different horizons: 1, 2, and 3 years. For each horizon, the first column includes only the bid, the second adds vintage and monthly fixed effects, and the third add the control variables used in earlier tables, including bidder characteristics. For ease of presentation, only the coefficients on the bid is displayed.

Panel A displays the result using the bid placed measured as a continuous variable. The bid variable takes the value of 0.90 for a bid that is 90% of NAV. Every unique bid is linked to the post-bid performance of the fund bidded for, conditional on that fund having cash flow data available in Preqin. In Panel B, the unit of observation changes to a fund-quarter observation. Fund are sorted into quartiles each quarter based on the highest bid received during the quarter. We repeat the estimation in Panel A, replacing the continuously measured bid level with indicator variables for the quartile a fund belongs to. The omitted category is the quartile of funds receiving the lowest bid within that quarter.[26]

The results suggest that the bid level is informative of a fund's future performance, in line with the prediction of the Berk and Stanton (2007) model of closed-end fund discounts. Interestingly, in Panel A this effect is largely present only when controlling for time fixed effects, which compares the relative performance of funds receiving lower or

[26]The average bid for funds in the bottom quartile is 74.0% of NAV, for the 2nd lowest quartile it is 88.2%, for the 2nd highest quartile 95.0%, and for the highest quartile 99.9%.

higher bids within a quarter. This indicates that bidders are able to distinguish which funds are worth more at a given point in time, but time-series variation in the discount does not reflect the time-series variation in fund returns.

The results in Panel B suggests an almost monotonic effect for funds' ranked higher on bids, though there is essentially no difference in future performance between the two quartiles containing funds receiving the highest bids. The coefficients allow for a simple interpretation of the economic magnitude, corresponding to an increase in post-bid fund performance for a given quartile of funds relative to the quartile of funds receiving the lowest bid. The estimates suggest that funds receiving the highest bids have PME of 0.057 to 0.058 higher on a one-year horizon, 0.068 to 0.072 higher on a 2-year horizon, and 0.103 to 0.125 higher at a three-year horizon. These effects are sizeable compared to estimates in Harris et al. (2016) that buyout funds on average have a PME of 1.18 over the entire fund life.

Having established that, within a given time period, the price bidders are willing to pay predict future fund performance, we turn to the question of whether these two effects cancel out. An investor should be happy to pick up a fund that performs relatively poor, as long as the discount is sufficiently high. In the short horizon we may expect the paper gain from buying at a discount to dominate even if stakes are fairly priced. For example, if a GP consistently values NAVs conservatively, the undervaluation will only be resolved at exits which may take place several years in the future. Similarly, if a premium is paid for a higher ability GP, it likely takes time for that higher ability to translate to value increases. Indeed, our analysis on funds' performance suggests that higher bids predict larger cumulative performance differences as the horizon increases.

Table 6 presents results of the relationship between bids and the hypothetical performance of bidders, had their bid been accepted at the time of the bid. The price paid by the bidder is assumed to be the bid price times the reference NAV, accounting for any intermediate cash flows between the reference NAV date and the bid date. The performance of the bidder is otherwise measured in the same way as the performance of funds. Panel A presents the results using the continuously measured bid value, while Panel B provides estimates using the quartile indicator variables that sort funds into quartiles based on the highest bid received in a quarter.

There are two main takeaways from the table. First, the bid is negatively related to bidders' performance for short horizons, but this negative relationship disappears almost entirely at longer horizons. The quartile ranking specification even suggests that those willing to pay more would perform better at longer horizons, as the increase

in fund performance outweighs the higher price.[27] Second, the negative relationship between the bid placed and the performance of the bidder in Panel A only disappears when including time fixed effects, and thus compare high and low bids within a given time-period. The quartile ranking does this by construction, and there is a significant difference between the coefficient estimates in Panel A between models with and without time fixed effects. This suggests that cross-sectional variation in discounts predicts cross-sectional variation in fund performance, whereas time-variation in discounts do not correspond to time-variation in fund performance.

One concern may be that the patterns we observe are due to the changed sample when observing different horizons, rather than the change in horizon itself. To alleviate such concerns, Table A.2 repeats Table 6, using only observations for which the dependent variable exists at the 3-year horizon. The results are qualitatively unchanged. Similar results are found in untabulated results for funds' future performance.

One may ask whether bids of all investor types are equally informative. Table 7 examines whether there are different sensitivities of bid prices to post-bid fund performance for different types of investors. The results indicate that bids by asset owners are the ones most sensitivity to funds' future performance. This could reflect that secondary funds and fund-of-funds build up large, diversified portfolios and are therefore interested in being present for any liquidity-shocked LP, offering to buy a large amount of stakes. Secondary funds are by far the most active in the market, with asset owners being the least active. However, it should be cautioned that these results should be interpreted with great caution, as the coefficient for secondary funds is not statistically significantly smaller in any specification, and only at the 10% level for fund-of-funds in some specifications.

So far we have shown that bid levels are positively related to funds' performance up until the point of the NAV reference date, and that bids are informative of future fund performance, measured from the first post-bid NAV. There is one additional window over which fund performance may impact the cross-sectional variation in the discount: valuation changes between the reference NAV date and the bid date. NAVs are typically reported quarterly, while bids may arrive at any point. To the potential buyers can estimate the likely fund returns in that period, it should reflect the price they are willing to pay.

We construct two measures to examine whether this is incorporated in the bid price. The first is a linearly interpolated measure of the fund return between the reference NAV

[27] At first glance it appears puzzling that the quartile ranking again suggests an almost monotonic increase in bid bid ranking at the longest horizon, while there is still a negative (albeit small and insignificant) coefficient on the bid placed even when including time fixed effects. The difference is attributable to the difference in treating multiple observations for a given fund around the same time. In Panel A, all unique bids are treated as individual observations. Thus, if a fund receives multiple bids within the same quarter, the lower bids will by construction be measured as achieving higher performance. Of course, in an auction process the lowest bid is not the one accepted. By contrast, in Panel B at most one fund-quarter observation is included, using the highest bid received in the quarter.

date and the first NAV after the bid. We assume that the ex post realised return of the fund accrued linearly over the two NAV reports, so if the period t_{NAV} to t_{bid} is one third of the time between the two NAV reports, one third of that return had accrued at t_{bid}. Clearly, this measure uses information not available to the bidder at the time of the bid, as it use information from a NAV valuation at a date that has not yet taken place, and even less been reported. The second measure is the movement on public markets between the reference NAV date and the bid date.[28] Unlike the first measure, this measure is available to the bidder at the time the bid is placed. As valuations of private equity funds move with the public stock market we expect this to be positively related to the price investors are willing to pay.

Table 8 adds these two variables to the final specification on bid determinants used in Table 3. As the in-between fund return requires the availability of an NAV both prior to and following the bid we lose some observations. Surprisingly, the results suggest that movements in the public market since the reference NAV date are not positively related to the bid. It is not only statistically insignificant, but the coefficient has a negative sign. By contrast, the unobserved intermediate fund performance is strongly positively related to the bid. The effect is not taken out by either including time fixed effects or the in-between market movements. In fact, the in-between market movements become significantly negatively related to the bid when both are included, though only statistically significant at the 10% level.

Taken together, the results of the paper that bidders in the secondary market are sophisticated, with cross-sectional variation in bids reflecting expected future fund returns. They also appear to incorporate unreported intermediate fund returns. This suggests that simply looking at a discount to evaluate the attractiveness of a stake is misleading, as it may reflect an inaccurate NAV. Overall, this provide some evidence in favour of the approach taken in Boyer et al. (2019). It should be noted that the results of this paper are strongest for cross-sectional variation in discounts at any given time. By contrast, time-series variation in discounts does not appear to be strongly related to realized future fund returns, and may reflect variation in required compensation for providing liquidity.

As a final point of the analysis we return to whether our results may be driven by the dataset consisting of bids rather than transaction prices. As before, we use $\Delta_{f,t}$ to denote the difference between the price at which a stake would transact and the bid price. Regarding the results for bidders' performance, an increase in $\Delta_{f,t}$ implies a lower bid and hence a lower initial investment which, all else equal, implies higher performance for the bidder. Thus, to the extent that the $\Delta_{f,t}$ differs among funds it would bias the

[28] As in other instances where we use public market returns, we tailor the return to the focus of the fund. The S&P500 is used for funds focusing on North America, Eurostoxx 600 for funds focused on Europe, and FTSE 250 for UK funds.

relationship between the bid and the bidders' performance downwards. As the main result is that there the negative relationship almost disappears over longer horizons, $\Delta_{f,t}$ works against that finding and suggests that if anything, the estimate is likely biased downwards.[29] For the funds' performance, variation in $\Delta_{f,t}$ has no mechanical impact, but adds noise which would work against us finding any relationship between the bid and future fund performance. We conclude that it is unlikely that our results are driven by the fact that we examine bids rather than transaction prices.

6 Conclusions

This paper examines the informativeness of bids placed in the secondary market for private equity fund stakes. The secondary market has grown rapidly over the last two decades, and capital earmarked to be deployed in the market has increased significantly. Despite this influx of capital, the average transaction occurs at a discount to the net asset value of the fund (Nadauld et al., 2019).

A common explanation for the discount is that of compensation to the buyers for providing liquidity (e.g. Maurin et al., 2020; Nadauld et al., 2019). While liquidity provision is likely playing a role (Albuquerque et al., 2018), it cannot be the full story: a quarter of bids arrive at par or at a premium, but still rarely lead to a transaction. In this paper we explore an alternative explanation motivated by the theory of closed-end fund discounts by Berk and Stanton (2007): discounts are informative of future expected fund performance.

The paper finds that cross-sectional variation in bids predicts cross-sectional variation in future fund performance. Sorting funds into quartiles based on the highest bid received during a quarter shows that the quartile of funds receiving the highest bids outperform the quartile of funds receiving the lowest bid by at least 0.102 over three years, measured as a public market equivalent (PME). This is a substantial difference given that the average buyout fund generates a PME of 1.18 over the entire life of a fund. We further find that bids adjust to the point where the hypothetical return to a bidder if a bid would be accepted is not increasing with the size of the discount, except for paper gains at very short horizons.

The results of the paper suggests a high level of sophistication among market participants, despite the scarcity of data available to evaluate private equity funds. This echoes findings in Brown et al. (2019) that investors in private equity funds are not duped by manipulated net asset values. Recent work by Boyer et al. (2019) explore transactions to construct a private equity index, an effort that is complicated by the low frequency of fund transactions. An interesting avenue for future research is whether

[29] This is not true if $\Delta_{f,t}$ is an increasing function of the bid placed. While we cannot guarantee that this is not the case, it seems unlikely as the mechanical impact of shrinking $\Delta_{f,t}$ is an increase in the bid. We also note that a fund may receive multiple bids in a given time period, and among those the Δ will be negatively related to the bid.

information in bids, essentially making up a limit order book, could be used to improve the accuracy of such index.

Figure 1: Global Secondary Transaction Volume

The figure displays annual volumes in the secondary market for private equity fund stakes, as estimated by Greenhill Cogent. Numbers compiled from annual reports of Greenhill Cogent's "Secondary Market Trends & Outlook" published between 2012 and 2020.

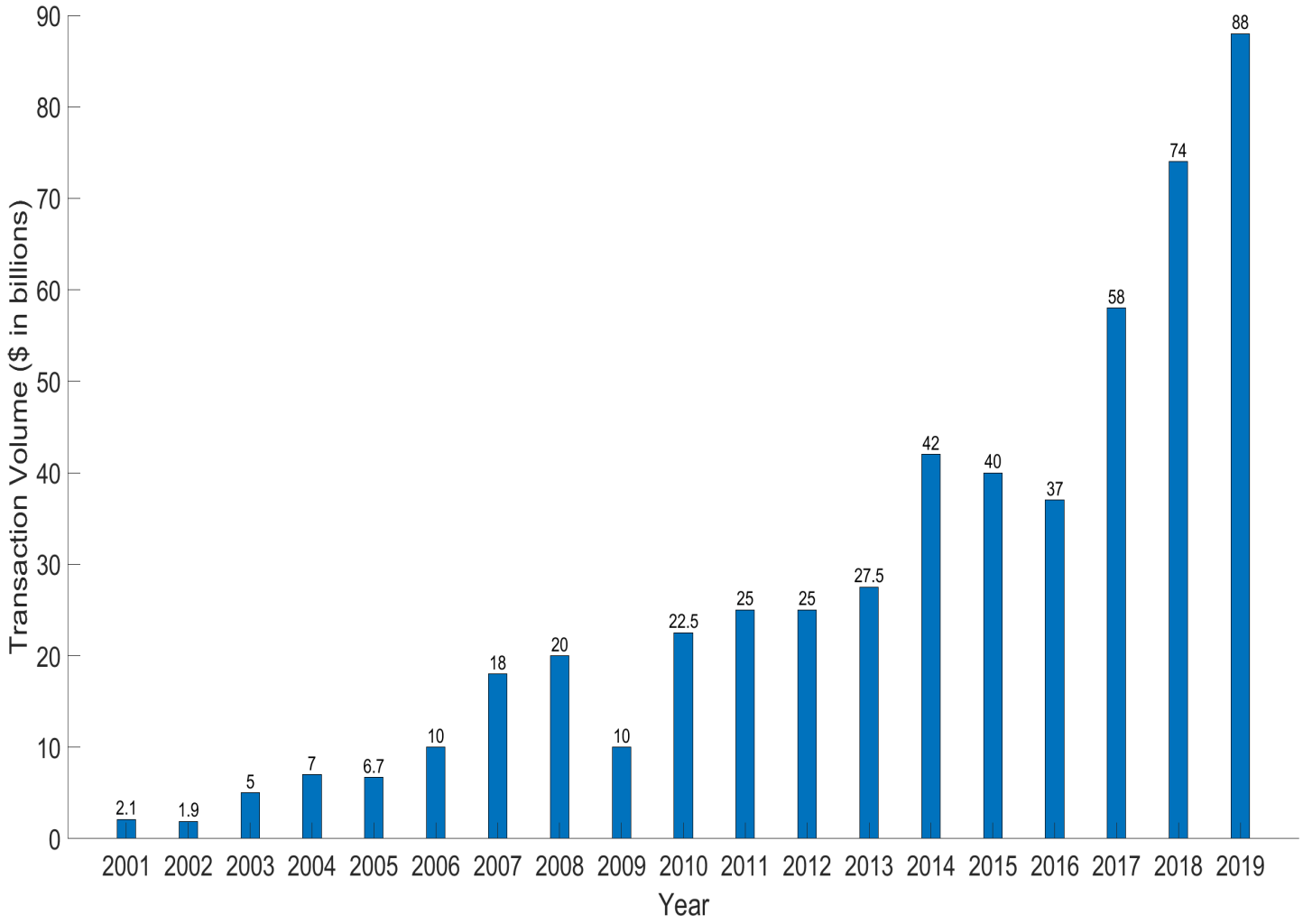


Figure 2: Number of Bids per Month

The figure plots the number of bids per month for buyout funds, venture capital funds and other funds. The series begins in March 2009 and ends in October 2016.

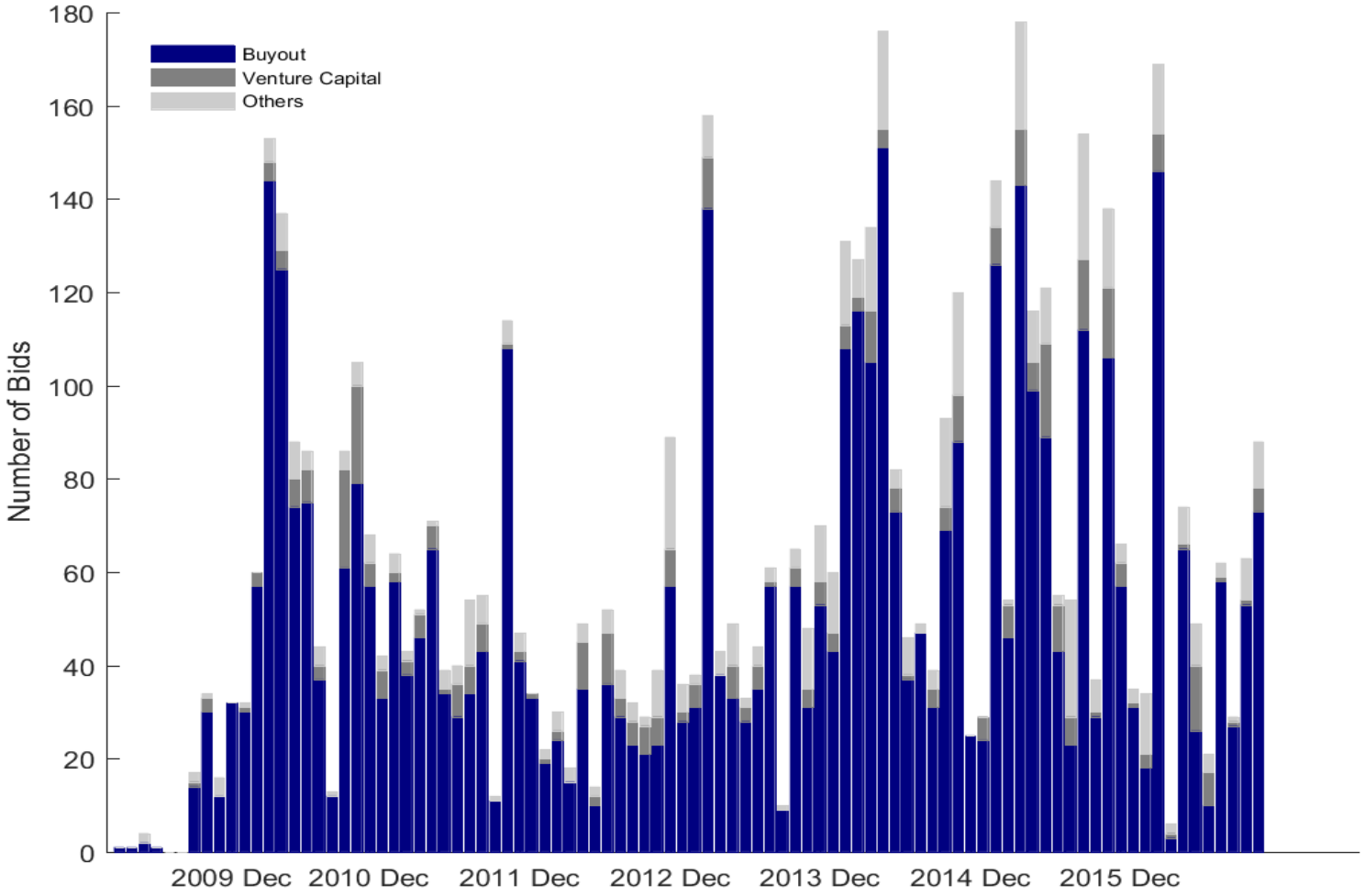
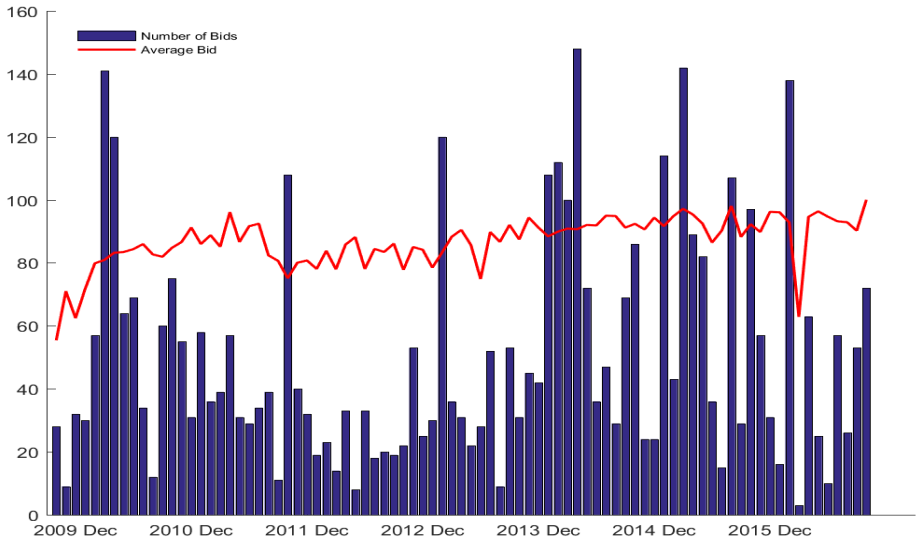


Figure 3: Average Bid over Time (% of NAV)

Panel A displays the monthly average bid on buyout funds from October 2009 until October 2016, together with the total number of bids received in the month. They share a joint scale on the y-axis, with bids displayed as a percentage of NAV, while the number of bids are a total count. Panel B displays the average high bid in our sample compared to the average high bid as published by Greenhill Cogent 2016. We define the 'high bid' as the highest bid a fund receives within a month. The frequency of observations from Greenhill Cogent varies over time. For 2010 through 2013 we have values semi-annually while in 2009, 2014 and 2015 we only observe it once per year. The average numbers presented for our sample is calculated over the matching time intervals. The last point in the figure corresponds to the the first half of 2015.

Panel A



Panel B

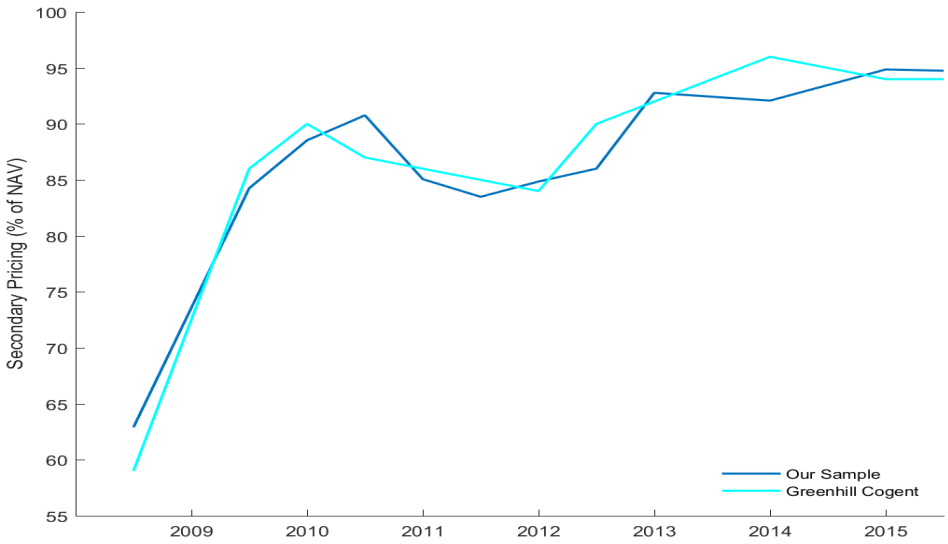


Figure 4: Dispersion of Bids

The histogram displays the fraction of bids that are made within a given bid range in our sample. Each bid range should be read as being $\geq$ low number and $<$ the higher number. The exceptions for this are the '100' category, which contains only bids that are exactly 100%, the '100-105' category, which contains bids that are strictly above 100 and below or equal to 105, and the < 40 and > 105 bins which contains all bids that are strictly below and above those numbers, respectively.

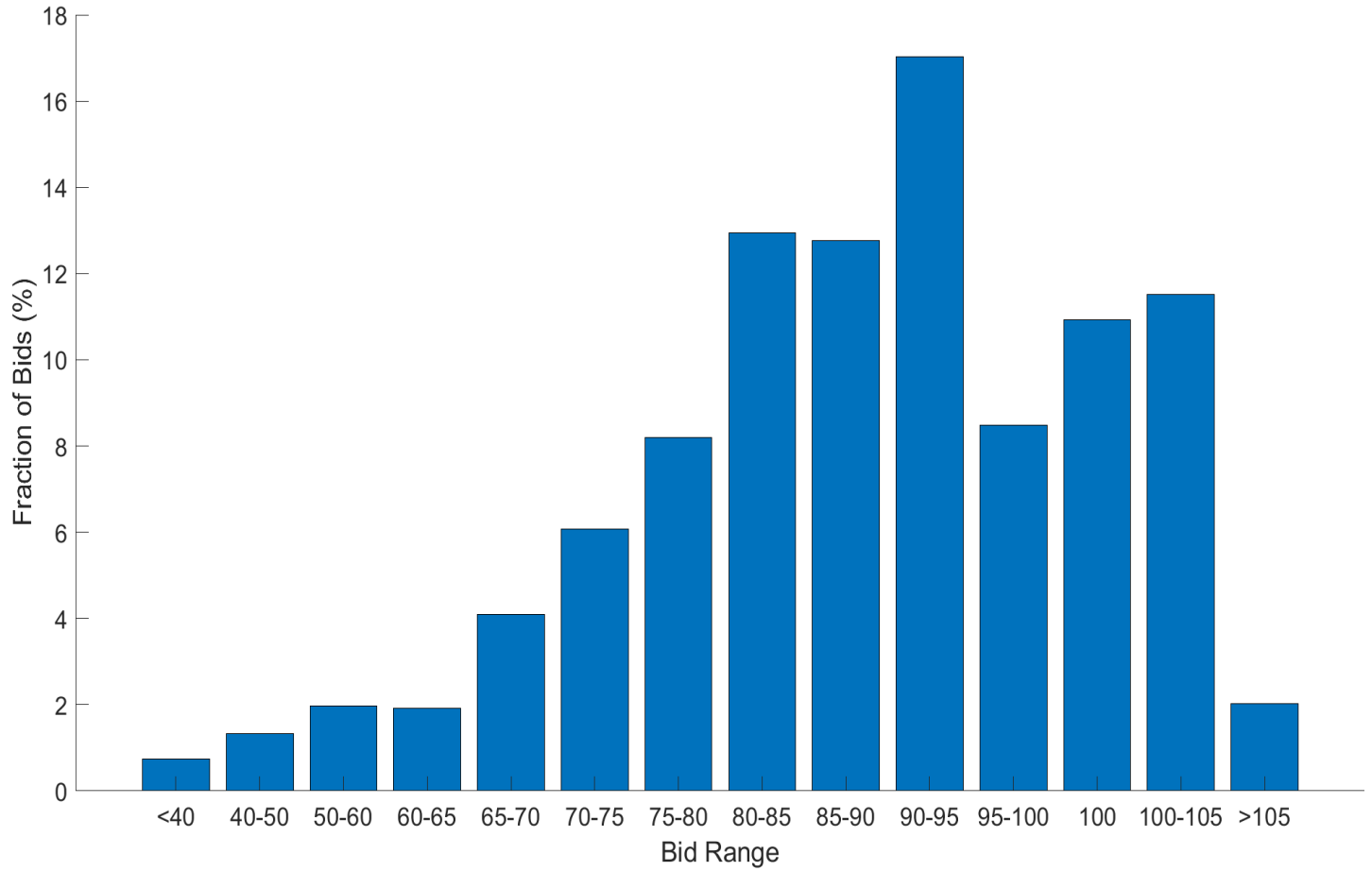


Table 1: Descriptive Statistics

This table reports summary statistics on the funds in the secondary market as well as the average bid. Panel A presents the results weighted by unique bids, by fund-quarter observations or by unique funds. A fund-quarter observation is defined by taking the average of all bids on a given fund within a quarter and treating that as one fund-quarter observation. A fund observation is defined by taking the average of all bids for a fund as one observation. Panel B presents a comparison of funds in the Preqin dataset and funds in our sample. The first column uses all funds in our sample for which we have a match in the Preqin cash flow database. The second column contains funds in our sample which do not exist in the Preqin database. The third column presents corresponding characteristics for funds in the Preqin database which are not part of our sample. The comparison funds from the Preqin database are buyout funds focusing on either US or Europe, they are required to have an NAV reported of at least 10% of capital committed during our sample period and they have a vintage of 2000 or later.

Panel A

	All Bid Observations			Fund-Quarter Observations			Fund Observations		
	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std
Bid	88.2	90.0	12.6	89.4	92.5	11.7	88.9	91.0	11.3
Fraction US Funds	0.31	0	0.46	0.36	0	0.48	0.39	0	0.49
Fund Size ($ billion)	4.8	3.5	4.87	4.3	2.8	4.59	2.3	0.9	3.25
Fund Age (years)	6.6	7	2.7	6.6	7	2.93	n/a	n/a	n/a
Number of Observations	4242	4242	4242	2213	2213	2213	488	488	488

Panel B

Funds in Preqin Dataset	Yes	Excluded	Yes
Funds in our Sample	Yes	Yes	Excluded
Average Bid	88.6	89.2	n/a
Fraction US Focused Funds	0.56	0.21	0.78
Fund Size ($ billion)	3.3	0.9	0.9
Number of Funds in Fund Family	8.1	n/a	5.0
Fraction Low Reputation Fund Family	0.06	n/a	0.09
Fund Performance (PME)	1.16	n/a	1.09
Number of Funds	255	233	287

Table 2: Probability of Receiving a Bid

This table presents the estimates of a logit model of the probability that a private equity fund receives a bid in a quarter. The dependent variable takes the value of 1 in any quarter that a fund receives at least one bid, and zero otherwise. The coefficients show the change in this probability for an infinitesimal (discrete) change in each continuous (binary) variable. The marginal effects are evaluated at the variables' sample means. The standard errors used to calculate z-statistics are reported in parenthesis below each estimate. The model is estimated including a constant and the independent variables are winsorized at the 1% level. The estimation is performed on fund-quarters in Preqin between the third quarter of 2009 and the third quarter of 2016. Only vintages of 2000 or later are included. For a specific fund-quarter combination to be included we require that the fund is no older than 12 years old and that the NAV is at least 10 % of committed capital. All variables are defined in Table B.1. The 'Fraction in Sample' is the fraction of fund-quarter observations in which we observe a bid. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively.

Fund Past Performance (PME)	0.012^{*}	0.026^{***}	0.019^{***}
	(0.0068)	(0.0061)	(0.0062)
Fund Size (log)	0.070^{***}	0.061^{***}	0.059^{***}
	(0.0023)	(0.0020)	(0.0019)
Fund Age	0.037^{***}	0.035^{***}	0.041^{***}
	(0.0034)	(0.0030)	(0.0073)
Fund Age Squared	-0.003^{***}	-0.003^{***}	-0.003^{***}
	(0.0003)	(0.0003)	(0.0003)
Number of Funds in Fund Family	-0.001^{*}	-0.001^{*}	-0.001^{*}
	(0.0005)	(0.0005)	(0.0005)
Low Reputation Fund Family	-0.009	-0.008	-0.006
	(0.0081)	(0.0075)	(0.0067)
US-focused (1/0)	-0.136^{***}	-0.118^{***}	-0.120^{***}
	(0.0061)	(0.0054)	(0.0055)
Quarter Fixed Effects	No	Yes	Yes
Vintage Fixed Effects	No	No	Yes
Fraction in Sample	0.127	0.127	0.127
Number of Observations	10752	10752	10752
Pseudo R^2	0.301	0.354	0.359

Table 3: Determinants of the Bid

The dependent variable is the bid (% of latest reported NAV). A bid of 70% takes the value 70. "Bid Sequence" is the number of bids placed by an investor on the fund in the last 180 days, including this bid. "Same HQ Region" is an indicator variable taking the value of 1 if the head quarter of the bidder and the fund are in the same country, and 0 otherwise. Suppressed from the table are indicator variables for fund size, classifying funds as small, medium (omitted), large, or very large. All variables are defined in Table B.1. Vintage fixed effects are included for all models. Column 3 includes month fixed effects, which is replaced by time-varying variables in columns 4 through 6. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by month, and are reported in parenthesis below each estimate.

	(1)	(2)	(3)	(4)	(5)
Fund Age ≤ 3	-8.21^{***}	-6.02^{***}	-5.79^{***}	-7.28^{***}	-7.91^{***}
	(1.44)	(1.08)	(1.31)	(1.30)	(1.88)
Fund Age ≥ 8	0.11	-1.29	-2.37^{**}	-2.50^{**}	-2.74^{**}
	(1.12)	(0.99)	(1.03)	(1.00)	(1.14)
(log) Bid Sequence	2.14^{***}	2.25^{***}	2.03^{***}	1.83^{***}	1.79^{***}
	(0.59)	(0.52)	(0.60)	(0.68)	(0.66)
Same HQ Region	1.16^{**}	0.73	1.07^{**}	0.95^{*}	0.88
	(0.53)	(0.56)	(0.51)	(0.53)	(0.55)
Bidder is a Fund-of-Funds	-7.12^{***}	-6.23^{***}	-6.90^{***}	-5.11^{***}	-5.07^{***}
	(0.91)	(1.11)	(0.97)	(1.00)	(0.99)
Bidder is a Secondary Fund	-5.45^{***}	-4.67^{***}	-5.44^{***}	-4.45^{***}	-4.17^{***}
	(0.68)	(1.06)	(0.91)	(0.89)	(0.83)
R_m ($t_{NAV} - 1$ year to t_{NAV})			8.54^{***}	8.38^{**}	7.53^{**}
			(1.99)	(3.49)	(3.42)
Price/Earnings Ratio			0.73^{**}	0.81^{**}	0.88^{**}
			(0.33)	(0.36)	(0.39)
Listed Private Equity Discount			22.96	23.62^{*}	23.64^{*}
			(14.35)	(13.89)	(13.91)
Distributions to Paid-in Capital					-4.22^{**}
					(1.72)
Dry Powder (%)					4.96^{*}
					(2.92)
Fund Past Performance (PME)					6.51^{***}
					(1.96)
Adjusted R^2	0.30	0.40	0.34	0.34	0.35
Number of Observations	4242	4242	4242	2905	2905
Fund Size Dummies	Yes	Yes	Yes	Yes	Yes
Vintage Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	No	Yes	No	No	No

Table 4: Funds' Discounted Cash Flows to Net Asset Value ratio

The dependent variable is the ratio of the fund's discounted cash flow to the reported Net Asset Value, minus one. All explanatory variables are demeaned. To be included in the estimation, the fund is required to have an NAV reported of at least 10% of committed capital, the fund should not be older than 10 years, we require that there is data on the fund until at least the fund's sixth year and that there is at least four quarters of cash flow data after the NAV date. Only European and US buyout funds are included in the estimation. We only include NAVs reported in Q3 2009 or later, matching our bid sample. All variables are defined in Table B.1. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by quarter, and are reported in parenthesis below each estimate.

	(1)	(2)	(3)	(4)	(5)
Intercept	0.11***	0.11***	0.11***	0.11***	0.11***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Fund Age ≤ 3	0.35***	0.36***	0.36***	0.36***	0.13***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Fund Age ≥ 8	−0.06**	−0.07**	−0.07***	−0.07***	−0.05*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Small Fund	−0.04	−0.04	−0.04	−0.04	−0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Large Fund	−0.06	−0.06	−0.06	−0.06	−0.05
	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
Very Large Fund	0.11**	0.11**	0.11**	0.11**	0.12**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
R_m (t_{NAV} − 1year to t_{NAV})		0.30***	0.20	0.18*	0.19*
		(0.10)	(0.13)	(0.10)	(0.11)
Equity Market P/E Ratio		0.01		−0.00	−0.00
		(0.01)		(0.02)	(0.02)
Listed PE Price/NAV			0.59***	0.75**	0.78**
			(0.17)	(0.32)	(0.33)
Distributions/Paid-in Capital					0.10*
					(0.05)
Dry Powder					0.55***
					(0.11)
Fund Performance (PME)					−0.08
					(0.07)
Adj R^2	0.16	0.17	0.18	0.19	0.21
N	6412	6412	6412	6412	6412

Table 5: Funds' Performance Post Bidding

The dependent variable is the *Funds' Performance Post Bidding*, defined as the fund's reported PME between the NAV closest following the bid date and 1, 2 or 3 years later. The NAV closest following the bid date is accounted for as an initial investment and the final NAV as a liquidating distribution. The public market index used depends on whether it is a European, US or UK fund. Control variables included are those used in Table 3, though time-varying variables are excluded to allow for time fixed effects to be included. Definitions of all variables can be found in Table B.1. Panel A presents result using the "Bid Placed" variable as a continuously measured bid level, while Panel B replaces it with dummies sorting funds into quartiles based on the highest bid received by a fund within a quarter. The dependent variable in Panel A is a fund's post-bidding performance for each unique bid, while Panel B it is restricted to one fund-observation per quarter. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by month, and are reported in parenthesis below each estimate.

Panel A: Bid measured as a continuous variable

	1 Year Post Bidding			2 Years Post Bidding			3 Years Post Bidding		
Bid Placed	0.166*	0.143***	0.138**	0.031	0.283***	0.245***	0.023	0.339***	0.324***
	(0.091)	(0.052)	(0.064)	(0.122)	(0.078)	(0.073)	(0.101)	(0.103)	(0.102)
Adj R^2	0.01	0.33	0.40	0.00	0.35	0.43	0.00	0.03	0.41
N	2149	2149	2149	1521	1521	1521	1133	1133	1133
Vintage Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Panel B: Funds sorted into quartiles based on bids received in a quarter

	1 Year Post Bidding			2 Years Post Bidding			3 Years Post Bidding		
2nd Lowest Bid Quartile	0.015	0.019	0.015	0.023	0.029*	0.023	0.037*	0.045**	0.038*
	(0.011)	(0.012)	(0.012)	(0.015)	(0.015)	(0.016)	(0.021)	(0.021)	(0.021)
2nd Highest Bid Quartile	0.055**	0.057**	0.055**	0.069**	0.073**	0.069**	0.100***	0.121***	0.103**
	(0.027)	(0.027)	(0.028)	(0.031)	(0.031)	(0.033)	(0.038)	(0.039)	(0.041)
Highest Bid Quartile	0.057**	0.058**	0.057**	0.068**	0.072**	0.069**	0.105***	0.125***	0.103***
	(0.025)	(0.025)	(0.027)	(0.030)	(0.029)	(0.031)	(0.034)	(0.034)	(0.036)
Adj R^2	0.01	0.03	0.12	0.01	0.04	0.15	0.02	0.04	0.16
N	1022	1022	1022	723	723	723	509	509	509
Vintage Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Table 6: Bidders' Performance

The dependent variable is the "Bidder's Performance", defined as the return the bidder would have experienced had the bid been accepted. It is calculated as a PME of the cash flows from the bid date up until the NAV reported 1, 2 or 3 years later, counting from the closest NAV following the bid date. The final NAV is accounted for as a liquidating distribution and the bidded amount, adjusted for cash flows in between the NAV date referred to by the bid and the bid date, as an initial investment. The public market index used depends on whether it is a European, US or UK fund. Control variables included are those used in Table 3, though time-varying variables are excluded to allow for time fixed effects to be included. Definitions of all variables can be found in Table B.1. Panel A presents result using the "Bid Placed" variable as a continuously measured bid level, while Panel B replaces it with dummies sorting funds into quartiles based on the highest bid received by a fund within a quarter. The dependent variable in Panel A is the bidder's performance post-bidding for each unique bid, while Panel B it is restricted to one fund-observation per quarter. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by month, and are reported in parenthesis below each estimate.

	1 Year Post Bidding			2 Years Post Bidding			3 Years Post Bidding		
Bid Placed	-0.317^{***}	-0.312^{***}	-0.331^{***}	-0.446^{***}	-0.117	-0.151^{*}	-0.409^{**}	-0.013	-0.017
	(0.109)	(0.073)	(0.078)	(0.165)	(0.113)	(0.094)	(0.202)	(0.204)	(0.127)
Adj R^2	0.03	0.33	0.40	0.04	0.37	0.44	0.30	0.30	0.41
N	2149	2149	2149	1521	1521	1521	1133	1133	1133
Vintage Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Panel B: Funds sorted into quartiles based on bids received in a quarter

	1 Year Post Bidding			2 Years Post Bidding			3 Years Post Bidding		
2nd Lowest Bid Quartile	-0.004	-0.002	-0.002	-0.003	0.019	0.017	-0.002	0.031	0.027
	(0.020)	(0.026)	(0.028)	(0.031)	(0.036)	(0.037)	(0.047)	(0.052)	(0.051)
2nd Highest Bid Quartile	-0.029	-0.021	-0.021	0.002	0.023	0.021	0.021	0.061	0.059
	(0.026)	(0.029)	(0.030)	(0.056)	(0.061)	(0.061)	(0.054)	(0.058)	(0.058)
Highest Bid Quartile	-0.032	-0.025	-0.026	0.002	0.020	0.019	0.020	0.059	0.056
	(0.025)	(0.031)	(0.032)	(0.052)	(0.054)	(0.056)	(0.052)	(0.063)	(0.062)
Adj R^2	0.01	0.03	0.12	0.01	0.04	0.15	0.02	0.04	0.16
N	1022	1022	1022	723	723	723	509	509	509
Vintage Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Table 7: Funds' Performance Post Bidding by Investor Types

The dependent variable is the "Funds' Performance Post Bidding", defined as the fund's reported PME between the NAV closest following the bid date and 1, 2 or 3 years later. The NAV closest following the bid date is accounted for as an initial investment and the final NAV as a liquidating distribution. The public market index used depends on whether it is a European, US or UK fund. Control variables included are those used in Table 3, though time-varying variables are excluded to allow for time fixed effects to be included. Definitions of all variables can be found in Table B.1. The bid placed variable is interacted with the type of investor, divided into secondary funds, other fund-of-funds, and asset owners (reference group) that group together all other investors such as pension funds, endowments and similarly. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by month, and are reported in parenthesis below each estimate.

	1 Year Post Bidding			2 Years Post Bidding			3 Years Post Bidding		
Bid Placed	0.301^{***}	0.286^{***}	0.281^{***}	0.074	0.411^{***}	0.369^{***}	0.023	0.452^{***}	0.443^{***}
	(0.103)	(0.087)	(0.094)	(0.134)	(0.123)	(0.127)	(0.151)	(0.160)	(0.158)
Bid Placed × Secondary Fund	−0.149	−0.146	−0.138	−0.101	−0.167	−0.154	−0.076	−0.175	−0.166
	(0.096)	(0.089)	(0.092)	(0.104)	(0.134)	(0.126)	(0.156)	(0.147)	(0.145)
Bid Placed × Fund-of-Funds	−0.142	-0.141^{*}	-0.143^{*}	−0.116	-0.158^{*}	-0.151^{*}	−0.081	-0.186^{*}	-0.185^{*}
	(0.091)	(0.078)	(0.078)	(0.108)	(0.086)	(0.081)	(0.120)	(0.104)	(0.105)
Adj R^2	0.03	0.33	0.40	0.04	0.37	0.44	0.30	0.30	0.41
N	2149	2149	2149	1521	1521	1521	1133	1133	1133
Vintage Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Table 8: Bid Levels and Intermediate Fund Returns

The dependent variable is the bid (% of latest reported NAV). A bid of 70% takes the value 70. "Fund Return (t_{NAV} to t_{Bid})" is a measure of the fund's (unreported) return between the date of the reference NAV (the most recent NAV) and the date of the bid. The return is a linearly interpolated return measure, where the return is the ex post realized return between the reference NAV and the first NAV following the bid date. The return is calculated as the increase in NAV between the two dates, net of any intermediate cash flows and as a percentage increase from the reference NAV. R_m (t_{NAV} to t_{Bid}) is measured as the market return between the reference NAV date and the bid date, using a regionally specified index depending on the fund's geographical focus. See Table B.1 for definitions of index used. Control variables are included in all models, and include the set of variables included in model (5) of Table 3, except the fourth column which drops the time-varying economic variables and instead includes month fixed effects. Vintage fixed effects are included for all models. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by month, and are reported in parenthesis below each estimate.

	(1)	(2)	(3)	(4)
Fund Return (t_{NAV} to t_{Bid})	20.33***		22.61***	21.68***
	(5.67)		(5.53)	(5.74)
R_m (t_{NAV} to t_{Bid})		−4.78	−11.22*	
		(4.82)	(6.34)	
Adjusted R^2	0.38	0.35	0.38	0.42
Number of Observations	2788	2788	2788	2788
Controls	Yes	Yes	Yes	Yes
Vintage Fixed Effects	Yes	Yes	Yes	Yes
Month Fixed Effects	No	No	No	Yes

Appendix

A Appendix Figures and Tables

Figure A.1: Characteristics of Funds Targeted by Bidders

The histograms display fund characteristics of funds that receive a bid. Panel A documents the distribution of bids targeting funds of a specific age. Panel B documents the distribution of the ratio of NAV to committed capital at the time of the bid. Panel C presents the fraction of committed capital that has been called at the time of the bid, while Panel D presents the fraction of total fund value, including distributions, that has been distributed at the time of the bid.

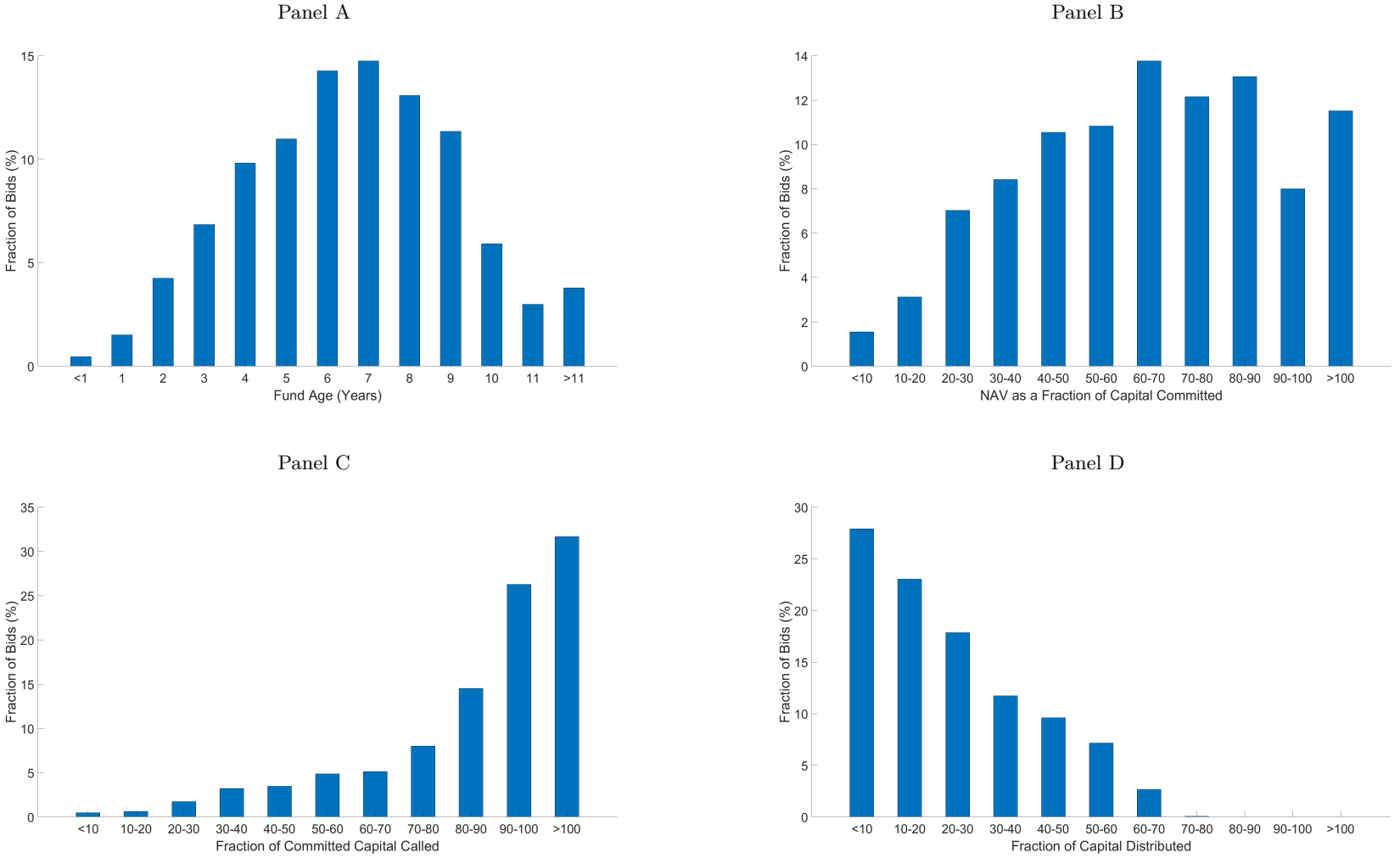


Table A.1: Funds' Discounted Cash Flows to Net Asset Value - Alternative Specification

The dependent variable is the log of the fund's discounted future cash flow (DCF). Statistical significance for the coefficient on (log) NAV is testing whether the coefficient is significantly different from 1. All models include an intercept (not displayed in the table). To be included in the estimation, the fund is required to have an NAV reported of at least 10% of committed capital, the fund should not be older than 10 years, we require that there is data on the fund until at least the fund's sixth year and that there is at least four quarters of cash flow data after the NAV date. Only European and US buyout funds are included in the estimation. We only include NAVs reported in Q3 2009 or later, matching our secondary sample. All variables are defined in Table B.1. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by quarter the NAV is reported in, and are reported in parenthesis below each estimate.

	(1)	(2)	(3)	(4)	(5)
(log) NAV	0.95	0.94*	0.94*	0.94*	1.06
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Fund Age ≤ 3	0.19***	0.22***	0.20***	0.21***	0.07*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Fund Age ≥ 8	−0.09***	−0.11***	−0.11***	−0.11***	−0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Small Fund	−0.06	−0.06	−0.06	−0.06	−0.07
	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
Large Fund	−0.01	−0.01	−0.01	−0.01	0.00
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Very Large Fund	0.13***	0.13***	0.13***	0.13***	0.14***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
R_m (t_{NAV} − 1year to t_{NAV})		0.24***	0.15*	0.15	0.15
		(0.09)	(0.09)	(0.10)	(0.11)
Equity Market P/E Ratio		0.02***		0.01	0.01
		(0.01)		(0.03)	(0.03)
Listed PE Price/NAV			0.77***	0.73**	0.72**
			(0.15)	(0.34)	(0.34)
Distributions/Paid-in Capital					0.09
					(0.06)
Dry Powder					0.54***
					(0.13)
Fund Performance (PME)					−0.05
					(0.08)
Adj R^2	0.59	0.60	0.60	0.60	0.61
N	6412	6412	6412	6412	6412

Table A.2: Bidders' Performance - Common Sample for all Horizons

The dependent variable is the "Bidder's Performance", defined as the return the bidder would have experienced had the bid been accepted. It is calculated as a PME of the cash flows from the bid date up until the NAV reported 1, 2 or 3 years later, counting from the closest NAV following the bid date. The final NAV is accounted for as a liquidating distribution and the bidded amount, adjusted for cash flows in between the NAV date referred to by the bid and the bid date, as an initial investment. The public market index used depends on whether it is a European, US or UK fund. Control variables included are those used in Table 3, though time-varying variables are excluded to allow for time fixed effects to be included. Definitions of all variables can be found in Table B.1. Panel A presents result using the "Bid Placed" variable as a continuously measured bid level, while Panel B replaces it with dummies sorting funds into quartiles based on the highest bid received by a fund within a quarter. The dependent variable in Panel A is a fund performance post-bidding for each unique bid, while Panel B it is restricted to one fund-observation per quarter. All variables are winsorized at the 1% level. ***, **, and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors are clustered by fund ID and by month, and are reported in parenthesis below each estimate.

	1 Year Post Bidding			2 Years Post Bidding			3 Years Post Bidding		
Bid Placed	-0.467^{***}	-0.308^{***}	-0.311^{***}	-0.543^{**}	-0.112	-0.117	-0.409^{**}	0.013	-0.017
	(0.168)	(0.085)	(0.078)	(0.217)	(0.111)	(0.102)	(0.202)	(0.204)	(0.127)
Adj R^2	0.07	0.43	0.50	0.05	0.40	0.49	0.03	0.30	0.41
N	1133	1133	1133	1133	1133	1133	1133	1133	1133
Vintage Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Panel B: Funds sorted into quartiles based on bids received in a quarter

	1 Year Post Bidding			2 Years Post Bidding			3 Years Post Bidding		
2nd Lowest Bid Quartile	-0.005	-0.002	-0.002	-0.004	0.020	0.019	-0.002	0.031	0.027
	(0.029)	(0.033)	(0.034)	(0.037)	(0.040)	(0.041)	(0.047)	(0.052)	(0.051)
2nd Highest Bid Quartile	-0.032	-0.024	-0.023	0.001	0.021	0.019	0.021	0.061	0.059
	(0.029)	(0.033)	(0.035)	(0.059)	(0.062)	(0.061)	(0.054)	(0.058)	(0.058)
Highest Bid Quartile	-0.046^{*}	-0.029	-0.030	0.002	0.021	0.020	0.020	0.059	0.056
	(0.027)	(0.034)	(0.035)	(0.054)	(0.056)	(0.056)	(0.052)	(0.063)	(0.062)
Adj R^2	0.01	0.03	0.12	0.01	0.04	0.15	0.02	0.04	0.16
N	509	509	509	509	509	509	509	509	509
Vintage Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

B Variable Definitions

Table B.1: Variable Definitions

Variable	Description
Dependent Variables	
Bid (% of NAV)	The bid placed for a particular fund, expressed as a percentage of the latest reported NAV. The variable will take the value 80 for a bid of 80%. The variable is used in Table 3.
Funds' Discounted Cash Flows to NAV ratio	The ratio is defined as DCF_t/NAV_t, where NAV_t is the reported NAV at time t and DCF_t is the discounted future cash flows, discounted to time t. DCF_t is calculated as the net present value of all cash flows of the fund that take place after t. If the fund is not fully liquidated at the end of our sample (June 2016), the final NAV has been incorporated in the calculation as a distribution. The discount rate used is the public market return between t and the cash flow. The index used is S&P500 for North American funds, Eurostoxx 600 for European funds, and FTSE 250 for UK funds.
Funds' Performance Post Bidding (X Years)	The fund's performance post bidding is defined as the public market equivalent of the fund between the reported NAV closest following the bid date, and the reported NAV X years later. The first NAV is accounted for as an initial investment and the final NAV as a distribution. The calculation of the public market equivalent is explained in the definition of PME.
Bidders' Performance (X Years)	The bidder's performance is defined as the public market equivalent of all cash flows between the bid date and ending X years later. In the case the date X years later does not coincide with a date at which the NAV is reported, the closest NAV following that date is used as the final time in the calculations. The price paid by the bidder is used as an initial investment. The price paid is the bid % times the NAV referred to by the bid, adding the any capital calls and subtracting any distributions made in between the NAV date and the bid date. The NAV at the final date is accounted for as a distribution. The calculation of the public market equivalent is explained in the definition of PME.
Bid and LP Variables	
Bidder is a Fund-of-Funds	Takes the value of 1 if the bid was made by a fund-of-funds, and 0 if it was made by a secondary fund or a asset owner.
Bidder is a Secondary Fund	Takes the value of 1 if the bid was made by a secondary fund, and 0 if it was made by a fund-of-funds or a asset owner.
Bidder is an Asset Owner	Takes the value of 1 if the bid was made by a asset owner, and 0 if it was made by a fund-of-funds or a secondary fund. The types of LPs included in the asset owner category are: insurance companies, banks, asset managers, government agencies, pension funds, foundations, endowments and others.

(*Continued*)

Table B.1−*Continued*

Variable	Description
Bid Placed	The bid placed for a particular fund, expressed as a fraction of the latest reported NAV.
Bid Sequence on Fund by Bidder (log)	The logarithm of the number of bids the bidder has placed on this particular fund in the last 180 days.
Fund HQ Region is the same as that of the Bidder	Takes the value of 1 if the LP and GP have head quarters in the same region, and zero otherwise. The region is defined as either US, Continental Europe, UK, or the rest of the world.
Fund Variables	
Age	Number of years since the fund's first capital call.
Fund Size (log)	The logarithm of the fund size as reported in Preqin.
Large Fund	Takes the value of 1 if the fund size is more than $1.5 billion but less than $5 billion.
Medium Fund	Takes the value of 1 if the fund size is more than $0.5 billion but less than $1.5 billion.
Number of Funds in Fund Family	The logarithm of the number of funds raised by the GP previously.
PME	The fund's to-date public market equivalent (PME). It is the ratio of the discounted value of all distributions to date (including the latest available NAV in case the fund is not liquidated in the end of our sample) to the discounted value of all capital calls to date. The discount rate used is the public market return, where the index used is S&P500 for North American funds, Eurostoxx 600 for European funds that are not UK funds, and FTSE 250 for UK funds.
Small Fund	Takes the value of 1 if the fund size is less than $0.5 billion.
US Fund	Takes the value of 1 if the fund is a US fund, and 0 otherwise.
Very Large Fund	Takes the value of 1 if the fund size is more than $5 billion, corresponding to the 90th percentile of funds in the Preqin database over the period of our study.
Economy Variables	
Equity Market Price/Earnings Ratio	The aggregate market price/earnings ratio in a given month, provided by Robert Shiller at http://www.econ.yale.edu/ shiller/data.htm. The measure used is the cyclically adjusted price/earnings ratio (CAPE).

(*Continued*)

Table B.1−*Continued*

Variable	Description
Listed Private Equity Price/NAV	A monthly index of the price/NAV, minus 1, of the listed private equity index LPX50 which is provided by the LPX group. The measure corresponds to the percentage premium, or discount, of listed private equity. The constituents of the index for which no NAV is available is excluded from the calculation of this index.
$R_m(t_{NAV}$ to $t_{Bid})$	The public market return between the NAV date and the Bid date. This variable use a regionally specified index depending on the fund's geographical focus. The index used is S&P500 for North American funds, Eurostoxx 600 for European funds, and FTSE 250 for UK funds.
$R_m(t_{NAV} - 1$ year to $t_{NAV})$	The public market return over the year prior to the NAV date. For the secondary data set the 'NAV date' is the NAV date referred to in the bid. The index used is S&P500 for North American funds, Eurostoxx 600 for European funds, and FTSE 250 for UK funds.

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4 The Dynamics of Pay-for-Performance Sensitivity in Private Equity Funds*

I explore the dynamics of pay-for-performance sensitivity in private equity funds arising from carried interest. Carry pay is conditional on beating a hurdle rate, making pay-for-performance sensitivity increase in fund performance. I show that within-fund variation in pay-for-performance sensitivity is positively related to company growth in portfolio companies acquired in buyouts. The effect is stronger when the importance of the direct component relative to the indirect component of pay for performance is high. Exogenous variation is generated by utilizing public market shocks, which impact the NAV of all private equity funds but have a heterogeneous impact on pay-for-performance sensitivity due to funds' varying degrees of capital invested and the non-linear payoff structure of carried interest. My findings provide evidence of the importance of incentives for value creation in private equity.

1 Introduction

Resolving agency conflicts between agents and principals is an important topic in economics and finance. One tool for alleviating such conflicts is to align incentives through the use of performance-sensitive compensation packages. Examples include equity grants and stock options to CEOs, performance-based fulcrum fees in mutual funds, and carried interest in hedge funds and private equity (PE) funds.

Private equity takes an active role in the companies they are invested in, and with $4.1 trillion of assets under management in 2019 (Preqin 2020) the industry is an important actor in the economy. It is therefore important to understand how well carried interest achieves its intended purpose. Compensation to managers of PE funds (general partners, or GPs) usually includes a mix of fixed and performance-based fees (Metrick and Yasuda, 2010). The fixed fee stems primarily from management fees (typically 1.5% to 2.5% of committed capital), while the performance-based fees stems mainly from carried

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interest, where the GP earns a fraction (usually 20%) of fund profits if fund performance exceeds a hurdle rate. Some argue that it is one of the drivers of strong PE returns (e.g. Jensen, 1989; Kaplan and Strömberg, 2009).

A GP's payoff from carried interest is similar to a call option, with the hurdle rate as its strike price. The sensitivity of pay to performance corresponds to the delta of this option. The hurdle rate is fixed and set at fund inception, leading the delta to vary with fund performance. As with call options, the delta is low (high) when a fund is far out of (in) the money.

A PE fund does not invest all the committed capital at once. Instead, it makes staggered investments during an investment period that normally spans five years. Consequently, when making investments late in the investment period, the delta depends on the success of earlier deals. Proponents of PE claim that they add value to their portfolio companies. Presumably, this takes effort on behalf of the GP, and agency theory predicts that we expect higher effort when the sensitivity of pay to performance is higher. In this paper, I ask how variation in a GP's pay-for-performance sensitivity relates to operational improvements at the portfolio companies acquired in buyouts.

The main finding of the paper is that there is a positive relationship between the growth rate of companies acquired in buyouts and the delta of the acquiring PE fund. The results suggest that a one standard deviation increase in delta is associated with between 2.7% and 3.5% higher annual revenue growth, measured from the pre-buyout period and up to four years post-buyout. Delta is not related to improved profitability. While estimates suggest a positive relationship, it is statistically insignificant and the economic magnitude is small.

Earlier studies document that one way PE facilitates growth in portfolio companies is through relaxing credit constraints, allowing for increased investment (Boucly et al., 2011; Cohn et al., 2020, e.g.). Interestingly, the observed positive relationship between company growth and delta does not reflect capital spending. There is not only a lack of significant relationship between delta and asset growth in the target company, the point estimates are consistently negative. This suggests that the results likely reflect organic growth.

This study utilizes a dataset of UK companies acquired in a buyout to measure improvements in operational performance. All companies in the UK, public and private, are required to submit filings to Companies House, the UK national registrar, which makes these filings publicly available. This setting provides two distinct advantages for the study at hand. First, a representative dataset containing both pre- and post-buyout financials can be assembled.[1] Second, UK companies submit annual ownership lists, allowing a

[1]Availability of data on privately held companies is often scarce. Consequently, researchers often utilizes samples containing companies with publicly available financials (e.g. Guo et al., 2011), or samples made available to them by individual investors (e.g. Acharya et al., 2013). Such samples are not necessarily representative. Cohn et al. (2014) document that among public-to-private buyouts, those with publicly available financials perform better than those without. I am not the first to utilize the UK setting for these reasons. Bernstein et al. (2019) examine how PE-backed companies fared during the financial crisis, while Chung (2011) focuses on the impact of PE ownership in private-to-private buyouts.

company to be linked to the acquiring fund. This is crucial as the delta is estimated at the fund level, while transaction databases commonly only list the acquiring PE firm.

To estimate the delta of GP pay I build on the framework developed by Metrick and Yasuda (2010). They provide a model for estimating the expected revenue to a GP, of which carried interest is one part. A PE fund consists of investments in portfolio companies with simulated return paths. Using a set of contractual features, the resulting stream of cash flows is allocated to the fund's investors (limited partners, or LPs) and the GP. In equilibrium, GPs must add value to portfolio companies to compensate LPs for the fees charged, and hence I calibrate the model so that LPs break even. The delta of a GP's compensation is measured as the expected increase in the present value of a GP's payoff from adding $1 extra of value to a portfolio company. To match an additional moment of the data I add leverage to their framework, and calibrate the model to match the empirical default rate in the sample.

To evaluate the dynamics of delta the model is estimated at intermediate points in funds' life, using reported cash flows and NAV valuations from Preqin.[2] I find that the delta is positively related to fund performance, and increasingly so as the fund matures and performance becomes more informative.

The delta captures only the direct pay for performance sensitivity. As documented by Chung et al. (2012), the indirect pay for performance — stemming from improved fundraising prospects — is of at least an equal magnitude to the direct component. They show that the relative importance of the direct component increases with GP experience: GPs with a proven track record are less reliant on current fund performance to successfully raise new funds. Their insight provides a cross-sectional prediction: the observed relationship between delta and operational improvements at target companies should be stronger when the direct component of pay is more important to a GP. Consistent with this prediction, the documented positive relationship is driven by highly reputable funds, with estimates suggesting a larger economic effect. A similar argument can be made for deals completed around successful fundraising events. If investors care mostly about the performance of the most recent fund when deciding to participate in future funds, the indirect pay for performance will drop following successful fundraising. Consistent with this prediction, the positive relationship between delta and operational improvements is stronger for deals completed near fundraising events.

So far, I have documented a positive correlation between a GP's pay-for-performance sensitivity and post-buyout growth in portfolio companies. This may reflect an effect of incentives provided by the pay-for-performance compensation. However, factors related to

[2] A detailed discussion of the model and deviations from Metrick and Yasuda (2010) is deferred to section 2.2 and appendix C.

the delta may be directly related to the operational improvements at portfolio companies. For example, an obvious alternative is that the results reflect managerial ability: GPs skilled at improving operations of portfolio companies likely translate that ability into high fund performance, leading to a high delta. Additionally, there is a time-varying mechanical relationship as PE performance closely follow public markets (e.g. Ang et al., 2018): virtually all funds are in the money when equity markets are doing well. To the extent that expected operational improvements are state-dependent, this leads to a correlation unrelated to incentives.

To overcome these issues, the empirical specification includes fund fixed effects and time fixed effects. The inclusion of fund fixed effects absorbs time-invariant differences in GP ability, and implies that the results of the paper correspond to within-fund estimates. The staggered nature of PE investments provides for natural within-fund comparisons. With the amount of investment capital available to a PE fund fixed at inception, there is no concern that capital flows, and diseconomies of scale, offset increases in delta due to good performance as in Berk and Green (2004).

To further strengthen the interpretation I exploit that the valuation of PE funds move with the public market (Ang et al., 2018), and that the delta increases with fund performance. A public market valuation shock is exogenous and common to all PE funds. While the shock is common, the resulting impact on delta varies between funds. The degree to which a market shock impacts a fund's delta largely depends on two factors: the fund's current performance and the degree to which the fund is invested. To illustrate, the value of a fund that has yet to make its first investment is not impacted at all by market movements, while one that is fully invested will see the value of all its investments impacted. Similarly, a fund far in or out of the money will not be much impacted, while one at the money will experience a big impact. This implies that market shocks can be used to generate exogenous variation in delta.[3]

Extracting the part of delta due to a market shock is done in two steps. First, I estimate what the NAV would have been absent any market movement, using a simple market model. Second, using this counterfactual NAV and the implied counterfactual fund performance, I estimate a delta absent the market shock. The difference between the normal delta and the counterfactual delta is attributable to the market movement.

I confirm the main result of the paper using only the part of delta attributable to market movements. The results suggest that a one standard deviation increase in the market-driven component of delta translates to an increased revenue growth rate of between 1.8%

[3]This strategy is conceptually similar to that used in Shue and Townsend (2017), where they utilize differences in the sensitivity to industry shocks of the value of options awarded to CEOs under fixed-value versus fixed-number option plans.

and 3.9%, depending on the model specification. Again, this growth is neither attributable to increased capital expenditure nor does it come at the expense of worsened profitability.

The paper provides insights to the wider question of how pay-for-performance compensation of managers impacts performance. This question has received considerable attention to in the context of CEOs, but is notoriously difficult to give a convincing answer to. Compensation packages are the outcome of a matching and bargaining process, so manager quality is likely related to both the magnitude and structure of compensation. Managers may influence the process in which compensation is set (Bebchuk et al., 2002) or time the delivery of news to the awarding of stock options (Aboody and Kasznik, 2000; Yermack, 1997); compensation packages can be renegotiated ex post (Brenner et al., 2000); and firms design compensation packages to exploit managerial characteristics such as optimism and overconfidence (Humphery-Jenner et al., 2016; Otto, 2014).[4] The private equity setting overcomes many of these issues as compensation terms are fixed at fund inception. This is similar to Agarwal et al. (2009), that examine how the managerial delta in hedge funds relates to fund performance. The PE setting provides additional benefits as it is a natural setting to perform within-fund estimations allowing the econometrician to control for time-invariant managerial ability. As PE funds are always long the equity market, unlike hedge funds, market shocks can be utilized to generate exogenous variation in delta.

The results of the paper are important for the private equity literature. Carried interest is intended to align the incentives of managers with that of investors, but we lack empirical evidence on the effect of variation in the sensitivity of pay to performance. Hüther et al. (2020) show that VC partnerships with more "GP-friendly" contracts, with carry on a deal-by-deal basis, are associated with higher returns. Robinson and Sensoy (2013) find that funds with higher fees do not deliver lower net-of-fee performance. However, these findings are subject to many of the same endogeneity concerns as the CEO compensation literature, in particular the matching of contract terms and manager quality. In that respect, this study provides additional insights by exploiting within-fund variation in the strength of incentives as well as plausibly exogenous variation.

By examining how the pay-for-performance sensitivity of GPs relate to operational improvements at target companies, the paper contributes to an extensive and growing literature exploring the impact of private equity ownership on the performance of portfolio companies (e.g. Acharya et al., 2013; Bernstein et al., 2019; Bernstein and

[4]Frydman and Jenter (2010) provides a survey of this literature. Notable papers on the efficacy of compensation packages are Jensen and Murphy (1990), showing that CEO compensation is weakly related to the dollar increase in firm value; Hall and Liebman (1998), showing that CEOs compensation is strongly related to the percentage increase in firm value; Yermack (1995), who does not find that stock options appear to be awarded in order to reduce agency costs; and Datta et al. (2001), showing that stronger incentives lead to better acquisitions.

Sheen, 2016; Boucly et al., 2011; Cohn et al., 2014; Davis et al., 2014, 2019; Guo et al., 2011; Kaplan, 1989).

The next section presents the institutional setting, develops the hypotheses of the paper, and outlines the framework for measuring pay-for-performance sensitivity in GPs pay. Section 3 describes the dataset in the paper. Section 4 outlines the empirical approach and presents the results of the paper. Section 5 concludes.

2 Theoretical Framework

This section outlines and discusses the model used to estimate the explicit incentives from carried interest. It begins with a brief discussion of the institutional setting, which is used to develop the hypotheses of the paper.

2.1 Institutional Setting

A private equity fund is a partnership between a group of investors (referred to as limited partners, or LPs), and a private equity firm (referred to as the general partner, or GP). When a fund is raised, LPs commit capital to the fund but do not provide it up front. The GP is provided significant freedom over what to invest in and the timing of those investments, although the fund has a maximum lifetime and a specified investment period. Once an investment is identified (or fees are being collected), the GP "calls" the capital. The amount and timing of capital calls is ex ante uncertain, but LPs are contractually obligated to meet the calls. When investments are exited, the resulting cash is distributed to LPs and cannot usually be recycled in new investments.

The terms of the partnership are defined in a limited partnership agreement which stipulates the length of the investment period, the maximum allowed lifetime of the fund, and the compensation structure to the GP. As documented in Metrick and Yasuda (2010), the most common compensation arrangement for buyout funds includes a 2% management fee and carried interest that gives the GP 20% of fund profits.[5] The vast majority of buyout funds utilizes a hurdle rate of 8% and of those that do, virtually all have a catch-up rate provision. Once a fund's performance reaches the hurdle rate, a catch-up provision allows the GP to receive 100% of the returns until the LPs and the GP are on the pre-specified profit-sharing (e.g. 80/20).

Axelson et al. (2009) provide a model demonstrating how the structuring of deal financing reduces agency conflicts between GPs and LPs. Compared to providing financing

[5]In addition to management fees and carried interest, Metrick and Yasuda (2010) report that buyout funds commonly charges transaction fees and monitoring fees to their portfolio companies. Transaction fees can be considered part of the fixed component of pay, while monitoring fees is often based on EBITDA and hence performance-based.

and compensation on a deal-by-deal basis, compensating GPs with a fraction of the fund's profits reduces the incentive to invest in bad deals. Ex ante committed financing thereby allows GPs to be patient and not rush to deploy capital. However, towards the end of an investment period the GP might not have sufficient discipline to not invest, particularly as the basis for the fixed management fee often shifts to capital deployed past the investment period. By complementing the ex ante equity with deal-by-deal debt financing, the debt providers add discipline which leads to further efficiency gains. While the limited partnership agreement is optimally designed ex ante, it does not perfectly cover all future states. In the model, underinvestment (overinvestment) takes place in bad (good) states of the world, as financing is hard (easy) to come by.

2.1.1 Hypotheses development

In the model of Axelson et al. (2009), GPs are assumed to possess skill in identifying as well as managing their investments. Presumably, the GP has to exert costly effort in order to add value to investments. Agency theory suggests that if managers can exert costly effort to increase performance, better performance is expected when the manager's pay is more sensitive to performance.[6] In private equity, operational improvements are an important way in which private equity funds generate value for their investors.[7]

Thus, the first hypothesis to be tested is

Hypothesis 1. *All else equal, operational improvements observed at target companies are higher when the pay-for-performance sensitivity of the GP's payoff is higher.*

The sensitivity of pay to performance provided by carried interest can be thought of as the expected increase in carried interest for each additional dollar of value added by the GP. This corresponds to the measure used by Jensen and Murphy (1990). The sensitivity of pay to performance mainly depends on the probability that the fund performance exceeds the hurdle rate, as no carry is paid out otherwise, and carry is a fixed fraction of fund profits when it is paid out. The presence of a catch-up rate provision implies a region of outcomes where gains from adding value is higher. Drivers of variation in this measure are discussed in section 2.2, where the model framework used to estimate the pay-for-performance sensitivity is presented.

[6] Jensen and Meckling (1976), Fama (1980), Fama and Jensen (1983a,b) discuss agency issues relating to the separation of ownership and control in firms. Holmström (1979) and Grossman and Hart (1983) provide models of optimal contracts when effort is unobservable and impacts contractable output with noise. There is some empirical evidence that firm value is positively related to managerial ownership and compensation that is more sensitive to firm performance (e.g. Abowd, 1990; McConnell and Servaes, 1990; Mehran, 1995). However, the evidence is mixed. Agrawal and Knoeber (1996) and Demsetz and Villalonga (2001) do not find evidence of a relationship between managerial ownership and firm performance.

[7] Early studies such as Kaplan (1989), Lichtenberg and Siegel (1990), Smith (1990), showed this for management buyouts, and more recent studies such as Guo et al. (2011) and Acharya et al. (2013) confirm the importance of operational improvements to generate returns in buyouts.

The explicit incentive stemming from carried interest is not the only motivation for fund managers to perform well. As demonstrated by Chung et al. (2012) and Barber and Yasuda (2017), high performance increases the likelihood to raise a new fund as well as the size of the fund conditional on one being raised. Thus, the implicit incentive is an important additional driver for GPs. As in Gibbons and Murphy (1992), learning about the ability of GPs is important; performance matters more for fundraising success for young GPs lacking reputation of having successfully managed multiple funds (Chung et al., 2012). Similarly, Barber and Yasuda (2017) document that performance is of much higher importance for the fundraising success of low reputation GPs. This implies that the explicit incentive is relatively more important for high reputation GPs. Indeed, Chung et al. (2012) show that the relative importance of the explicit incentive is increasing in the experience of a GP.

Therefore, the second hypothesis is

Hypothesis 2. *All else equal, the relationship between operational improvements observed at target companies and the pay-for-performance sensitivity of the GP's payoff should be stronger for high-reputation GPs.*

When a GP has successfully raised a new fund there are at least two reasons why attention and effort may be shifted to the new fund. First, if investors care about IRRs when deciding to invest in new funds by the GP, investments early in a fund's life are far more important than later deals, as IRRs are heavily influenced by early cash flows.[8] Second, to the extent that investors pay more attention to the most recent fund's performance when deciding to participate in new funds by a GP, the performance of the newly raised fund becomes matters more for future fundraising success. Both these points suggest that, following successful fundraising, the importance of the explicit incentive relative to the implicit incentive increases in the old fund. Additionally, if the GP's old fund is performing poorly, the direct pay-for-performance sensitivity may be higher in the newly raised fund.

This makes the third hypothesis

Hypothesis 3. *All else equal, the relationship between operational improvements observed at target companies and the pay-for-performance sensitivity of the GP's payoff should be stronger post-fundraising.*

Having established the three hypotheses to be tested against the data, we now turn to the framework used to estimate the pay-for-performance sensitivity of a GP's payoff.

[8] Chung et al. (2012) document that higher IRRs increase the likelihood of fundraising and the size conditional on raising a fund. Larocque et al. (2019) run a horse-race to test whether IRR or TVPI is more important for investors when deciding whether to participate in follow-on funds, and find that IRR is favoured.

2.2 Estimating Explicit Incentives in Private Equity Funds

This section outlines the methodology used for estimating the pay-for-performance sensitivity at various points in a fund's life. Two inputs to the model are from the assembled dataset of UK companies acquired in a buyout. The description of that data is deferred to section 3.

The methodology of the paper builds on the framework developed by Metrick and Yasuda (2010). They model the expected revenue from fees in private equity funds, of which carried interest is one component and the focus of this study. Carried interest can be viewed as a call option on a fraction of the fund's profit, with the hurdle rate acting as the strike price: GPs receive their share of profits only if the fund's performance exceeds the hurdle rate. However, there are several features of private equity funds that make the valuation of carried interest less straightforward than plain call options. A private equity fund is a portfolio of staggered investments; profits from individual investments are aggregated to a fund level; entry and exit dates are ex ante uncertain; and the GP may add value to the investment. This paper largely follows Metrick and Yasuda (2010) in dealing with these issues, and deviations from their framework are clearly noted.

The purpose of this paper is not to evaluate the model of Metrick and Yasuda (2010) but to use it to estimate the pay-for-performance sensitivity of carried interest. Consequently, section 2.2.1 provides only a brief description of their model, while highlighting any alterations made. Section 2.2.2 discusses how the paper estimates the pay-for-performance sensitivity measure. For the interested reader, Metrick and Yasuda (2010) provide an extensive analysis of the impact of altering model inputs, and discuss the assumptions underpinning the model. The qualitative patterns of the pay-for-performance measure in this study are robust to varying model inputs along the lines done in Metrick and Yasuda (2010).

2.2.1 Modelling Expected Carried Interest

This paper follows Metrick and Yasuda (2010) in using Monte Carlo simulations to estimate the expected value of carried interest and other cash flows in private equity funds. A simulation consists of: generating a PE fund portfolio, which consists of investments in portfolio companies; simulating a value path for each portfolio company; simulating exit timings for each investment; generating fees from a set of pre-specified contractual features; attribute cash flows to LPs and GPs; and calculate the present value of these cash flows for a risk-neutral agent.

The value X_t^i of a portfolio company i at time t is assumed to follow a Gaussian diffusion process of the form

$$\frac{dX_t^i}{X_t^i} = rdt + \sigma\left(\sqrt{1-\rho^2}dW_t^i + \rho dW_t^F\right), \tag{1}$$

where W_t^i and W_t^F are two mutually independent standard Brownian motions. W_t^i is specific to the portfolio company while W_t^F is common among all portfolio companies. It is further assumed that the company-specific processes are independent of each other, so that ρ captures the correlation between portfolio companies stemming from a market-wide factor. As in Metrick and Yasuda (2010), ρ is assumed to be 0.2 while the risk-free rate r is assumed to be 0.05.

The simulated X_t^i path captures the total value of the portfolio company. In a deviation from Metrick and Yasuda (2010), this paper includes leverage at the portfolio company level, allowing for the equity position to be wiped out. Interest on debt is assumed to be rolled up for simplicity. If the value of the company at any point prior to the exit date drops to the value of debt, control of the company is transferred to creditors and the equity position is wiped out. This ensures that debt is risk-free, and the interest rate r ensures that debt holders break even.

The inclusion of leverage allows σ to be calibrated to match a moment of the data on portfolio companies: the fraction of buyouts where equity holders are wiped out. Without this calibration, σ has to be assumed. A leverage ratio of 2:1 is used.[9]

As LPs are charged fees, GPs need to add value in equilibrium to ensure that LPs break even. To account for value added, a fixed amount is added to the starting value of each investment. Conceptually, this amounts to adding the discounted value added by the GP to the initial value of the investment.

In practice, the amount of value added required is uncertain at the beginning of the simulation process, as the amount of fees charged is itself a function of value added. Additionally, the added value increases enterprise value which reduces leverage, and therefore lowers the probability of default. Thus, value added feeds into the calibration of σ, which in turn impacts expected carried interest, and hence influence the value added required to ensure that LPs break even. Value added and σ are determined together in an iterative process where one is calibrated after the other. The process is repeated until it converges so that expected present value to LPs after fees equal the present value of their capital calls, and the default rate matches the empirically observed one.

Fixed fees are charged on committed capital during the investment period, and on the remaining investment base after that. The fixed fees plus investment capital equals the committed capital in each simulation.[10]

In Metrick and Yasuda (2010), holding periods are simulated using an an exponential model with instantaneous hazard rate of 0.20 is used, corresponding to an average

[9]The leverage ratio corresponds to the one documented for buyouts in western Europe in Axelson et al. (2013). Alternative leverage ratios lead to different σ, while σ_E remains virtually unchanged.

[10]In Metrick and Yasuda (2010), fixed fees for buyout funds are on average \$11.64 per \$100 of committed capital. The corresponding number in this paper amounts to \$11.01.

duration of 5 years. In this paper the holding periods are drawn with replacement from the empirical distribution of holding periods, described in section 3. In an earlier version, this paper utilized the hazard model approach, with qualitatively similar results. Limited partnership agreements typically preclude holding investments past the 12th year of the fund without explicit LP agreement (Metrick and Yasuda, 2010). Therefore, any remaining investments are liquidated at the end of the 12th year.

The number of investments per fund is set to 16, and the investment pace is set deterministically to be 26%, 23%, 25%, 18%, and 8% over an investment period of the fund's first five year.[11] Both the entry and exit assumptions ignore any timing effects or impact of realized returns on exit decisions. While unlikely to be true, Metrick and Yasuda (2010) document that it does not significantly alter the estimation of fees.

The fund terms assumed are the ones reported to be employed by virtually all buyout funds in Metrick and Yasuda (2010) and Robinson and Sensoy (2013), with: carried interest at 20%; a hurdle rate of 8%; a catch-up rate of 100%; the carry basis being equal to committed capital on the whole fund, rather than measured at a deal-by-deal level; and the management fee is assumed to be 2%, with the basis being committed capital in the investment period and net invested capital thereafter.[12] It is further assumed that all committed capital, increased by the hurdle rate, has to be returned to LPs before the GP gets any carried interest.[13]

Table C.1 gathers model inputs and the sources used to justify model choices. A summary of the model outputs after calibrating parameters is provided in Table C.2, where the are compared to model outputs for buyout funds with comparable fund terms in Metrick and Yasuda (2010). All fees are lower in the model estimated in this paper. Transaction and monitoring fees used here are from Phalippou et al. (2018), which documents lower percentage fees, as well as a higher share rebated to LPs, compared to those used in Metrick and Yasuda (2010). The larger amount of portfolio companies in the fund (16 compared to 11) provides greater diversification, reducing expected carried

[11]The number of investments per fund is taken from Braun et al. (2017), while the investment pace follows Metrick and Yasuda (2010). In section 2.2.2, the estimations will be conducted from a point during the investment period, with some investments already undertaken. In that section, the investment pace is scaled to ensure that any uncalled capital is fully invested at the end of the investment period. As the basis for management fees is often switched to net invested capital from committed capital, GPs have an incentive to ensure that all committed capital is invested. Evidence in Arcot et al. (2015) and Degeorge et al. (2016) is consistent with the idea that GPs accelerate their investment pace at the end of the investment period when they have large amount unspent capital.

[12]Preqin has data on fee structures for a subset of funds in the database. Numbers in Preqin largely support the assumptions used here. Of buyout funds in Preqin with fee data: 96.0% (of 860 funds) have a carried interest of 20%; 94.5% (of 474 funds) have a hurdle rate of 8%; 65.1% (of 573 funds) charge carry on the whole fund; and 75.3% have a management fee of 2%.

[13]There are provisions where the GP can earn carry early, for example when the valuation of a fund's ongoing investments indicates that the fund is in the carry. In such instances there is normally a clawback provision where the GP has to pay back early carry in the event the final performance is not good enough. Such early carry is valuable to the GP due to earlier payments.

interest. With fees lower, the required value added to make LPs break even is reduced, leading to lower net invested capital and consequently reduced management fees, as well as a further decrease in expected carried interest.

The calibrated value added by GPs is \$9.23, while the calibrated $\sigma = 0.174$, corresponding to an equity $\sigma_E = 0.521$.[14] With these calibrations, LPs break even in expectation, and the number of buyouts in which equity holders are wiped out is 19.4%, the fraction of fully exited buyouts where the equity is wiped out, documented in Table 2. These calibrated values are taken as granted when empirically estimating a GP's pay-for-performance sensitivity in the next section.

Appendix C provides further details on the Monte Carlo simulation and the procedure followed to calibrate value added and σ.

2.2.2 Estimating the Pay-for-Performance Sensitivity

We wish to measure the sensitivity of a manager's payoff to increased performance, here interpreted as adding more value to a given investment. In the language of option pricing, we wish to measure the delta of the GP's payoff function. The delta is defined as

$$\Delta = \frac{\partial E\left[\text{GP Payoff}\right]}{\partial \text{ Value Added}}. \tag{2}$$

To operationalize this measure, the delta used in this study will be estimated as the expected change in the GP payoff from adding \$1 extra of value to the next transaction undertaken. This definition allows the delta to be estimated at any point in the fund's life.

It is instructive to examine what we expect will drive variation in Δ. To this end, consider a simple model where a PE fund makes a single investment of \$100 at $t = 0$ and is liquidated at $t = 2$. In each period, the value of the investment increases by $u > 1.01$ with probability p, and decreases by $d = \frac{1}{u}$ with probability $(1 - p)$. Suppose further that there are no fees except for carried interest of 20%, and that there is no hurdle rate.

Figure A.1 draws all possible paths for this investment. At $t = 2$ there are three potential nodes. At each node, C denotes the value of carried interest, with the subscripts uu, ud, and dd denoting the path taken to a particular node. In this simple specification, the GP only earns carry at the top node, with $C_{uu} = 0.2 * 100(u^2 - 1)$. At the middle node, profits in the fund is exactly 0, and as such the GP is just short of earning some carry.

Suppose now that the GP adds \$1 of value at one of the middle nodes, say the down node. This increases the value of the investment at that point to $\$100d + \$1$. If the next draw of the value process is u, the added value ensures that the fund makes a profit of u, and the GP's share from carried interest is $0.2u$. If instead the draw from

[14] Metrick and Yasuda (2010) assume $\sigma = 0.6$.

the value process leads to a down step, the added value is not enough to ensure that the fund makes a profit, and no carry is paid out.

Let C^{Δ} denote the change in carry payment at $t = 2$ due to increasing value by \$1 at an earlier node, with the subscript denoting the path since adding value. C_d^{Δ} thus denote the change in carry if \$1 of value was added at $t = 1$ and the draw reduced the investment value. Similarly, C_{ud}^{Δ} denotes the change in carry if the value was added at $t = 0$, and we end in the middle node. With this terminology we can calculated the GP's pay-for-performance sensitivity Δ as the present value of the expected C^{Δ}.

Figure A.2 summarizes the change in carry C^{Δ} at the end nodes, as well as summarizing the pay-for-performance sensitivity Δ at earlier nodes. The superscript of Δ denotes the time period in which value is added, while the subscript (when applicable) denotes at which intermediate node value is added.

This simple model provide some useful insights into what we expect will drive variation in pay-for-performance sensitivity. First, it is clear that Δ is increasing in fund performance, as illustrated by $\Delta_u^1 > \Delta_d^1$. The reason this is the case is that higher performing funds are more likely to be in the carry, and adding an additional dollar of value therefore generates increased payoffs to the GP with higher probability. Second, if we add additional time periods to the model, we find that nodes of comparable performance generally have a different Δ. The intuition for this difference is similar to that of time to maturity for options: to-date performance becomes increasingly informative of final performance as we approach liquidation.

With the intuition clear, we now turn to empirically estimating Δ. The simulation model described in the previous section described simulating a PE fund from inception. By contrast, here we wish to examine how the dynamics of delta as a fund ages, and how early success, or lack thereof, impacts the delta. Therefore, a major deviation from Metrick and Yasuda (2010) arises from running the simulation at various points in a fund's life, accounting for intermediate cash flows and valuation changes in the fund up until the point the simulation starts. The equilibrium value added, and the calibrated σ, from the previous section are taken as granted in this section.

The following adjustments are made to the estimation of the expected carried interest: the series of cash-flows to-date are used to establish the amount and timing of investments already undertaken, net of estimated fixed fees; the holding periods of current investments are drawn from the empirical distribution of holding periods, conditional on that holding period exceeding the current time the investment has been held; the investment speed of remaining investment capital is scaled so that the fund is fully invested at the end of the investment period; the currently reported NAV is assumed to represent a fair valuation of

investments held to date;[15] as a simulated investment gets the full value added immediately, while in practice any such process would take place over time, a fraction of this amount is assumed to have been incorporated, while the remainder is added at the start of the simulation. The fraction assumed to have been incorporate represents the average duration of existing investments divided by the average holding period of investments.

The model is estimated empirically for all quarters with NAV valuations and cash flow data for buyout funds in Preqin, up until the fund's 20th quarter. For each fund-quarter, the simulation generates 10,000 paths for all portfolio investments. The simulation is performed twice for each fund-quarter, once with and once without adding an additional dollar of value.[16] The delta is measured as the difference in the average present value of GP pay. In total, delta is estimated for 13927 fund-quarters.

Figure 1 summarizes the empirical fit of delta as a function of fund performance and fund age. The figure is generated as the best fit of a simple linear model of fund IRR, fund age measured in quarters, and an interaction of the two. The figure empirically confirms the intuition provided by the simple model earlier: Δ is increasing in fund performance, and increasingly so as the fund matures and fund performance becomes more informative of final performance. The figure is complemented by Table A.1 which summarizes the model fit. Tellingly, while fund performance is relatively informative on its own, the adjusted R^2 increases from 0.136 to 0.468 when interacting it with fund age. While there is much variation not captured by these simple terms, they are clearly important drivers of the variation in Δ. What these results further suggests is that any shock to performance will not impact the delta of all funds equally, as the sensitivity to performance depends on when in a fund's life the shock takes place. We will return to this in section 4.1.3 to generate exogenous variation in delta.

3 Data

This section describes the dataset utilized in this paper. The dataset consists of two parts: i) a partly hand-collected dataset containing accounting data, deal outcomes, and ownership information of UK-registered companies acquired in buyouts; and ii) a Preqin dataset containing fund-level cash flows and valuations.

[15] The number of investments assumed to be held is estimated as the fraction of investment capital that has been spent less any distributions. As we cannot observe the precise timings of each investment nor individual company valuations, the holding period of all investments is assumed be the cash-flow weighted duration of investment capital. The value of each investment is assumed to represent an equal fraction of NAV.

[16] For each fund-quarter, the same seed is used at the start of the simulation process both times to ensure that variation in expected pay is solely due to the increased value added. This significantly reduces the standard error of the estimated delta, giving a high precision with only 10,000 runs. Different seeds are used for each of the 10,000 runs, and for every fund-quarter that delta is estimated for.

The portfolio company level dataset is used to generate inputs to the model described in section 2.2. In particular, empirically observed holding periods are used for investment durations, and the model is calibrated to match the level of deals in which equity holders are wiped out. The deal-level financials are used to measure operational improvements for the purpose of evaluating the hypotheses outlined in section 2.1.1.

To relate the estimated pay-for-performance sensitivities of GPs' pay to operational improvements, we need to know the acquiring fund in buyouts. Transaction announcements usually only contain information about the acquiring PE firm. Ownership filings are used to establish the PE fund providing the financing and, in syndicated deals, the lead investor. Finally, estimating GPs' pay-for-performance sensitivity at intermediate points in a fund's life requires fund-level cash-flow and valuation data, which is what the Preqin dataset is used for.

Appendix B contains additional details of the data collection process.

3.1 Sample Selection

Assembling a representative dataset on portfolio companies owned by private equity is a challenge in any private equity study. As portfolio companies are privately held they have limited disclosure requirements in most countries. Consequently, researchers often rely on a set of companies with publicly available financials (e.g. Guo et al., 2011) or on datasets that have been made available to them by investors or GPs (e.g. Acharya et al., 2013).

In the largest buyout market in the world, the US, financials are generally only available for private companies if they have publicly traded debt or subsequently undergoes an IPO and make financials available for some years prior to the listing. Cohn et al. (2014) document that companies with publicly available financials perform better than buyouts lacking publicly available financials. Davis et al. (2019) document marked differences between different types of buyouts, with employment shrinking in public-to-private buyouts while increasing for other types of buyouts. These studies highlight the need for representative samples containing various types of buyouts.

Cohn et al. (2014) and Cohn et al. (2020) utilize confidential corporate tax return data to track buyouts while privately trading. While corporate tax return data allows a more representative sample, it does not provide the same detailed information that consolidated financial reports do. As an example, Cohn et al. (2014) points out that their analysis relies on tax reporting definitions of revenues and expenses that are subject to efforts to avoid tax payments. Furthermore, the lack of depreciation and amortisation information implies that they are unable to work with the income measure of most interest in buyouts: EBITDA.

In this study I focus on buyouts of companies in the second largest buyout market in the world: the United Kingdom. In the UK, both public and private companies are

required to submit filings to the UK national registrar, Companies House. These filings are made publicly available, and include annual reports containing financials, "annual returns" (more recently "confirmation statements") containing precise holdings of all shareholders in a company, and filings relating to insolvency procedures (called "administration" in the UK). The UK therefore offers a unique setting where a representative dataset of buyouts can be assembled.[17]

To generate a set of buyouts involving UK-registered companies I follow Strömberg (2008) and use the screening tool in Capital IQ. Appendix B describes the screening criteria used in detail. The transaction screening captures buyouts, as defined by Capital IQ, in which a majority ownership stake is sold. Venture capital investments, growth investments and deals for minority stake positions are excluded from the study to ensure a focus on companies in which the acquiring buyout fund has sufficient control to implement changes.

Table 1 outlines the sample construction process. 1964 buyouts of UK companies in the period 1999 to 2018 are identified from the Capital IQ screen. Of these, 850 are randomly selected to be processed. A random selection is necessary due to a substantial amount of manual work required in processing the data.

Of the 850 processed transactions, 59 are dropped for reasons outlined in the table and discussed in Appendix B. The type of buyout is classified for each of the 791 fully processed deals, while the outcome of a deal, or deal exit, is determined in all but 4 deals. This is the largest sample used in the paper, and it provides inputs to the model described in section 2.2.

Company financials are required to measure operational improvements and evaluate the hypotheses outlined in section 2.1.1. To that end, 230 buyouts are dropped that do not have financials available in at least the year prior to the buyout and the year following the buyout, required to measure changes in operating performance around the acquisition event. To be consistent with earlier private equity studies (e.g. Bernstein et al., 2019), a further 69 buyouts of companies operating in the financial (SICs 600-699) or utility (SICs 489-493) sectors are excluded, leaving us with 494 buyouts with financials available.[18]

There are two primary reasons why financials are unavailable: the company lack independent accounts pre-buyout, or consolidated accounts move outside of the UK post-buyout. The majority of cases where pre-buyout financials are missing are divisional buyouts, as not all divisions submit independent annual reports. A typical buyout involves

[17] I am not the first to utilize the UK setting to study private companies. Brav (2009) and Michaely and Roberts (2012) study the UK to gain insights from privately trading companies. In the private equity literature, Chung (2011) examines the effect of buyouts on privately held UK companies. More recently, Bernstein et al. (2019) study how UK companies under private equity ownership fared during the financial crisis.

[18] The results of the paper are robust and remain qualitatively unchanged if we include these sectors. The final sample increases from 246 to 285 when including these sectors.

the acquiring private equity firm setting up one or several shell companies in preparation of the acquisition. In virtually all buyouts, one of these shell companies begins consolidating the financials of the group. I lose access to the accounts, and consequently exclude the deal from the sample, if the top consolidating entity is registered outside of the UK.[19]

Finally, 248 buyouts are excluded because the fund is only involved in a single transaction, or because the Δ of the acquiring fund cannot be estimated due to lack of cash flow data in Preqin. The empirical strategy describe in section 4 utilizes within-fund variation, requiring at least two deals per fund. This leaves the final sample at 246 buyouts.

3.2 Sample Composition

The type of buyout is determined based on the type of ownership prior to the buyout. To establish the exit route I utilize a combination of sources. Capital IQ, Zephyr, and news articles are scanned for information regarding sales. When a sale is identified I corroborate the information through reading annual reports of the acquired company and, when possible, the acquirer.

If no mention of a sale is identified I look at whether the company ended up in insolvency procedures, called being placed in "administration" in the UK. When a company is placed in administration, the administrator regularly submit filings to Companies House on the progress.[20] A company, or part of it, can be acquired out of administration. There are cases in the sample where Capital IQ (and, less commonly, Zephyr) incorrectly attribute the seller in these cases as the PE firm, even when none of the proceeds go to the PE firm. This is why sales identified in the first step are corroborated by reading annual report and searching for potential insolvency.[21]

In the remaining cases I utilize ownership filings to detect when a PE firm ceases to be the ultimate owner. This process either confirms that the PE firm remains the ultimate owner, or document when a change in ownership takes place. In the latter case I consult annual reports to identify the reason behind the change in ownership. This exercise picks up some sales not picked up by the other sources. Typically, these concern small companies

[19] While unconsolidated accounts are sometimes still provided by companies lower in the group structure which may be UK-registered, they are not reliable indications of operational performance as intra-group transactions are not netted out, and various entities in the group may take on different costs. Only the consolidated accounts at the top properly account for everything.

[20] Administration is the UK equivalent of Chapter 11 in the US. The filings submitted by an administrator include: a "Statement of administrator's proposal", which provides background information on the events leading to administration, the strategy and progress to date of the administrator(s), and an assessment of the likely outcome for the various classes of creditors; and semi-annual "Administrator's progress report" outlining the progress of the administrator.

[21] Since the Enterprise Act 2002, administrators can be appointed out of court. This enabled pre-packaged administration, where a sale is negotiated prior to the company being placed in administration, with the sale taking place immediately after. Almost all misclassified sales by Capital IQ relate to pre-administration packages. Even in pre-packaged administration cases the administrator submits filings to Companies House.

that are sold to the management team or other individuals. Importantly, this exercise also picks up cases where creditors seize control of a company by, for example, a debt-to-equity swap, or other events in which the equity holders receive no compensation for their stakes.

Table 2 summarizes the sample in terms of buyout type, exit routes, and holding periods. Panel A presents the composition of buyout types for the full sample as well as four 5-year sub-periods. Buyout types are defined in Appendix D.1. The most common type of buyout in the sample is secondary buyouts with 34.1% of the sample. Secondary buyouts are followed by private-to-private buyouts, with 26.3% of the sample; divisional buyouts, with 23.1%; public-to-private buyouts, with 13.4%; and distressed buyouts, with 3.0%.

The time-trends are depicted on a year-by-year basis in Figure 2. The clearest trend is the increased prevalence of secondary buyouts over time at the expense of the other categories. It is evident in the figure that the sample is weighted towards the earlier part of the sample period, with coverage particularly low for the most recent years of 2016-2018. This raises some concerns about representativeness, and should be kept in mind in the following analysis. However, the time-distribution corresponds to the overall distribution of the transactions identified by Capital IQ, as illustrated in Figure A.3.

Panel B of Table 2 presents the composition of exit routes. The most common exit route, with 31.6% of all transactions, is through a sale to a financial institution. This vast majority of these sales are to other private equity firms. The second most common exit route, with 29.0%, is through a trade sale to another company or the management team. The third most common route, representing 16.2% of all transactions, is losing control either through administration processes or with creditors seizing control without compensating equity holders. Almost as many transactions, 15.9%, remained under private equity ownership as of 2019-09-30. 6.2% of all exits take place through an IPO.

The 16.2% figure (19.4% of exited) of buyouts that end in a exit where the private equity owner receives nothing is high compared to the 8% bankruptcy rate of exited UK deals reported in Strömberg (2008). The discrepancy partly reflect differences in sample period, as the sample in this paper spans the outcome for portfolio companies owned through the financial crisis. Another contributing factor is that, for UK companies, 12% of exits are unknown in Strömberg (2008), compared to 0.5% in this paper. It is plausible that at least part of the 12% unknown exits are less reported outcomes, for example when creditors seize control. In the sample in the paper, 9.4% (11.1% of exited) of the transactions go through formal administration processes while 6.8% (8.1%) are cases where creditors seized control of the business, which are usually only mentioned in the annual reports.[22]

[22]The numbers from Strömberg (2008) are from Table 4, Panel B. The numbers in this study are comparable to the overall bankruptcy rate of 18.4% documented in Table 1 of Degeorge et al. (2016). Note that deals classified as losing control in this paper do not necessarily correspond to a 100% write-off, as there may be intermediate cash flows to the private equity fund.

Figure 3 document the distribution of exit route over time, with transactions grouped by the year of the buyout. The figure documents a clear cyclicality in deals that eventually ends up with the private equity firm losing control. This figure is highest for transactions taking place just before market crashes; 30% of deals completed in 2007 ended with the private equity firm losing control. Figure A.4 depicts the composition of exit routes by the year the exit takes place in, excluding those where the private equity firm remains in control. Interestingly, while 2009 experienced the highest number of companies ending up in financial distress, both in absolute numbers and as a fraction of all exits, the numbers remained above the sample-average up until 2012. In annual reports and administrator reports, it is often mentioned that companies experienced difficulties following the financial crisis, though it took some time before the company entered formal insolvency procedures, or creditors seized control. This may reflect the long maturities on loans documented in Achleitner et al. (2011), or efforts by private equity firms to support their portfolio companies through distressed times as documented in Bernstein et al. (2019).

To put these figures in perspective it is useful to contrast the number of exits in a year with the total number of companies under private equity ownership during the year. Figure A.5 depicts the outcome of all companies that were under private equity ownership for at least part of a year. The figure makes clear that although the rate of losing control is elevated in the period 2008 to 2012, no single year exceeded a failure rate of 7%, as most companies remained under private equity control and overall exit activity was low.

Panel C of Table 2 presents the holding periods, defined as number of years from the transaction date to the exit date, of all exited transactions. The average (median) holding period is 4.99 (4.43) years. Figure A.6 complements the table and presents the holding periods by year of the buyout. For buyouts towards the end of the sample period there is a substantial amount of companies still under private equity ownership, implying that those with holding periods were the ones to quickly exit. The average (median) holding period increases to 5.09 (4.59) if we include only buyouts completed up until 2013, while if we look at only buyouts completed up until 2008 the corresponding numbers are 5.27 (4.88). Overall, the typical buyout in the sample lasts about 5 years, compared to a median of 4.3 years for fully realized deals in Braun et al. (2017) and an average 4.4 years in Degeorge et al. (2016).

3.3 Accounting Data

The accounting data in the study comes from Fame, a Bureau van Dijk (BvD) database. BvD digitalizes the financials available in the scanned annual reports that are publicly available at Companies House. The FAME database provides financials for up to 20

years worth of annual reports.[23] Since my sample period includes transactions as far back as 1999, I have manually complemented the Fame database with pre-buyout financials available in annual reports, downloaded from Companies House, when necessary.

In buyouts, the acquiring private equity firm typically creates one or several acquisition vehicles to facilitate the acquisition. These entities are shell companies with no economic activity on their own prior to the acquisition. Figure A.7 presents a simple example of the change in the group structure of MPM Products, following a buyout by ECI Partners in 2016.

Although all private companies have to file annual reports with Companies House, wholly owned subsidiaries may submit unconsolidated accounts; it is sufficient that one (parent) company in a company group submits consolidated accounts. Unconsolidated accounts can be misleading as they do not net out intra-group transactions, tend to understate costs, occasionally misrepresent turnover, and frequently lack financial information altogether. One of the vehicles created for the acquisition virtually always consolidates group accounts after a buyout. As part of the data collection I document the entity reporting consolidated accounts for each company-year, and merge financials of the different consolidating entities to create a coherent time-series of financials for each target.[24]

It may be instructive to take a concrete example to illustrate why tracking the unconsolidated accounts of the underlying portfolio company can be misleading, even when financials are available. In ECI's buyout of MPM Products, the portfolio company submits unconsolidated accounts post-buyout. For the fiscal year 2017 (2018), the unconsolidated revenue is 7% (11%) lower than the consolidated revenue. While revenue is lower, the unconsolidated accounts understate costs, which means that the unconsolidated EBITDA/Revenue margin is overstated by 1.1 (1.7) percentage units, or 15% (17%) above the consolidated EBITDA margin.

Table 3 presents summary statistics for the portfolio companies in the final sample, measured at the most recent fiscal year-end prior to the buyout. Panel A present summary statistics in levels. The average (median) company in the sample have revenues of £157.2 million (£69.3 million), an EBITDA/revenue margin of 15.9% (14.1%), and 1797 (614) employees. Panels B and C report growth rates leading up to the buyout. At a 1-year (2-year) horizon, the average company increases revenue by 17.7% (49.9%), the number of employees by 11.2% (30.0%), and improve the EBITDA margin by 0.9 (2.0) percentage

[23] Fame covers companies in the UK and Ireland, while Orbis and Amadeus, two other BvD products, have a much wider geographical coverage. The main advantage of Fame is that it provides 20 years data per company, compared to 10 years provided by Orbis and Amadeus.

[24] Fame provides time-series of financials for individual companies, but one needs to manually track the ultimate consolidating entity. Fame does indicate whether financials are unconsolidated or consolidated, but within a group structure there may be multiple entities that consolidate financials at various levels.

points. Panel D presents industry composition. Services is by far the dominant sector covering 45% of all companies, followed by manufacturing (23%) and retail (16%).

To assess representativeness of the subsample used in the analysis, Table A.2 compares the summary statistics to the full sample of 494 companies with financials. Panels A, B and C compares the descriptive financials available. The subsample in the paper contains larger companies on average, having £28.8 million more in revenues and 369 more employees. The companies in the sample have also grown faster prior to the buyout, and are 0.9 percentage units more profitable. Panels D, E, and F document the differences in buyout types, exit routes and industry composition. Consistent with the larger companies in the sample, public-to-private buyouts are overrepresented in the subsample used in the paper. Exit routes and industry composition are both comparable to that of the full sample. It is not too surprising that companies in the sample are larger, as the acquiring fund is required to have Preqin cash flow data available; the average US or European buyout fund with Preqin cash flow data is a $1.7 billion fund, while the average buyout fund in Preqin's larger universe is a $0.9 billion fund. While expected, it is important to keep in mind that the analysis may not be representative of smaller buyouts.[25]

3.4 Fund cash flow data

To estimate the pay-for-performance sensitivity measure of the buying fund we need information on cash flows and NAV valuations. To this end, the buying funds are matched with a Preqin database containing fund characteristics, cash flows, and NAV valuations for a large amount of private equity funds. Fuzzy lookup is used to match funds by name and other identifying information is used to corroborate and resolve any uncertain matches.[26]

Preqin relies on freedom of information requests, as well as voluntary disclosures by GPs, and as such it is likely not a representative of the whole PE universe. As noted in Brown et al. (2015), Burgiss is considered the most accurate and comprehensive database. However, this paper requires access to fund names in order to match the

[25]Compared to recent studies, the companies in the sample are relatively large, with the exception of studies focusing exclusively on public-to-private buyouts. In studies of UK buyouts, the average company has sales of £158.6 million in Renneboog et al. (2007) (public-to-private only), £10.4 million in Chung et al. (2012) (private-to-private only), and £98 million in Bernstein et al. (2019). Comparing to studies in other countries: the average French company has €32.6 million in sales in Boucly et al. (2011); the average company acquired in a private-to-private buyout in the US has sales of $117.4 million in Cohn et al. (2020), while the average company acquired in public-to-private buyouts has sales of $604.2 million in Cohn et al. (2014).

[26]To establish a match, a fund is required to have the same name and sequence number (e.g. EQT IV). In practice, it is common with variations in the names of funds between various databases and the ownership filings (e.g. EQT IV Fund, EQT IV LP, EQT IV LLC, etc.). Furthermore abbreviations are often used in one place (e.g. GTCR Fund VII) while another spells out the full name (e.g. Golder Thoma Cressey Rauner VII). To ensure that matches are accurate, a name match is corroborated through sanity checks utilizing a fund's vintage year together with the transaction date, and whenever available the fund listed in Capital IQ as the acquiring fund is utilized.

buying fund to performance data. As Burgiss is provided on an anonymized basis to researchers, it is not suitable for this study. The dataset with the best coverage that allows matching on fund names is the Preqin database which is used in this study. Brown et al. (2015) and Harris et al. (2014) find that the overall performance of buyout funds is similar between the Preqin and Burgiss databases.

4 Results

This section develops the empirical approach taken to test the hypotheses in section 2.1.1 and present the results of the paper.

4.1 Operational Performance and Pay-for-Performance Sensitivity

We are interested in how operational improvements at portfolio companies are related to the sensitivity of a GP's pay-for-performance sensitivity, defined in section 2.2.1.

As there is not a single measure of operational performance, the analysis will utilize several different dependent variables. To facilitate the current discussion I focus on revenue growth. It is not clear at what horizon we might expect any improvements to occur, or whether they will be persistent. Revenue growth will therefore be measured from the pre-buyout period $t-1$ to various post-buyout periods $t+x$. The following equation is estimated,

$$\begin{aligned} Y_{i,j,t-1:t+x} =& \alpha + \lambda \cdot \Delta_{j,t} + \phi_j + \phi_t + \sum_{s=1}^{5} \beta_s 1\{\text{fund age}_t = \text{s}\} \\ &+ \Gamma_1 X_{i,t-1} + \Gamma_2 X_{i,t} + \epsilon_{i,j,t}, \end{aligned} \tag{3}$$

where $Y_{i,j,t-1:t+x}$ is the annualized revenue growth between $t-1$ to $t+x$ of portfolio company i, acquired by the private equity fund j in year t. $\Delta_{j,t}$ is the pay-for-performance sensitivity of fund j measured at the most recent NAV prior to the transaction.

The coefficient of interest is λ, which captures the relationship between the pay-for-performance sensitivity and revenue growth.

The set of controls included is rather strict, but is chosen to avoid omitted variable bias. In section 2.2.2 we established that $\Delta_{j,t}$ is increasing in fund performance. If there is heterogeneity in ability among GPs, we expect high ability GPs to have higher Δ as well as to be associated with larger operational improvements in portfolio companies. If the ability of a fund-manager does not change over a fund life, we can take out this effect by including fund fixed effects ϕ_j, and the resulting estimation corresponds to a within-fund estimate. The private equity setting lends itself well for within-fund estimations: as carried interest is based on fund profits, the staggered nature of investing naturally leads to deals being undertaken under varying $\Delta_{j,t}$.

We include time fixed effects ϕ_t as the performance of private equity funds, and consequently $\Delta_{j,t}$, is related to overall market movements (e.g. Ang et al., 2018). To the extent that operational improvements are easier to implement in certain states of the economy, we need to control for market conditions.[27]

Indicator variables denoting the year in which an investment is made are included to take out some possible mechanical changes in $\Delta_{j,t}$. Private equity funds often experience a "J-curve" effect, where performance is low in the early years due to fees being collected on committed capital, while gains arise only from invested capital. Including indicator variables for fund age also serve to mitigate concerns that private equity funds might invest in different types of companies at different stages of the fund life.[28]

Finally, we may expect some portfolio companies to be more likely to improve operations. For example, private equity are more likely to be able to relax credit constraints of small private companies than of large, publicly traded ones. The model therefore includes a set of company characteristics $X_{i,t-1}$, measured prior to the buyout, to control for any impact of observable characteristics. The included controls are (log) revenue, (log) total assets, and EBITDA/revenue profitability. The book leverage, measured in the fiscal year of the buyout, is included in $X_{i,t}$.

The results for annualized revenue growth are presented in Panel A of Table 4. The results show that a GP's pay-for-performance sensitivity is positively associated with revenue growth for all horizons, though not statistically significant at the $t-1$ to $t+1$ horizon, and only at the 10% level for the $t-1$ to $t+2$ horizon. The coefficient estimates suggest that the economic magnitude is sizeable. A one standard deviation change in $\Delta_{j,t}$, 0.0242 in the sample, is associated with an increase between 2.7% and 3.5% in the rate of revenue growth.

Panel B examines company growth using an alternative measure: employee growth. This measure largely confirms the positive association of $\Delta_{j,t}$ with company growth, though it is only statistically significant for two horizons, $t+2$ and $t+3$. The point

[27] Boucly et al. (2011) and Chung (2011) show that one way in which private equity help portfolio companies is by relaxing credit constraint to facilitate growth. Presumably, the ability to do so depends on credit conditions in the market. As an example, Bernstein et al. (2019) document that investment decreased for all portfolio companies after the financial crisis, though private equity backing mitigated the decrease relative to matched controls. Davis et al. (2019) find that productivity improvements at target companies are larger when credit conditions are tight. The type of company invested in may also differ at different market conditions. Nanda and Rhodes-Kropf (2013) document that venture capital funds invest in riskier and more innovative companies during hot markets.

[28] Arcot et al. (2015) and Degeorge et al. (2016) document that secondary buyouts perform poorly when made late in the investment period if the GP has significant unspent capital. Among venture capital funds, Barrot (2017) find that venture capital funds with longer remaining horizons invest in companies at earlier stages of their development. In terms of GP age, Ljungqvist et al. (2020) document that young GPs invest in riskier companies to establish a track record. I return to this when examining the impact of GP reputation on the estimates.

estimates suggest that a one standard deviation increase in $\Delta_{j,t}$ is associated with 4.1% to 4.6% higher growth rates.

While these results are interesting, they may simply reflect an increased tendency to engage in capital-intensive growth strategies when $\Delta_{j,t}$ is high. Boucly et al. (2011) and Chung (2011) find that both sales and CAPEX increase following a buyout, which they interpret as evidence that private equity ownership relaxes credit constraints. Similarly, add-on acquisitions are common in buyouts, taking place in at least 41.3% of deals in Cohn et al. (2020).

To examine if this is driving the relationship of $\Delta_{j,t}$ with company growth, Panel C examines growth in total assets as the dependent variable. Somewhat surprisingly, the relationship between $\Delta_{j,t}$ and asset growth is not only statistically insignificant, the coefficient is negative at all horizons. It appears as if the growth at the company level is not due to more capital being spent, but instead reflects higher organic growth.[29]

Panel D presents results examining whether $\Delta_{j,t}$ is associated with improved profitability at the portfolio companies. While the coefficient is positive, it is both statistically insignificant and economically small.

The results provide evidence in support of Hypothesis 1 as higher GP pay-for-performance sensitivity is positively related to increased company growth that is not due to increased capital expenditure. To the extent that GPs improve profitability at their portfolio companies, such improvement appears to not be related to the pay-for-performance sensitivity of the GP's payoff.

Given the relatively small sample size of the paper, one may naturally worry that the documented results are dependent on the specific set of controls included. To examine the robustness of the results presented, Table A.3 summarizes the main result on revenue growth for various model specifications. Regardless of specification, the estimated coefficient is always positive. As in the main table, it is not statistically significant for the $t-1$ to $t+1$ horizon. For the $t-1$ to $t+2$ horizon it is statistically significant in four out of seven specifications. For the $t-1$ to $t+3$ and $t+4$ horizons the coefficient is statistically significant in every specification except for the $t+3$ horizon with no controls included. Overall, the result appears robust, especially for the longer time horizons.[30]

[29]Total assets is examined here as it incorporates goodwill that often arises from add-on acquisitions. However, growth in total assets also captures goodwill from the initial buyout. In untabulated results I strip out the effect of growth in goodwill and other intangible assets, by replacing total asset growth with growth in tangible assets. The qualitative patterns in Panel C remains unchanged for all tables presented in the paper using this alternative measure of capital expenditure.

[30]For brevity, similar tables are not presented for the other three measures of operational improvements. For employee growth, the results are similar to those in Table 4 for all specifications, with a significant positive coefficient for the horizons $t-1$ to $t+2$ and $t+3$. The main exception is a lack of significance when only including time fixed effects. The relationship with asset growth remains statistically insignificant, and is negative in all specifications with the exception of the $t+1$ horizon for the first four specifications. For profitability margin the relationship is positive in almost all specifications, while always economically small and statistically insignificant.

Table A.3 suggests that the explanatory power of $\Delta_{j,t}$ is small, particularly on its own. In the baseline specification with all controls, the inclusion of $\Delta_{j,t}$ increases the adjusted R^2 by between 0.020 to 0.026 in the three longer horizons. For the $t-1$ to $t+1$ horizon the contribution is negligible.

Another concern is that the results may reflect the continuation of a pre-trend, where GPs with high pay-for-performance sensitivity acquire companies with higher growth rates. As the estimation is essentially a continuous difference-in-difference estimate, we want to ensure that we have parallel trends prior to the buyout.

To this end, we can pool observations in the years around the buyout, and estimate separate coefficients for the fund's $\Delta_{j,t}$ for each year around the buyout event. Let t denote the (fiscal) year in which the buyout takes place, and $t+s$ the years around the buyout. We can formally test the parallel trends assumption by estimating

$$\begin{aligned} Y_{i,j,t+s} =& \alpha_i + \sum_s \lambda_s \cdot \Delta_{j,t} + \phi_j + \phi_t + \sum_{k=1}^{5} \beta_k 1\{\text{fund age}_t = \text{k}\} \\ &+ \sum_s \gamma_s + \Gamma_1 X_{i,t-1} \cdot Post_{t+s} + \Gamma_2 X_{i,t} \cdot Post_{t+s} + \epsilon_{i,j,t+s}, \end{aligned} \tag{4}$$

where $Y_{i,j,t+s}$ is the company revenue at time $t+s$, which is s years from the buyout. Unlike the previous tables, revenue is measured in levels, and consequently we will use log revenue. α_i is a company fixed effect. We estimate a separate coefficient λ_s for $\Delta_{j,t}$ for each year around the buyout, with $t-1$ left as the reference year. Similarly, γ_s are indicator variables for each of the years around the buyout, with $t-1$ as the reference year. As before, ϕ_j, and ϕ_t denotes fund fixed effects and fixed effects for the year of the transaction, respectively. The company control variables $X_{i,t-1}$ and $X_{i,t}$ are here interacted with a post dummy, taking the value 1 for all years after the buyout event, and 0 otherwise.

Table A.4 presents the results of this estimation. Columns 1–3 have log revenue as the dependent variable while columns 4–6 presents the results for the EBITDA margin. Overall, the results are largely consistent with the main table, with a positive relationship between a GP's pay-for-performance sensitivity and revenue growth, while there is no consistent relationship with profitability. As in the main table, the relationship between $\Delta_{j,t}$ and revenue is stronger at longer horizons.

It is worth nothing that the coefficients on $\Delta_{j,t}$ and revenue are consistently positive, albeit statistically insignificant, in the pre-buyout years. While it might have been more comforting if they had been closer to zero, the pattern does not cause much reason to be alarmed. If the trend observed was one of a monotonically increasing coefficient, whose increase continued post-buyout, it would appear as if a trend simply continued. This is not the case however. All estimates are relative to the reference year $t-1$. A positive coefficient for $\Delta_{j,t}$ in $t-3$ therefore suggests that companies acquired by

GPs with a high pay-for-performance sensitivity experienced a slower revenue growth between $t-3$ and $t-1$, compared to the average company. In all specifications, the coefficient is lower in $t-2$ than in $t-3$. If anything, the trend is going in the opposite direction and is reversed following the buyout.

While untabulated for brevity, the qualitative patterns are similar to the main table for the log of total assets and the log of number of employees. The results presented in the next two subsections are also qualitatively similar to those examined here when estimating a parallel trends specification.

4.1.1 Impact of reputation

The measure of pay-for-performance sensitivity used in this paper covers the direct part of pay for performance. However, performance is also relevant for fundraising success and thus indirectly providing pay for performance. Performance matters less for fundraising success of highly reputable GPs (Chung et al., 2012; Barber and Yasuda, 2017). Therefore, the direct component of pay for performance is relatively more important for high reputation GPs. We now turn to examine Hypothesis 2, which predicts that the observed relationship between $\Delta_{j,t}$ and company growth should be stronger for highly reputable GPs.

The paper follows Barber and Yasuda (2017) in defining a low reputation GP. A GP is classified as low reputation if it has: cumulatively raised less than $1 billion prior to the current fund; have raised less than three funds in the past; and have no past top quartile funds that are five years or older at the time the new fund is raised. High reputation is the complement to low reputation funds. To construct this measure I utilize the Preqin universe of funds, and rely on their classification of the quartile in which a given fund's performance belongs to. While their classification is based on IRRs, there are many more funds with this information available than there is with cash flow data which would allow me to manually construct a quartile ranking based on, for example, a public market equivalent.

Table 5 presents the results from estimations of an augmented version of (3), where a separate coefficient for $\Delta_{j,t}$ is estimated for high and low reputation GPs, and by adding a dummy variable indicating whether the acquiring fund in a given deal belongs to a low reputation GP.

The table makes clear that the results in Table 4 are largely driven by high reputation GPs, where we expect the direct pay-for-performance sensitivity of payoffs to be relatively more important. The one exception to this general trend is the $t-1$ to $t+4$ horizon, where the estimated coefficient, though statistically insignificant, is higher for low reputation funds. It is worth noting that at this horizon, there are only 17 observations relates to transactions made by low reputable funds.

The statistical and economic significance of the estimates are generally higher for high reputation funds compared to the baseline specification. For revenue growth, the point estimates suggest that a one standard deviation increase in $\Delta_{j,t}$ is associated with as much as 5.2% higher annual growth rate, though it is reduced to 2.7% at the $t+4$ horizon. The corresponding numbers for employee growth are a 5.4% and 4.5% increased growth rate for the $t+2$ and $t+3$ horizons, respectively. The pattern is similar to the baseline specification for growth in total assets and profitability improvements, with all coefficients being statistically insignificant.

While not tabulated, the estimated coefficients for $\Delta_{j,t}$ are only statistically different for high and low reputation GPs in a few model specifications. In panel A the high-reputation $\Delta_{j,t}$ is statistically higher than the low reputation one at the 10% level for the $t-1$ to $t+1$ and $t+2$ horizons, and in Panel D at the at the 5% level in the $t-1$ to $t+2$ horizon. None of the other estimated coefficients for high-reputation $\Delta_{j,t}$ are statistically different from the estimated coefficients for low-reputation $\Delta_{j,t}$.

The evidence is therefore largely consistent with Hypothesis 2, but we cannot rule out that the observed pattern reflects imprecisely estimated coefficients. In particular, the evidence for the $t-1$ to $t+4$ horizon is not consistent with the hypothesis.

At this point it is worth to consider an alternative explanation to our results. It is possible that the increased growth is not caused by any type of added value to the company but rather a shift in risk. If high-growth strategies are inherently risky, the higher growth rate could be accompanied by an increased risk of default. While there is no apparent relationship between $\Delta_{j,t}$ and a deterioration in profitability, this could be due to a form of survivorship bias in the data: companies that enter insolvency processes tend to not submit their accounts in the last fiscal year prior to entering insolvency processes. Similar omissions may as well take place when creditors seize control, if it happens close to the end of a fiscal year. If high-growth strategies are riskier, we would then observe more years of the ex post successful ones. With 23.3% of all realized exits in the sample analyzed here end up with the equity position wiped out, this is a serious concern.

If this drives our results, we expect a fund's $\Delta_{j,t}$ to be positively related to the probability of default. Table A.5 presents estimates of the probability that a deal ends up in formal insolvency procedures, gets seized by creditors, or the private equity firm loses control in a financial restructuring. The first five columns present OLS estimates of a linear probability model, while the last five columns present estimates from a logit model. An OLS estimate is presented as an alternative due to the inclusion of fixed effects in some specification, which may lead to an incidental parameter problem.

Panel A presents estimates for the relationship of a fund's delta to the risk of bankruptcy, while Panel B allows for a differential effect depending on whether a fund

is managed by a high or low reputation GP. All estimated coefficients in Panel A are statistically insignificant, are are consistently negative across all specifications. In Panel B, it is clear that the negative coefficient is driven by high-reputation funds, as the coefficient is larger in magnitude, while coefficients for low-reputation funds are consistently positive. Again, none of the coefficients are statistically significant, and neither is the difference between coefficients of high- and low-reputation GPs. As our previous results refer to high-reputation funds, these estimates suggest that it is unlikely that they are driven by risk taking and survivorship bias in the data.[31]

4.1.2 Deals made close to fundraising events

As the implicit incentive largely stems from the need to perform well in your current fund to raise another one, studying periods around successful fundraising could be informative. There are three reasons to expect a stronger relationship for deals made close to a fundraising event. First, Larocque et al. (2019) document that IRR is of higher importance to investors than money multiples in decisions to participate in new funds. As early cash flows are disproportionately influencing IRRs, the implicit incentive to perform well is much stronger in a newly raised fund. Second, to the extent that investors care mostly about the performance of the most recent fund, a successful fundraising lowers the relative importance of implicit incentives in the old fund. Third, when allocating scarce resources between funds, GPs may shift resources to the one with the most potential gains. The $\Delta_{j,t}$ of the old fund is then increasingly relevant relative to that of the new fund; if a GP is currently far out of the money there is little incentives to spend scarce resources on the older fund. Taken together, we expect the importance of $\Delta_{j,t}$ to be larger for deals executed close to a fundrasing event.

To operationalize this, I define the end of a successful fundraise as the first quarter in which the successor fund has a capital call or, in the absence of cash flow data, the second quarter of the vintage year of the successor fund. Fundraising campaigns may last up to more than a year and a half (Barber and Yasuda, 2017), and the first capital call is likely to occur at some point after successfully raising a new fund. Consequently, a transaction is therefore classified as being completed "close to fundraising" if it is completed within eight quarters of the fundraising. This clearly captures some buyouts completed during the fundraising period, and likely some completed prior to the fundraising campaign started. It is still considered a useful albeit arbitrary cutoff, as the GP would have to fundraise with to-date fund performance which is unlikely to include very recent

[31] For brevity I do not present similar analysis for the next two subsections, though the patterns are qualitatively similar.

transactions.[32] Additionally, most of the evaluated performance of the portfolio company will cover the period outside of the fundraising period.[33]

Table 6 presents the results of estimating separate coefficients for $\Delta_{j,t}$ for transactions completed close to fundraising and those far from fundraising. Compared to the baseline estimations, the estimated coefficient on $\Delta_{j,t}$ is higher when the fund is close to fundraising for both revenue growth and employee growth, for all horizons except the $t-1$ to $t+4$ one. The economic magnitude for a one standard deviation increase in $\Delta_{j,t}$ translates to between 6.0% and 8.4% higher annual revenue growth for the three horizons for which the coefficicents are statistically significant. The corresponding numbers for employee growth are between 5.7% and 7.1% higher growth rates. Interestingly, total asset growth is negatively related to $\Delta_{j,t}$ for deals completed close to fundraising at the $t-1$ to $t+2$, $t+3$, and $t+4$ horizons. This suggests that, if anything, the estimates on revenue growth are understated. There is also weak evidence of improved profitability at the $t-1$ to $t+4$ horizon, but as it is not consistent over multiple horizons it is not very convincing.

For revenue growth, the estimated coefficients are larger for deals completed close to fundraising events than those far from fundraising events. The difference is statistically significant at the 10% level for the first three horizons. A similar picture is true for employee growth, though the coefficients are only statistically different at the shortest two horizons at the 10% level. For total asset growth, the coefficients for statistically smaller for deals completed close to fundraising events than those estimated far from fundraising events, significant at the 5% level for the $t+2$ horizon, and at the 1% level at the $t+3$ and $t+4$ horizons. The profitability estimates are statistically different at the 5% level at the longest horizon. Overall, the results are largely consistent with Hypothesis 3.

4.1.3 Public market movements as exogenous shocks

While previous sections have utilised controls to attempt to control for expected confounding factors, it is difficult to argue that the remaining variation is truly exogenous. Here we will utilize changes that is outside the control of GPs: movements in the stock market. The aim is to get heterogeneous variation in our measure of pay-for-performance sensitivity from an exogenous shock, while at the same time control for overall economic conditions that may otherwise be related to operational improvements.

[32] On a practical note, there are only 7 transactions in the sample that took place after the defined fundraising event.

[33] The results presented are robust to alternative windows defining a transaction as being "close to fundraising" if it is completed between ten to six quarters prior to a fundraising event. The definition used here would classify a fund as being "far from fundraising" if a successor fund was never raised. In Brown et al. (2019) they assume that such funds attempt to fundraise towards the end of the fund life. In this paper such assumption would classify all such transactions as being far from fundraising, leading to no practical change.

The intuition for using market shocks is relatively straight-forward. The measure of pay-for-performance sensitivity depends on a fund's performance, which is partly determined by the current value of the fund that is impacted by public market movements (e.g. Ang et al., 2018). For funds operating in a given market, a market shock is common. Despite the shock being common, the pay-for-performance sensitivity measure will not be impacted equally for all funds. There are two main reasons for this.

First, the non-linear payoff structure of carried interest implies that the effect on $\Delta_{j,t}$ from a shock depends on the fund's current performance. A fund far out of or far in the money is barely impacted, whereas a fund at the money sees a big impact from a change in valuations. Second, the degree to which funds are exposed to any given market shock depends on the fraction of capital that is currently invested, largely a function of fund age. As an extreme example, a fund that has yet to make its first investment has no exposure, as it owns no companies whose valuations are impacted. The varying sensitivity to performance as a function of fund age was demonstrated in Figure 1. This heterogeneous response to a common, exogenous, shock provides for the potential to get utilize exogenous variation in the measure. This strategy is conceptually similar to that used in Shue and Townsend (2017).

I assume that market movements impact the NAV of a fund by $r_{m,t}$. Define a counterfactual $\widetilde{\text{NAV}}_{j,t}$ as the NAV the fund would have had absent the market movement $r_{m,t}$. For fund j at time t, it is defined as

$$\widetilde{\text{NAV}}_{j,t} = \frac{(\text{NAV}_{j,t} - \text{CC}_{j,t} + \text{D}_{j,t})}{1 + r_{m,t}} + \text{CC}_{j,t} - \text{D}_{j,t},$$

where $CC_{j,t}$ and $D_{j,t}$ denotes capital calls and distributions of fund j during quarter t, respectively. The impact of $r_{m,t}$ on $\Delta_{j,t}$ is given by decomposing

$$\Delta_{j,t} = \widetilde{\Delta}_{j,t} + \Delta^m_{j,t}, \tag{5}$$

where the estimation of $\widetilde{\Delta}_{j,t}$ uses $\widetilde{\text{NAV}}_{j,t}$ in place of $\text{NAV}_{j,t}$. $\Delta^m_{j,t}$ is defined as the difference $\Delta_{j,t} - \widetilde{\Delta}_{j,t}$, and is interpreted as the part of $\Delta_{j,t}$ that is attributable to the market shock. Fund NAV valuations as well as capital calls and cash flows are available at a quarterly level, and $r_{m,t}$ is measured over the same interval. As the funds in the sample may have different geographical exposure, the precise market return used is either S&P500, FTSE250, or Eurostoxx 600 if the fund is focused on the US, UK, or Europe, respectively. In practice, US-focused funds are not very common as the sample of portfolio companies are registered in the UK.

Table 7 presents the results from using only the part of pay-for-performance sensitivity that is attributable to a market shock. Overall the table confirms the main result of the paper: higher pay-for-performance sensitivity of a fund is associated with higher company

growth. For revenue growth, the estimated coefficient is statistically significant at all horizons except for the $t-1$ to $t+3$ horizon, and only at the 10% level for the $t-1$ to $t+4$ horizon. The economic magnitude for a one standard deviation change in $\Delta^m_{j,t}$ translates to an increased growth rate of between 1.8% and 3.9%.

Compared to the baseline table, the evidence is weaker in support of a relationship with employee growth. The coefficient is only statistically significant at the 10% level for the shortest two horizons, while there is no support for higher employee growth at longer horizons. As before, the coefficient is negative but statistically insignificant for total asset growth, while for profitability it is mostly positive, always economically small, and never statistically significant.

By constructing the measure of $\Delta^m_{j,t}$ in this way it is implicitly assumed that a PE fund immediately and fully incorporates any market movement in NAV valuations, and that a beta of one is appropriate. It is not clear that this is the right approach. Ang et al. (2018) report an autocorrelation of 0.40 for the Cambridge Associates buyout index, suggesting that there is some lag in incorporating overall market movements. As an alternative I therefore utilize the extreme other end, assuming that the lag is a full quarter. This implies that reported NAVs correspond to the "counterfactual" of what it would have been absent the market shock, and that the true NAV is given by adding the impact of a market movement. Using $\widetilde{\text{NAV}}'_{j,t}$ to denote the NAV after correcting for the market movement, we have

$$\widetilde{\text{NAV}}'_{j,t} = (\text{NAV}_{j,t} - \text{CC}_{j,t} + \text{D}_{j,t})\,(1 + r_{m,t}) + \text{CC}_{j,t} - \text{D}_{j,t},$$

where $CC_{j,t}$ and $D_{j,t}$ again denotes capital calls and distributions of fund j in quarter t, respectively. This estimate is used to estimate a $\widetilde{\Delta}'_{j,t}$ by replacing the reported NAV by $\widetilde{\text{NAV}}'_{j,t}$. The impact of a market movement $\Delta^m_{j,t}$ is given by

$$\widetilde{\Delta}'_{j,t} - \Delta_{j,t} = \Delta^m_{j,t} \tag{6}$$

Table A.6 presents results using this alternative definition of $\Delta^m_{j,t}$, and they are overall less convincing than the original specification. For revenue growth, the coefficients are only statistically different from zero at the $t-1$ to $t+1$ and $t+2$ horizons, and only at the 10% level. The economic magnitude is also lower, where the highest impact for one standard deviation change in $\Delta^m_{j,t}$ translates to 2.7% higher revenue growth. There is no evidence of a positive impact on employee growth here, and the coefficient is even negative, though not statistically different, at the longest two horizons. The results are qualitatively similar for total assets growth and profitability improvements.

As the results are markedly less convincing using this alternative approach, it begs the question as to which assumption is the more realistic one. The positive autocorrelation

in Ang et al. (2018) suggests that while market movements in a given period are not fully incorporated, they are at least partially incorporated. The literature documents a range of market beta estimates for private equity funds. Jegadeesh et al. (2015) use prices of listed fund-of-funds investing in unlisted private equity funds and find a beta of 1, Driessen et al. (2012) and Franzoni et al. (2012) find a beta of 1.3 for buyout funds, while Ang et al. (2018) estimate a market beta ranging from 1.18 to 1.77 depending on model specification. If returns are partially incorporated, and a relevant beta is in excess of one, the appropriate correction is likely closer to the first approach.

In untabulated analysis I replicate Tables 5 and 6 using $\Delta^m_{j,t}$ in place of $\Delta_{j,t}$. The impact of high reputation is very similar to what is seen in Table 5. Both statistical and economic significance is larger for the estimated coefficients on $\Delta^m_{j,t}$ for high reputation GPs, compared to estimates in Table 7. Coefficients that were not significant previously do not become significant. For revenue growt, the coefficients for high reputation GP are higher than the ones for low reputation GPs, and the differences are statistically different on at least the 5% level for all horizons except for $t-1$ to $t+4$. The patterns described in this paragraph holds true for both versions of $\Delta^m_{j,t}$ estimated.

Looking instead at deals completed close a fundraising event the evidence weaker in support of Hypothesis 3. For revenue growth, the estimates are not consistently larger for deals completed close to a fundraising event, and the difference in estimated coefficients is never significant. Only the $t-1$ to $t+1$ horizon have larger estimated coefficients for deals close to fundraising compared to the baseline, and it is the only horizon where any coefficient is statistically significant from zero. Again this pattern is true for both versions of $\Delta^m_{j,t}$.

For employee growth, the estimated coefficients are higher compared to the baseline for all horizons but $t-1$ to $t+4$, but the difference between the estimated coefficients on $\Delta^m_{j,t}$ for deals completed close to a fundraising event are not statistically different to those completed far from a fundraising event. This pattern is only true for the first version of $\Delta^m_{j,t}$. For the second version of $\Delta^m_{j,t}$, neither estimated coefficients are statistically different from zero for employee growth. There are no significant results for total asset growth and profitability improvements, and no noteworthy patterns that are different from the baseline estimation.

4.1.4 Summary

The analysis presented tests the hypotheses outlined in section 2.1.1. Hypothesis 1 predicts a positive relationship between operational improvements in portfolio companies and the pay-for-performance sensitivity of a GP's payoff in the acquiring private equity fund. The evidence is largely supporting this hypothesis in terms of being positively associated with

company growth, measured either as revenue growth or growth in number of employees. There is no evidence of a positive relationship with profitability improvements. The evidence presented is generally robust to model specification. The result is also robust to using only exogenous variation in the pay-for-performance sensitivity, utilizing shocks to the equity market as an exogenous shock.

Hypothesis 2 predicts that the positive relationship in Hypothesis 1 should be more pronounced for highly reputable GPs, as the implicit incentive is expected to be of relatively higher importance for low reputation GPs. The evidence is largely supportive of the hypothesis whether using the main specification or only the exogenous variation in pay-for-performance sensitivity. Though the documented patterns are very consistent, one needs to be cautious as the difference in estimated coefficients is not always statistically different.

Hypothesis 3 predicts that the positive relationship in Hypothesis 1 should be more pronounced when a fund is close to raising a new fund, as the implicit incentive is expected to be much stronger for the newly raised fund. The evidence is mixed in support of this hypothesis. While the baseline specification is generally supportive of the hypothesis, it is not robust to using only exogenous variation in the pay-for-performance sensitivity.

It is worth considering some limitations to the analysis of the paper. First, the analysis has focused on operational improvements at portfolio companies. However, this is merely a proxy for the measure that GPs truly care about: deal returns. While improvements in operational performance of a portfolio company improve deal returns (e.g. Guo et al., 2011), it is not the only avenue through which returns can be generated. It is comforting that the documented growth does not appear to be generated via spending more capital, as it is unclear whether such growth through capital expenditure improves deal returns. The focus on operational improvements is made out of necessity due to a lack of available deal-level return data. We may expect that relying on this proxy adds noise to our tests, which would make it less likely that we find any results.

Second, only the explicit incentive provided by direct pay for performance provided is formally modelled and tested in this paper. Clearly, implicit incentives play an important role as demonstrated by Chung et al. (2012). While including a model incorporating both explicit and implicit incentives is beyond the scope of this paper, the second and third hypotheses utilizes implications of the role of implicit incentives to sharpen the predictions of the paper. An interesting avenue for future research is to jointly examine the role of explicit and implicit incentives.[34]

[34]The implicit incentive from the increased ability to raise a fund when performing better is likely a matter of performance relative to other funds, as suggested by results in Barber and Yasuda (2017). By contrast, hurdle rates tend to be fixed. The identification strategy used in this paper of utilizing exogenous market shocks therefore appears like one interesting approach for disentangling the implicit and explicit incentives, while changes in the supply of capital from potential LPs could potentially be used to instrument shocks to implicit incentives.

Third, the model used to estimate pay-for-performance sensitivity of carried interest treats all funds as being equal. In reality, the terms facing specific funds will differ between funds, and as such the resulting delta would differ from the one estimated. Additionally, GPs may have subjective beliefs about their ability that deviates from the ones imposed by the model. This implies that the pay-for-performance sensitivity faced by a GP differs from the one suggested by the model. To the extent that GPs have rational beliefs, the model would underestimate (overestimate) the pay-for-performance sensitivity of GPs with high (low) ability early in a fund's life. Such measurement error should work against the results of the paper, as high (low) ability GPs experience a smaller increase (decrease) in pay-for-performance sensitivity following good (poor) performance compared to what is suggested by the model. The results from utilizing exogenous market shocks may be less exposed to these errors, as it compares a difference in pay-for-performance sensitivity estimated using the same model. The differencing may remove part of the impact from a misspecified model, though it is unlikely to completely resolve the issue for the same reasons that a common shock generates heterogeneous impacts on the pay-for-performance sensitivity measure.

Finally, it is important to remember that the sample size is relatively small and limited to UK companies.

5 Conclusion

Carried interest in private equity funds provides a strong direct component of pay-for-performance as it gives the private equity firm a fraction of fund profits. Carried interest is typically paid out only if fund performance exceeds a pre-set, fixed, hurdle rate. This makes carried interest akin to a call option, with the hurdle rate as its strike price. As with call options, the sensitivity of pay to improved performance is largely a function of the likelihood of being in the carry. Consequently, the strength of the pay-for-performance varies over a fund's life, and this paper examines these dynamics.

The paper builds on the framework in Metrick and Yasuda (2010) to measure expected pay-for-performance during a fund's life. Pay-for-performance sensitivity is increasing in fund performance, and increasingly so as the fund matures. This is analogous to call options, where the delta of the option increase in a stock's price, and increasingly so as time-to-maturity decreases.

Private equity have been shown to improve operations of portfolio companies (e.g. Bernstein and Sheen, 2016; Davis et al., 2014), which presumably takes effort on behalf of the GP. Agency theory is clear in its predictions that higher effort is expected when an agent's pay is more strongly linked to exerting effort. The paper therefore

relates the estimated pay-for-performance sensitivity to the operational performance of portfolio companies invested in. It does so using a newly assembled dataset on UK companies acquired in buyouts.

Deals executed by funds at times when pay-for-performance sensitivity is high are related to higher organic growth. Clearly, pay-for-performance sensitivity is not randomly assigned to funds and determinants of the measure, in particular managerial ability, are expected to be related to operational improvements at the portfolio companies. To account for managerial ability, the paper utilizes within-fund estimations which effectively compare deals conducted by the same fund at different points during a fund's life. Private equity is an ideal setting for conducting within-fund estimations due to the staggered nature of investments. The further strengthen the interpretation the paper utilizes shocks in the public market to get exogenous variation in the measure. Public market returns are a good candidate for such variation as private equity returns are closely linked to public markets (e.g. Ang et al., 2018), while funds are not equally exposed at any given time. This implies that a common shock have heterogeneous impact on funds' pay-for-performance sensitivity.

This paper contributes to our understanding of how the incentives of general partners in private equity funds impact value creation at the portfolio company level. While the aggregate value of incentives have been documented (Metrick and Yasuda, 2010; Chung et al., 2012), this is the first paper to explore the dynamics within a fund. How managerial incentives from pay-for-performance compensation relate to value creation is a topic of general interest in finance, although it is notoriously difficult to causally attribute any observed correlations to an effect of incentives, especially when studying CEOs (e.g. Edmans et al., 2017). This paper utilizes the private equity setting with fixed compensation terms to account for many of the complicating features present when studying CEOs, and to generate plausibly exogenous variation in the measure.

However, the paper only examines the direct component of pay-for-performance sensitivity. An important avenue for future research is to jointly examine the direct and indirect components of pay-for-performance compensation.

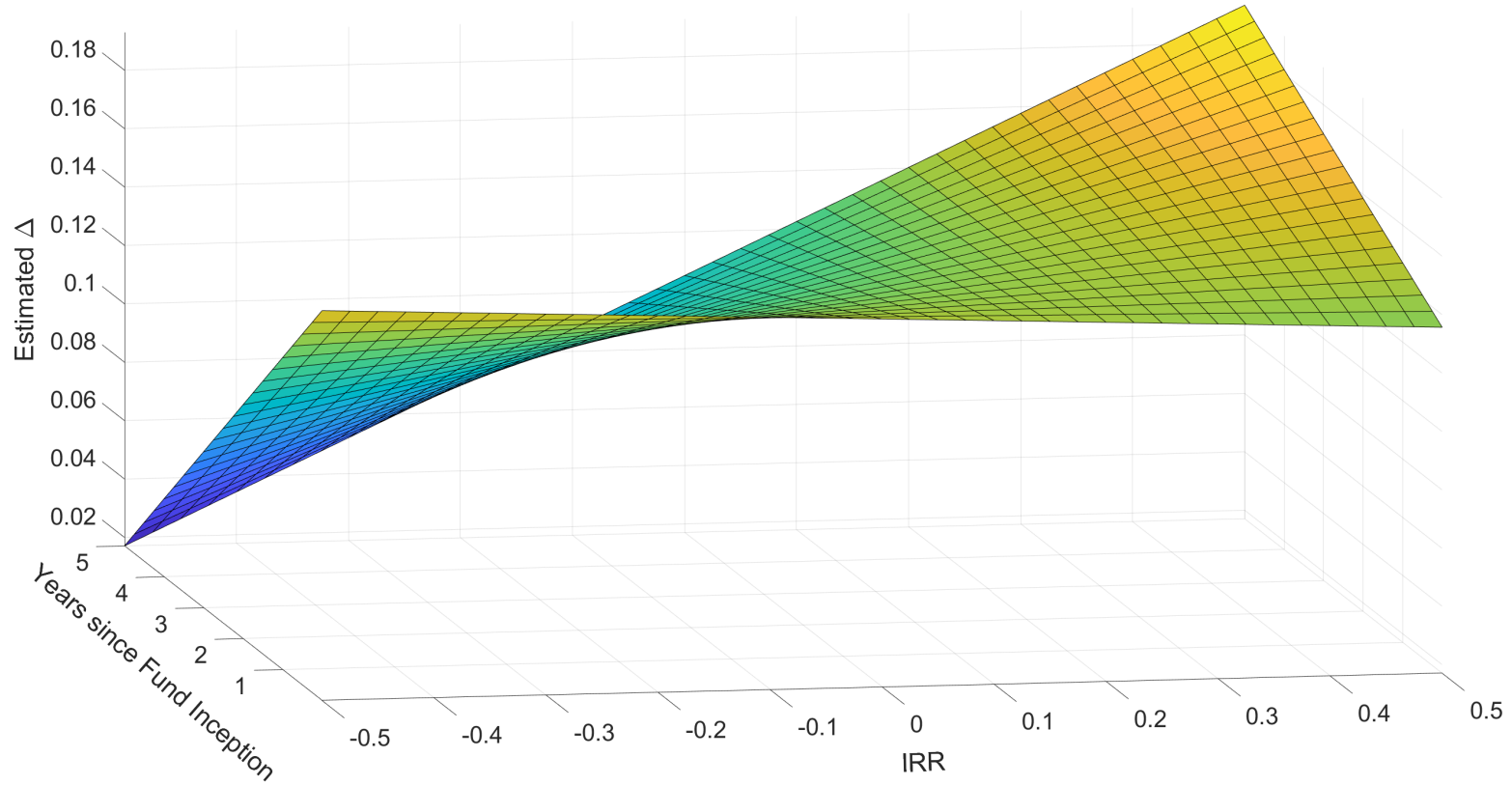


Figure 1: Pay-for-Performance Sensitivity Summary

This figure plots the variation in a GP's pay-for-performance sensitivity Δ, defined in Section 2.2.2, as a function of fund performance, measured as IRR, and fund age, measured in years. The figure depicts the best fit of the model $\Delta_{j,t} = \alpha + \beta_1 \text{IRR}_{j,t} + \beta_2 \text{Fund Age}_{j,t} + \beta_3 \text{IRR}_{j,t} \times \text{Fund Age}_{j,t} + \epsilon_{j,t}$, where j denotes a fund, and t the fund age measured in quarters from the first cash flow of the fund. The model is fitted for the estimated pay-for-performance sensitivities of 13927 fund-quarters for buyout funds with available NAV and cash flow data in Preqin. All fund-quarters up until the fund's 20th quarter is included.

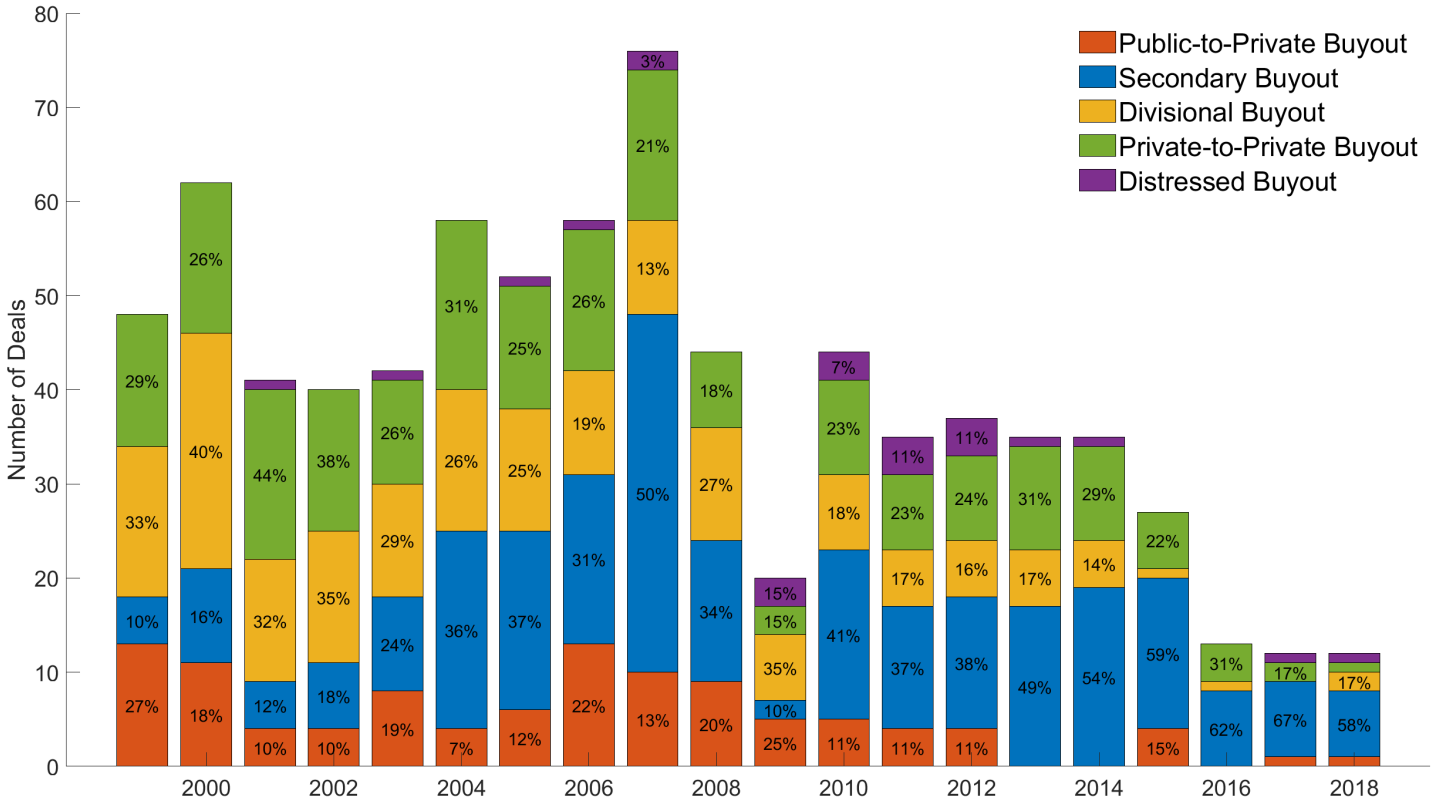


Figure 2: Sample Composition - Type of Buyout

This figure presents the sample composition of buyout types by the year in which the buyout transaction completed. The height of each bar represent the number of buyouts in a given year as displayed on the y-axis. The percentages displayed in each colored bar correspond to the fraction of buyouts within the year of that type. Percentages are omitted from bars containing a single deal. Buyout type categories are defined in Table D.1.

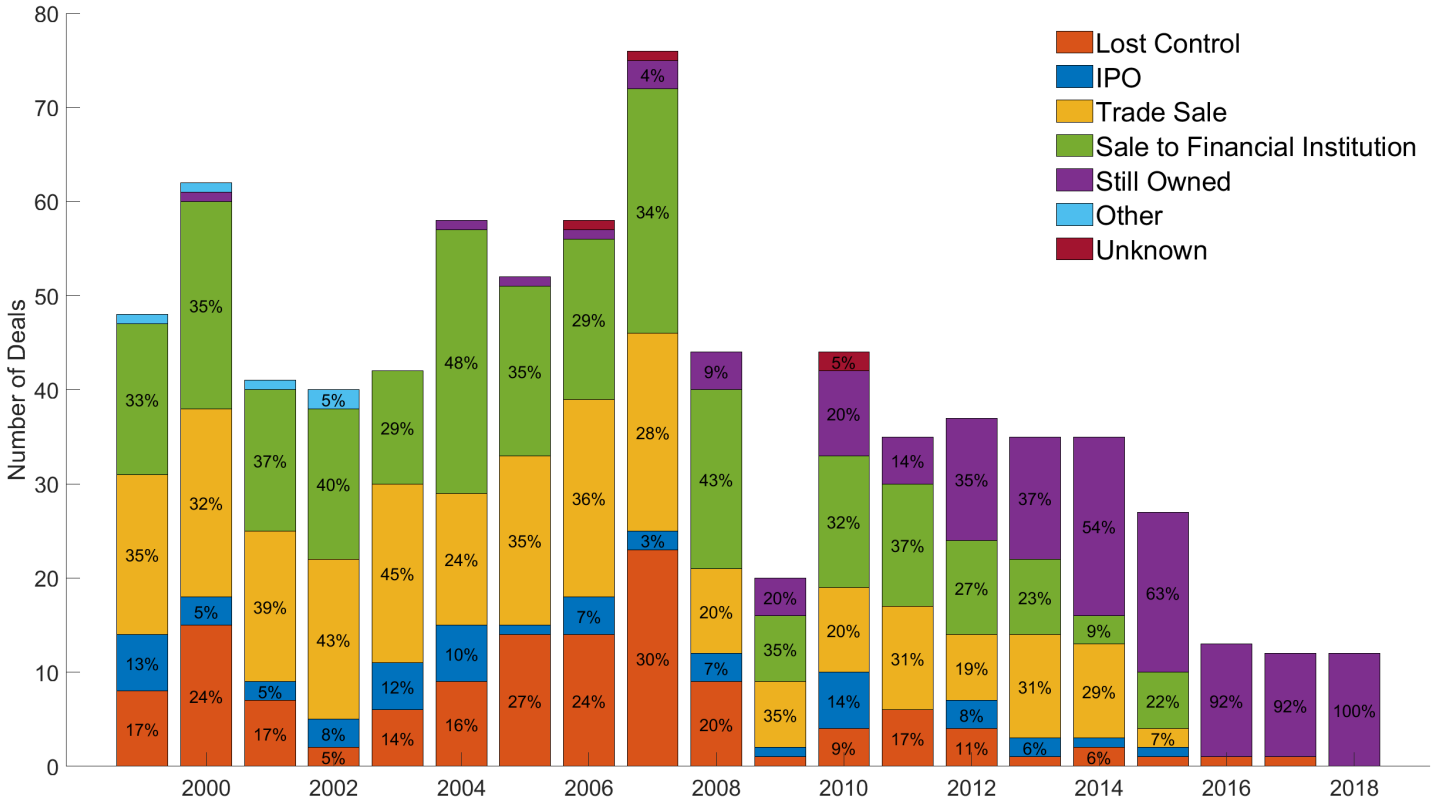


Figure 3: Sample Composition - Exit Route

This figure presents the sample composition of exit routes for the private equity owner of companies acquired in a buyout. The transactions are organized by the year in which the buyout took place, while the exit may have taken place at a later date, or not yet taken place. The height of each bar represent the number of buyouts in a given year as displayed on the y-axis. All exit routes are as of 2019-09-30. Percentages displayed in the colored bars correspond to the fraction of that year's buyouts that ended up with a given exit route. Percentages are omitted from bars containing a single deal. The "Other" category consists of 5 cases where the portfolio company was owned by a private equity fund until liquidated and ceased trading. Remaining exit routes are defined in Table D.1.

Table 1: Sample Construction

This table presents how the final sample in the paper is derived. Transactions without participation of a private equity firm or where the private equity firm(s) only acquired a majority stake are excluded from the sample. Company names are taken from the transaction synopsis provided by Capital IQ, and if no UK company of that name is found the transaction is excluded. The screen for buyout transactions in Capital IQ was undertaken 2019-01-02.

Number of UK buyouts identified in Capital IQ from 1999 - 2018	1964
Less: Buyouts not included in the 850 randomly selected	(1114)
Number of PE transactions processed	850
Less: Transactions where no UK company of a stated name was found	(19)
Less: Transactions without PE firm participation	(15)
Less: Transactions where majority ownership did not pass to a PE firm	(10)
Less: Duplicate transactions identified	(7)
Less: Transactions initially identified but no longer in Capital IQ	(5)
Less: Transactions of companies exempted from submitting filings	(3)
Number of buyouts with Entry and Exit information	791
Less: Transactions without accounting data in year t-1 and t+1	(230)
Less: Transactions of financial companies or public utilities	(69)
Initial sample with financials available	494
Less: Transactions where acquiring fund is involved in only one transaction or lack cash flow and NAV data in Preqin	(248)
Final sample	246

Table 2: Sample Composition

This table presents the composition of buyout types, exit route for the private equity owner, and holding periods. Panel A presents the composition of the type of buyout in the sample. Panel B presents exit routes. Panel C presents descriptives on holding periods, expressed in number of years from entry to exit, of all deals with an exit as of 2019-09-30. The time-periods represents the year in which the buyout took place. The "Other" category consists of 5 cases where the portfolio company was owned by a private equity fund until liquidated and ceased trading. All other variable definitions are found in Table D.1.

Panel A: Buyout Type

	Full Sample	1999 - 2003	2004 - 2008	2009 - 2013	2014 - 2018
Public-to-Private	0.134	0.172	0.146	0.105	0.061
Secondary Buyouts	0.341	0.159	0.385	0.374	0.586
Divisional	0.231	0.343	0.212	0.193	0.091
Private-to-Private	0.263	0.318	0.243	0.240	0.232
Distressed	0.030	0.009	0.014	0.088	0.030
N	791	233	288	171	99

Panel B: Exit Route

		Year of Entry			
	Full Sample	1999 - 2003	2004 - 2008	2009 - 2013	2014 - 2018
Lost Control	0.162	0.163	0.240	0.094	0.051
IPO	0.062	0.082	0.056	0.070	0.020
Trade Sale	0.290	0.382	0.288	0.263	0.121
Sale to Fin. Inst.	0.316	0.348	0.375	0.304	0.091
Still Owned	0.159	0.004	0.035	0.257	0.717
Other	0.006	0.021	-	-	-
Not Known	0.005	-	0.007	0.012	-
N	791	233	288	171	99

Panel C: Holding Periods (exited deals)

		Year of Entry			
	Full Sample	1999 - 2003	2004 - 2008	2009 - 2013	2014 - 2018
Mean	4.99	4.92	5.56	4.33	2.85
Median	4.43	4.58	5.46	4.04	2.85
Standard Deviation	2.74	2.87	2.91	1.83	0.91
25th Percentile	2.99	3.04	3.01	3.22	2.52
75th Percentile	6.65	6.27	7.84	5.26	3.34
N	661	232	277	124	28

Table 3: Summary Statistics

This table presents descriptive statistics of the financials of companies in the final sample. Panel A presents characteristics as of the most recent fiscal year prior to the buyout, referred to as year -1. Panel B presents changes in these measures from year -2 to year -1, while Panel C presents changes from year -3 to year -1. Panel D presents the industry composition.

Panel A: Portfolio company characteristics in year prior to buyout

	N	Mean	Median	SD	25th pct	75th pct
Revenue (M£)	246	157.2	69.3	248.7	23.8	166.1
EBITDA (M£)	246	19.6	8.8	28.9	3.5	20.2
Total Assets (M£)	246	156.4	66.1	240.5	18.5	168.1
Number of Employees	238	1797	614	2741	212	1919
EBITDA Margin	246	0.159	0.141	0.106	0.084	0.212

Panel B: 1-year pre-buyout growth

	N	Mean	Median	SD	25th pct	75th pct
Revenue	227	0.177	0.119	0.276	0.035	0.249
EBITDA	227	0.165	0.182	1.268	-0.019	0.502
Total Assets	229	0.176	0.071	0.391	-0.009	0.247
Number of Employees	217	0.112	0.062	0.253	-0.012	0.169
EBITDA Margin	227	0.009	0.010	0.061	-0.008	0.029

Panel C: 2-years pre-buyout growth

	N	Mean	Median	SD	25th pct	75th pct
Revenue	214	0.499	0.285	0.750	0.092	0.624
EBITDA	213	0.792	0.414	2.762	0.063	1.060
Total Assets	218	0.452	0.194	0.869	0.018	0.535
Number of Employees	203	0.300	0.112	0.653	-0.024	0.416
EBITDA Margin	213	0.020	0.012	0.071	-0.009	0.042

Panel D: Industry Composition (%)

Mining	1.3
Construction	2.1
Manufacturing	23.0
Transportation	7.6
Wholesale	4.7
Retail	16.0
Services	45.4

Table 4: Operational Improvements and Pay-for-Performance Sensitivity

This table presents estimates of operational improvements in relation to the fund's pay-for-performance sensitivity $\Delta_{j,t}$. The four columns represent improvements from the year prior to the buyout, $t-1$, to one, two, three, and four years after the buyout. The dependent variable is annualized revenue growth in Panel A, annualized employee growth in Panel B, annualized growth in total assets in Panel C, and the cumulative improvement in the EBITDA/Revenue margin in Panel D. Each model specification includes time, fund, and industry fixed effects; dummies for the fund year in which the transaction took place; and log revenue, log total assets, and EBITDA margin in $t-1$, as well as book leverage post transaction. All variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are clustered at the acquiring fund level. Estimates followed by the symbols ***, **, or * are statistically significant at the 1%, 5%, and 10% levels, respectively.

Panel A - Revenue Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t}$	0.536	1.466^{*}	1.346^{**}	1.113^{***}
	(0.747)	(0.786)	(0.629)	(0.346)
Adjusted R^2	0.299	0.310	0.472	0.599
N	246	218	178	127

Panel B - Employee Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t}$	0.312	1.885^{**}	1.700^{**}	0.489
	(0.914)	(0.725)	(0.675)	(1.024)
Adjusted R^2	0.219	0.301	0.411	0.282
N	238	207	169	120

Panel C - Growth Total Assets (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t}$	−0.035	−1.508	−1.151	−1.017
	(1.839)	(1.356)	(1.006)	(1.301)
Adjusted R^2	0.143	0.138	0.156	0.126
N	246	218	178	127

Panel D - Cumulative change in Return on Sales (EBITDA/Revenue)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t}$	0.016	0.028	0.024	0.137
	(0.187)	(0.179)	(0.180)	(0.314)
Adjusted R^2	0.031	0.126	0.166	0.329
N	246	218	178	127
Transaction-Year FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Fund-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Table 5: Operational Improvements and Pay-for-Performance Sensitivity - Impact of Fund Reputation

This table presents estimates of operational improvements in relation to the fund's pay-for-performance sensitivity $\Delta_{j,t}$ interacted with a dummy indicating if the acquiring fund is run by a low or high reputation GP. A GP is classified as low reputation if it has: cumulatively raised less than $1 billion dollar prior to the current fund; raised less than three funds in the past; and have no past top quartile fund that is at least five years old at the time of the current fund. High reputation GP is the complement. The four columns represent improvements from the year prior to the buyout, $t-1$, to one, two, three, and four years after the buyout. The dependent variable is annualized revenue growth in Panel A, annualized employee growth in Panel B, annualized growth in total assets in Panel C, and the cumulative improvement in the EBITDA/Revenue margin in Panel D. Each model specification includes time, fund, and industry fixed effects; dummies for the fund year in which the transaction took place; and log revenue, log total assets, and EBITDA margin in $t-1$, as well as book leverage post transaction. All variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are clustered at the acquiring fund level. Estimates followed by the symbols ***, **, or * are statistically significant at the 1%, 5%, and 10% levels, respectively.

Panel A - Revenue Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t} \times 1\{\text{High Rep}\}$	0.819	2.164^{***}	1.457^{**}	1.096^{***}
	(0.819)	(0.777)	(0.636)	(0.262)
Fund $\Delta_{j,t} \times 1\{\text{Low Rep}\}$	-1.537	-0.366	0.650	2.729
	(0.947)	(0.733)	(1.210)	(1.903)
$1\{\text{Low Rep}\}$	0.280	0.415^{***}	0.141	-0.460^{***}
	(0.175)	(0.138)	(0.143)	(0.169)
Adjusted R^2	0.299	0.321	0.467	0.603
N	246	218	178	127

Panel B - Employee Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t} \times 1\{\text{High Rep}\}$	0.669	2.240^{***}	1.877^{**}	0.694
	(1.048)	(0.743)	(0.893)	(0.866)
Fund $\Delta_{j,t} \times 1\{\text{High Rep}\}$	-1.230	0.044	0.968	5.094
	(1.276)	(0.663)	(0.959)	(4.060)
$1\{\text{Low Rep}\}$	0.275	0.319^{**}	0.160	-0.768
	(0.220)	(0.144)	(0.209)	(0.568)
Adjusted R^2	0.213	0.300	0.403	0.315
N	238	207	169	120
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Fund-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Table 5 — *Continued*

Panel C - Growth Total Assets (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t} \times 1\{\text{High Rep}\}$	−0.136	−1.256	−1.097	−1.063
	(2.165)	(1.803)	(1.386)	(1.479)
Fund $\Delta_{j,t} \times 1\{\text{Low Rep}\}$	−0.251	−0.265	−0.555	−4.764
	(3.842)	(3.825)	(3.062)	(4.528)
$1\{\text{Low Rep}\}$	−0.013	0.085	0.060	0.943*
	(0.403)	(0.469)	(0.352)	(0.535)
Adjusted R^2	0.135	0.128	0.155	0.127
N	246	218	178	127

Panel D - Cumulative change in Return on Sales (EBITDA/Revenue)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta_{j,t} \times 1\{\text{High Rep}\}$	0.039	0.188	0.047	0.116
	(0.251)	(0.194)	(0.217)	(0.298)
Fund $\Delta_{j,t} \times 1\{\text{Low Rep}\}$	−0.478	−0.602	0.124	−1.049
	(0.468)	(0.410)	(0.198)	(1.296)
$1\{\text{Low Rep}\}$	0.061	0.102*	−0.003	0.163
	(0.088)	(0.056)	(0.045)	(0.167)
Adjusted R^2	0.040	0.159	0.154	0.365
N	246	218	178	127
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Fund-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Table 6: Operational Improvements and Pay-for-Performance Sensitivity - Impact of Completed Fundraising

This table presents estimates of operational improvements in relation to the fund's pay-for-performance sensitivity $\Delta_{j,t}$, interacted with a dummy indicating if a transaction was completed close to a fundraising event, where close means at most eight quarters before the fundraising event. A fundraising event is the first quarter a cash flow is reported in a successor fund, or the second quarter of a fund's vintage year in the absence of cash flow data. The four columns represent improvements from the year prior to the buyout, $t-1$, to one, two, three, and four years after the buyout. The dependent variable is annualized revenue growth in Panel A, annualized employee growth in Panel B, annualized growth in total assets in Panel C, and the cumulative improvement in the EBITDA/Revenue margin in Panel D. Each model specification includes time, fund, and industry fixed effects; dummies for the fund year in which the transaction took place; and log revenue, log total assets, and EBITDA margin in $t-1$, as well as book leverage post transaction. All variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are clustered at the acquiring fund level. Estimates followed by the symbols ***, **, or * are statistically significant at the 1%, 5%, and 10% levels, respectively.

Panel A - Revenue Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
$\Delta_{j,t} \times 1\{\text{Close to Fundraising}\}$	3.466*	2.904**	2.504**	0.768
	(1.885)	(1.116)	(1.119)	(0.886)
$\Delta_{j,t} \times 1\{\text{Far from Fundraising}\}$	0.372	0.789	0.461	0.135
	(0.860)	(0.609)	(0.404)	(0.513)
$1\{\text{Close to Fundraising}\}$	−0.465*	−0.301*	−0.269	−0.052
	(0.268)	(0.174)	(0.175)	(0.115)
Adjusted R^2	0.307	0.337	0.478	0.598
N	246	218	178	127

Panel B - Employee Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
$\Delta_{j,t} \times 1\{\text{Close to Fundraising}\}$	2.957*	2.358*	2.681*	0.706
	(1.730)	(1.195)	(1.542)	(1.044)
$\Delta_{j,t} \times 1\{\text{Far from Fundraising}\}$	−0.234	0.483	0.216	−0.127
	(0.660)	(0.530)	(0.446)	(0.763)
$1\{\text{Close to Fundraising}\}$	−0.385	−0.201	−0.304	−0.072
	(0.265)	(0.196)	(0.248)	(0.170)
Adjusted R^2	0.256	0.357	0.405	0.291
N	238	207	169	120
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Fund-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Table 6 — *Continued*

Panel C - Growth Total Assets (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
$\Delta_{j,t} \times 1\{\text{Close to Fundraising}\}$	-3.232	-4.834^{*}	-4.471^{***}	-4.278^{***}
	(4.052)	(2.448)	(1.202)	(1.106)
$\Delta_{j,t} \times 1\{\text{Far fom Fundraising}\}$	1.758	0.613	0.278	0.400
	(1.989)	(1.244)	(1.119)	(1.199)
$1\{\text{Close to Fundraising}\}$	0.607	0.764^{*}	0.706^{***}	0.763^{***}
	(0.746)	(0.407)	(0.258)	(0.257)
Adjusted R^2	0.135	0.128	0.155	0.127
N	246	218	178	127

Panel D - Cumulative change in Return on Sales (EBITDA/Revenue)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
$\Delta_{j,t} \times 1\{\text{Close to Fundraising}\}$	0.226	0.072	0.177	0.506^{*}
	(0.598)	(0.336)	(0.340)	(0.262)
$\Delta_{j,t} \times 1\{\text{Far from Fundraising}\}$	-0.071	-0.140	-0.089	-0.203
	(0.218)	(0.202)	(0.168)	(0.272)
$1\{\text{Close to Fundraising}\}$	-0.048	-0.016	-0.029	-0.093
	(0.110)	(0.071)	(0.064)	(0.057)
Adjusted R^2	0.040	0.159	0.154	0.365
N	246	218	178	127
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Fund-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Table 7: Operational Improvements and Pay-for-Performance Sensitivity due to Market Shocks

This table presents estimates of operational improvements in relation to the part of a fund's pay-for-performance sensitivity that is due to a recent market shock, $\Delta^m_{j,t}$, as defined in section 4.1.3. In this table, the NAV of the PE fund is assumed to have fully incorporated the market shock. The four columns represent improvements from the year prior to the buyout, $t-1$, to one, two, three, and four years after the buyout. The dependent variable is annualized revenue growth in Panel A, annualized employee growth in Panel B, annualized growth in total assets in Panel C, and the cumulative improvement in the EBITDA/Revenue margin in Panel D. Each model specification includes time, fund, and industry fixed effects; dummies for the fund year in which the transaction took place; and log revenue, log total assets, and EBITDA margin in $t-1$, as well as book leverage post transaction. All variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are clustered at the acquiring fund level. Estimates followed by the symbols ***, **, or * are statistically significant at the 1%, 5%, and 10% levels, respectively.

Panel A - Revenue Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	4.671**	3.605**	0.765	2.188*
	(1.840)	(1.504)	(0.997)	(1.155)
Adjusted R^2	0.305	0.314	0.469	0.596
N	246	218	178	127

Panel B - Employee Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	3.718*	3.111*	1.559	0.185
	(1.911)	(1.622)	(2.178)	(3.056)
Adjusted R^2	0.225	0.299	0.407	0.272
N	238	207	169	120

Panel C - Growth Total Assets (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	−0.040	−0.395	−0.724	−1.876
	(7.725)	(4.560)	(3.220)	(4.809)
Adjusted R^2	0.140	0.135	0.151	0.114
N	246	218	178	127

Panel D - Cumulative change in Return on Sales (EBITDA/Revenue)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	−0.030	0.019	0.011	0.099
	(0.175)	(0.168)	(0.177)	(0.299)
Adjusted R^2	0.030	0.114	0.154	0.316
N	246	218	178	127
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Fund-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Appendices

A Appendix Figures and Tables

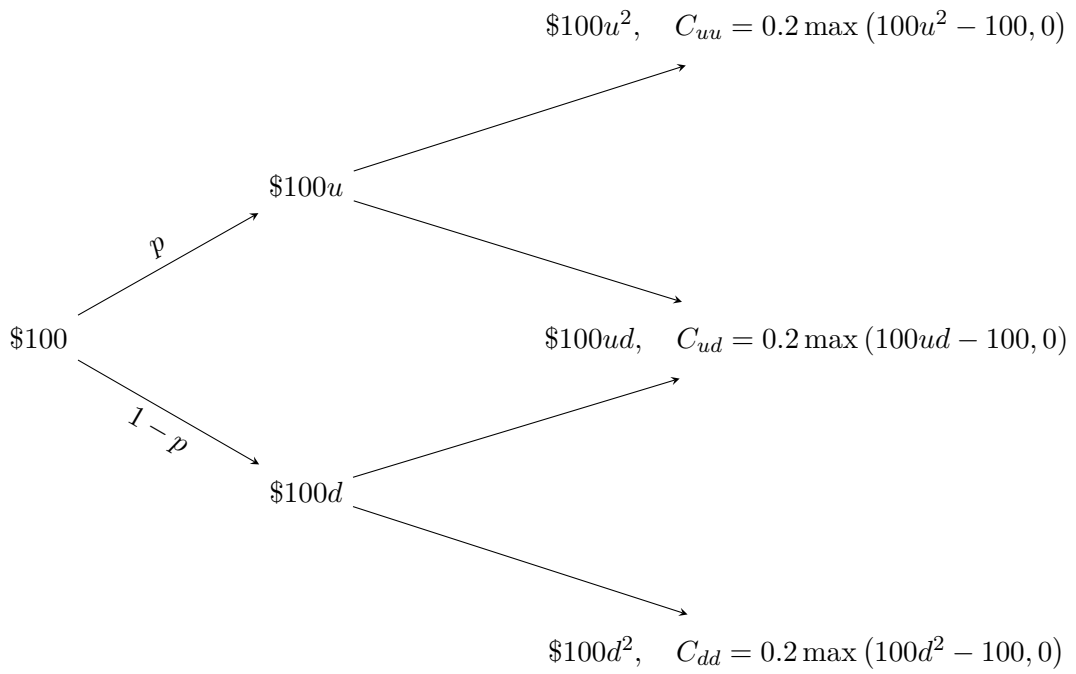


Figure A.1: Illustration of a Simplified Portfolio Company Path

This figure depicts a simplified illustration of possible paths from a simulation of the value of a private equity fund. It corresponds to the value of a fund that makes a single investment of \$100 at $t = 0$ and is liquidated at $t = 2$. The investment increase in value by $u > 1.01$ with probability p, and decrease in value with $d = \frac{1}{u}$ with probability $1 - p$. At each potential end node, C_{uu}, C_{ud} and C_{dd} denotes the value of the payoff to the GP from carried interest at the node. Carried interest is calculated in the absence of a hurdle rate to simplify the illustration, and the GP receives 20% of any profits.

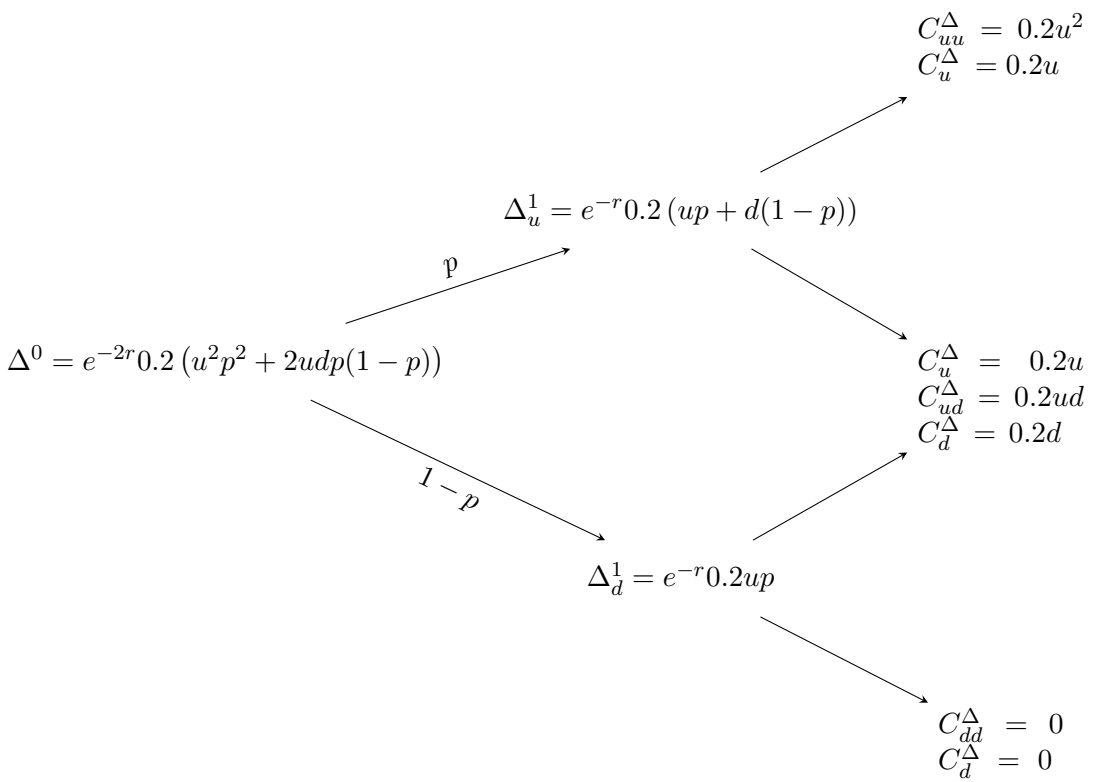


Figure A.2: Illustration of Calculation of Pay-for-Performance Sensitivity Measure

This figure complements figure A.1 by providing the value of a GP's Δ at every node prior to $t = 2$ for the same model setup outlined for that figure. Δ^t is defined as the present value of the expected increase in carried interest paid to the GP from adding \$1 of additional value at node t. When relevant, a subscript indicates the path taken from the original node at $t = 0$ to the specific Δ^t. C^{Δ} denotes the increase in carried interest paid at the $t = 2$ nodes from increasing the value of the investment by \$1 at an earlier node. The subscripts to C^{Δ} indicates the path taken from the node at which value was added. For example, C^{Δ}_{uu} is defined as the increase in carry payment C_{uu} from adding \$1 of additional value at the start node at $t = 0$. Without additional value added, the carry payment $C_{uu} = 20(u^2 - 1)$, while with the additional value added it is $C_{uu} = 20(u^2 - 1) + 0.2u^2$, making the difference $C^{\Delta}_{uu} = 0.2u^2$. C^{Δ} is positive at the middle node as the fund profit in absence of any additional value added is zero, and no hurdle rate is used in this illustration. C^{Δ} is zero at the bottom node at $t = 2$ since the added value is not sufficient to offset the loss in value from the path taken there.

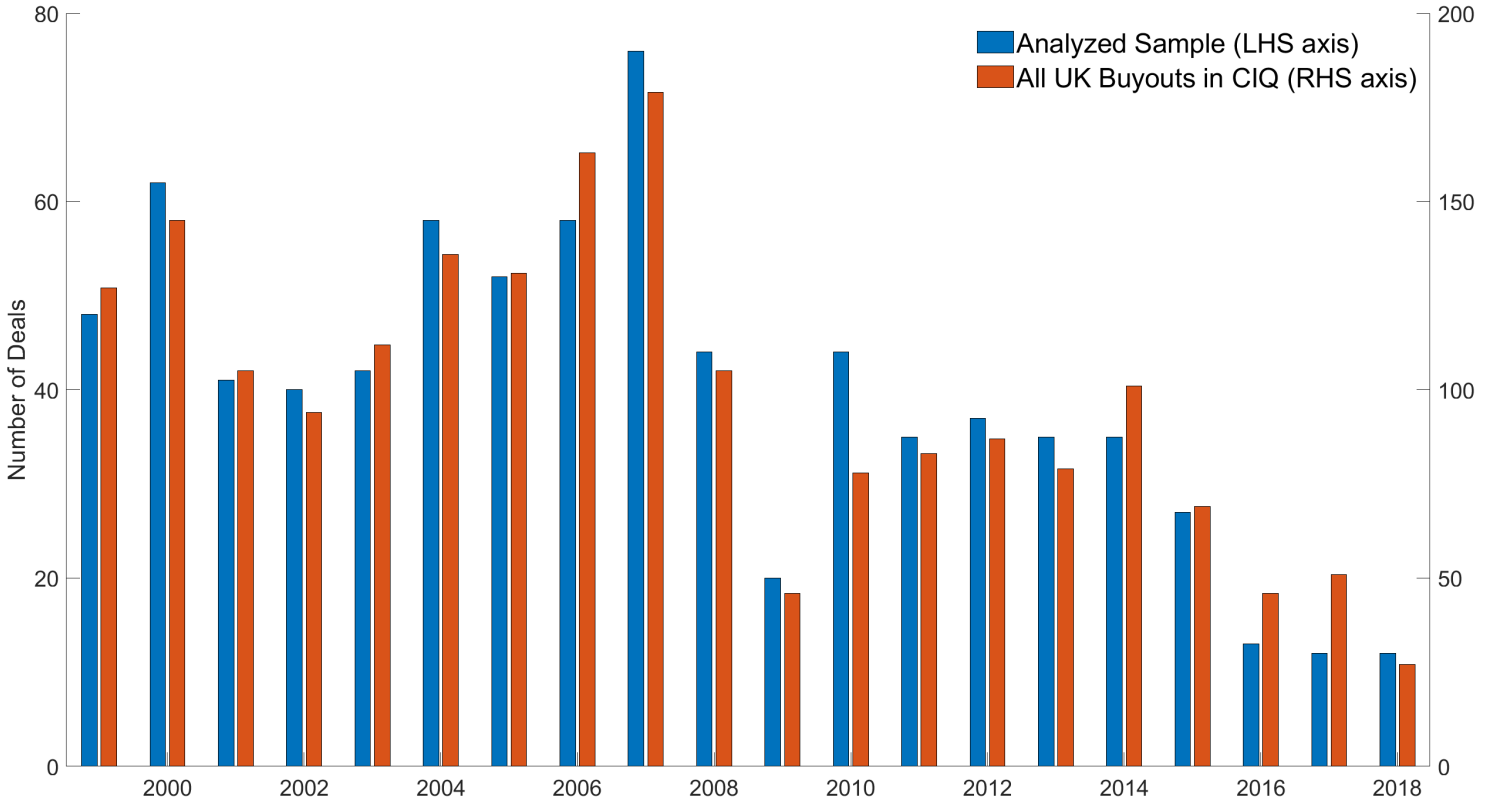


Figure A.3: Number of Deals - Comparison Random Sample and Full Set

This figure depicts the distribution of buyouts per year for the deals that are part of the sample analyzed in the paper, as well as for the full set of UK buyouts identified in the transaction scan done in Capital IQ. The height of each bar represents the number of buyouts in a year. The left-hand side y-axis refers to the sample in the paper, while the right-hand side y-axis represent all UK buyouts identified in Capital IQ.

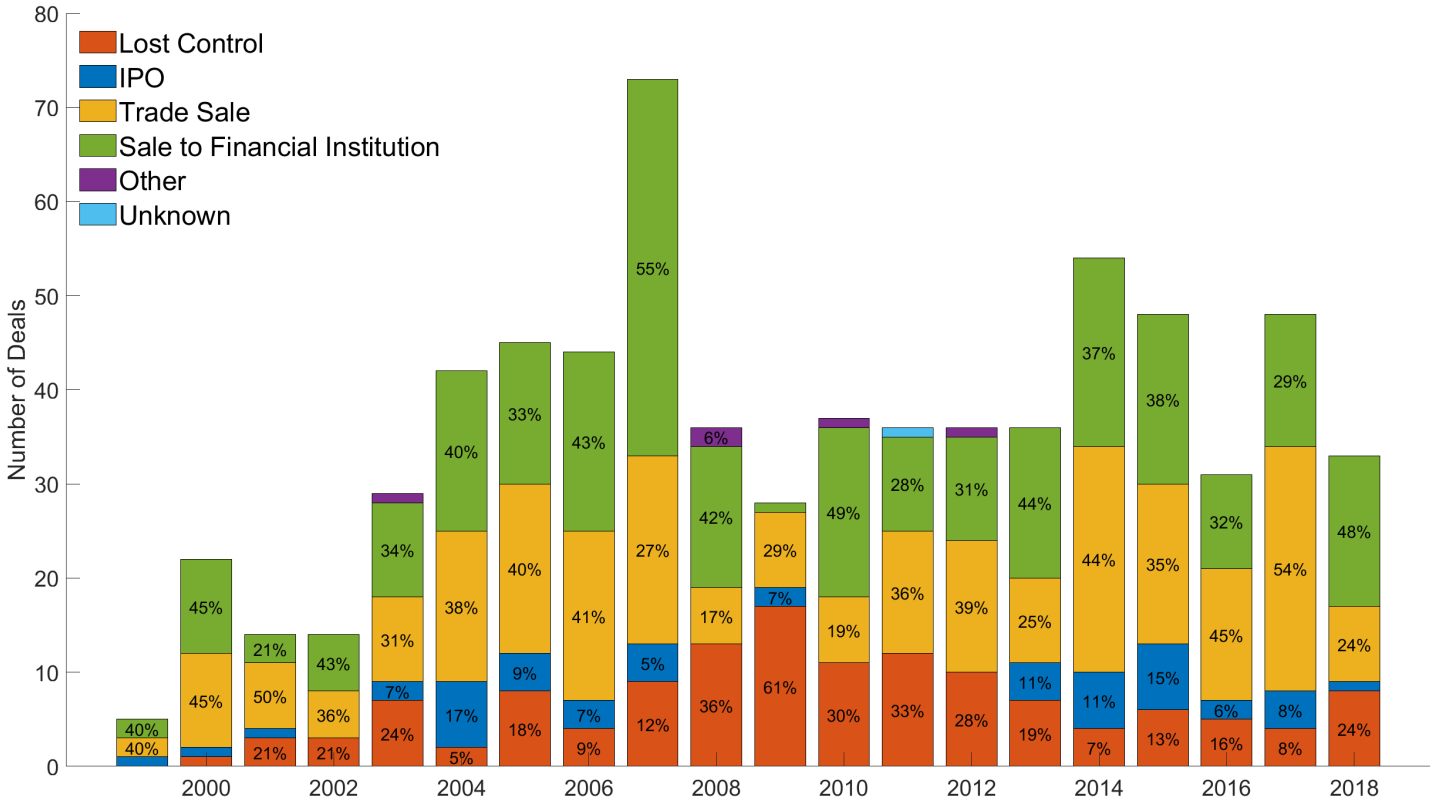


Figure A.4: Exit Route by Year of Exit

This figure depicts the sample composition of the exit route of the private equity owner from companies acquired in a buyout. The transactions are organized by the year in which the exit took place. Companies still under private equity ownership as of 2019-09-30 are not included in the figure. The height of each bar represents the number of buyouts exited in a given year and is displayed on the y-axis. Percentages displayed in the colored bars correspond to the fraction of the exits in a year that were of that specific exit route. Percentages are omitted from bars containing a single deal. The "Other" category consists of 5 cases where the portfolio company was owned by a private equity fund until liquidated and ceased trading. Remaining exit routes are defined in Table D.1.

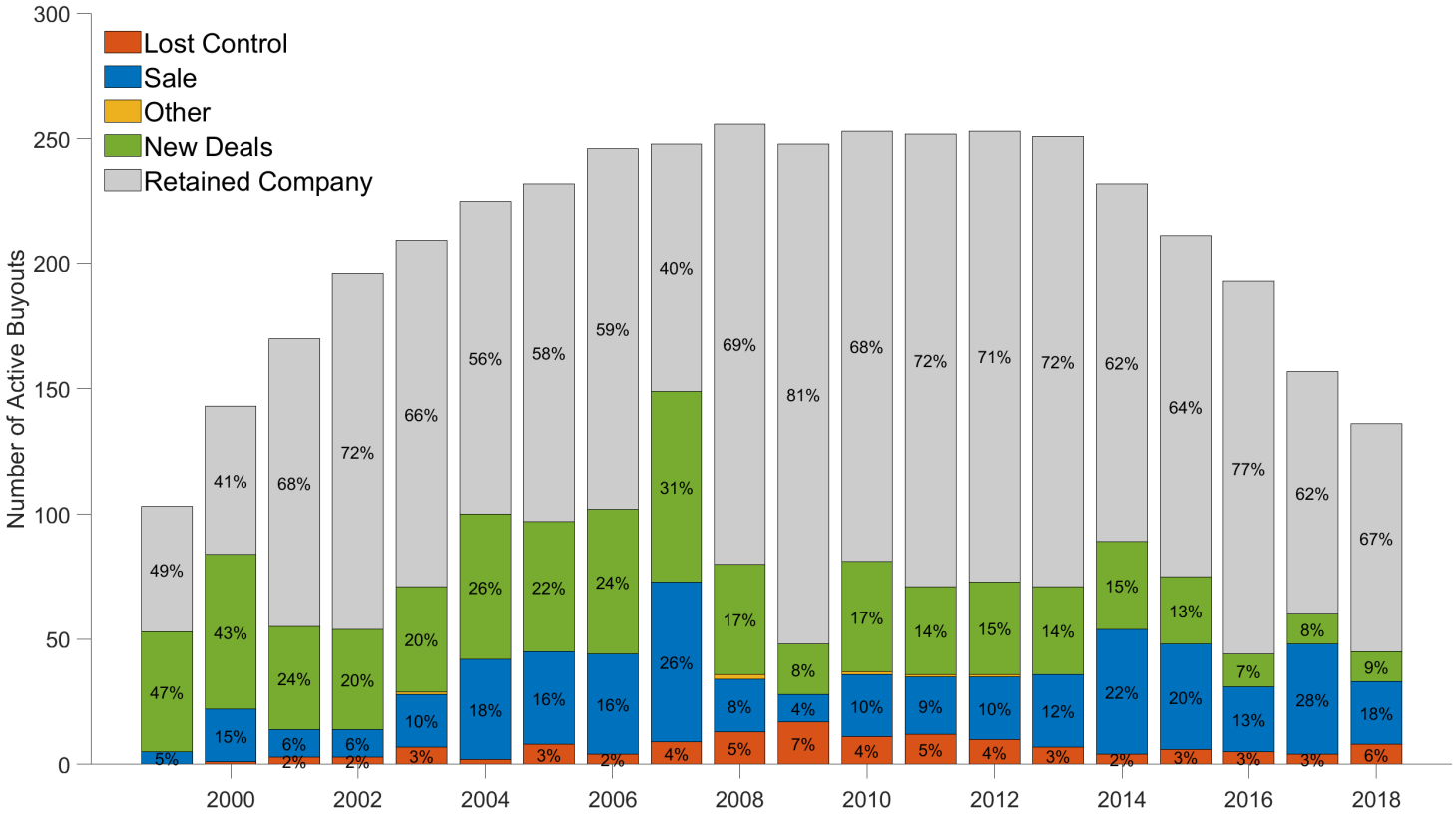


Figure A.5: Outcome Per Year of Active Buyouts

This figure depicts the composition of the outcome of all active buyouts per year. The height of each bar represents the number of companies owned by private equity during at least part of the year. Percentages displayed in the colored bars correspond to the fraction of deals in a year where private equity either: lost control; sold the company; acquired the company; or retained the company. The "Sale" category contains the exit types "IPO", "Trade Sale", and "Sale to Financial Institution". A "Retained Company" is one that is owned at the start of the year and still held at the end of the year. Percentages are omitted from bars representing less than 1% of active deals of the year. The "Other" category consists of 5 cases where the portfolio company was liquidated and ceased trading. All exit routes are defined in Table D.1.

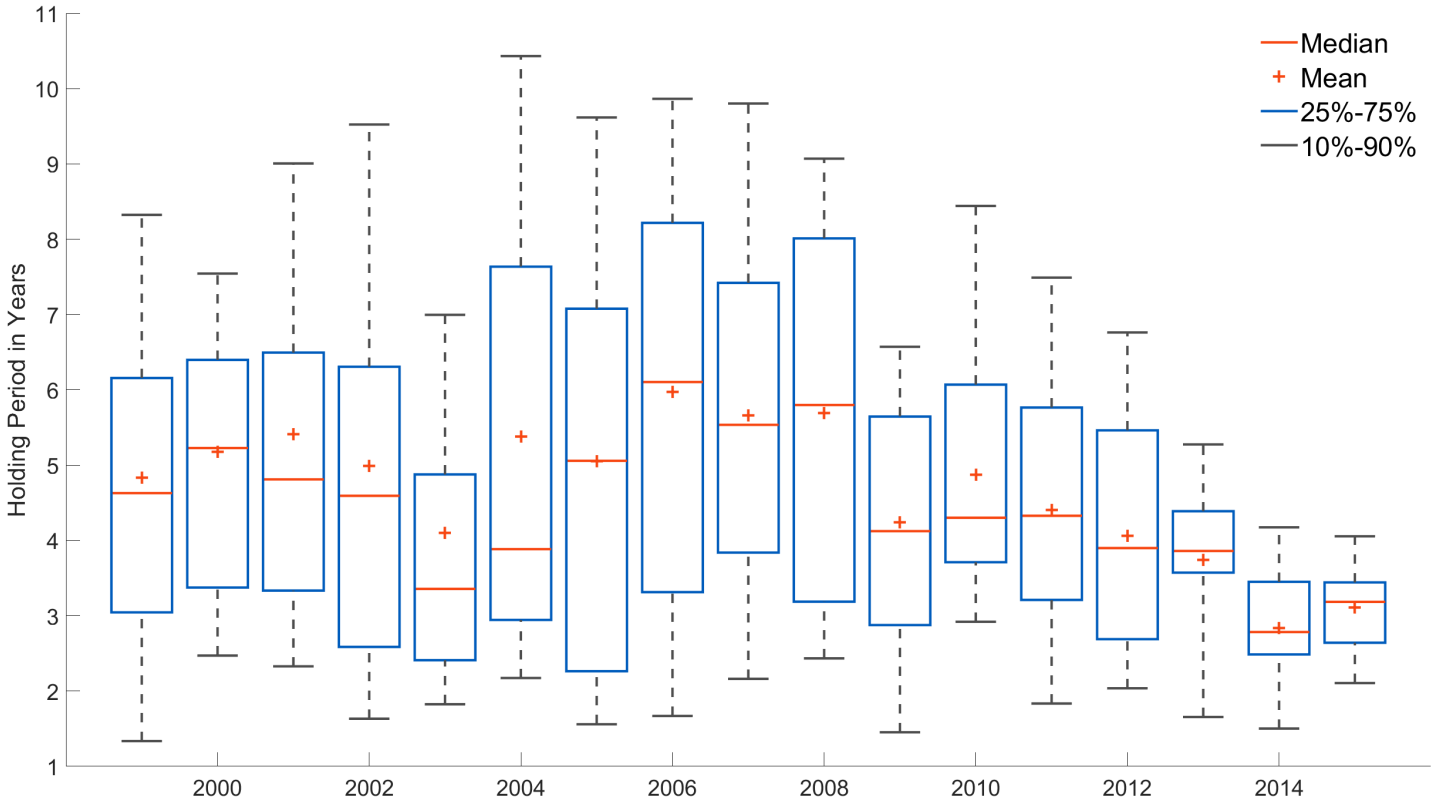


Figure A.6: Holding Periods

This figure depicts the distribution of holding periods of all buyouts completed between 1999 and 2015 and that are fully exited (659 in total). The figures are organized by the year in which the buyout took place. The holding period is measured as the number of years from the date the transaction was completed until the date of the exit, displayed on the y-axis.

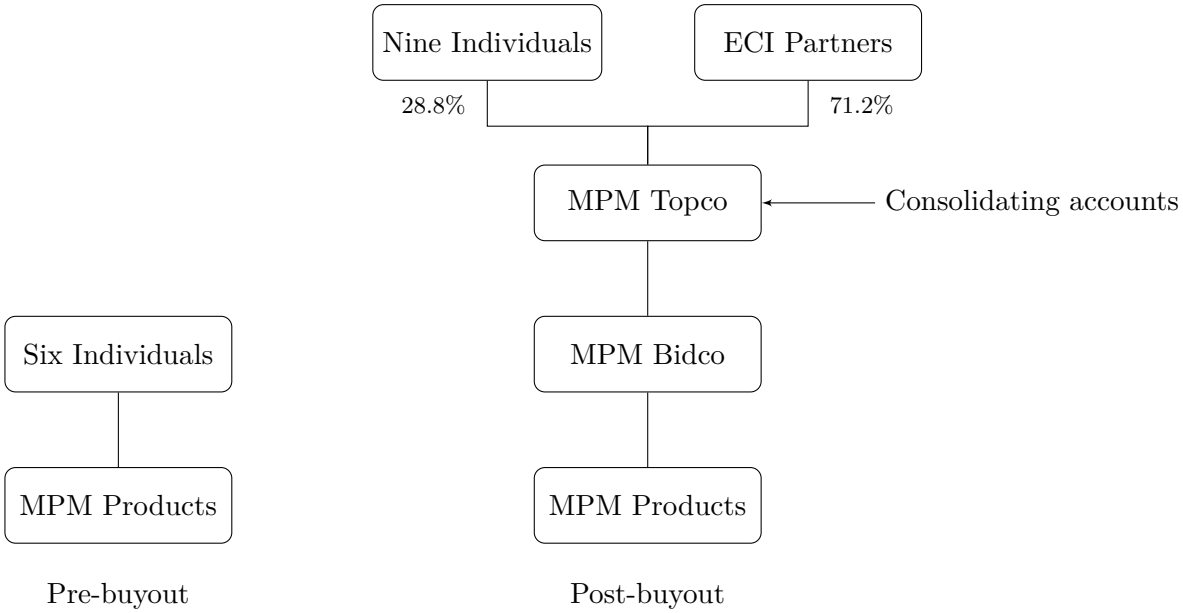


Figure A.7: Corporate Structure Example

This figure depicts the change in ownership structure following a buyout of MPM Products by ECI Partners in 2016. Prior to the buyout, the company consisted of a single entity directly owned by six individuals. To facilitate the acquisition, ECI created two vehicles, "MPM Bidco" and "MPM Topco". MPM Bidco is wholly owned by MPM Topco, and is the entity acquiring all shares of MPM Products. Following the buyout, MPM Topco prepares consolidated group accounts and the ultimate ownership of MPM topco is split between ECI Partners and nine individuals. ECI Partners' ownership stake in MPM Topco goes through an additional three layers of wholly owned entities which are omitted from the figure. The ownership percentages are compiled from the first Confirmation Statement submitted by MPM Topco in March 2017.

Table A.1: Pay-for-Performance Sensitivity and Fund Performance

This table presents estimates of the estimated pay-for-performance sensitivity $\Delta_{j,t}$ of a PE fund j estimated in quarter t of the fund's life. $\Delta_{j,t}$ is estimated as described in Section 2.2.2 for all quarters and all buyout funds with NAV valuations and cash flow data available in Preqin. All models include an intercept that is omitted from the table. Fund IRR is measured at the time the delta is estimated, using the reported NAV as a final distribution. Fund age is measured in number of quarters since the first fund cash flow. All variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are double clustered at the PE fund level and the fund age level. Estimates followed by the symbols ***, **, or * are statistically significant at the 1%, 5%, and 10% levels, respectively.

Dependent Variable: Pay-for-performance sensitivity $\Delta_{j,t}$

	(1)	(2)	(3)
Fund IRR	0.0338^{***}		-0.0151^{**}
	(0.0060)		(0.0067)
Fund Age		-0.0007^{*}	-0.0019^{***}
		(0.0004)	(0.0005)
Fund IRR× Fund Age			0.0095^{***}
			(0.0016)
Adjusted R^2	0.136	0.012	0.468
N	13927	13927	13927

Table A.2: Summary Statistics - Comparison with Full Buyout Sample

This table presents a comparison of descriptive statistics between companies in the sample and the full set of companies with financials available. The two sample constructions are described in Table 1. Panel A compares statistics for the most recent fiscal year prior to the buyout, referred to as year -1. Panel B presents the change in these accounting measures from year -2 until year -1. Panel C presents changes from year -3 until year -1. Panels D, E, and C compares the buyout types, exit routes, and industry composition, respectively. The final column in panels A, B and C tests differences in means, and numbers followed by ***, **, or * indicate statistically significant means at the 1%, 5%, and 10% levels, respectively.

Panel A: Portfolio company characteristics in year prior to buyout

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue (M£)	246	157.2	69.3	248.7	494	128.4	56.5	206.7	28.80
EBITDA (M£)	246	19.6	8.8	28.9	494	16.5	7.1	25.2	3.15
Total Assets (M£)	246	156.4	66.1	240.5	494	139.1	53.7	220.1	17.39
Number of Employees	238	1797	614	2741	482	1428	456	2397	368.60*
EBITDA Margin	246	0.159	0.141	0.106	494	0.150	0.136	0.108	0.01

Panel B: 1-year pre-buyout growth

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	227	0.177	0.119	0.276	460	0.145	0.099	0.251	0.03
EBITDA	227	0.165	0.182	1.268	460	0.184	0.155	1.436	−0.02
Total Assets	229	0.176	0.071	0.391	464	0.140	0.041	0.400	0.04
Number of Employees	217	0.112	0.062	0.253	448	0.095	0.043	0.252	0.02
EBITDA Margin	227	0.009	0.010	0.061	460	0.006	0.007	0.068	0.00

Panel C: 2-years pre-buyout growth

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	214	0.499	0.285	0.750	433	0.378	0.203	0.608	0.12**
EBITDA	213	0.792	0.414	2.762	432	0.583	0.327	2.347	0.21
Total Assets	218	0.452	0.194	0.869	442	0.360	0.140	0.792	0.09
Number of Employees	203	0.300	0.112	0.653	422	0.253	0.110	0.586	0.05
EBITDA Margin	213	0.020	0.012	0.071	432	0.012	0.010	0.071	0.01

Table A.2 — *Continued*

Panel D: Buyout type

	Sample in Paper	Full Sample
Public-to-Private	0.211	0.134
Private-to-Private	0.273	0.263
Divisional Buyout	0.182	0.231
Secondary Buyout	0.326	0.342
Distressed Buyout	0.008	0.030
N	246	791

Panel E: Exit Route

	Sample in Paper	Full Sample
Lost Control	0.202	0.162
IPO	0.079	0.062
Trade Sale	0.269	0.290
Sale to Financial Institution	0.306	0.316
Still Owned	0.136	0.159
Other	-	0.006
Not Known	0.008	0.005
N	246	791

Panel F: Industry Composition

	Sample in Paper	Full Sample
Mining	1.3%	1.2%
Construction	2.1%	3.5%
Manufacturing	23.0%	27.7%
Transportation	7.6%	7.0%
Wholesale	4.7%	5.6%
Retail	16.0%	12.7%
Services	45.4%	42.2%

Table A.3: Revenue and Pay-for-Performance Sensitivity - Alternative Specifications

This table presents estimates of annualized revenue growth in relation to the fund's pay-for-performance sensitivity $\Delta_{j,t}$. The seven columns indicate specifications with various levels of controls included, as indicated at the bottom of the table. "Controls" include log revenue, log total assets, and EBITDA margin in $t-1$, as well as book leverage post transaction. All variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are clustered at the acquiring fund level. Estimates followed by the symbols ***, **, or * are statistically significant at the 1%, 5%, and 10% levels, respectively.

Panel A - Revenue Growth $t-1$ to $t+1$ (N = 246)							
Fund $\Delta_{j,t}$	0.549	0.764	0.693	0.330	0.277	0.588	0.536
	(0.425)	(0.360)	(0.452)	(0.628)	(0.713)	(0.762)	(0.747)
Adjusted R^2	0.001	0.114	0.045	0.143	0.141	0.306	0.299
Panel B - Revenue Growth $t-1$ to $t+2$ (N = 218)							
Fund $\Delta_{j,t}$	0.608**	0.842**	0.673	0.957	0.953	1.445**	1.466*
	(0.292)	(0.360)	(0.600)	(0.604)	(0.700)	(0.724)	(0.786)
Adjusted R^2	0.003	0.121	0.056	0.159	0.158	0.328	0.310
Panel C - Revenue Growth $t-1$ to $t+3$ (N = 178)							
Fund $\Delta_{j,t}$	0.374	0.742*	0.851*	1.284**	1.237**	1.434**	1.346**
	(0.340)	(0.395)	(0.485)	(0.492)	(0.589)	(0.576)	(0.629)
Adjusted R^2	0.001	0.164	0.056	0.207	0.205	0.476	0.472
Panel D - Revenue Growth $t-1$ to $t+4$ (N = 127)							
Fund $\Delta_{j,t}$	0.884***	1.004**	1.078**	1.161***	1.101**	1.156***	1.113***
	(0.310)	(0.446)	(0.420)	(0.401)	(0.430)	(0.417)	(0.346)
Adjusted R^2	0.023	0.188	0.058	0.227	0.219	0.564	0.599
Transaction-Year FE	No	Yes	No	Yes	Yes	Yes	Yes
Fund FE	No	No	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	No	No	Yes	Yes	Yes
Fund-Year FE	No	No	No	No	No	No	Yes
Controls	No	No	No	No	No	Yes	Yes

Table A.4: Operational Improvements over Time

This table presents estimates of operational performance measure in relation to the fund's pay-for-performance sensitivity $\Delta_{j,t}$. The dependent variable is (log) revenue in columns 1–3, and EBITDA margin in columns 4–6. A separate coefficient is estimated for the fund's pay-for-performance sensitivity $\Delta_{j,t}$, for each year around the buyout, using $t-1$ as the reference year. Note that $\Delta_{j,t}$ itself does not vary across those years. A separate coefficient is similarly estimated for dummies for each year $t+s$ with $t-1$ being the reference point. The dummy coefficients are omitted from the presentation of the table. All specifications include fiscal year fixed effects, company fixed effects, dummies for the fund-year in which the transaction takes place, and company controls interacted with a Post dummy. The Post dummy takes the value of 1 in the post-buyout period, and 0 otherwise. Company controls included are log revenue, log total assets, and EBITDA margin measured in $t-1$, as well as book leverage measured post transaction. Columns 2 and 5 add fixed effects for the acquiring fund, and columns 3 and 6 add industry fixed effects. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are clustered at the acquiring fund level. Estimates followed by the symbols ***, **, and * are statistically significant at the 1%, 5%, and 10% levels, respectively.

	(log) Revenue			EBITDA/Revenue		
$t-3 \times$ Fund $\Delta_{j,t}$	1.126	0.766	1.212	0.032	0.000	−0.067
	(1.228)	(1.033)	(1.208)	(0.268)	(0.263)	(0.266)
$t-2 \times$ Fund $\Delta_{j,t}$	0.604	0.254	0.659	0.029	0.021	−0.060
	(0.689)	(0.798)	(0.688)	(0.224)	(0.221)	(0.221)
$t \times$ Fund $\Delta_{j,t}$	0.722	0.171	0.852	0.176	0.217*	0.110
	(0.676)	(0.944)	(0.682)	(0.140)	(0.126)	(0.126)
$t+1 \times$ Fund $\Delta_{j,t}$	1.158**	0.737	1.334**	0.164	0.210	0.078
	(0.538)	(0.869)	(0.542)	(0.197)	(0.187)	(0.181)
$t+2 \times$ Fund $\Delta_{j,t}$	1.953***	1.639	2.192***	0.154	0.199	0.069
	(0.733)	(1.035)	(0.715)	(0.239)	(0.238)	(0.233)
$t+3 \times$ Fund $\Delta_{j,t}$	1.990*	2.148*	2.245**	0.059	0.032	−0.048
	(1.068)	(1.187)	(1.060)	(0.249)	(0.243)	(0.221)
$t+4 \times$ Fund $\Delta_{j,t}$	4.563***	5.225***	4.921***	0.137	0.102	0.078
	(1.218)	(1.384)	(1.239)	(0.324)	(0.268)	(0.284)
Adjusted R^2	0.957	0.943	0.958	0.766	0.714	0.763
N	1702	1702	1702	1701	1701	1701
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Fiscal Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	No	Yes	Yes	No	Yes	Yes
Industry FE	No	No	Yes	No	No	Yes
Fund-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Table A.5: Likelihood of Bankruptcy

This table presents estimates of the likelihood that a buyout ends up in insolvency procedures, creditors seize control, or a financial restructuring resulting in a new owner taking over without compensating previous equity holders. The dependent variable takes the value of 1 if this happens, and zero for all other types of exits. Deals in which the company is still controlled by the private equity firm as of 2019-09-30 are not included in the estimation. The variable of interest is the fund's pay-for-performance sensitivity $\Delta_{j,t}$. In Panel A it is presented alone, while it is interacted with a high and low reputation indicator variable in Panel B. Columns 1-5 presents estimations using OLS, while columns 6-10 presents the estimations of a Logit model. The five columns differ in the set of control variables included. All models includes time fixed effects. From columns 2 and 7, fund fixed effects are included. Columns 3 and 8 add industry fixed effects. In columns 4 and 9, indicator variables are included for the year in a fund's life the deal took place. Columns 5 and 10 add company controls. Company controls include (log) revenue, (log) total assets, the EBITDA margin, and book leverage. Company controls are measured at the end of the fiscal year prior to the transaction, with the exception of leverage which is measured after the transaction. For the Logit model, the reported coefficient estimates correspond to marginal effects evaluated at sample averages. All continuous variables are winsorized at a 1% level. Standard errors, double clustered at the fund level and the year of the deal in the OLS model, are reported in parenthesis under each estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A

	OLS					Logit				
Fund $\Delta_{j,t}$	−0.418	−1.202	−1.017	−0.804	−1.103	−0.430	−1.771	−1.864	−1.735	−2.444
	(1.751)	(2.023)	(2.016)	(1.982)	(2.089)	(1.215)	(1.558)	(1.530)	(1.551)	(1.567)
Adjusted (Pseudo) R^2	0.000	0.031	0.030	0.016	0.000	0.075	0.162	0.219	0.232	0.234
N	213	213	213	213	213	213	213	213	213	213

Panel B

	OLS					Logit				
Fund $\Delta_{j,t} \times 1\{\text{High Rep}\}$	−1.329	−2.432	−2.656	−2.895	−1.103	−1.272	−2.681	−3.234	−3.273	−2.444
	(1.726)	(2.015)	(2.023)	(2.013)	(2.089)	(1.460)	(1.577)	(1.587)	(1.588)	(1.567)
Fund $\Delta_{j,t} \times 1\{\text{Low Rep}\}$	2.118	0.693	2.543	2.145	2.081	3.458	1.900	3.035	2.863	1.121
	(2.373)	(1.546)	(2.067)	(2.017)	(1.979)	(2.784)	(3.251)	(2.894)	(2.985)	(3.055)
Adjusted (Pseudo) R^2	0.001	0.039	0.044	0.029	0.014	0.106	0.228	0.258	0.277	0.284
N	213	213	213	213	213	213	213	213	213	213
Transaction Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Fund-Year FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Controls	No	No	No	No	Yes	No	No	No	No	Yes

Table A.6: Operational Improvements and Pay-for-Performance Sensitivity due to Market Shocks - Alternative Specification

This table presents estimates of operational improvements in relation to the part of a fund's pay-for-performance sensitivity that is due to a recent market shock, $\Delta^m_{j,t}$, defined in section 4.1.3. In this table, the NAV of the PE fund is assumed to not have incorporated the market shock yet. The four columns represent improvements from the year prior to the buyout, $t-1$, to one, two, three, and four years after the buyout. The dependent variable is annualized revenue growth in Panel A, annualized employee growth in Panel B, annualized growth in total assets in Panel C, and the cumulative improvement in the EBITDA/Revenue margin in Panel D. Each model specification includes time, fund, and industry fixed effects; dummies for the fund year in which the transaction took place; and log revenue, log total assets, and EBITDA margin in $t-1$, as well as book leverage post transaction. All variables are winsorized at a 1% level. Standard errors, reported in parenthesis under each estimate, are clustered at the acquiring fund level. Estimates followed by the symbols ***, **, or * are statistically significant at the 1%, 5%, and 10% levels, respectively.

Panel A - Revenue Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	2.666*	2.389*	0.352	1.374
	(1.430)	(1.218)	(0.900)	(1.136)
Adjusted R^2	0.304	0.307	0.462	0.577
N	246	218	178	127

Panel B - Employee Growth (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	2.873	1.155	−0.970	−1.427
	(1.838)	(0.841)	(0.849)	(1.564)
Adjusted R^2	0.221	0.284	0.396	0.281
N	238	207	169	120

Panel C - Growth Total Assets (annualized)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	−4.662	−1.234	−1.385	−2.098
	(3.451)	(2.560)	(1.708)	(2.633)
Adjusted R^2	0.140	0.135	0.153	0.119
N	246	218	178	127

Panel D - Cumulative change in Return on Sales (EBITDA/Revenue)

	$t-1$ to $t+1$	$t-1$ to $t+2$	$t-1$ to $t+3$	$t-1$ to $t+4$
Fund $\Delta^m_{j,t}$	1.094	0.349	0.916	−0.966
	(1.104)	(1.891)	(2.027)	(2.217)
Adjusted R^2	0.032	0.122	0.161	0.321
N	246	218	178	127
Time FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Fund-Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

B Additional Data Description

This appendix complements the main data description in Section 3, by providing details the sample construction process and some additional details on the accounting data used in the paper.

B.1 Sample Construction

I follow Strömberg (2008) and use Capital IQ (CIQ) to identify buyout transactions. The transaction screen was undertaken 2019-01-02. The following criteria were used in a "Capital IQ Transaction Screen" to generate the initial set of transactions:

- "Transaction Primary Features" set to: Merger/Acquisition – Acquisition of Equity Stake or Private Placement – PIPE or Private Placement – Growth capital/Private Equity;
- "Merger/Acquisition Features" set to: "Going Private Transaction" or "Leveraged Buy Out (LBO)" or "Management Buyout" or "Platform" or "Privatization of Government Entity" or "Management Participated" or "Secondary LBO" or "Acquisition of Majority Stake";
- "Secondary features" set to: "Leveraged Buy Out (LBO)", or "Management Buyout", or "Secondary LBO", or "Going Private Transaction";
- "Investment Firm Type (Buyers/Investors)" is listed as "PE/VC";
- Transaction is listed as "closed" or "effective".

The initial screen picked up transactions that were initial toe-hold investments, a purchase of remaining minor stakes, or the purchase of a minority stake. The focus here are transactions in which a private equity buyout fund gains control of the company. Therefore, transactions that are classified as either "Minority Stake Investment" or "Majority Shareholder Purchasing Remaining Shares", or where the investor was classified as a "VC", are dropped from the sample. This leaves an initial set of 11,549 transactions.

For all unique companies in these transactions, the following items are extracted: company name; country of incorporation; filing currency; and the country of primary office location. All UK companies are selected based on being incorporated in the UK or, if that item is not available, either have GBP as its filing currency or has its primary office in the UK. Due to the limited number of years with financials available in the Bureau van Dijk (BvD) databases, we restrict the sample to transactions completed between 1999 and 2018. This leaves the initial set of 1964 buyouts of UK companies that forms the first row of Table 1.

Of the identified buyouts of UK companies 850 are randomly selected to be processed. Each transaction requires a substantial amount of manual work, necessitating working with a random part of the sample. Figure A.3 outlines the composition of buyouts over time of those randomly selected versus those not processed. Overall, the distribution of buyouts over time is quite similar, though Capital IQ coverage is low for the later years in the sample.

57 transactions are dropped from the sample for the following reasons:

- 19 companies are dropped as no UK company could be found either in Companies House or Fame under the name of the acquired company in Capital IQ today or, when it differed, the name of the acquired company in the transaction synopsis provided by Capital IQ. Both Companies House and Fame contains previously registered names of companies, so when no match can be found it likely reflects either a mistake in the naming in Capital IQ or that some non-UK companies are identified during the process of selecting UK-registered companies.
- 15 transactions are dropped as no PE firm participated. PE firm participation is verified using annual reports and ownership filings.
- 10 transactions are dropped because the PE firm did not acquire a controlling stake. This information is gathered from post-buyout ownership filings.
- 7 transactions are duplicates, where two separate company IDs in Capital IQ have been assigned to the same transaction, with two separate transaction IDs.
- 5 transactions are dropped as the transaction ID identified in the initial screen were no longer present in Capital IQ at the time a match was attempted to be established with Fame.
- 3 transactions are dropped because the acquired companies were too small and were exempted from submitting filings throughout the period of interest.

The remaining 791 buyouts are fully processed with the type of buyout classified and the type of exit documented with the date and the type of exit. For the 16.2% of transactions that are classified as still being owned by private equity this is as of 2019-09-30, when a potential sale was last searched for. A lack of news about a sale is not sufficient to classify a company as still in private equity hands. Ownership filings are used to verify the ownership status and searches for insolvency filings are undertaken in Companies House. There are 4 cases where the outcome could not be determined. In one of these it is suspected that creditors seized control as the ownership passed to a syndicate of

financial institutions after a period of large reported losses. However, to be consistent, only events which are explicitly mentioned in the annual reports are included as it is possible that they paid the previous owner to acquire the company. The remaining three unknown cases concerns individuals taking over control of the company with no mention as to what happened to the previous private equity owners.

B.2 Additional Details on the Accounting Data

The main source of the accounting data used in the paper is Fame, a BvD database. The filings available in Companies House are scanned documents, and BvD provides a digitalized version of them in a panel format for individual company IDs. The ID assigned to a company in BvD is the one the company is registered with in Companies House.

Fame provides financials for up to 20 years worth of annual reports. For the earlier transactions in the sample this implies that the pre-buyout period is not always covered. For these deals I manually complement the financials from annual reports downloaded from Companies House. There are two additional scenarios when I manually complement the Fame data.

First, occasionally there are fiscal years inexplicably missing from Fame, despite the annual reports being available in Companies House. I add these years manually to avoid gaps in the data where there are none.

Second, the acquisition event typically gives rise to a large amount of goodwill in the acquiring parent company, and subsequent add-on acquisitions may further increase the goodwill post in the balance sheet. The goodwill is typically amortised over a period of years and may be subject to impairment charges. Fame provides an EBITDA number that accounts for depreciation and amortisation. However, it is not uncommon that one or both of the two numbers are missing from individual years. Additionally, impairment charges are only rarely included by Fame, though they are both common and usually of considerable magnitude. I have manually gone through Fame to detect missing depreciation/amortisation entries, and scanned annual reports for mentions of impairment charges to verify whether they are picked up by Fame.[35] When Fame miss impairment charges I complement the EBITDA calculations.[36] This process is applied to the pre-buyout years as well as the period under private equity ownership to avoid any bias arising from different treatment of the data during the period of PE ownership.

[35]Impairment and write-downs can be made for fixed assets and intangible assets such as goodwill. Fame tends to not account for either. The charge always shows up somewhere in Fame as a cost to make net income calculations correct. While there is some variation of where they place it, the most common appears to be to the cost in general "Administration Expenses", and sometimes as an exceptional item.

[36]The increase in interest payments and the typical increase in amortisation is the reason why EBITDA measures are commonly used to evaluate the performance of PE portfolio companies.

Not all companies are required to provide the same level of detail in their annual reports. In particular, companies classified as "small" are only required to submit abridged accounts, which contains limited information and excludes a profit and loss statement. These filings therefore cannot be used in the data analysis. The classification requirements for small companies has changed over time, and any company-year in which a company qualified as a small company is dropped from the sample.[37]

[37]To be classified as a small company, it needs to be smaller in at least two out of three qualifying measures: turnover, total assets, and number of employees. The limit on number of employees has been stable at 50 over time. The following requirements and time periods are relevant for the sample in this paper, with numbers for turnover (total assets): prior to 2004-01-10, £2.8m (£1.4m); prior to 2008-04-06, £5.6m (£2.8m); prior to 2015-04-06, £6.5m (£3.26m); since 2015-04-06, £10.2m (5.1m). Classifications are from Section 247 of the Companies Act 1985 and Section 382 of the Companies Act 2006, both links accessed 2019-08-22. I am grateful to the policy team at Companies House for providing these links.

C Details on Monte Carlo Procedure

This appendix provides additional details on the simulation process used for estimating expected carried interest described in section 2.2.

The estimation of expected carried interest relies on Monte Carlo simulations of the value paths of individual investments in a private equity portfolio. The simulation consists of several step, that largely match those outlined in Figure 1 in Metrick and Yasuda (2010), with one added step on the calibration part. The following steps describe the baseline process when the model is calibrated:

1. Model inputs are defined. These include contract terms defining fee payments, as well as number of investments, timing of investments, and other model parameters. All model parameters are defined in Table C.1, which also provides sources justifying the values used.

2. Initial values are set for the value added by GPs, and the initial parameter σ. Both of these are set as the midpoint of a range containing wide enough to span the value which the calibration converges on. The range is decreased in an iterative process according to point 5.

3. 100,000 simulations of a private equity fund portfolio are generated. For each investment in the portfolio, the following is drawn:

   (a) A holding period is drawn from the empirical distribution of holding periods. If the fund age at the exit date implied by the holding period exceeds the fund's 12th year, the investment is instead exited at the end of that year.

   (b) Portfolio company paths are generated using the process defined in 2.2.1.

   (c) The entire generated path is checked to ensure that the value of equity > 0 at all times. If not, company passes to creditors and the private equity fund writes off the investment.

   (d) Cash flows of individual investments are aggregated to the fund level, and distributed to the GP and LPs according to the contract terms defined in step 1.

   (e) The resulting cash flows are discounted to the fund inception date using a risk-neutral rate r.

4. The expected values of fees and cash flows are computed as average values over the 100,000 trials.

5. The input values of either σ or value added by the GP is adjusted. As the two items interact, they are adjusted alternatively in an iterative process according to the following rules:

   (a) σ is calibrated to ensure that the likelihood of default equals the empirically observed one, as documented in Table 3. The low value of σ is set to the current midpoint in the range if model output of default $<$ empirically observed default level. If the model output of default $>$ empirically observed default level, the high value of the σ range is set to the current midpoint.

   (b) Value added by the GP is calibrated to ensure that the present value of LPs capital call equals the present value of cash distributions to LPs. If the net present value of cash flows to LPs < 0, the low value of the value added range is set to the current midpoint, while if net present value > 0, the high value added range is set to the current midpoint.

Steps 2 to 5 are repeated until σ is accurate to within three decimal points (17.4%), and value added is determined with two decimal points per \$100 of committed capital (\$9.23). The process of updating guesses requires increasingly precise estimates to ensure the update converges. As the range halves every iteration, the number of simulations need to increase by a factor four to decrease the standard deviation of the estimated value by half. I ensure that the range stays within six standard deviations at all times, which the 100,000 runs guarantees for most of the iterations. However, the number of simulations needs to be updated towards the more precise estimates, and 25.6 million simulations are run in the final iteration.

Changes to σ and value added feed into the calibrated value of each other. Therefore, to reduce the computational time required, the first few rounds of the iterations only estimate σ to an accuracy of two decimal points (whole percent) and value added to one decimal point. Note that each estimation of σ (and value added) itself requires a number of iterations to reach the desired accuracy. When this process converges, the number of simulations increase to reach the desired accuracy is achieved. The final output of the model is summarized in Table C.2.

The main focus of the paper is estimating the change in expected GP pay from adding one dollar of additional value to one investment, as outlined in section 2.2.2. When empirically estimating the process for each reported NAV in Preqin, a seed is utilized to ensure that the same portfolio company paths are generated with and without an additional dollar of value added, making that the only source of variation. This significantly reduces the standard error of the estimation, ensuring that 10,000 simulated portfolio paths yields an accurate estimate of the pay-for-performance sensitivity measure.

The paper does not present any analysis of variation in contract terms. Metrick and Yasuda (2010) document how GPs' expected pay from various fee sources varies when the contract terms vary. While this is important for overall fee levels, the impact is much smaller on the pay-for-performance sensitivity measure that is the focus of this study. The main reason is that the equilibrium approach alters the expected value added by a GP to ensure that LPs break even in expectation. Thus, altered contract terms change the calibrated values, but have little impact on the estimated pay-for-performance sensitivity measure. Importantly, the qualitative patterns summarized in Figure 1 are virtually unchanged for alternative contract terms.

Table C.1: Model Parameters

Parameter	Value	Source
ρ	0.2	Used in Metrick and Yasuda (2010), numbers from estimates in Campbell et al. (2001) for small-cap stocks.
σ	17.4%	Calibrated so fraction of simulated portfolio paths ending in default equals the empirically observed rate of 19.4% of all exited deals documented in Table 2.
r	5%	By assumption.
Carried interest level	20%	Used by 83.3% of buyout funds in Metrick and Yasuda (2010), and 96.0% out of the 860 funds in Preqin with information about level of carried interest.
Carry basis	Committed capital	Used by 83.3% of buyout funds in Metrick and Yasuda (2010). LPs receive their committed capital, and hurdle rate, back before carried interest is paid out to the GP.
Catch-up rate	100%	Reported by Metrick and Yasuda (2010) to be used by a majority of funds with a hurdle rate.
Exit date		Drawn from the empirical distribution of holding periods of exited deals in the sample, described in Table 2 and Figure A.6. An investment is terminated early if the value of the portfolio company at any point equals debt. Any remaining investments at the end of a fund's 12th year are liquidated.
Hurdle rate	8%	Used by a majority of buyout funds in Metrick and Yasuda (2010), and by 94.5% out of the 474 buyout funds in Preqin with information about hurdle rates.
Investment pace	26%, 23%, 25%, 18%, and 8%	Investment pace per year as reported in Metrick and Yasuda (2010). For estimations where funds are partly invested, the investment pace is scaled as required to ensure a fully invested fund at the end of the investment period. Arcot et al. (2015) and Degeorge et al. (2016) provide evidence that GPs accelerate investments towards the end of the investment period if there is unspent committed capital.
Leverage (D/E)	2:1	Leverage of buyouts in western Europe documented by Axelson et al. (2013). Here expressed as D/E.
Management fee	2%	Most common management fee level among buyout funds in Preqin, used by 75.3% (out of 799).

(*Continues*)

Table C.1 — *Continued*

Parameter	Value	Source
Management fee basis		Committed capital during investment period, net invested capital thereafter. Used by 84% of buyout funds in Metrick and Yasuda (2010).
Monitoring fees (% of Total enterprise value)	0.72%	Sum of "regular monitoring" (0.44%) and "accelerated monitoring" fees (0.28%) as a fraction of TEV in Phalippou et al. (2018).
Investments per fund	16	Average number of deals per fund in Braun et al. (2017).
Transaction fees (% of Total enterprise value)	0.88%	Sum of "transaction fees" (0.81%) and "add-on transaction fees" (0.07%) as a fraction of TEV in Phalippou et al. (2018).
LP rebate rate of monitoring fees	70%	Average rebate on monitoring fees in Phalippou et al. (2018).
LP rebate rate of transaction fees	72%	Average rebate on transaction fees in Phalippou et al. (2018).

Table C.2: Model Output

This table summarizes the model outputs for simulations run at fund inception, after calibrating σ and value added by GPs as described in Section 2.2. The values presented are for a fund with \$100 of committed capital. It compares the model output to those for buyout funds in Metrick and Yasuda (2010) using comparable fund terms. The calibrated value added that make LPs break even is not available for buyout funds in Metrick and Yasuda (2010). They do provide values for VC funds which is \$18.71. Average total revenues to buyout funds in their paper is \$5.36 lower, suggesting that value added is likely around \$13.35. In their paper, σ is not calibrated but assumed to be 0.60. As this paper adds leverage at the portfolio company level, the proper comparison to their assumed value is the volatility of the equity position $\sigma_E = 0.521$.

	Output in paper	Metrick and Yasuda (2010)
Carry per \$100	\$4.06	\$5.08
Management fees per \$100	\$10.48	\$11.09
Transaction fees per \$100	\$0.56	\$1.68
Monitoring fees per \$100	\$0.19	\$0.87
Total GP revenue per \$100	\$15.26	\$18.72
Calibrated σ	17.36%	n/a
Calibrated value added per \$100	\$9.23	n/a

D Variable Definitions

Table D.1: Variable Definitions

Variable name	Description
Buyout Types	
Distressed Buyout	A transaction where the acquired company was in financial distress prior to the buyout. It is defined as being acquired from one of the following situations: acquired from bankruptcy procedures (called "administration" in the UK); acquired in a refinancing or restructuring deal where creditors are not fully compensated; and one case where the acquiring private equity firm was paid by the previous owner to take on the company and its debt.
Divisional Buyout	A transaction where the acquired company was a subsidiary or division of a larger corporation prior to the buyout.
Private-to-Private Buyout	A transaction where the acquired company was privately trading prior to the buyout, with individuals controlling the company, and is not classified as a distressed buyout.
Public-to-Private Buyout	A transaction where the acquired company was publicly listed at the time of the buyout.
Secondary Buyout	A transaction where the acquired company was a portfolio company of another private equity firm prior to the transaction. This category includes cases where the portfolio company is passed between private equity ownership more than once.
Exit Routes	
IPO	An exit is classified as an IPO if the private equity owner exits via an initial public offering. Usually, a private equity owner do not sell all shares at the IPO, instead exiting over a period of time following the IPO. The exit date is defined as the date at which majority ownership is lost, whether that is the IPO date or a later date. The exit route is classified as an IPO if the stake is reduced below a majority stake while the company is still publicly trading.
Lost Control	A private equity owner is defined as having lost control of the company if any of the following happens: creditors seize control of the company; the company is placed in bankruptcy procedures (called "administration" in the UK); or control passes to a new owner in a financial restructuring of the company, where the equity holders receive no compensation. These are events that are generally not disclosed publicly, and the eventual outcome is found through disclosures in Annual Reports and, in the case of bankruptcy procedures, through reports submitted submitted to Companies House by the court-appointed administrators.

(*Continues*)

Table D.1 — *Continued*

Variable name	Description
Other (Exit Route)	There are five cases in the sample where the exit route cannot be classified into either of the other five exit route categories. These five cases involve the private equity firm maintaining ownership of the portfolio company until the company has been sold in pieces or liquidated by other means, and afterwards seize trading.
Trade Sale	A sale is classified as a trade sale when the company is sold to a non-investment firm or to individuals.
Sale to Financial Institution	A sale is classified as a sale to a financial institution when the company is sold to a investment firm. The vast majority of these cases are sales to private equity funds but also includes sales to pension funds, sovereign wealth funds and other investment firms.
Still Owned	A company is classified as still being owned if there are no recorded transactions as of 2019-09-30, and the most recent annual report or ownership list still indicates the private equity firm as the ultimate majority owner.
Dependent Variables	
Employee Growth	The percentage increase in number of employees from $t-1$ to $t+x$. Represented as an annualized growth rate over the $x+1$ years.
Growth Tangible Assets	The percentage increase in tangible assets from $t-1$ to $t+x$. Represented as an annualized growth rate over the $x+1$ years. This measure is used as an alternative to growth in total assets to exclude the impact of goodwill on the growth rate.
Growth Total Assets	The percentage increase in total assets from $t-1$ to $t+x$. Represented as an annualized growth rate over the $x+1$ years. Total assets includes goodwill arising from acquisitions, including that generated by the buyout itself.
Revenue Growth	The percentage increase in revenue from $t-1$ to $t+x$. Represented as an annualized growth rate over the $x+1$ years.
Return on Sales (ROS)	Defined as Earnings before Interest, Taxes, Depreciation and Amortisation (EBITDA) divided by Revenue. EBITDA is adjusted for impairment charges, write-offs and revaluations to tangible and intangible assets. In the analysis, the cumulative change in ROS from $t-1$ until $t+x$ is used.

(*Continues*)

Table D.1 — *Continued*

Variable name	Description
Explanatory Variables	
Close to Fundraising	An indicator variable taking the value of 1 if a transaction took place close to a fundraising event, and zero otherwise. This is defined as a fundraising event taking place within eight quarters of the closing date of the transaction. A fundraising event is defined as the first quarter in which a cash flow is observed in the follow-on fund or, when cash flow data is not available, the second quarter of the follow-on fund's vintage year.
Far from Fundraising	An indicator variable taking the value of 1 if a transaction did not take place close to a fundraising event, and 0 otherwise.
Fund $\Delta_{j,t}$	The expected increase in a GP's payoff from carried interest from adding \$1 to the next investment made, estimated using the framework described in section 2.2.
Fund $\Delta^m_{j,t}$	The part of $\Delta_{j,t}$ attributable to market movements in the most recent quarter. See section 4.1.3 for details on construction.
Fund IRR	The internal rate of return of the fund. In this paper the IRR is measured prior to a fund being fully liquidated. To calculate it, the current NAV valuation is accounted for as a final distribution.
Fund Age	Age in quarters, with the fund's first quarter is the one in which the first capital call takes place.
High Reputation	An indicator variable taking on the value of 1 in buyouts where the acquiring GP is classified as a high reputation GP. A GP is classified as high reputation if it is not classified as low reputation.
Low Reputation	An indicator variable taking on the value of 1 in buyouts where the acquiring GP is classified as a low reputation GP. A GP is classified as low reputation if it has: cumulatively raised than \$1 billion prior to the current fund; have raised less than three funds in the past; and have no past top quartile funds that are five years or older at the time the new fund is raised.

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5 | Managerial Ownership and Operational Improvements in Buyouts*

This paper examines the impact of managerial ownership on operational performance for companies backed by private equity. High post-buyout CEO equity ownership stakes are associated with improved profitability. This result could arise for several reasons, such as the impact of incentives or matching of talented CEOs to companies. To distinguish between these explanations, the paper utilizes that the CEO is often replaced in buyouts. The ownership-performance result is only present when a CEO is retained, suggesting that the matching explanation is unlikely to be a main driver. In addition, the result is stronger when absolute changes in ownership are used rather than ownership levels. Taken together, these results suggest that changes in incentives from managerial ownership stakes induced by buyouts likely contribute to improved operational performance.

1 Introduction

Private equity has become a prominent ownership form, with $4.1 trillion in assets under management globally (Preqin 2020) and sponsoring more than 4000 deals during 2018 in the US alone (Pitchbook 2019). Given its large role in the economy, it is important to understand if and how private equity impacts the performance of portfolio companies. Although the existing literature suggests that private equity generates improvements to portfolio companies' operations, we do not know which actions taken generate these improvements.[1]

Starting with Jensen and Murphy (1990), there has been a long debate over whether the equity ownership of CEOs provides sufficient incentives to generate value for shareholders. A salient feature of private equity acquisitions is that managerial equity ownership increases (e.g. Kaplan and Stein, 1993; Cronqvist and Fahlenbrach, 2013). Increasing the

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[1]Examples of studies documenting operational improvements are Acharya et al. (2013); Bernstein and Sheen (2016); Boucly et al. (2011); Davis et al. (2014, 2019); Guo et al. (2011); and Kaplan (1989).

equity ownership stake increases the pay-for-performance sensitivity of the management team, providing stronger incentives to generate value. Gompers et al. (2016) document that private equity firms believe that improving incentives is the second most important source of value creation.[2] This paper examines how the change in managerial ownership induced by a buyout is related portfolio company performance.

To examine this question I assemble a unique dataset containing operational performance and managerial ownership of companies acquired in a buyout. Since companies under private equity ownership are privately trading, this data is generally not available unless the company subsequently goes public or has publicly traded debt, limiting the potential sample and raising concerns that the sample is not representative (Cohn et al., 2014; Davis et al., 2019). I overcome this challenge by focusing on portfolio companies registered in the United Kingdom. All UK companies, public and private, are required to submit filings to the national registrar office, Companies House, which makes the filings publicly available. Required filings include annual reports as well as annual breakdowns of the precise ownership of every shareholder in the company. I compile ownership filings by hand to measure managerial ownership before and after the buyout.[3] Using a random sample of 322 UK portfolio companies, this paper provides new insights into the impact of managerial ownership on the performance of companies acquired in a buyout.

The main finding of the paper is that the post-buyout CEO ownership share is positively correlated with improvements in profitability (EBITDA/Revenue).[4] The results suggest that companies with a 10 percentage points higher CEO equity ownership stake (one standard deviation) improve their profitability margin by 3.1%—3.6% from the unconditional average profitability. The relationship is more pronounced for changes in CEO ownership stakes, where a 10 percentage points increase in the ownership translates to a 4.3%—5.0% increase in profitability.

Clearly, the interpretation of any observed relationship between managerial ownership and operational performance depends on whether the CEO is retained or replaced. Cornelli and Karakas (2015) document that the CEO of a target company is often replaced by the acquiring private equity firm, which is the case in 39% of the buyouts in my sample. Interestingly, the positive relationship between managerial ownership and profitability

[2]The most important source is "improving revenue or improve demand factors" (Table 23). As improved incentives may improve revenue, these are not mutually exclusive.

[3]This is not the first paper to utilize the UK setting to study private companies. Brav (2009) and Michaely and Roberts (2012) used the UK setting go gain insights from privately trading companies, while Bernstein et al. (2019) study how private equity ownership impacted portfolio companies through the financial crisis.

[4]Results are similar for gross profitability and can be provided upon request to the author. Buyout transactions usually create large goodwill posts, increasing total assets as well as significant goodwill amortisation posts. Because of this, the focus is on EBITDA as a profit measure, and return on sales as a profitability measure rather than return on assets.

improvements found in this study is driven entirely by the subsample of buyouts where the CEO is retained. By contrast, the coefficient is statistically insignificant and close to zero when the CEO is replaced. The economic magnitude is up to 60% higher when the CEO is retained compared to the full sample.

The positive relationship between operational performance and increased managerial equity ownership may reflect matching of talented CEOs to companies as in Gabaix and Landier (2008). Higher ability CEOs should be able to bargain for a bigger share, as well as accept compensation packages that are more dependent on performance. The results could also correspond to the outcome of efficient bargaining from managers with inside information (Blanchflower et al., 1996). Additionally, they may capture an effect of incentives provided through the ownership stake. The arrival of private equity almost invariably induces a shock to the managerial ownership share. To the extent managers have limited say over the post-buyout share, the change in ownership level represents a shock to CEO incentives.

The different sample splits help differentiating between these potential explanations. If the positive relationship between managerial ownership and performance reflects attracting talented CEOs, we would expect the results to be stronger when the CEO is replaced as the pool of potential CEOs is larger. Instead, the positive relationship is only observed when the CEO is retained, which casts doubt on this explanation. When a CEO is retained, a change in the ownership stake implies a change in incentives, while CEO ability is held constant. Furthermore, the incentive story suggests that changes in ownership are more relevant than the level of ownership, which is what I find. In contrast, the bargaining story suggests that the relevant metric is the ownership share of the management team.

To further sharpen the interpretation of the results I examine the determinants of CEO equity ownership post-buyout. These results are largely consistent with a desire to provide incentives. There is a negative relationship between ownership stake and initial profitability. Taken together with the main results of the paper, this is consistent with private equity firms setting contracts to maximize value. Providing management with higher equity stakes comes at a cost as it limits the upside of the acquirer. Therefore, we expect higher management stakes in companies where profitability improvements are particularly valuable: those with low initial profitability. Furthermore, the pre-buyout ownership stake is positively related to the post-buyout stake, but only when the CEO is retained. This is consistent with an attempt to increase incentives from pre-buyout levels. Taken together, the results of the paper support the view that improving managerial incentives plays an important part in value creation by private equity firms.

A natural question to ask is how profitability improvements come about. Improved profitability may reflect reduced costs or increased revenues with the existing cost base.

The results of the paper indicate that the profitability improvement related to increases in managerial ownership stems from reducing costs rather than increasing productivity. This could indicate that private equity firms provide CEOs with larger stakes when cost cutting is desired. If cost cutting is associated with a high private cost to the CEO, this is consistent with an optimal contracting view.

Any study on private equity portfolio companies has to deal with the fact that companies are not randomly assigned to be buyout targets. Thus, simply comparing buyout targets with non-targeted companies is tricky. Therefore the analysis relies on cross-sectional variation in managerial ownership among buyout targets, rather than comparing buyout targets and other companies. Following Boucly et al. (2011), the analysis includes matched control companies to account for industry-time fixed effects, but the variation in managerial ownership is only among the targets of a buyout.

However, even among buyout targets there is a concern that the optimal compensation package varies with unobserved company characteristics. But this explanation cannot explain why it is only in the retained CEO subsample that we see positive relationships between managerial ownership and operational performance, and between pre- and post-buyout CEO ownership stakes. Presumably, a high pre-buyout ownership stake would indicate a higher CEO ownership stake in the optimal contract whether the CEO is retained or not.

Finally, distinguishing between the efficient bargaining and the incentive story is problematic as they often give similar predictions. For example, imagine a manager of a division in a conglomerate with knowledge of how to improve that division. She may approach a private equity firm with the intention to increase her ownership stake prior to implementing the necessary improvements. The larger stake provides incentives to take action, but presumably the manager's inside information allows her to bargain for a larger stake. Absent exogenous shocks to the ownership stake provided to CEOs, this paper cannot claim causality, merely offering robust supportive evidence of the idea that higher CEO incentives lead to improved operational performance.

This paper speaks directly to the literature on operational improvements provided by private equity. Early studies by Kaplan (1989), Lichtenberg and Siegel (1990), and Smith (1990), showed that management buyouts are associated with improved operations, and that this generates value for the private equity sponsors. More recently, Guo et al. (2011), and Acharya et al. (2013) document the importance of operational improvements for generating value in buyouts. Boucly et al. (2011), using a sample of French portfolio companies, suggest one important channel through which private equity can help their portfolio companies: relaxing credit constraints to facilitate growth. Davis et al. (2014) and Davis et al. (2019) provide evidence that private equity facilitates reallocation of capital to

more productive establishments, generating an overall increase in total factor productivity. This paper adds to this literature by documenting how a specific change induced by a buyout — changes in managerial ownership — relates to operational improvements.

As discussed in Jeng and Lerner (2016), data limitations is always an issue in private equity research, and certainly when studying privately held portfolio companies with limited disclosure requirements. Cohn et al. (2014) directly show how this may impact the interpretation of results, as companies with publicly available financials perform better than those without. Davis et al. (2019) highlight that not all buyouts are the same, with public-to-private buyouts differing markedly from other types of buyouts. This speaks to one of the strengths of this study, as the UK setting allows the inclusion of all types of buyouts, and all companies are required to submit annual reports.

The UK setting also allows for collecting a large-scale sample of managerial ownership both pre- and post-buyout, and linking it to operational performance. This is a significant improvement over the existing large-scale study focusing on managerial ownership of private equity targets by Leslie and Oyer (2009).[5] They utilize a set of public-to-private buyouts to obtain pre-buyout ownership data, while using a different set of companies going public through an IPO to measure managerial ownership levels after a period of private equity ownership. Since these sets are different, the authors are unable to measure changes induced at the time of the buyout. Additionally, the authors lack company financials during the period of private equity ownership.

Beginning with Kaplan and Strömberg (2003), private equity and venture capital have been used to explore optimal governance, examining the choices taken by value-maximizing principals. Cornelli and Karakas (2015) study the role of boards and find that CEO turnover decreases and becomes less contingent on performance when private equity sponsors have higher involvement in the company. Edgerton (2012) shows that private equity sponsors curb excessive usage of corporate jets. Cronqvist and Fahlenbrach (2013) provide a detailed overview how CEO contracts are changed for a set of 20 private equity deals. This paper contributes to this stream of papers by linking how changes in managerial ownership is related to operational performance.

The question of how managerial ownership impacts the value of a company is an important question in the agency literature. Agency theory suggests that if managers can exert costly effort to increase performance, then we expect better performance

[5]Cronqvist and Fahlenbrach (2013) also examines CEOs of companies acquired in public-to-private buyouts. They obtain detailed information about the contract offered to CEOs in 20 large deals, offering insights into optimal contracting. While this paper lacks that level of detail, it covers more transactions and combines the ownership data with operational performance data.

when the pay of the manager is more tightly linked to performance.[6] Existing studies on managerial ownership in publicly held companies have to overcome multiple issues: compensation packages are the outcome of a matching and bargaining process; managers may influence the process in which compensation is set (Bebchuk et al., 2002) or time the delivery of news to the awarding of stock options (Yermack, 1997; Aboody and Kasznik, 2000); compensation packages can be renegotiated ex post (Brenner et al., 2000); and companies design compensation packages to exploit managerial characteristics such as optimism and overconfidence (Otto, 2014; Humphery-Jenner et al., 2016). To the extent that a buyout shocks the ownership level of managers, this study provides evidence of the importance of managerial ownership.

The next section presents the institutional setting. Section 3 describes the dataset and provides summary statistics. Section 4 presents the empirical approach and the results of the paper, while section 5 concludes.

2 Institutional Setting

A private equity fund is a partnership between a group of investors (referred to as Limited Partners, or LPs), and a private equity firm (referred to as the General Partner, or GP). "Private equity" encompasses many different strategies that varies in the the stage of a company's life at which investments are made, and the level of control the GP gets. This paper focuses on buyouts in which the GP acquires a controlling equity stake in the target company. Venture capital and growth investments are therefore not part of the study.

When a fund is raised, LPs commit capital to the fund but the capital is not provided up front. The GP is provided significant freedom over what to invest in and the timing of those investments, though the fund has a maximum lifetime and an investment period during which to invest the committed capital. Once an investment is identified, the GP "calls" capital from LPs. When investments are exited, the resulting cash is distributed to LPs and usually cannot be recycled.

The terms of the partnership are defined in the limited partnership agreement which stipulates the length of the investment period, the maximum allowed lifetime of the fund, and the compensation structure to the GP. As documented in Metrick and Yasuda (2010), the most common compensation arrangement for buyout funds includes a 2% management fee and 20% carried interest, allowing the GP to share in the profits if

[6] Jensen and Meckling (1976), Fama (1980), Fama and Jensen (1983b,a) are examples of this theoretical agency literature. Holmström (1979) and Grossman and Hart (1983) provide models of optimal contracts when effort is unobservable and impacts contractable output with noise. There is some empirical evidence that company value is positively impacted from increased managerial ownership and when compensation is more sensitive to company performance (e.g. Abowd, 1990; McConnell and Servaes, 1990; Mehran, 1995). However, the evidence is mixed. Agrawal and Knoeber (1996) and Demsetz and Villalonga (2001) do not find evidence of a relationship between managerial ownership and company performance.

they perform well. In addition to the direct pay for performance, Chung et al. (2012) demonstrates that the indirect pay from improving performance — the increased ability of a GP to successfully raise new funds that provide future fees — is of at least the same magnitude to the direct compensation. The structure of a GP's compensation package therefore provides strong incentives to focus on taking actions that are value maximizing for their portfolio companies.

As GPs obtain a controlling stake in companies, they can implement changes deemed value increasing. The clear focus on value maximization, coupled with control rights, implies that private equity firms approximate strong principals in agency models. For this reason, the actions taken by GPs may be informative of governance actions taken to maximize firm value. An early example is Kaplan and Strömberg (2003). They provide empirical evidence that contracts set up by venture capitalists largely conform to what optimal contracting theory suggests they should be. In a similar vein, Cronqvist and Fahlenbrach (2013) provide a detailed examination of changes in CEO contracts for a set of 20 large companies taken private in buyouts in order to learn about what strong principals change in contracts with agents. The most significant change they find is that a significant portion of equity grants performance-vests based on prespecified measures, and that CEOs forfeit unvested equity in the event they are fired.[7]

Proponents of private equity, like Jensen (1989), argue that private equity firms add value to companies by focusing managers on generating cash flow, and by providing high-powered incentives that align the interests of managers with those of investors. Kaplan and Stein (1993) and Cronqvist and Fahlenbrach (2013) document that the percentage ownership of CEOs increases following a buyout, supporting this view. The increase takes place despite a reduced dollar amount invested by retained CEOs. A simultaneous "cash-out" and increased ownership is possible due to the increase in leverage following the buyout. The reduced equity share of the enterprise value implies that any dollar amount invested represents a higher equity share post-buyout.

To further increase the pay-for-performance sensitivity of the management team, the acquiring private equity firm can split the equity share using multiple share classes. For example, the fraction held by the management team of the residual claim can be

[7]Private equity is also used to study the impact of boards by Cornelli and Karakas (2015). Their main results are that CEOs are less likely to be fired, and termination is less sensitive to performance, when the private equity owner has seats on the board. They interpret their findings as private equity owners having a longer horizon and being more patient, and utilizing information learned while monitoring. Edgerton (2012) examines actions taken by private equity owners to evaluate if (some) CEOs in listed companies enjoy excessive perks. He focuses on the case of corporate jets, which are costly but may be justified if increasing the productivity of CEOs. While hard to disentangle these views in any given company, he shows that jets are kept after being acquired by private equity in companies with modest jet ownership, suggesting a valuable role. However, companies with the biggest fleets experience a clear reduction in jets, suggesting that at least a subset of companies have excessive perks.

increased through a use of preference shares and ordinary shares. We now turn to the data used in the paper that allows us to precisely measure the fraction of the residual ownership held by the management team.

3 Data

This section describes the dataset utilized in the paper. The dataset contains information on the operational performance of UK-registered portfolio companies acquired in a buyout, complemented with hand-collected information of the managerial ownership pre- and post-buyout. The accounting dataset partially overlaps with that used in the second paper of the thesis where it is discussed in more detail. To avoid unnecessary repetition for the reader, some details on the data collection collection process, considered not essential for the current paper, are relegated to Appendix B.

As private companies lack market valuations, one needs to resort to accounting data to assess the performance of portfolio companies. Accessing accounting information on privately held companies is a challenge in private equity research. Consequently, many studies on private equity portfolio companies rely on samples where the researchers have been given access to deals from a particular investor (e.g. Acharya et al., 2013), or on companies with publicly available financials (e.g. Guo et al., 2011). Accounting data may be publicly available if companies have publicly traded debt or eventually goes public through an IPO, and in that process submits past accounts. In both of these scenarios, one does not obtain a comprehensive sample and there is a concern that the resulting sample is not fully representative.[8]

Precise ownership information tends to be even less accessible. Existing studies rely on subsets of companies that have either been or subsequently become publicly listed (e.g. Kaplan and Stein, 1993; Leslie and Oyer, 2009). The study of changes in contractual terms for CEOs by Cronqvist and Fahlenbrach (2013) relies on a sample of 20 public-to-private buyouts, for which they obtain detailed information on CEO contracts.

In this paper I focus on UK companies to overcome challenges of data availability. All companies in the UK, public and private, are required to submit filings to "Companies House", the United Kingdom official national registrar office. Companies House makes all accounts publicly available in the form of scanned PDFs. The information available from Companies House is gathered in electronic form by Bureau van Dijk (BvD) in their

[8]Cohn et al. (2014) use tax data on all public-to-private deals to show that there is a marked difference in the performance between companies with publicly available financials and those without, with the latter showing worse performance. Davis et al. (2019) find a stark difference between public-to-private buyouts and buyouts of already private targets, with the former (latter) experiencing sharp declines (increases) in number of employees.

FAME database.[9] Companies House also requires annual filings containing a list of all shareholders in the company, with their names and precise ownership documented.[10]

3.1 Sample Selection

This paper follows Strömberg (2008) and uses Capital IQ to identify UK companies that are targets of a buyout in the years 1999-2018. Appendix B.1 describes the screening process in detail, but essentially it captures buyouts, as defined by Capital IQ, in which a majority ownership stake is sold. This means that venture capital investments, growth investments and other minority stake positions are not included in this study.

Table 1 outlines the process for constructing the sample. The initial screen in Capital IQ identifies 1964 companies targeted in a buyout. Of these, 850 are randomly selected to be processed. There is a substantial amount of manual work required in processing the data, which explains why only part of the entire dataset is utilized in the paper. 57 transactions are dropped for reasons outlined in the table. To enable an analysis of changes in operational performance of target companies, a company is required to have financial data available in at least the year prior to the buyout, $t-1$, and the year following the buyout $t+1$. This restriction reduces the sample size with a further 230 transactions. 69 companies operating in the financial (SICs 600-699) or public utility (SIC 489-493) sectors are dropped to be consistent with earlier studies (e.g. Bernstein et al., 2019).

This leaves a sample of 494 buyouts for which financials are available in the pre- and post-buyout period. A further 134 transactions are dropped because ownership data is inaccessible in either the pre- or post-buyout period, or ownership filings are missing. The main reason for inaccessible ownership information is that the ultimate holding company, of which the management team potentially holds a stake, is registered in the Cayman Islands, Jersey, or some other jurisdiction outside of the UK. This practice has become increasingly common over time, and consequently the sample is tilted towards the earlier part of the sample period, relative to the full set of buyouts. For the pre-buyout period, ownership data is sometimes inaccessible for divisional or secondary buyouts, if the ultimate parent company is not a UK company.

[9] Information in FAME is available for a given registered company for up to the 20 most recent annual reports. Note that this restriction is better than the 10 year requirement present in Orbis and Amadeus, two other commonly used BvD databases which provides coverage over a wider region than just the UK. The UK setting, and BvD databases, have been utilized to gain insights from privately held companies by Brav (2009) and Michaely and Roberts (2012).

[10] I am not the first to utilize the UK setting to gain insights on PE-sponsored companies. The setting is used by Bernstein et al. (2019) to study how companies backed by private equity fared during the financial crisis, and by Chung (2011) to examine the performance of private-to-private buyouts. To the best of my knowledge, this is the first study which utilizes UK ownership filings to measure the managerial ownership share. Chung (2011) uses these filings to document the change in number of shareholders and the percentage held by the largest shareholder following a buyout, but he does not specifically measure managerial ownership stakes, nor does he link these changes to subsequent improvements in operational performance.

Finally, the paper utilizes a set of matched control companies to account for industry trends by including industry-year fixed effects, as suggested in Gormley and Matsa (2013). A match cannot be found for all companies, and consequently 38 additional transactions are dropped from the sample. This leaves 322 transactions in the final sample.

3.1.1 Accounting Data

The main source for financials is Fame, a Bureau van Dijk (BvD) database. BvD provides a digitalized database of information contained in the annual reports that all UK-registered companies are required to submit to Companies House. While Fame provides a coherent time-series for each registered entity, it is not sufficient to track the target company to get a comparable series of pre- and post-buyout financials.

A typical buyout is completed through the creation of one or several acquisition vehicles which have no economic activity on their own. Upon acquiring the target company, these newly created vehicles become parent companies to the target company (and any subsidiaries). In the UK, wholly owned subsidiaries in a corporate group are not required to submit accounts, as long as at least one parent provides consolidated accounts. In virtually all buyouts, one of the newly created entities take on the role of providing group consolidated accounts. Sometimes the consolidating entity shifts multiple times during the period under private equity ownership, even when the ultimate owner remains the same. While the target company may continue to submit accounts, they are usually unconsolidated. Unconsolidated accounts often provide an unrepresentative view of operating performance as they do not net out intra-group transactions, tend to understate costs, occasionally misrepresent turnover, and frequently lack relevant financial information altogether.

For every transaction in the sample I document the relevant reporting entity for every company-year. This information is gathered directly from annual reports of the target portfolio company, downloaded from Companies House. The annual report contains information of the ultimate consolidating entity if the company is a wholly owned subsidiary in a group. In the case of divisional buyouts, the unconsolidated accounts of the division are used for pre-buyout financials, as the larger consolidated group accounts include divisions that are not acquired in the buyout. This process provides a time-series of the reporting entity for every transaction in the sample. The financials downloaded from Fame are merged using the correct reporting entity, providing a coherent time-series linked to each transaction.

Table 2 provides a summary of the target companies in the sample, measured in the last fiscal year prior to the buyout, denoted $t-1$. Panel A provides these descriptives in levels. The average (median) company has revenues of £119.6 (£54.9) million, an

EBITDA margin of 16.0% (14.2%), assets in place worth £117.3 (£48.5) million, and have 1432 (448) employees. Panel B provides growth rates in the period $t-2$ to $t-1$. The average (median) company increases revenue by 17.8% (12.5%), assets expand by 17.0% (7.0%), the number of employees increases by 11.6% (6.4%), and the EBITDA margin increases by 1.0 (0.9) percentage points.

Panel C summarizes the buyout types in the sample. The most common is secondary buyouts representing 38.8% of buyouts in the sample, followed by private-to-private buyouts (25.8%), divisional buyouts (20.8%), public-to-private buyouts (13.7%), and distressed buyouts (0.9%). Secondary buyouts have grown in importance over time, with almost all other categories declining. Secondary buyouts represent a majority of the deals in the sample after the financial crisis.

Panel D summarizes the exit routes of the buyouts in the transaction. The time-period splits correspond to the year the buyout was completed in, not the year of the exit. Consistent with the increased prevalence of secondary buyouts, sales to financial institutions — of which the by far most common is another private equity firm — represents the most common exit route with 37.0% of all exits. The second most common exit route, representing 26.4% of all exits, is a trade sale, where another company or individuals acquire the company. 17.1% of all buyouts with an exit end with the private equity owners losing control without being compensated. This category includes formal insolvency procedures ("administration" in the UK), creditors seizing control, and financial restructuring where a new owner comes in, only partially compensating creditors while previous equity owners are wiped out. 12.7% of all deals have yet to see an exit as of 2019-09-30, with most of the recent deals still being owned. 6.5% of the deals are exited through a listing on the public market.

Table A.1 provides a comparison of the company characteristics of companies in the sample with the larger set for which financials are available. Such a comparison is instructive to evaluate whether the subsample with ownership data available systematically differs from a typical buyout.[11], Panels A, B, and C compare company characteristics and growth rates leading up to the buyout. While not statistically different due to large standard deviation, the companies in the sample is somewhat smaller and more profitable that the typical buyout. Pre-buyout revenues are £8.8 million, or 6.9% lower, for the subset of companies in the sample compared to the larger sample. Revenue has however increased at a more rapid pace, perhaps because of the smaller size. The

[11]While we would ideally like to compare the sample with the whole population of buyout deals, financials are only available for the randomly selected subset that has been processed. In the second paper of the thesis, a comparison is provided of the distribution of deals over time for the randomly selected sample compared to all 1964 identified buyout transactions in Capital IQ. The distribution over time is found to be very similar, suggesting a random selection from the population.

companies in the sample have higher EBITDA/revenue profitability margins at 16.0%, compared to 15.0% for the overall sample.[12]

Panels D, E and F of Table A.1 provide comparisons of the types of buyout, exit route, and industry composition. In these dimensions, the subset used in the paper is quite representative of the overall sample. Secondary buyouts are more common as both entry and exit route. The service industry is overrepresented by 4.5 percentage points, mainly at the expense of the manufacturing industry which is underrepresented by 3.2 percentage points.

The composition of type of buyouts and exits are largely consistent with Strömberg (2008), though with a higher proportion of secondary buyouts at entry, and selling to financial institutions at exit. Both of these have grown in importance over time and partly reflect the more recent sample examined here. The 17% figure of deals which end up in bankruptcy procedure or where the company is seized by creditors is high compared to the 8% of UK buyouts ending in bankruptcy reported by Strömberg (2008). However, 11% of the exits in his study are not known, with 22% of deals in 2006-2007 being unknown. Presumably, deals without a succesful sale are more likely to have an unknown outcome, such as creditors seizing control and continuing running the business. In addition, the timing of his study implies that the impact of the financial crisis is not part of his exit figures. For most of the companies in this sample that ended up in administration or lost control to creditors following the financial crisis, this took placed during the period 2009-2012, following attempts to restructure the debt.[13] The figures in this sample are comparable to the 18% of deals ending up in bankruptcy in Degeorge et al. (2016).

3.1.2 Managerial Ownership Data

The most novel piece of data utilized in this paper is ownership data of CEOs in companies acquired in buyouts. Ownership information is available in the UK as all

[12]The companies in this paper are smaller than those studied in the second paper in the thesis. Companies there are larger than the typical buyout, a consequence of the acquiring fund being larger than the typical fund due to the requirement that the acquiring fund has cash flow data in Preqin. The typical portfolio company in this paper is still relatively large compared to other studies, except for those focusing exclusively on public-to-private buyouts. In studies of UK buyouts, the average target company has sales of £158.6 million in Renneboog et al. (2007) (public-to-private only), £10.4 million in Chung et al. (2012) (private-to-private only), and £98 million in Bernstein et al. (2019). Comparing to studies in other countries: the average French company has €32.6 million in sales in Boucly et al. (2011); the average company acquired in a private-to-private buyout in the US has sales of $117.4 million in Cohn et al. (2020), while the average company acquired in public-to-private buyouts has sales of $604.2 million in Cohn et al. (2014).

[13]In the event a financial restructuring took place that concluded with the private equity firm retaining a majority stake, it is not part of the 17% figure. While the restructuring process is not formally studied, there are multiple cases where the private equity owner injects equity as part of a restructuring deal with creditors to maintain its majority stake. These examples are consistent with the evidence in Bernstein et al. (2019) that private equity owners can provide support to portfolio companies to get through financially challenging periods.

companies annually submit a filing called "Annual Return" (more recently, "Confirmation Statements"). In the annual return, a company provides details about the directors of the company, the amount of all classes of outstanding shares, and the precise ownership of every individual shareholder in the company. Interestingly, this information is more detailed for private companies as any ownership, no matter how small, is included with the name of the shareholder. By contrast, a similar list is not publicly available for publicly listed companies, though the annual report discloses large shareholders as well as information on the ownership of directors in the company.

The filings are available in a scanned format, and are sometimes handwritten, especially for the earlier part of the sample. I manually compile the ownership status by name, to measure the fraction of ownership belonging to the CEO, non-CEO directors, other individuals, and the private equity firm. This information is collected at two points: the last annual return filed prior to the buyout; and the first filing after the buyout. This allows measuring not only the level of ownership but also changes in ownership shares. In buyouts, different classes of shares are often constructed and distributed with various voting rights, though the different versions of ordinary shares tend to rank pari passu for cash flow rights. It is also common to utilize various classes with different cash flow rights, for example preference shares. In the UK in particular, there is a common practice to use shareholder loans. Shareholder loans are not part of the annual return, instead showing up as liabilities on the balance sheet.

Two complications arise when collecting ownership data pre-buyout. First, when a company is publicly listed prior to the buyout, only the ownership of the CEO and other directors is available in, and collected from, annual reports. Outstanding options are included in the ownership share of directors by estimating the delta of these options, assuming that the Black-Scholes option pricing formula holds. Other long-term incentive share plans in place are counted in full, as if the requirements would be met in the future. In practice, including or excluding these items makes almost no difference to the results of the paper as they correspond to a tiny fraction of the ownership shares of public companies. Second, in divisional buyouts, any managerial ownership stakes tend to be in shares of the ultimate parent company. The pre-ownership measures for these directors therefore represents ownership in the ultimate parent company.[14]

Table 3 summarizes the common stake held by CEOs in the sample. Panel A displays the post-buyout ownership stake held by the CEO, and Panel B summarizes

[14]It is not uncommon that at least one of the directors in the targeted division is also a director at the ultimate parent. Commonly, the acquired division represents a small fraction of the parent, and parent directors do not join the acquired division in the buyout. It is likely that these directors' main focus is not on the (relatively) small division but rather on the larger company. Therefore, any ownership by directors having a directorship in the ultimate parent is excluded from the management team ownership share for these divisions, unless a director followed the acquired company which happens in two single cases.

CEO ownership before the buyout takes place. The first row in each panel displays the overall sample numbers, while the remaining five rows provides a break down by type of buyout. The average (median) CEO ownership stake is 11.5% (8.5%) after the buyout, compared to 17.4% (6.9%) before the buyout.

The average reduction in CEO ownership following the buyout contrasts earlier studies by Kaplan and Stein (1993), Leslie and Oyer (2009), and Cronqvist and Fahlenbrach (2013). This difference can be reconciled with the type of buyouts included in these studies, as they study only public-to-private buyouts while this paper includes all types of buyout. Indeed, average CEO ownership increases for public-to-private buyouts here as well, from 7.1% to 10.1%. The main category driving the high pre-buyout ownership is private-to-private buyouts, where the average (median) CEO ownership is 38.3% (38.8%). The high ownership share reflects that a substantial fraction of private-to-private buyouts are companies owned by a founder, or family-owned companies in which the CEO holds a large stake.

The average post-buyout ownership is highest in private-to-private buyouts (15.7%), followed by secondary buyouts (10.5%), distressed buyouts (10.3%), public-to-private buyouts (10.1%), and divisional buyouts (8.5%). The pattern is similar in the pre-buyout ownership numbers, with secondary buyouts switching place with distressed buyouts.

Table A.2 provides additional descriptives on the ownership of all directors. Post-buyout, the CEO almost always holds the largest share of any other personnel, and in the average company the CEO share represent 40% of the entire management team's share.

4 Results

This section develops the empirical approach taken in and presents the findings of the analysis.

The goal of the paper is to examine how CEO ownership stakes relate to improvements in operational performance of companies acquired in a buyout. Ideally, this would entail comparing otherwise identical companies, randomly selected to be acquired in a buyout and where the managerial ownership stakes are randomly decided. That is not the reality of the data however. Private equity firms do not select their targets randomly, and the ownership stake provided to a CEO is likely related to observed and unobserved characteristics of the company, the CEO, and possibly the company's future prospects. With the ideal comparison not available, this paper utilizes a difference-in-difference approach to get closer to the ideal setting.

Following Boucly et al. (2011) and Bernstein et al. (2019), a control group is constructed of companies that are comparable to target companies on observable characteristics. This

enables us to control for industry-wide shocks by including industry-year fixed effects, as suggested in Gormley and Matsa (2013).

The focus of the paper is not on the overall difference in operational improvements of companies acquired in buyouts compared to their matched peers. Instead, we ask whether any differential improvements are a function of the ownership stake awarded to a CEO post-buyout. Again, this stake is clearly not randomly selected. Edmans et al. (2017) note that although models are clear on predictions that higher incentives should increase company value gross of CEO compensation, that does not necessarily translate to a relationship between company value and CEO ownership in the data. If incentives are set optimally, cross-sectional variation in incentives relate to different fundamental inputs in the optimization process. To the extent that there is deviation from optimality, we would however expect improvements when incentives are set closer to the optimum. Changes made by private equity firms have been interpreted as those taken by strong principals to improve governance in for example Cronqvist and Fahlenbrach (2013) and Edgerton (2012). Therefore, the paper will focus on changes in the ownership stakes rather than the ownership level. Changes are particularly informative when a CEO is retained, as that corresponds to changed incentives for a given individual.[15]

Identification ultimately relies on the extent to which the approach taken plausibly deals with the endogeneity issues present. The paper evaluates multiple potential interpretation of the results, and utilizes the private equity setting to sharpen these predictions whenever possible.

4.1 Cross-Sectional Variation in Ownership

To set the scene, we begin by documenting how cross-sectional variation in post-buyout CEO ownership stakes relates to operational improvements in companies acquired in a buyout. Several company outcome variables will be examined. To facilitate the discussion I will refer to revenue. As the focus is on operational improvements, it is natural to compare a pre- and a post-buyout period, allowing for a differential growth in revenue as a function of the ownership stake given to the CEO following the buyout. We include a pre-period of up to three years pre-buyout, and a post-buyout period of up to four full fiscal years post-buyout. The following model is estimated:

$$\begin{aligned} Y_{i,t,j} =& \alpha_i + \alpha_t + \alpha_j + \beta \text{CEO Ownership}_i * \text{Post}_{i,t} \\ &+ \lambda \text{Post}_{i,t} + \theta X_i * \text{Post}_{i,t} + \varepsilon_{i,j,t}, \end{aligned} \tag{1}$$

[15] It is important to point out here that awarding the CEO with a higher stake dilutes the PE firm's stake. Hence, increasing incentives through higher CEO ownership stakes may improve operational performance without improving the value of the PE firm's stake, and the evidence should be interpreted as gross-of-pay effects.

where $Y_{i,j,t}$ is (the log of) revenue for company i, operating in industry j, measured in year t; α_i, α_j, and α_t are company, industry, and year fixed effects, respectively; CEO Ownership$_i$ measures the fraction of ordinary shares held by the CEO post-buyout; Post$_{i,t}$ is an indicator variable which takes the value of 1 if the end of a fiscal-year falls in the period after the buyout is completed, and zero if it is before; X_i contains controls at the company level, measured at the year prior to the buyout.

The inclusion of company fixed effects together with a post period implies that the estimates capture changes within a company. The interaction of the post-period dummy with the CEO Ownership variable allows for a differential impact in companies as a function of the ownership stake held by the CEO. Time fixed effects and industry fixed effects are included in some specifications to take out the impact of economy-wide shocks and differences in levels between industries.

Company characteristics are included as controls for two reasons. First, it is conceivable that companies of certain characteristics are more likely to improve in specific dimensions. For example, Boucly et al. (2011) and Cohn et al. (2020) show that private equity ownership support company growth for small companies by relaxing financial constraints. It is also conceivable that companies with an initial low profitability have more room for profitability improvements. Second, characteristics of the company are likely to be related to the CEO ownership stake. For example, CEO risk aversion suggests lower stakes in larger companies to limit a CEO's wealth at risk. Similarly, companies with low profitability may require restructuring. If that is a particularly a risky undertaking it could suggests lower stakes held due to risk aversion, or larger stakes because more compensation is required to entice the CEO to take the job in the first place. Indeed, section 4.4 presents evidence consistent with the idea that the post-buyout CEO ownership stake is related to company characteristics. The general idea is that we need to control for these variables to avoid an omitted variable bias in the coefficient on the CEO's ownership stake.

The set of company controls included are: log revenue, EBITDA margin, and deal leverage. These are measured in the year prior to the buyout, with the exception of deal leverage which is the book value of leverage, measured at the first annual report after the buyout is completed.

Private equity firms typically focus on EBITDA as the measure of company profitability, and indeed even write compensation-based contracts on the measure (Cronqvist and Fahlenbrach, 2013). If a private equity firm wishes to focus on improving EBITDA, there are essentially two ways to achieve this: growing the company with a constant profit margin, or improving profitability. Revenue growth and EBITDA margin, defined as EBITDA/Revenue, are therefore the main dependent variables in the study.

Table 4 presents the estimates of (1), with standard errors clustered at the company level. Columns 1-3 present results with log revenue as the dependent variable, while columns 4-6 display results using the EBITDA margin as the dependent variable. Both dependent variables are estimated with three models, varying in the set of fixed effects included. The first model (columns 1 and 4) includes company fixed effects and year fixed effects. The second (columns 2 and 5) adds industry fixed effects. The third removes company controls.

The results show that companies with higher post-buyout CEO ownership are associated with improved profitability, while the coefficient on revenue suggests an economically small and statistically insignificant positive association to CEO ownership. In terms of economic magnitude, the results suggest that companies with a 10 percentage points higher CEO ownership experience improvements in the profitability margin of 40–50 basis points. This corresponds to a 2.5%–3.1% increase from the unconditional average pre-buyout profitability margin. In comparison, the statistically insignificant coefficients for revenue suggest an increase in revenue of 1.24%–1.77%.

The post dummy indicates that, controlling for the ownership stake given to the CEO, companies acquired in buyouts experience large growth in revenue following the acquisition, while profitability, if anything, is reduced. However, note that this growth is not compared to any matched peers and may have happened even in the absence of a buyout.

4.1.1 Controlling for industry effects

The results presented so far compare cross-sectional variation among companies acquired in a buyout. There is a natural concern that companies with varying levels of managerial ownership vary significantly in other characteristics. If managerial ownership differs between industries, we wish to filter out any variation in performance between industries from the impact of managerial ownership. This study follows the methodology of Boucly et al. (2011) and compare changes in operational performance with that of matched peers. This facilitates the inclusion of industry-year fixed effects to account for industry-wide shocks as suggested by Gormley and Matsa (2013). This may be particularly relevant to control for in a private equity setting, as Jenkinson et al. (2018) provide evidence that private equity may exhibit some skill in selecting outperforming industries.

The matching procedure used in this paper is similar to that used by Boucly et al. (2011) and Bernstein et al. (2019). A portfolio company is matched with up to five companies that i) belong to the same 2-digit SIC industry; ii) are not owned by another private equity firm; iii) are within a ±15% revenue band of the acquired company in the year prior to the buyout; and iv) have an EBITDA profitability deviating by at most ±5

percentage points of the target acquired company in the year prior to the buyout.[16] In the event that more than five potential matches are found, the closest five in a squared distance sense are used, with revenue and profitability given equal weight. The results presented are qualitatively similar for alternative bands, as well as the inclusion of number of employees as a matching variable, with results available from the author upon request.[17]

With matched control companies, we augment the main specification (1) to account for variation between companies acquired by private equity and controls companies. Thus, the model to be estimated is,

$$\begin{aligned} Y_{i,t,j} =& \alpha_i + \alpha_t \times \alpha_j + \beta \text{CEO Ownership}_i * \text{Post}_{i,t} * \text{PE}_i \\ &+ \gamma \text{Post}_{i,t} * \text{PE}_i + \lambda \text{Post}_{i,t} + \theta X_i * \text{Post}_{i,t} + \varepsilon_{i,j,t}, \end{aligned} \tag{2}$$

where $Y_{i,j,t}$ is (the log of) revenue for company i, operating in industry j, measured in year t; α_i, α_j, and α_t are company, industry, and year fixed effects, respectively; CEO Ownership_i measures the fraction of ordinary shares held by the CEO post-buyout; $\text{Post}_{i,t}$ is an indicator variable which takes the value of 1 if the end of a fiscal-year falls in the period after the buyout is completed, and zero if it is before; X_i contains controls at the company level measured at the year prior to the buyout. The newly added term PE_i takes the value of 1 if company i was acquired in a buyout, and 0 if it is a matched control company.

By including a matched control set, the estimation now examines the increase in the post-buyout value of the dependent variables for companies acquired in a buyout relative to matched control companies. The focus is again on β_1, which captures the extent to which the difference in operational improvements between PE-backed companies and matched peers is different in companies with higher post-buyout CEO ownership shares. CEO ownership is measured only for PE-backed companies and not for the matched peers, which is why the additional interactions are not included in the estimation.[18]

[16] As the entity reporting consolidated accounts is normally a holding company while under PE ownership, the reporting entity's SIC code is usually starting with 67, corresponding to a holding company of an investment office. This classification is not informative of the activity of the portfolio company, and instead the SIC classification of the portfolio company is used in the matching process as well as in construction of industry fixed effects.

[17] As pointed out by Boucly et al. (2011), while tighter bands improve the similarity in matched companies, it leads to more companies ending up with fewer, or no, matched controls. The alternative bands that have been attempted are revenue within ±5% and ±30%, and profitability margins of either ±3 percentage points or ±10 percentage points. When number of employees are included, a similar band as for revenue has been utilized.

[18] The reason we do not measure CEO ownership stakes is primarily because we are interested in the change in the ownership stake resulting from the buyout acquisition, as will be the focus from the next section. While one can measure this for peers as well, in practice the CEO ownership stake is rarely changed, especially in private companies. If it would be measured, the vast majority of changes would therefore take the value of 0 and it is not expected to have much impact on the results of the paper. In addition, changes in ownership stakes that are not shocked bring it own set of endogeneity issues as it reflect active choices by companies.

Table 5 reports the estimates of (2). Columns 1-3 use log revenue as the dependent variable, while columns 4-6 instead use the EBITDA margin of the company as the dependent variable. The first model (columns 1 and 4) includes company fixed effects, company controls and year fixed effects. The second model (columns 2 and 5) replaces the year fixed effects with industry-year fixed effects. The third model (columns 3 and 6) drops the company control variables. Standard errors are clustered at the company level.

The results are similar to the previous table. Companies with higher post-buyout CEO ownership are associated with increased profitability, but not higher revenue, following the buyout. In terms of economic magnitude, the point estimate suggests that the improvement in profitability margin relative to matched peers is 49–58 basis points higher in a company in which the CEO ownership is 10 percentage points higher. This corresponds to a 3.1%–3.6% increase from the unconditional mean profit margin prior to the buyout. The point estimates for revenue suggests a decrease of 2.2%–3.0% for a company with a 10 percentage points higher CEO ownership, although the estimated coefficients are statistically insignificant.

The direct comparison of companies acquired in a buyout compared to the matched peers indicates a sharp difference in revenue: buyout targets grow more rapidly. Buyout targets increase revenue by about 32% more than their peers. To the extent there is a difference in profitability margin improvements, it is driven by companies with higher CEO ownership stakes. It is worth noting that profitability margins are lower in the post-period for both PE targets and the matched peers, except for buyout companies with high levels of CEO ownership.

4.2 Interpretation of the Results

Tables 4 and 5 establish the main correlation of the paper: profitability improves more for companies acquired in a buyout where the CEO receives a higher ownership stake. There are however several explanations as to what may cause this correlation. Three possible explanations are examined here, and the private equity setting is utilized in an attempt to tease out which of these appear to be plausible.

First, the correlation observed may reflect talented CEOs being matched to companies as in Gabaix and Landier (2008). The idea is that there is a distribution of ability among CEOs, and the companies that are willing to offer the highest pay will attract the best CEOs. As a higher ownership stake implies a higher payoff in a successful exit, companies in which a CEO is offered a larger stake attract higher ability CEOs that improve operations.

Second, the observed relationship might reflect private information held by the management team. If the existing CEO stays on and have company-specific knowledge of costly but value-increasing actions, they gain bargaining power in the negotiations

with the private equity acquirer. This inside information explanation would suggest that the management team obtain a higher ownership share when there is greater potential to improve operations.

Third, the higher ownership stakes may provide the management team with incentives to take costly actions that increases value. The role of incentives is theoretically clear, but convincing empirical evidence of a causal effect of incentives is notoriously hard to come by (Edmans et al., 2017).

4.2.1 Changes in ownership stakes

In a buyout, the ownership share held by the CEO is virtually always altered. This allows the econometrician to work with changes in ownership and not only cross-sectional variation. This is helpful as we can control for pre-buyout ownership levels. To the extent that unobservable, company-specific, characteristics determine the optimal level of ownership in a given company, controlling for pre-buyout ownership stakes allows us to partially control for it.

In terms of the three proposed explanations for the observed results, the attracting talented CEO explanation suggests that the post-buyout stake is what matters in attracting the best CEOs, regardless of what the pre-buyout stake was. Similarly, the bargaining story suggests that management with better information will extract a larger post-buyout share. Thus, in both of these explanations the post-buyout ownership stake should be the most relevant factor for improvements in operational performance. By contrast, the incentive mechanism suggests that only increased ownership stakes should lead to improved performance as that is when the incentive is altered. Merely retaining the post-buyout stake at a high, pre-buyout, level does not increase incentives, and hence we would not expect an improvement of operational performance. It should be noted that the bargaining story is based on private information of the CEO. A high pre-buyout ownership share might enable CEOs with positive private information to reinvest a larger share to increase the post-buyout stake, so this is not a conclusive test between those this explanation and that of incentives.

Table 6 presents the results from running the previous model with the post-buyout ownership level decomposed into a pre-buyout ownership level, and the change from the pre- to the post-buyout period. The results make clear that the relationship between the post-buyout CEO ownership stake and profitability improvements is largely driven by changes in CEO ownership. As before, revenue is not consistently related to the ownership stake. In terms of economic magnitude, a 10 percentage unit increase in CEO ownership translates to a 68–80 basis point increase in the EBITDA margin, or a 4.3%–5.0% increase from the average pre-buyout levels.

Although the estimated coefficient is higher for changes in ownership than for the pre-buyout level of ownership, the estimated coefficients are not statistically different from each other. Nonetheless, these results are consistent with the notion that a change in ownership level is more relevant for improving operations.

4.2.2 The parallel trends assumption

The analysis relies on a triple difference-in-difference estimation, comparing operational improvements among buyout targets to that of matched peers, allowing any difference to vary with the ownership stake awarded to the CEO. As in any difference-in-difference estimation, the identifying assumption is that the measured difference would not had taken place had the "treatment" not happened. As previously argued, we expect cross-sectional variation in ownership stakes due to company fundamentals. What the buyout acquisition brings in form of "treatment" is shocking the ownership stake of the CEO. Therefore, the change in CEO ownership stakes, rather than the CEO ownership level, is what could plausibly be inferred as a treatment brought about by a buyout.

It is not easy to convincingly argue that the acquired companies would have behaved similarly had the treatment not taken place. A minimum requirement, though not sufficient, is that the continuously measured treatment do not display any pre-trends that merely continues, so that at least in this dimension companies that experienced a large increase in the CEO's stake are similar to those that did not, controlling for other covariates. We can formally test this by estimating the model

$$\begin{aligned} Y_{i,t,j} =& \alpha_i + \alpha_t \times \alpha_j + \sum_s \beta_s \left(\Delta\text{CEO Ownership}_i * \text{PE}_i\right) \\ &+ \sum_s \upsilon_s \Big(\text{CEO Ownership}_{i,t-1} * \text{PE}_i\Big) \\ &+ \sum_s \gamma_s \left(\text{PE}_i\right) + \sum_s \lambda_s + \theta X_i * \text{Post}_{i,t} + \varepsilon_{i,j,t}, \end{aligned} \tag{3}$$

where $\beta_s, \upsilon_s, \gamma_s$, and λ_s are estimated separately for each year in the pre- and post-buyout period, with $t-1$ used as the reference year.

Table 7 presents the results of this estimation. Overall, there is a substantial increase in the relationship between changes in CEO ownership stakes and company profitability following the buyout. Economically, the increase appears to be largest for the first two full years under PE ownership ($t+1$ and $t+2$), while becoming weaker both economically and statistically the further out we go.

While the jump in relationship between profitability and ΔCEO ownership around the buyout event is comforting, the table is not quite as strongly suggesting a lack of relationship in the pre-period as one might wish for. The coefficients are consistently positive, though never statistically significant.

However, it is worth thinking about what we are worried about. If the trend observed was that of a monotonically increasing coefficient, whose increase continued post-buyout, it is not plausible to argue that there is an impact of the buyout. This is not the case however. All estimates are relative to the reference year $t-1$. A positive coefficient for ΔCEO ownership in $t-3$ therefore suggests that companies that experienced high increases in CEO ownership were more profitable in $t-3$ than in $t-1$. In all specifications, the coefficient is lower in $t-2$ than in $t-3$. If anything, the trend is going in the opposite direction, and is reversed following the buyout. One possible interpretation is that the acquiring private equity firm increases the CEO stake particularly much in companies that have experienced a recent drop in profitability.

Turning to the results on revenue there is a consistent negative, though statistically insignificant, correlation between ΔCEO ownership in all years. Unlike the profitability regressions, there is no consistent increase or decrease in the coefficients that suggest an impact of the treatment.

To alleviate potential concerns that the observed trends are driven by the inclusion of the specific set of matched peers I repeat the estimation excluding all matched peers. The results are presented in Table A.3. There is a similar reversal in trend on profitability in this table which indicates that the inclusion of matched peers are not driving the results. The estimates on revenue provide some weak evidence that revenue increase more when the CEO ownership is increased more, though it is not consistently estimated for all periods or over all models so should be interpreted carefully.

Overall, the results are largely supportive that the main result of a positive relationship between changes in CEO ownership stakes and profitability improvements is not driven by the continuation of a pre-trend. However, this is not sufficient to conclude a causal effect of increasing a CEO's ownership stake. To accept that, we have to believe that no other simultaneous changes takes places which drives profitability improvements. Since buyouts may bring about multiple unobserved changes that potentially impact profitability, this is difficult to argue. If such changes are correlated with increased CEO stakes we suffer from omitted variable bias and would incorrectly attribute the effect to the change in CEO stakes. For example, if GPs attempt to incentivize CEOs by providing larger stakes when they believe a restructuring is necessary to improve profitability, they may take a more active role in other aspects of running the company.

We can take some steps to mitigate this concern. First, note that companies acquired in buyouts do not experience improvements in profitability on average. This true both on an absolute level, and when compared to matched peers. Details on the results comparing the matched peers are provided in Appendix C, which provides additional descriptive statistics on the acquired companies in the sample compared to the set of matched companies. To

briefly summarize the results, buyout targets increase revenue substantially more than matched peers, though there is an existing trend of higher growth among buyout targets. However, buyout targets experience no improvement in profitability, either on an absolute scale or relative to matched peers. Hence, only targets in which the CEO ownership stake increase experience profitability improvements. It is therefore unlikely that the results of the paper captures a common effect arising from transitioning into PE ownership.

4.2.3 Retained or replaced CEO

An important feature of buyouts is that the CEO is often replaced by the acquiring PE house (e.g. Cornelli and Karakas, 2015). A natural split of the sample is therefore deals in which the CEO is retained and those in which the CEO is replaced. In this paper, the CEO is retained in 197 transactions (61%), and replaced in the remaining 125 (39%).

The act of replacing a CEO is clearly endogenously chosen by the acquirer, potentially due to a perceived inability of the current management team to perform. While this suggests that the two subsets may perform differently on average, a sample split can nonetheless be informative of the relevant interpretation of the paper's main result.

Suppose that the main underlying mechanism for the result is that the most talented CEOs are attracted to companies offering the highest ownership stakes. Arguably, this explanation is more relevant when the CEO is replaced, since the acquirer needs to attract a new person to the role and the pool of potential CEOs is large. By contrast, the story of inside information and bargaining power assumes that the CEO is an insider, not brought in from the outside. Similarly, the incentive story is more plausible when a CEO is retained, as an ownership change then represents an change in incentives for the same manager. In this scenario it cannot be that a higher ownership stake attracts a higher ability CEO, as the CEO remains the same person.[19] This may also be instructive to the discussion on whether increases in CEO ownership correlates with other actions taken by the acquiring PE firms. If PE firms that take a more active role in running the company are more likely to replace the CEO, we may learn whether this concern is small or large depending on which subsample drives the results of the paper.

Table 8 presents the result of estimating the model in the paper separately for deals in which the CEO is retained and deals in which the CEO is replaced. Panel A contains the results for the subsample in which the CEO is retained, while Panel B presents the results for the subsample in which the CEO is replaced.

As is evident from the two tables, the documented relationship between improved profitability and changes in ownership is driven by the subsample where the CEO is replaced, and it is economically stronger for the change in ownership stake compared

[19] It is not quite clear how to interpret an "increase" in ownership when a CEO is replaced.

to the level. In terms of economic magnitude, a 10 percentage point increase in CEO ownership when the CEO is retained is related to a 77–102 basis points increase in profitability, corresponding to a 4.8%–6.4% increase from the unconditional average pre-buyout level. By contrast, in the subsample where the CEO is replaced, the coefficient is statistically indifferent from zero, and the magnitude of the coefficient is much smaller. In neither sample is the coefficient on pre-buyout ownership level statistically significant for profitability improvements. For revenue, there is no statistically significant relationship between changes in revenue and CEO ownership when the CEO is retained. By contrast, higher ownership stakes in companies with a replaced CEO are associated with a reduction in revenue. However, the statistical significance is somewhat weak, so these results should be interpreted with caution.

As buyouts commonly employ a large amount of leverage, the junior ownership stake held by the CEO is akin to an option. It is possible that CEOs with larger stakes pursue riskier strategies as higher volatility increase the value of an option claim. This could be problematic, as companies that enter financial difficulties tend to not submit their reports in the last fiscal year prior to entering insolvency processes. Hence, if strategies with higher variance are employed and we observe fewer of the bad outcomes, it could bias our results in the direction of what we find.

To evaluate whether this is a concern we can estimate whether CEO ownership stakes are related to the probability that the company is seized by creditors or enter insolvency procedures. Table A.4 presents such estimates for all exited deals. The model is estimated using a linear probability model in the first five columns, while a logit model specification is estimated in the last five columns. It is clear from the table that increases in CEO ownership stakes do not appear to be related to an increase in the probability of default, particularly when the CEO is retained. All estimated coefficients are statistically insignificant, and the sign is always negative. Consequently, the results of the paper do not appear to be driven by increased risk-taking.

Naturally, one may wonder whether companies in which the CEO is retained differs systematically from those in which the CEO is replaced. Private equity firms may for example be inclined to replace CEOs in companies that are doing poorly. Clearly, whether a PE firm attempts to retain a CEO or not is an endogenous choice, as is the decision of the CEO to stay on if offered the opportunity. We cannot observe the decision-making process, but we can compare these companies on observable dimensions.

Table A.5 compares companies for which the CEO is retained versus those for which the CEO is replaced. There is only small differences between these companies in levels in the year prior to the buyout. This is quite remarkable given that these two sets are not matched in any dimensions. The average company in which the CEO is replaced is slightly larger,

though the median is smaller. Companies in which the CEO is replaced have more assets, and this is the only difference which is statistically significant. Importantly for the main result of the paper, there is no difference in profitability margins for the average company, and the median company in which the CEO is replaced have higher profitability margins.

There are slightly more differences in trends, as companies that retain the CEO grow faster in the period leading up to the buyout, though this is only statistically different for revenue at the one-year horizon. Interestingly, there is no clear trend on profitability margin improvements: companies with a retained CEO has improved it a bit more in the last year, but not over the two-year horizon.

We can also compare differences in CEO ownership levels between companies with retained versus replaced CEOs. Table A.6 present this for both the post- and pre-buyout ownership levels in Panels A and B, respectively. The ownership levels post-buyout are remarkably similar, suggesting that there is a common level of ownership that private equity firms prefer their managers to hold. There is some evidence that retained CEOs have higher post-buyout ownership shares for private-to-private buyouts and secondary buyouts, where the mean difference is statistically significant at the 10% level. Presumably, this is because these are the categories with the highest pre-buyout ownership status. It is also clear that the distribution of buyouts in which the CEO is replaced or retained is different: private-to-private buyouts are overrepresented among buyouts in which the CEO is replaced.

There is far clearer differences in the pre-buyout ownership levels: companies in which the CEO is replaced have much higher pre-buyout ownership levels, driven largely by a higher fraction of private-to-private buyouts and a significantly higher ownership level among private-to-private buyouts. The average (median) private-to-private buyout in which the CEO is replaced has pre-buyout CEO ownership of 45.2% (50.0%). These are often founder-owned or family-run businesses with one or a few, large, shareholders. If improving incentives is an important contribution of buyouts leading to improved operational performance, these are not the type of buyouts where one expects buyouts to play a large role, as there is no pre-buyout issues of separation of ownership and control.

Taken together, the results presented in Tables 6, 8, and 8 are mostly consistent with the incentive story, while matching of talented CEOs to companies does not appear to be the main explanation. While the results of the paper are consistent with the incentive story, they are generally consistent with the explanation of managerial bargaining power with private information on value-increasing actions. To give a strong claim of the incentive story we would need a plausibly exogenous instrument for changes in the ownership stake, and such clean identification is not provided here.

4.3 Sources of Profitability Improvements

If we believe the previously presented results, a natural follow-up question is how these profitability gains are achieved. How private equity generate returns is a hotly debated topic, with proponents arguing that private equity improves operations while critics argue that they are detrimental to other stakeholders of the company. For example, Boucly et al. (2011) show that PE ownership can release financial constraints of companies, while Bernstein and Sheen (2016) provide convincing evidence that restaurants over which private equity firms have control becomes cleaner and safer compared to franchised restaurants in the same chain. By contrast, Antoni et al. (2019) document that private equity targets in Germany experience a reduction in employment and employee earnings. Eaton et al. (2019) show that buyouts lead to higher tuition and per-student debt, while there is lower graduation rates, loan repayment rates, and earnings among graduates.

In light of this debate it is interesting to examine how changes in CEO ownership are associated with the components of the profitability improvements. In principle, profitability improvements can be the result of increasing revenue with costs growing at a slower rate, or cutting costs while revenue decreases at a slower rate. We therefore turn to examine how changes in CEO ownership is related to three items: operational costs; revenue; and EBITDA.

Table 9 presents results for the subsamples in which the CEO is retained in Panel A, while Panel B presents results when the CEO replaced. This split is relevant as the main result of the paper originates from the retained CEO subsample, so we expect differences along this dimension. To make observations comparable between companies of different sizes, each variable is standardized to be presented on a per employee basis. The dependent variable in columns 1-3 is the log of operating costs/employee, in columns 4-6 it is the log of revenue/employee, and in columns 7-9 it is the log of EBITDA/employee.[20]

For the subsample where the CEO is retained, costs per employee is negatively related to both increases and the pre-level of CEO ownership stakes, though only statistically significant at the 10% level. Revenue per employee is also negatively related to ownership stakes, though not statistically significant. As both costs and revenue are reduced, the impact on EBITDA/employee is relatively small. While the coefficient is (statistically insignificant and) negative, the magnitude is smaller than the effect on revenue, resulting in a net improvement of profitability. This suggests that the profitability improvements

[20]Other standardisations are possible, such as dividing by total assets. However, as goodwill from the acquisition impact total assets it is distorted by the acquisition price, which is why number of employees are used to standardize. Taking logs exclude negative EBITDA observations, and we consequently lose some observations for EBITDA. Operational costs are not available for every company, which is why the number of observations is lower than that of revenue.

associated with increased CEO ownership come about primarily through cutting costs, rather than increasing revenue.

By contrast, the subsample where the CEO is replaced display a very different pattern. Here costs per employee generally increases in companies with a higher post-buyout CEO ownership stake, though the coefficient is not statistically significant in all models. Revenue, while positive, is much smaller in magnitude, resulting in a modest negative relationship between CEO ownership and EBITDA per employee. Note that the coefficients for EBITDA and revenue are not statistically significant, so one needs to be careful in reading too much into these point estimates. Still, as this essentially corresponds to a decomposition of the profitability effects documented in earlier tables, it is suggestive that the effect of CEO ownership stakes differs markedly between the subsamples where the CEO is retained and where the CEO is replaced.

4.4 Determinants of Post-Buyout CEO Ownership

Having established a positive association between increases in CEO ownership and profitability improvements, we now turn to examine which factors are relevant for determining the ownership stake given to CEOs.

Looking at company characteristics, we expect company size, leverage, and profitability to play a role. A given percentage of ownership represents more wealth invested in a larger company. If CEOs are risk averse, we therefore expect them to have lower percentage ownership stakes in larger companies. Similarly, conditional on size, a dollar invested provides a higher percentage equity ownership stake in companies with higher leverage. Working in the opposite direction, leverage increases the risk of the equity in a company. Finally, a company with low profitability may require substantial restructuring. If such actions are risky endeavours, a risk averse CEO may demand pay to be less contingent on performance. However, if such restructuring events are dependent on CEO effort, the acquiring private equity firm could be inclined to provide higher-powered incentives. Additionally, the results presented so far suggest that higher ownership stakes are associated with improved profitability. All else equal, an improvement of profitability of one percentage point is worth more if the original profitability is 1% than if it is 10%. This suggests that PE firms may wish to award higher CEO ownership stakes in companies with low initial profitability. A higher CEO ownership stake implies less upside for the private equity firm, and a higher stake should therefore be awarded when it worth more.

In addition to company characteristics, there are several reasons to expect that the pre-buyout ownership stake held by the CEO is positively related to the post-buyout CEO ownership stake. First, if unobserved company characteristics contribute to the optimal CEO ownership stake, we may suspect that companies with higher ownership

stakes pre-buyout will have a high optimal ownership stake post-buyout. This should be relevant whether the CEO is retained or replaced. Second, to the extent that the private equity acquirer is attempting to improve incentives for retained CEOs we would expect the pre-buyout ownership stake to positively correlate with the post-buyout stake; a relatively small post-buyout ownership stake can improve incentives if pre-buyout ownership level is even lower, while a large pre-buyout stake requires an even higher post-buyout stake to increase incentives. Finally, for retained CEOs we should expect a wealth effect: CEOs with a large pre-buyout stakes receive large payouts from the acquisition and become wealthier. All else equal, this suggest that CEOs with higher pre-buyout stakes should be more willing to invest a large dollar amount, as it represents a smaller fraction of their wealth. Indeed, Cronqvist and Fahlenbrach (2013) and Kaplan and Stein (1993) provide evidence that while CEOs cash-out in dollar terms, the average ratio of post-LBO % ownership / pre-LBO % ownership is 2.86.

To examine the determinants of post-buyout CEO ownership, a Tobit model as well as an OLS model are estimated. As ownership stakes are bounded between 0 and 1, the Tobit model appears appropriate. However, Tobit models may struggle with the inclusion of fixed effects and as such an OLS model is estimated for comparison. Fortunately, the two models provide very similar estimates for all models suggesting that this is not a major issue. Transaction year effects are included to control for time-varying trends in ownership. Deal type dummies (e.g. public-to-private, secondary LBO) are included as they have quite different pre-buyout ownership stakes as reported in Table 3.

The estimates of the two models are reported in Table 10. OLS estimates are presented in columns 1-3, while the Tobit estimates are presented in columns 4-6. In columns 1 and 3, only company characteristics are included. Columns 2 and 5 adds the pre-buyout CEO ownership stakes together with an interaction term indicating whether the CEO is retained or not. In columns 3 and 6, acquisition type dummies are included.

Company size is negatively related to the post-buyout ownership stake of a CEO, consistent with the ideas of risk averse CEOs and wealth constraints. The coefficient on leverage is positive, but not statistically significant. Profitability is negatively related to the ownership stake, suggesting that a desire to provide incentives to improve profitability may dominate. Interestingly, a CEO's pre-buyout ownership stake is positively related to the post-buyout ownership stake, but only when the CEOs is retained. This suggests that the desire to improve incentives is important for private equity acquirers.

It is somewhat surprising that there is no relation to be found in companies where the CEO is replaced. One might expect the pre-buyout CEO stake contains some information about the optimal stake of ownership in the company. However, this result could reflect the higher proportion of very high pre-buyout ownership stakes in founder-controlled

companies. However, if that is the explanation we would expect that the inclusion of buyout type dummies would mitigate this, as this is only the case in private-to-private buyouts. This is not the case. In unreported results I have looked at whether the results are different if separately estimate a coefficient for pre-ownership levels below and above 50%, but find no significant relationship between the pre- and post-buyout ownership stakes in companies where the CEO is replaced.

To summarize, these results are consistent with CEO risk-aversion and an attempt by private equity firms to provide incentives to the CEO of the acquired company.

5 Conclusion

This paper examines the impact of managerial ownership on operational performance of companies acquired in a buyout. Knowledge of how specific changes implemented by private equity firms relate to operational performance in portfolio companies is scarce, and the main contribution of the paper is to examine the impact of one of the salient features of private equity ownership: changes in managerial equity ownership stakes. The paper assembles a new, partially hand-collected, dataset of financial information and managerial ownership details for private equity portfolio companies registered in the UK.

The paper finds that companies with higher CEO equity ownership stakes experience improved profitability. The results are economically stronger for changes in ownership stakes compared to the level of ownership, and are driven by deals in which the CEO is retained. For retained CEOs, a change in the ownership stake corresponds to altered incentives, while managerial ability is held constant. High ownership stakes are awarded in companies where improving profitability is particularly valuable: those with low initial profitability. Stakes are higher when the CEO ownership stake is high pre-buyout, but only when the CEO is retained, consistent with an attempt to improve incentives from their pre-buyout levels.

The results are consistent with an interpretation that incentives play an important role, though it cannot be ruled out that they reflect bargaining power of management team's with knowledge of valuable actions. It is important to note that the results of the paper should not be interpreted as causal. A potential avenue for future research is utilizing the private equity setting to examine plausibly exogenous variation in ownership stakes awarded.

Table 1: Sample Construction

This table presents how the final sample in the paper is derived. Transactions without participation of a private equity firm or where the private equity firm(s) only acquired a majority stake are excluded from the sample. Company names are taken from the transaction synopsis provided by Capital IQ, and if no UK company of that name is found the transaction is excluded. The screen for buyout transactions in Capital IQ was undertaken 2019-01-02. When ownership data is inaccessible it is typically because the ultimate holding company is registered in the Cayman Islands, Jersey, Luxembourg, or another country outside of the UK where ownership details are not available. The 8 transactions with missing ownership filings are due to missing pages from the scanned documents in Companies House, and one case where the submitted annual return is empty.

Number of UK buyouts identified in Capital IQ from 1999 - 2018	1964
Less: Buyouts not included in the 850 randomly selected	(1114)
Number of PE transactions processed	850
Less: Transactions where no UK company of a stated name was found	(19)
Less: Transactions without PE firm participation	(15)
Less: Transactions where majority ownership did not pass to a PE firm	(10)
Less: Duplicate transactions identified	(7)
Less: Transactions initially identified but no longer in Capital IQ	(5)
Less: Transactions of companies exempted from submitting filings	(3)
Number of buyouts with entry and exit information	791
Less: Transactions without accounting data in year t-1 and t+1	(230)
Less: Transactions of financial companies or public utilities	(69)
Number of buyouts with financials available	494
Less: Transactions with inaccessible ownership data post-buyout	(99)
Less: Transactions with inaccessible ownership data pre-buyout	(27)
Less: Transactions with missing ownership filings	(8)
Less: Transactions for which no matched control companies is found	(38)
Final sample	322

Table 2: Summary Statistics

This table presents descriptive statistics of the portfolio companies in the sample. Panel A describes characteristics of companies acquired in buyouts, measured at the most recent fiscal year prior to the buyout, referred to as year -1. Panel B presents the change in these accounting measures from year -2 to year -1. Panel C presents the distribution of buyout types. Panel D presents the distribution of exit routes as of 2019-09-30. If no exit had occurred at that point it is indicated that the company is still owned. The time-periods represents the year in which the buyout took place. The "Other" category consists of 1 case where the portfolio company was owned by a private equity fund until it ceased trading.

Panel A: Portfolio company characteristics in year prior to buyout

	N	Mean	Median	SD	25th pct	75th pct
Revenue (£ million)	322	119.6	54.9	198.3	21.5	130.6
EBITDA (£ million)	322	15.2	7.8	21.3	3.4	16.5
Total Assets (£ million)	322	117.3	48.5	186.3	17.9	124.7
Number of Employees	317	1432	448	2445	186	1235
EBITDA Margin	322	0.160	0.142	0.103	0.092	0.218

Panel B: 1-year pre-buyout growth

	N	Mean	Median	SD	25th pct	75th pct
Revenue Growth	302	0.178	0.125	0.261	0.042	0.255
EBITDA	302	0.205	0.191	1.450	-0.000	0.446
Total Assets Growth	305	0.166	0.070	0.413	-0.024	0.238
Employee Growth	295	0.116	0.064	0.251	0.000	0.175
ΔEBITDA Margin	302	0.010	0.009	0.055	-0.008	0.027

Panel C: Type of Acquisition

	Full Sample	1999-2003	2004-2008	2009-2013	2014-2018
Public-to-Private	0.137	0.200	0.125	0.057	0.107
Private-to-Private	0.258	0.295	0.213	0.283	0.286
Divisional Buyout	0.208	0.333	0.184	0.094	0.071
Secondary Buyout	0.388	0.162	0.463	0.566	0.536
Distressed Buyout	0.009	0.010	0.015	-	-
N	322	105	136	53	28

Panel D: Type of Exit

	Full Sample	1999-2003	2004-2008	2009-2013	2014-2018
Lost Control	0.171	0.162	0.257	0.019	0.071
IPO	0.065	0.105	0.044	0.057	0.036
Trade Sale	0.264	0.381	0.228	0.208	0.107
Sale to Fin. Inst.	0.370	0.343	0.426	0.434	0.071
Still Owned	0.127	-	0.044	0.283	0.714
Other	0.003	0.010	-	-	-
N	322	105	136	53	28

Table 3: Summary Statistics - CEO Ownership

This table presents descriptive statistics of the pre- and post-buyout CEO ownership stakes in portfolio companies acquired in buyouts. Panel A presents the percentage ownership of ordinary shares that is held by the CEO following a buyout of the company. The statistics are presented for the full sample on the first row, and then split up by the different types of buyouts in the remainder of the rows. Panel B presents statistics for the pre-buyout CEO ownership stakes.

Panel A: CEO Ownership after the Buyout

	N	Mean	Median	SD	25th pct	75th pct
Full sample	322	0.115	0.085	0.099	0.049	0.143
Public-to-Private Buyout	43	0.101	0.073	0.103	0.041	0.112
Private-to-Private Buyout	85	0.157	0.110	0.126	0.063	0.224
Divisional Buyout	61	0.085	0.068	0.067	0.037	0.113
Secondary Buyout	127	0.105	0.088	0.081	0.047	0.137
Distressed Buyout	6	0.103	0.101	0.037	0.082	0.142

Panel B: CEO Ownership prior to the Buyout

	N	Mean	Median	SD	25th pct	75th pct
Full sample	322	0.174	0.069	0.246	0.010	0.201
Public-to-Private Buyout	43	0.071	0.032	0.139	0.011	0.072
Private-to-Private Buyout	85	0.383	0.388	0.321	0.043	0.569
Divisional Buyout	61	0.054	0.000	0.184	0.000	0.007
Secondary Buyout	127	0.127	0.090	0.138	0.042	0.163
Distressed Buyout	6	0.162	0.105	0.207	0.000	0.278

Table 4: Operational Improvements and CEO Ownership

This table reports the estimates of a (continuous) difference-in-difference fixed effect model of CEO equity ownership on measures of company performance. The dependent variable is (log) revenue in columns 1-3, and EBITDA margin in columns 4-6. The main independent variable is "CEO Ownership", defined as the fraction of outstanding common equity that is owned by the CEO of the company targeted in the buyout, measured just after the buyout takes place. All specifications include company fixed effects and calendar year fixed effects. Columns 1, 2, 4, and 5 include company level controls, interacted with a Post dummy. The Post dummy takes the value of 1 in the post-buyout period, and is 0 otherwise. The company level controls are measured in the fiscal year prior the buyout and are: (log) revenue; EBITDA margin; and book leverage (measured after the buyout). Specifications in columns 2 and 5 add industry fixed effects. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors are clustered at the company level and presented in parentheses below the estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	(log) Revenue			EBITDA/Revenue		
CEO Ownership × Post	0.136	0.177	0.124	0.044**	0.050**	0.040*
	(0.153)	(0.154)	(0.135)	(0.018)	(0.021)	(0.021)
Post	0.407***	0.394***	0.530***	−0.007**	−0.008**	−0.002
	(0.096)	(0.093)	(0.093)	(0.003)	(0.004)	(0.005)
Adjusted R^2	0.938	0.943	0.927	0.697	0.699	0.687
N	1573	1573	1573	1572	1572	1572
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No

Table 5: Operational Improvements and CEO Ownership, with Matched Peers

This table reports the estimates of a (continuous) difference-in-difference fixed effect model of CEO equity ownership on measures of company performance. The dependent variable is (log) revenue in columns 1-3, and EBITDA margin in columns 4-6. The main independent variable is "CEO Ownership", defined as the fraction of outstanding common equity that is owned by the CEO of the company targeted in the buyout, measured just after the buyout takes place. Each buyout target is matched with up to five potential peers that are included in the estimation. Section 4.1.1 contains details of the matching procedure. The dummy "PE" takes the value of 1 if the target was acquired in a buyout, and 0 otherwise. All specifications include company fixed effects. Columns 1, 2, 4, and 5 include company level controls, interacted with a Post dummy. The Post dummy takes the value of 1 in the post-buyout period, and is 0 otherwise. The company level controls are measured in the fiscal year prior the buyout and are: (log) revenue; EBITDA margin; and book leverage (measured after the buyout). Columns 1 and 4 includes year fixed effects, which are replaced by industry-year fixed effects in the remaining columns. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors are clustered at the company level and presented in parentheses below the estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	(log) Revenue			EBITDA/Revenue		
CEO Ownership × Post	−0.261	−0.220	−0.297	0.054**	0.058**	0.049*
	(0.248)	(0.233)	(0.229)	(0.027)	(0.028)	(0.027)
Post × PE	0.338***	0.320***	0.320***	0.001	0.001	−0.002
	(0.057)	(0.049)	(0.047)	(0.005)	(0.009)	(0.007)
Post	0.175***	0.056	0.095***	−0.009***	−0.012***	−0.010**
	(0.042)	(0.048)	(0.028)	(0.002)	(0.002)	(0.004)
Adjusted R^2	0.898	0.902	0.889	0.523	0.525	0.512
N	7071	7071	7071	7052	7052	7052
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	Yes	No	No
Industry × Year FE	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No

Table 6: Operational Improvements and Changes in CEO Ownership

This table reports the estimates of a (continuous) difference-in-difference fixed effect model of CEO equity ownership on measures of company performance. The dependent variable is (log) revenue in columns 1-3, and EBITDA margin in columns 4-6. The main independent variables from Table 5, the post-buyout ownership share held by the CEO, is here split up into a pre-buyout ownership share and the change. "ΔCEO Ownership" is defined as the change from the pre-buyout to the post-buyout level in fraction of outstanding common equity that is owned by the CEO of the company targeted in the buyout, while "CEO Ownership$_{t-1}$" corresponds to the pre-buyout ownership share. Each buyout target is matched with up to five potential peers that are included in the estimation. Section 4.1.1 contains details of the matching procedure. The dummy "PE" takes the value of 1 if the target was acquired in a buyout, and 0 otherwise. All specifications include company fixed effects. Columns 1, 2, 4, and 5 include company level controls, interacted with a Post dummy. The Post dummy takes the value of 1 in the post-buyout period, and is 0 otherwise. The company level controls are measured in the fiscal year prior the buyout and are: (log) revenue; EBITDA margin; and book leverage (measured after the buyout). Columns 1 and 4 includes year fixed effects, which are replaced by industry-year fixed effects in the remaining columns. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors are clustered at the company level and presented in parentheses below the estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	(log) Revenue			EBITDA/Revenue		
ΔCEO Ownership × Post × PE	−0.247	0.009	0.100	0.068**	0.080**	0.080**
	(0.172)	(0.218)	(0.190)	(0.031)	(0.039)	(0.040)
CEO Ownership$_{t-1}$ × Post × PE	−0.051	−0.041	0.020	0.049	0.071	0.051
	(0.187)	(0.222)	(0.217)	(1.416)	(1.459)	(0.040)
Post × PE	0.211**	0.131	0.243***	−0.007	−0.029	0.008
	(0.102)	(0.106)	(0.079)	(0.021)	(0.026)	(0.006)
Post	0.055	0.114**	0.034	0.028***	0.030**	−0.015***
	(0.042)	(0.055)	(0.025)	(0.011)	(0.010)	(0.003)
Adjusted R^2	0.900	0.904	0.891	0.523	0.525	0.512
N	7071	7071	7071	7052	7052	7052
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	Yes	No	No
Industry × Year FE	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No

Table 7: Operational Improvements over Time

This table reports the estimates of the parallel trends test outlined in section 4.2.2. The dependent variable is (log) revenue in columns 1-3, and EBITDA margin in columns 4-6. "ΔCEO Ownership" is defined as the change from the pre-buyout to the post-buyout level in fraction of outstanding common equity that is owned by the CEO of the company acquired in the buyout. A separate coefficient is estimated for ΔCEO Ownership for each year around the buyout, using $t-1$ as the reference year. Note that ΔCEO Ownership itself does not vary. A separate coefficient is similarly estimated for each year around the buyout event for CEO Ownership$_{t-1}$, as well as dummies for $t+s \times PE$ and $t+s$, though omitted from the presentation of the table. Each buyout target is matched with up to five potential peers that are included in the estimation. Section 4.1.1 contains details of the matching procedure. The dummy "PE" takes the value of 1 if the target was acquired in a buyout, and 0 otherwise. All specifications include company fixed effects as well as company controls interacted with a Post dummy. The Post dummy takes the value of 1 in the post-buyout period, and 0 otherwise. The company controls are measured in the fiscal year prior the buyout and are: (log) revenue; EBITDA margin; and deal leverage. Specifications in columns 1 and 4 include year fixed effects, which are replaced by industry-year fixed effects in remaining columns. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors, clustered at the company level, are presented in parentheses below each estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	(log) Revenue			EBITDA/Revenue		
$t-3 \times$ PE $\times$ ΔCEO Ownership	−0.172	−0.309	−0.219	0.066	0.075	0.064
	(0.340)	(0.262)	(0.320)	(0.044)	(0.053)	(0.061)
$t-2 \times$ PE $\times$ ΔCEO Ownership	−0.245	−0.336	−0.298	0.047	0.029	0.014
	(0.216)	(0.241)	(0.240)	(0.042)	(0.048)	(0.049)
$t \times$ PE $\times$ ΔCEO Ownership	−0.285	−0.339	−0.399	0.119*	0.082	0.080
	(0.284)	(0.246)	(0.325)	(0.072)	(0.074)	(0.070)
$t+1 \times$ PE $\times$ ΔCEO Ownership	−0.243	−0.290	−0.200	0.129**	0.099*	0.118**
	(0.154)	(0.232)	(0.176)	(0.053)	(0.055)	(0.059)
$t+2 \times$ PE $\times$ ΔCEO Ownership	−0.105	−0.190	−0.117	0.122***	0.127***	0.153***
	(0.198)	(0.274)	(0.224)	(0.043)	(0.043)	(0.055)
$t+3 \times$ PE $\times$ ΔCEO Ownership	−0.207	−0.312	−0.292	0.109**	0.098*	0.114**
	(0.187)	(0.214)	(0.204)	(0.055)	(0.056)	(0.057)
$t+4 \times$ PE $\times$ ΔCEO Ownership	−0.064	−0.167	−0.101	0.093	0.086	0.086
	(0.217)	(0.247)	(0.255)	(0.061)	(0.085)	(0.079)
Adjusted R^2	0.916	0.919	0.929	0.544	0.548	0.555
N	7071	7071	7071	7052	7052	7052
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	Yes	No	No
Industry × Year FE	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No

Table 8: Operational Improvements and Change in CEO Ownership - Impact of CEO staying or leaving

This table reports the estimates of a (continuous) difference-in-difference fixed effect model of changes in CEO equity ownership on measures of company performance. Panel A reports estimates for the subsample in which the CEO is retained, while Panel B does it for the subsample in which the CEO is replaced. The dependent variable is (log) revenue in columns 1-3, and EBITDA margin in columns 4-6. The main independent variables are "ΔCEO Ownership", defined as the change from the pre-buyout to the post-buyout level in fraction of outstanding common equity that is owned by the CEO of the company targeted in the buyout, while "CEO Ownership$_{t-1}$" corresponds to the pre-buyout ownership share. Each buyout target is matched with up to five potential peers that are included in the estimation. Section 4.1.1 contains details of the matching procedure. The dummy "PE" takes the value of 1 if the target was acquired in a buyout, and 0 otherwise. All specifications include company fixed effects. Columns 1, 2, 4, and 5 include company level controls, interacted with a Post dummy. The Post dummy takes the value of 1 in the post-buyout period, and is 0 otherwise. The company level controls are measured in the fiscal year prior the buyout and are: (log) revenue; EBITDA margin; and book leverage (measured after the buyout). Columns 1 and 4 includes year fixed effects, which are replaced by industry-year fixed effects in the remaining columns. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors are clustered at the company level and presented in parentheses below the estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Subsample with retained CEO

	(log) Revenue			EBITDA/Revenue		
ΔCEO Ownership × Post × PE	−0.128	−0.093	−0.110	0.077**	0.099**	0.102**
	(0.228)	(0.207)	(0.273)	(0.035)	(0.049)	(0.048)
CEO Ownership$_{t-1}$ × Post × PE	−0.092	−0.065	−0.060	0.019	0.040	0.050
	(0.205)	(0.233)	(0.220)	(0.032)	(0.034)	(0.037)
Adjusted R^2	0.893	0.900	0.908	0.605	0.606	0.616
N	4451	4451	4451	4432	4432	4432

Panel B: Subsample with replaced CEO

	(log) Revenue			EBITDA/Revenue		
ΔCEO Ownership × Post × PE	−0.843**	−0.726*	−0.606	0.015	0.005	0.026
	(0.331)	(0.380)	(0.406)	(0.061)	(0.083)	(0.089)
CEO Ownership$_{t-1}$ × Post × PE	−0.744**	−0.551	−0.419	−0.017	−0.002	0.017
	(0.361)	(0.365)	(0.428)	(0.058)	(0.086)	(0.090)
Adjusted R^2	0.896	0.900	0.914	0.524	0.525	0.541
N	2620	2620	2620	2520	2620	2620
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	Yes	No	No
Industry × Year FE	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No

Table 9: CEO Ownership and Employee Effects

This table reports the estimates of a (continuous) difference-in-difference fixed effect model of changes in CEO equity ownership on measures of company performance. Panel A reports estimates for the subsample in which the CEO is retained, while Panel B does it for the subsample in which the CEO is replaced. The dependent variable is (log) operating cost per employee in columns 1-3, (log) revenue per employee in columns 4-6. and (log) EBITDA per employee in columns 7-9. The main independent variables are "ΔCEO Ownership", defined as the change from the pre-buyout to the post-buyout level in fraction of outstanding common equity that is owned by the CEO of the company targeted in the buyout, and "CEO Ownership$_{t-1}$", the pre-buyout ownership share. Estimates of variables not shown but included in the model are available upon request to the author. Each buyout target is matched with up to five potential peers that are included in the estimation. Section 4.1.1 contains details of the matching procedure. The specifications in the table are as in Table 6. All continuous variables are winsorized at a 1% level. T-statistics are reported in parenthesis under each estimates, with standard errors clustered at the company level. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Subsample with retained CEO

	(log) Cost per Employee			(log) Revenue per Employee			(log) EBITDA per Employee		
ΔCEO Ownership × Post × PE	−0.251*	−0.303*	−0.300*	−0.107	−0.113	−0.139	−0.065	−0.032	-0.056
	(0.130)	(0.178)	(0.171)	(0.113)	(0.174)	(0.167)	(0.379)	(0.453)	(0.385)
CEO Ownership$_{t-1}$ × Post × PE	−0.242*	−0.288*	−0.286*	−0.199	−0.185	−0.206	−0.119	0.069	0.054
	(0.131)	(0.154)	(0.146)	(0.132)	(0.171)	(0.161)	(0.344)	(0.403)	(0.385)
Adjusted R^2	0.901	0.907	0.903	0.908	0.915	0.916	0.762	0.762	0.764
N	4075	4075	4075	4159	4159	4159	3873	3873	3873

Panel B: Subsample with replaced CEO

	(log) Cost per Employee			(log) Revenue per Employee			(log) EBITDA per Employee		
ΔCEO Ownership × Post × PE	0.470	0.622	0.839**	0.004	0.178	0.413	−0.163	0.145	-0.158
	(0.374)	(0.445)	(2.239)	(0.180)	(0.308)	(1.020)	(0.616)	(0.580)	(-0.384)
CEO Ownership$_{t-1}$ × Post × PE	0.546	0.479	0.755*	−0.043	0.086	0.237	−0.021	0.007	-0.272
	(0.422)	(0.397)	(1.883)	(0.192)	(0.297)	(0.612)	(0.683)	(0.601)	(-0.595)
Adjusted R^2	0.875	0.881	0.882	0.937	0.943	0.943	0.801	0.800	0.809
N	2357	2357	2357	2460	2460	2460	2231	2231	2231
Company FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	Yes	No	No	Yes	No	No
Industry × Year FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No

Table 10: Determinants of CEO Ownership

This table presents estimations of the determinants of the ownership share held by the CEO of a portfolio company directly after a buyout. The CEO ownership share is defined as the fraction of ordinary shares owned by the CEO. Columns 1-3 presents estimations using OLS, while columns 4-6 presents the estimations of a Tobit model. The accounting variables are measured at the end of the fiscal year prior to the transaction. The one exception is leverage, which is measured at the time of the transaction. "CEO Retained" is an indicator variable taking the value of 1 if the CEO is retained, and 0 otherwise. All models includes time fixed effects. Columns 3 and 6 includes a separate intercept term for the five types of acquisitions "public-to-private", "private-to-private", "divisional buyouts", "secondary buyouts", and "distressed buyouts". For the Tobit model, the reported coefficient estimates correspond to marginal effects evaluated at sample averages. All continuous variables are winsorized at a 1% level. Standard errors are reported in parenthesis under each estimates. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	OLS			Tobit		
(Log) Revenue	-0.024^{***}	-0.016^{***}	-0.017^{***}	-0.022^{***}	-0.015^{***}	-0.016^{***}
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)
Leverage	0.031	0.019	0.017	0.036	0.025	0.024
	(0.033)	(0.032)	(0.030)	(0.029)	(0.028)	(0.028)
EBITDA/Revenue	-0.134^{***}	-0.112^{***}	-0.151^{***}	-0.101^{***}	-0.117^{***}	-0.151^{***}
	(0.051)	(0.040)	(0.051)	(0.034)	(0.036)	(0.045)
CEO pre-Ownership		0.027	0.020		0.027	0.023
		(0.027)	(0.029)		(0.026)	(0.026)
CEO pre-Ownership		0.225^{***}	0.225^{***}		0.204^{***}	0.204^{***}
$\times 1\{\text{CEO Retained}\}$		(0.044)	(0.044)		(0.039)	(0.039)
$1\{\text{CEO Retained}\}$		-0.005	-0.003		-0.002	0.000
		(0.014)	(0.014)		(0.014)	(0.013)
Adjusted (Pseudo) R^2	0.109	0.255	0.263	0.089	0.207	0.213
N	322	322	322	322	322	322
Transaction Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Acquisition type dummies	No	No	Yes	No	No	Yes

Appendices

A Appendix Tables

Table A.1: Summary Statistics - Comparison with Full Buyout Sample

This table presents a comparison of descriptive statistics between companies in the sample and the full set of companies with financials available. The two sample constructions are described in Table 1. Panel A compares statistics for the most recent fiscal year prior to the buyout, referred to as year -1. Panel B presents the change in these accounting measures from year -2 until year -1. Panel C presents changes from year -3 until year -1. Panels D, E, and C compares the buyout types, exit routes, and industry composition, respectively. The final column in panels A, B and C tests differences in means, and numbers followed by ***, **, or * indicate statistically significant means at the 1%, 5%, or 10% levels, respectively.

Panel A: Company characteristics in year prior to buyout

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue (M£)	322	119.6	54.9	198.3	494	128.4	56.5	206.7	−8.78
EBITDA (M£)	322	15.2	7.8	21.3	494	16.5	7.1	25.2	−1.34
Total Assets (M£)	322	117.3	48.5	186.3	494	139.1	53.7	220.1	−21.74
Number of Employees	317	1432	448	2445	482	1428	456	2397	3.88
EBITDA Margin	322	0.160	0.142	0.103	494	0.150	0.136	0.108	0.01

Panel B: 1-year pre-buyout growth

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	302	0.178	0.125	0.261	460	0.145	0.099	0.251	0.033*
EBITDA	302	0.205	0.191	1.450	460	0.184	0.155	1.436	0.022
Total Assets	305	0.166	0.070	0.413	464	0.140	0.041	0.400	0.026
Number of Employees	295	0.116	0.064	0.251	448	0.095	0.043	0.252	0.021
EBITDA Margin	302	0.010	0.009	0.055	460	0.006	0.007	0.068	0.004

Panel C: 2-years pre-buyout growth

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	289	0.469	0.289	0.681	433	0.378	0.203	0.608	0.091*
EBITDA	288	0.839	0.400	2.592	432	0.583	0.327	2.347	0.256
Total Assets	294	0.414	0.196	0.785	442	0.360	0.140	0.792	0.055
Number of Employees	283	0.294	0.158	0.610	422	0.253	0.110	0.586	0.041
EBITDA Margin	288	0.017	0.011	0.065	432	0.012	0.010	0.071	0.005

Table A.1 - *Continued*

Panel D: Buyout type

	Sample in Paper	Full Sample
Public-to-Private	0.137	0.134
Private-to-Private	0.258	0.263
Divisional Buyout	0.208	0.231
Secondary Buyout	0.388	0.342
Distressed Buyout	0.009	0.030
N	322	791

Panel E: Exit Route

	Sample in Paper	Full Sample
Lost Control	0.171	0.162
IPO	0.065	0.062
Trade Sale	0.264	0.290
Sale to Financial Institution	0.370	0.316
Still Owned	0.127	0.159
Other	0.003	0.006
Not Known	-	0.005
N	322	791

Panel F: Industry Composition

	Sample in Paper	Full Sample
Mining	0.8%	1.2%
Construction	3.0%	3.5%
Manufacturing	24.5%	27.7%
Transportation	7.5%	7.0%
Wholesale	3.8%	5.6%
Retail	13.6%	12.7%
Services	46.8%	42.2%

Table A.2: Summary Statistics - Managerial Ownership

This table presents descriptive statistics of the pre- and post-buyout managerial ownership in buyout targets. Panel A presents the percentage ownership of ordinary shares that is held by the management team following a buyout of the company. The statistics are presented for the full sample on the first row, and then split up by the different types of buyouts in the remainder of the rows. Panel B presents statistics for the pre-buyout managerial ownership stakes.

Panel A: Management Team Ownership after the Buyout

	N	Mean	Median	SD	25th pct	75th pct
Full sample	322	0.283	0.249	0.183	0.150	0.384
Public-to-Private Buyout	43	0.238	0.182	0.200	0.118	0.314
Private-to-Private Buyout	85	0.346	0.310	0.190	0.185	0.423
Divisional Buyout	61	0.222	0.192	0.147	0.133	0.250
Secondary Buyout	127	0.291	0.266	0.178	0.169	0.386
Distressed Buyout	6	0.217	0.248	0.079	0.142	0.280

Panel B: Management Team Ownership prior to the Buyout

	N	Mean	Median	SD	25th pct	75th pct
Full sample	322	0.369	0.232	0.364	0.051	0.645
Public-to-Private Buyout	43	0.143	0.093	0.163	0.033	0.184
Private-to-Private Buyout	85	0.783	0.985	0.368	0.489	1.000
Divisional Buyout	61	0.094	0.000	0.244	0.000	0.030
Secondary Buyout	127	0.333	0.264	0.236	0.160	0.500
Distressed Buyout	6	0.328	0.172	0.421	0.002	0.600

Table A.3: Operational Improvements over Time - Buyout Targets Only

This table reports the estimates of the parallel trends test outlined in section 4.2.2, excluding the matched control sample. The dependent variable is (log) revenue in columns 1-3, and EBITDA margin in columns 4-6. "ΔCEO Ownership" is defined as the change from the pre-buyout to the post-buyout level in fraction of outstanding common equity that is owned by the CEO of the company acquired in the buyout. A separate coefficient is estimated for ΔCEO Ownership for each year around the buyout, using $t-1$ as the reference year. Note that ΔCEO Ownership itself does not vary. A separate coefficient is similarly estimated for each year around the buyout event for CEO Ownership$_{t-1}$, as well dummies for $t+s\times PE$ and $t+s$, though omitted from the presentation of the table. Each buyout target is matched with up to five potential peers that are included in the specification. Section 4.1.1 contains details of the matching procedure. The dummy "PE" takes the value of 1 if the target was acquired in a buyout, and 0 otherwise. All specifications include company fixed effects as well as company controls interacted with a Post dummy. The Post dummy takes the value of 1 in the post-buyout period, and 0 otherwise. The company controls are measured in the fiscal year prior the buyout and are: (log) revenue; revenue growth; EBITDA margin; and deal leverage. Specifications in columns 1 and 4 include year fixed effects, which are replaced by industry-year fixed effects in remaining columns. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors, clustered at the company level, are presented in parentheses below each estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	(log) Revenue			EBITDA/Revenue		
$t-3\times$ ΔCEO Ownership	0.101	0.109	0.094	0.039**	0.038**	0.042**
	(0.080)	(0.072)	(0.091)	(0.017)	(0.018)	(0.018)
$t-2\times$ ΔCEO Ownership	0.084	0.085	0.065	0.028	0.028	0.031
	(0.075)	(0.074)	(0.090)	(0.026)	(0.027)	(0.029)
$t\times$ ΔCEO Ownership	0.020	0.038	0.070	0.020	0.021	0.022
	(0.082)	(0.086)	(0.097)	(0.018)	(0.018)	(0.019)
$t+1\times$ ΔCEO Ownership	0.089	0.134*	0.125	0.085***	0.090***	0.088***
	(0.075)	(0.076)	(0.097)	(0.026)	(0.027)	(0.028)
$t+2\times$ ΔCEO Ownership	0.098*	0.149***	0.116**	0.106***	0.116***	0.105***
	(0.052)	(0.055)	(0.059)	(0.019)	(0.020)	(0.022)
$t+3\times$ ΔCEO Ownership	0.021	0.076	0.033	0.064***	0.067***	0.067***
	(0.141)	(0.135)	(0.142)	(0.024)	(0.023)	(0.025)
$t+4\times$ ΔCEO Ownership	0.059	0.136	0.064	0.068**	0.070**	0.079***
	(0.128)	(0.141)	(0.146)	(0.027)	(0.029)	(0.027)
Adjusted R^2	0.955	0.956	0.957	0.711	0.712	0.712
N	1573	1573	1573	1572	1572	1572
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No

Table A.4: Likelihood of Bankruptcy

This table presents estimations of the likelihood that a buyout ends up in insolvency procedures, creditors seize control, or a financial restructuring resulting in a new owner taking over with the old equity holders receiving no compensation. The dependent variable takes the value 1 if this happens, and zero for all other types of exits. Deals that are still controlled by the private equity firm as of 2019-09-30 are not included in the estimation. A CEO's ownership stake is defined as the fraction of ordinary shares owned by the CEO. "CEO Ownership$_{t-1}$" measures this stake in the pre-buyout period, while "Δ CEO Ownership" measures the change in this measure from the pre-buyout to the post-buyout period. "1{CEO Retained}" is an indicator variable taking the value of 1 if the CEO is retained, and 0 otherwise. Columns 1-5 presents estimations using OLS, while columns 6-10 presents the estimations of a Logit model. The five columns differ in the set of control variables included. All models includes time fixed effects. From columns 3 and 8, industry fixed effects are included. Columns 4 and 9 add company controls, and columns 5 and 10 includes a separate intercept term for each of the five types of acquisitions "public-to-private", "private-to-private", "divisional buyouts", "secondary buyouts", and "distressed buyouts". Company controls include (log) revenue, the EBITDA margin, and book leverage. They are measured at the end of the fiscal year prior to the transaction, with the exception of leverage which is measured at the time of the transaction. For the Logit model, the reported coefficient estimates correspond to marginal effects evaluated at sample averages. All continuous variables are winsorized at a 1% level. Standard errors are reported in parenthesis under each estimates. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	OLS					Logit				
Δ CEO Ownership	−0.385	−0.118	−0.260	−0.195	−0.219	−0.381	−0.094	−0.334	−0.221	−0.284
	(0.243)	(0.383)	(0.387)	(0.408)	(0.409)	(0.253)	(0.365)	(0.399)	(0.402)	(0.409)
CEO Ownership$_{t-1}$	−0.158	0.175	0.030	0.156	0.178	−0.179	0.166	−0.067	0.117	0.105
	(0.231)	(0.378)	(0.382)	(0.404)	(0.414)	(0.239)	(0.361)	(0.394)	(0.401)	(0.411)
Δ CEO Ownership		−0.379	−0.344	−0.364	−0.273		−0.467	−0.406	−0.478	−0.296
×1{CEO Retained}		(0.515)	(0.514)	(0.530)	(0.527)		(0.538)	(0.546)	(0.550)	(0.545)
CEO Ownership$_{t-1}$		−0.544	−0.429	−0.494	−0.520		−0.582	−0.460	−0.566	−0.544
×1{CEO Retained}		(0.484)	(0.483)	(0.497)	(0.494)		(0.490)	(0.507)	(0.509)	(0.508)
1{CEO Retained}		0.091	0.086	0.101	0.109		0.099	0.095	0.116	0.131
		(0.077)	(0.077)	(0.079)	(0.079)		(0.077)	(0.078)	(0.079)	(0.080)
Adjusted (Pseudo) R^2	0.036	0.032	0.044	0.040	0.056	0.110	0.112	0.139	0.148	0.178
N	281	281	281	281	281	281	281	281	281	281
Transaction Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Company Controls	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Acquisition Type Dummies	No	No	No	No	Yes	No	No	No	No	Yes

Table A.5: Summary Statistics of Companies with Retained and Replaced CEO

This table presents a comparison of descriptive statistics between companies in the sample in which the CEO was retained versus companies in which the CEO was replaced. Panel A present company descriptives for the most recent fiscal year prior to the buyout, referred to as year -1. Panel B presents the change in these accounting measures from year -2 until year -1. Panel C presents changes from year -3 until year -1. The final column tests differences in means, and numbers followed by ***, **, or * indicate statistically significant means at the 1%, 5%, and 10% levels, respectively.

Panel A: Company characteristics in year prior to buyout

	CEO Retained				CEO Replaced				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue (M£)	197	117.1	60.0	167.5	125	123.7	47.6	241.0	−6.55
EBITDA (M£)	197	15.3	8.8	20.0	125	14.9	6.0	23.5	0.44
Total Assets (M£)	197	108.7	50.2	151.1	125	131.1	39.8	232.5	−22.52*
Number of Employees	194	1330	582	2198	123	1599	340	2804	-269
EBITDA Margin	197	0.160	0.140	0.101	125	0.160	0.154	0.102	0.00

Panel B: 1-year pre-buyout growth

	CEO Retained				CEO Replaced				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	185	0.203	0.136	0.290	117	0.136	0.120	0.199	0.068**
EBITDA	185	0.273	0.199	1.466	117	0.094	0.178	1.423	0.179
Total Assets	187	0.160	0.068	0.411	118	0.176	0.087	0.420	−0.016
Number of Employees	179	0.127	0.069	0.237	116	0.098	0.061	0.272	0.028
EBITDA Margin	185	0.015	0.011	0.057	117	0.002	0.007	0.051	0.013

Panel C: 2-years pre-buyout growth

	CEO Retained				CEO Replaced				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	177	0.490	0.289	0.685	112	0.434	0.289	0.676	0.056
EBITDA	176	0.901	0.488	2.381	112	0.738	0.369	2.916	0.163
Total Assets	180	0.443	0.209	0.813	114	0.366	0.170	0.739	0.077
Number of Employees	172	0.333	0.165	0.646	111	0.226	0.118	0.540	0.107
EBITDA Margin	176	0.015	0.012	0.063	112	0.019	0.010	0.069	−0.003

Table A.6: Summary Statistics - CEO Ownership

This table presents descriptive statistics of the pre- and post-buyout CEO ownership in buyout targets, comparing the subsample of companies in which the CEO was retained with those in which the CEO was replaced. Panel A presents the percentage ownership of ordinary shares that is held by the CEO following a buyout of the company. The statistics are presented for the full subsample on the first row, and then split up by the different types of buyouts in the remainder of the rows. Panel B presents statistics for the pre-buyout CEO ownership stakes. The final column tests differences in means, and numbers followed by ***, **, or * indicate statistically significant means at the 1%, 5%, and 10% levels, respectively.

Panel A: CEO Ownership after the Buyout

	CEO Retained				CEO Replaced				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Full sample	197	0.117	0.093	0.097	125	0.107	0.083	0.089	−0.010
Public-to-Private Buyout	27	0.103	0.076	0.103	16	0.116	0.083	0.089	−0.013
Private-to-Private Buyout	35	0.178	0.144	0.138	50	0.126	0.100	0.095	0.052*
Divisional Buyout	41	0.084	0.071	0.059	20	0.094	0.072	0.114	−0.010
Secondary Buyout	91	0.114	0.097	0.082	36	0.086	0.068	0.076	0.028*
Distressed Buyout	1	0.143	0.143	n/a	5	0.112	0.085	0.032	0.031

Panel B: CEO Ownership prior to the Buyout

	CEO Retained				CEO Replaced				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Full sample	197	0.111	0.050	0.172	125	0.258	0.112	0.293	−0.147***
Public-to-Private Buyout	27	0.046	0.028	0.045	16	0.144	0.040	0.247	−0.098
Private-to-Private Buyout	35	0.243	0.132	0.273	50	0.452	0.500	0.302	−0.209***
Divisional Buyout	41	0.006	0.000	0.019	20	0.144	0.006	0.310	−0.138*
Secondary Buyout	91	0.127	0.087	0.149	36	0.110	0.090	0.095	0.017
Distressed Buyout	1	0.500	0.500	n/a	5	0.154	0.118	0.070	0.346

B Data Description

This appendix provides additional details on the data collection process. Note that most of this is covered in the second paper of the thesis.

B.1 Sample Construction

I follow Strömberg (2008) and use Capital IQ (CIQ) to identify buyout transactions. The transaction screen was undertaken 2019-01-02. The following criteria were used in a "Capital IQ Transaction Screen" to generate the initial set of transactions:

- "Transaction Primary Features" set to: Merger/Acquisition – Acquisition of Equity Stake or Private Placement – PIPE or Private Placement – Growth capital/Private Equity;
- "Merger/Acquisition Features" set to: "Going Private Transaction" or "Leveraged Buy Out (LBO)" or "Management Buyout" or "Platform" or "Privatization of Government Entity" or "Management Participated" or "Secondary LBO" or "Acquisition of Majority Stake";
- "Secondary features" set to: "Leveraged Buy Out (LBO)", or "Management Buyout", or "Secondary LBO", or "Going Private Transaction";
- "Investment Firm Type (Buyers/Investors)" is listed as "PE/VC";
- Transaction is listed as "closed" or "effective".

The initial screen picked up transactions that were initial toe-hold investments, a purchase of remaining minor stakes, or the purchase of a minority stake. The focus here are transactions in which a private equity buyout fund gains control of the company. Therefore, transactions that are classified as either "Minority Stake Investment" or "Majority Shareholder Purchasing Remaining Shares", or where the investor was classified as a "VC", are dropped from the sample. This leaves an initial set of 11,549 transactions.

For all unique companies in these transactions, the following items are extracted: company name; country of incorporation; filing currency; and the country of primary office location. All UK companies are selected based on being incorporated in the UK or, if that item is not available, either have GBP as its filing currency or has its primary office in the UK. Due to the limited number of years with financials available in the Bureau van Dijk (BvD) databases, we restrict the sample to transactions completed between 1999 and 2018. This leaves the initial set of 1964 buyouts of UK companies that forms the first row of Table 1.

Of the identified buyouts of UK companies 850 are randomly selected to be processed. Each transaction requires a substantial amount of manual work, necessitating working with a random part of the sample. Figure A.3 in Chapter 4 outlines the composition of buyouts over time of those randomly selected versus those not processed. Overall, the distribution of buyouts over time is quite similar, though Capital IQ coverage is low for the later years in the sample.

57 transactions are dropped from the sample for the following reasons:

- 19 companies are dropped as no UK company could be found either in Companies House or Fame under the name of the acquired company in Capital IQ today or, when it differed, the name of the acquired company in the transaction synopsis provided by Capital IQ. Both Companies House and Fame contains previously registered names of companies, so when no match can be found it likely reflects either a mistake in the naming in Capital IQ or that some non-UK companies are identified during the process of selecting UK-registered companies.
- 15 transactions are dropped as no PE firm participated. PE firm participation is verified using annual reports and ownership filings.
- 10 transactions are dropped because the PE firm did not acquire a controlling stake. This information is gathered from post-buyout ownership filings.
- 7 transactions are duplicates, where two separate company IDs in Capital IQ have been assigned to the same transaction, with two separate transaction IDs.
- 5 transactions are dropped as the transaction ID identified in the initial screen were no longer present in Capital IQ at the time a match was attempted to be established with Fame.
- 3 transactions are dropped because the acquired companies were too small and were exempted from submitting filings throughout the period of interest.

The remaining 791 buyouts are fully processed with the type of buyout classified and the type of exit documented with the date and the type of exit. The type of buyout is determined based on the type of ownership prior to the buyout. To establish the exit route I utilize a combination of sources. Capital IQ, Zephyr, and news articles are scanned for information regarding sales. When a sale is identified I corroborate the information through reading annual reports of the acquired company and, when possible, the acquirer.

If no mention of a sale is identified I look at whether the company ended up in insolvency procedures, called being placed in "administration" in the UK. When a company is placed

in administration, the administrator regularly submit filings to Companies House on the progress.[21] A company, or part of it, can be acquired out of administration. There are cases in the sample where Capital IQ (and, less commonly, Zephyr) incorrectly attribute the seller in these cases as the PE firm, even when none of the proceeds go to the PE firm. This is why sales identified in the first step are corroborated by reading annual report and searching for potential insolvency.[22]

For the remaining unclassified cases I utilize ownership filings to detect when a PE firm cease to be the ultimate owner. This process either confirms that the PE firm remains the ultimate owner, or document when a change in ownership takes place. In the latter case I consult annual reports to find out the reason behind the change in ownership. This exercise picks up some sales not picked up by the other sources. Typically, these concern small companies when sold to the management team or other individuals. Importantly, this exercise also picks up cases where creditors seize control of a company by, for example, a debt-to-equity swap or other events in which the equity holders receive no compensation for their stakes.

For the 12.7% of transactions in the paper that are classified as still being owned by private equity that is as of 2019-09-30, when a potential sale was last searched for. A lack of news about a sale is not sufficient to classify a company as still in private equity hands. Ownership filings are used to verify the ownership status and searches for insolvency filings are undertaken in Companies House.

B.2 Additional Details on the Accounting Data

In this paper I utilize the first year in which annual reports are submitted following a buyout, referred to as year $t = 0$. Except by accident, the first annual report does not cover exactly one calendar year worth of trading. The annual report itself will refer to the period covered from the day of incorporation until the fiscal year end, but in practice no trading takes place prior to the completion of the buyout acquisition. For the first annual report of newly created companies, I collect the date that trading activity commences from the annual report, and annualize income statement numbers through linear extrapolation. Note that balance sheet items are snapshots and therefore requires

[21] Administration is the UK equivalent of Chapter 11 in the US. The filings submitted by an administrator include: a "Statement of administrator's proposal", which provides background information on the events leading to administration, the strategy and progress to date of the administrator(s), and an assessment of the likely outcome for the various classes of creditors; and semi-annual "Administrator's progress report" outlining the progress and outcome for creditors.

[22] Since the Enterprise Act 2002, administrators can be appointed out of court. This enabled pre-packaged administration, where a sale is negotiated prior to the company being placed in administration, with the sale taking place immediately after. Almost all misclassified sales by Capital IQ relate to pre-administration packages. Even in pre-packaged administration cases the administrator submits filings to Companies House.

no adjustment. If the trading period covers less than 4 months of a year, the income statement items are treated as missing since a shorter period may not be representative of the full year. The results of the paper are robust to varying this accepted window to between 3 and 6 months, or dropping $t = 0$ completely from the analysis.[23]

Fame provides financials for up to 20 years worth of annual reports. For the earlier transactions in the sample this implies that the pre-buyout period is not always covered. For these deals I manually complement the financials from annual reports. There are two additional cases which prompts me to manually complement the Fame data.

First, occasionally there are fiscal years inexplicably missing from Fame even when the annual report is available in Companies House. I add these years manually to avoid gaps in the data.

Second, the acquisition event typically gives rise to a large amount of goodwill in the acquiring parent company, and subsequent add-on acquisitions may further increase the goodwill post in the balance sheet. The goodwill is amortised over a period of years and may be subject to impairment charges. Fame does provide an EBITDA number that accounts for depreciation and amortisation. However, it is not uncommon that one or both of the two numbers are missing from individual years. Additionally, impairment charges are only rarely included by Fame, though they are both common and of considerable size. I have manually gone through Fame to detect missing depreciation/amortisastion entries, and read annual reports to detect mentions of impairment charges to check whether Fame picked them up.[24] When impairments are not picked up by Fame I complement the EBITDA calculations.[25] This process is applied to the pre-buyout years as well as the period under private equity ownership to avoid any bias arising from different treatment of the data when under PE ownership. In total, financials for 843 company-years are either added or amended.[26]

Not all companies have to provide the same level of detail in their annual reports. In particular, companies classified as "small" are only required to submit abridged accounts containing limited information which excludes profit and loss information. These filings

[23]Earlier studies on operational improvements generally do not include the year of acquisition in their analysis and hence do not suffer from this problem. As noted earlier, the consolidating parent company sometimes shift multiple times during holding period in which case it is relevant to account for this problem outside of $t = 0$.

[24]Impairment and write-downs can concern both fixed assets and intangible assets such as goodwill, and both are commonly not accounted for by Fame. The charge always shows up somewhere in Fame, and while there is some variation, the most common approaach appears to be to include it in general "Administration Expenses", and sometimes as an exceptional item.

[25]The increase in interest payments and the typical increase in amortisation is the reason why EBITDA measures are commonly used to evaluate the performance of PE portfolio companies.

[26]A similar approach is taken to ensure that the accounts of matched peers are correct and available. The vast majority of amendments are made for companies acquired in a buyout and relate to missed impairment charges on goodwill, an item that is virtually always present in buyout targets and much less frequently a major item in matched peers.

therefore cannot be used in the data analysis. The requirements to be classified as a small company has changed over time, and any company-year in which a company qualified as small is dropped from the sample.[27]

[27]To be classified as a small company, a company needs to be smaller in at least two out of three qualifying measures: turnover, total assets, and number of employees. The limit on number of employees has been stable at 50 over time. The following requirements and time periods are relevant for the sample in this paper, with numbers for turnover (total assets): prior to 2004-01-10, £2.8m (£1.4m); prior to 2008-04-06, £5.6m (£2.8m); prior to 2015-04-06, £6.5m (£3.26m); since 2015-04-06, £10.2m (5.1m). Classifications are from Section 247 of the Companies Act 1985 and Section 382 of the Companies Act 2006, both links accessed 2019-08-22. I am grateful to the policy team at Companies House for providing these links.

C Comparison PE targets and Matched Peers

This appendix provides a brief comparison of the quality of the matching procedure outlined in section 4.1.1.

Table C.1 provides a comparison of the companies in the sample versus that of matched control companies, measured at the end of the last fiscal year end prior to the buyout. Panel A presents the results in levels, Panel B the changes over the last year and Panel C the changes over the last two years.

As the control set was matched on companies being similar along the lines of revenue and EBITDA margin, these two items and and EBITDA are very similar in levels. The matched controls have more total assets, but fewer employees, although neither difference is statistically significant due to large variation within each group. When it comes to the changes leading up to the buyout, the typical buyout target have experienced higher growth rates, especially measured over the 2-year horizon. Though both groups have experienced improvements in the EBITDA margin, that improvement is larger among the matched peers.

Table C.2 formally tests differences in (log) revenue and EBITDA profitability margins using the same parallel trends specification as in section 4.2.2 in the main text. The table makes clear that targets acquired in a buyout grow much faster than the matched control group. However, the table also emphasize the point in the descriptives: these companies were already on a path of higher growth, though the buyout appears to accelerate the pace of the growth. There is no significant difference in profitability improvements between buyout targets and the matched control group. If anything, companies acquired in buyouts experience a slight worsening of profitability after the buyout relative to the control group, though this is not consistent over all models and horizons and is never statistically significant.

These tables make clear that the matching procedure have not produced a perfect match given the existence of pre-trends. It is important to note that the identification strategy of the paper does not rely on the parallel trend assumption being met in this difference-in-difference specification, as long as the trends are not different between buyout targets experience large increases in CEO ownership and those that do not. It is also worth pointing out that the pre-trend growth in revenue that appears to accelerate after the buyout is similar to that observed in Boucly et al. (2011).

Table C.1: Summary Statistics - Comparisons Buyout Targets versus Matched Controls

This table presents a comparison of descriptive statistics between companies in the sample and the set of matched control companies. Panel A compares statistics for the most recent fiscal year prior to the buyout, referred to as year -1. Panel B presents the change in these accounting measures from year -2 until year -1. Panel C presents changes from year -3 until year -1. The final column tests differences in means, and numbers followed by ***, **, or * indicate statistically significant means at the 1%, 5%, and 10% levels, respectively.

Panel A: Company characteristics in year prior to buyout

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue (M£)	322	119.6	54.9	198.3	1190	116.4	54.7	135.6	3.24
EBITDA (M£)	322	15.2	7.8	21.3	1190	14.5	7.5	18.1	0.69
Total Assets (M£)	322	117.3	48.5	186.3	1189	139.1	59.5	183.6	−19.80
Number of Employees	317	1432	448	2445	1107	1233	402	1708	199.00
EBITDA Margin	322	0.160	0.142	0.103	1190	0.156	0.140	0.091	0.004

Panel B: 1-year pre-buyout growth

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	302	0.178	0.125	0.261	1058	0.165	0.108	0.239	0.013
EBITDA	302	0.205	0.191	1.450	1055	0.226	0.146	2.738	−0.021
Total Assets	305	0.166	0.070	0.413	1076	0.154	0.106	0.222	0.012
Number of Employees	295	0.116	0.064	0.251	985	0.078	0.042	0.154	0.038*
EBITDA Margin	302	0.010	0.009	0.055	1055	0.024	0.009	0.058	−0.014**

Panel C: 2-years pre-buyout growth

	Sample in Paper				Full Sample				
	N	Mean	Median	SD	N	Mean	Median	SD	Mean diff.
Revenue	289	0.469	0.289	0.681	873	0.381	0.269	0.690	0.088
EBITDA	288	0.839	0.400	2.592	865	0.362	0.379	3.027	0.477*
Total Assets	294	0.414	0.196	0.785	917	0.363	0.246	0.555	0.051
Number of Employees	283	0.294	0.158	0.610	819	0.212	0.118	0.367	0.082*
EBITDA Margin	288	0.017	0.011	0.065	865	0.031	0.013	0.073	−0.014**

Table C.2: Operational Improvements of Buyout Targets versus Matched Controls

This table reports the estimates of a parallel trends test comparing companies acquired in a buyout to that of matched peers. The procedure is similar to that outlined in section 4.2.2, excluding CEO ownership variables. The dependent variable is (log) revenue in columns 1-3, and EBITDA margin in columns 4-6. A separate coefficient is estimated for a PE dummy for each year $t - s$, as well as an indicator variable for each year $t - s$ that is omitted for brevity. The year $t - 1$ is used as a reference point. The PE dummy takes the value 1 if a company was acquired in a buyout, and 0 if it is a matched control company. All specifications include company fixed effects as well as year fixed effects. Industry fixed effects are added in columns 2 and 5, and company controls interacted with a Post dummy are dropped in columns 3 and 6. The Post dummy takes the value of 1 in the post-buyout period, and 0 otherwise. The company controls are measured in the fiscal year prior the buyout and are: (log) revenue; revenue growth; EBITDA margin; and deal leverage. The pre-buyout period includes up to three years prior to the buyout, while the post-period includes the year in which the buyout took place, and up to four years after or until an exit occurs, whichever happens first. All continuous variables are winsorized at a 1% level. Standard errors, clustered at the company level, are presented in parentheses below each estimate. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% levels, respectively.

	(log) Revenue			EBITDA/Revenue		
$t-3 \times$ PE	-0.086^{***}	-0.092^{***}	-0.091^{**}	0.004	0.002	0.002
	(0.030)	(0.030)	(0.038)	(0.007)	(0.007)	(0.007)
$t-2 \times$ PE	-0.014	-0.017	-0.023	0.009	0.008	0.008
	(0.040)	(0.040)	(0.042)	(0.008)	(0.008)	(0.008)
$t \times$ PE	0.223^{***}	0.228^{***}	0.205^{***}	-0.007	-0.001	-0.015
	(0.066)	(0.068)	(0.076)	(0.019)	(0.018)	(0.023)
$t+1 \times$ PE	0.293^{***}	0.298^{***}	0.271^{***}	-0.001	0.005	-0.010
	(0.058)	(0.061)	(0.064)	(0.020)	(0.019)	(0.022)
$t+2 \times$ PE	0.336^{***}	0.340^{***}	0.323^{***}	0.000	0.006	-0.010
	(0.064)	(0.067)	(0.070)	(0.021)	(0.021)	(0.026)
$t+3 \times$ PE	0.380^{***}	0.384^{***}	0.370^{***}	-0.008	-0.002	-0.015
	(0.074)	(0.076)	(0.079)	(0.019)	(0.019)	(0.025)
$t+4 \times$ PE	0.374^{***}	0.379^{***}	0.368^{***}	-0.008	-0.001	-0.012
	(0.087)	(0.091)	(0.082)	(0.022)	(0.021)	(0.024)
Adjusted R^2	0.927	0.927	0.931	0.546	0.550	0.556
N	7087	7087	7087	7068	7068	7068
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	No	Yes	Yes
Company Controls	Yes	Yes	No	Yes	Yes	No

D Variables in the data set

Table D.1: Variable Definitions

Variable name	Description
Buyout Types	
Distressed Buyout	A transaction where the acquired company was in financial distress prior to the buyout. It is defined as being acquired from one of the following situations: acquired from bankruptcy procedures (called "administration" in the UK); acquired in a refinancing or restructuring deal where creditors are not fully compensated; and one case where the acquiring private equity firm was paid by the previous owner to take on the company and its debt.
Divisional Buyout	A transaction where the acquired company was a subsidiary or division of a larger corporation prior to the buyout.
Private-to-Private Buyout	A transaction where the acquired company was privately trading prior to the buyout, with individuals controlling the company, and is not classified as a distressed buyout.
Public-to-Private Buyout	A transaction where the acquired company was publicly listed prior to the buyout.
Secondary Buyout	A transaction where the acquired company was a portfolio company of another private equity firm prior to the transaction. This category includes cases where the portfolio company is passed between private equity ownership more than once.
Exit Routes	
IPO	An exit is classified as an IPO if the private equity owner exits via an initial public offering. Usually, a private equity owner do not sell all shares at the IPO, instead exiting over a period of time following the IPO. The exit date is defined as the date at which majority ownership is lost, whether that is the IPO date or a later date. The exit route is classified as an IPO if the stake is reduced below a majority stake while the company is still publicly trading.
Lost Control	A private equity owner is defined as having lost control of the company if any of the following happens: creditors seize control of the company; the company is placed in bankruptcy procedures (called "administration" in the UK); or control passes to a new owner in a financial restructuring of the company, where the equity holders receive no compensation. These are events that are generally not disclosed publicly, and the eventual outcome is found through disclosures in Annual Reports and, in the case of bankruptcy procedures, through reports submitted submitted to Companies House by the court-appointed administrators.

(*Continues*)

Table D.1 – *Continued*

Variable name	Description
Other (Exit Route)	There are five cases in the sample where the exit route cannot be classified into either of the other five exit route categories. These five cases involve the private equity firm maintaining ownership of the portfolio company until the company has been sold in pieces or liquidated by other means, and afterwards seize trading.
Trade Sale	A sale is classified as a trade sale when the company is sold to a non-investment firm or to individuals.
Sale to Financial Institution	A sale is classified as a sale to a financial institution when the company is sold to a investment firm. The vast majority of these cases are sales to private equity funds but also includes sales to pension funds, sovereign wealth funds and other investment firms.
Still Owned	A company is classified as still being owned if there are no recorded transactions as of 2019-09-30, and the most recent annual report or ownership list still indicates the private equity firm as the ultimate majority owner.
Company Variables	
CEO Ownership	The fraction of common shares held by the CEO of the company. This variable is compiled by hand from ownership filings ("Annual Returns" or, more recently, "Confirmation Statements") containing precise ownerships of individual shareholders. The variable is measured at two points: in the last annual return submitted prior to the buyout and the first annual return submitted following the completion of the transaction. The measure ΔCEO Ownership is defined as the difference in the two measures.
EBITDA (ROS)	Earnings before Interest, Taxes, Depreciation and Amortisation (EBITDA). EBITDA is adjusted for impairment charges, write-offs and revaluations to tangible and intangible assets.
Replaced CEO	An indicator variable taking the value 1 if the CEO pre-buyout does not remain as CEO post-buyout, and 0 otherwise.
Retained CEO	An indicator variable taking the value 1 if the CEO pre-buyout remains as CEO post-buyout, and 0 otherwise.

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6 | Conclusion

In this dissertation, I propose three empirical analyses on private equity, an industry that has grown rapidly over the past forty years and is now a prominent ownership form. The common idea of these studies is to examine private equity investments. Investments in, and by, private equity funds differ substantially from investments in, and by, other common fund structures such as mutual funds.

Chapter 1 of this thesis introduces the institutional setting and the broad field of private equity within which these papers contribute. In Chapter 2, I review the extant state of the literature. The chapter offers a detailed review on three specific areas: i) investing in private equity funds and issues facing investors; ii) how private equity funds are structured, and how that structure is related to potential agency conflicts between investors (limited partners, or LPs) and fund managers (general partners, GPs); and iii) the economic impact of private equity ownership on the portfolio companies that private equity funds invest in.

The three papers of the thesis contribute to each of these three areas. The first paper, *The accuracy of net asset values in private equity: Evidence from the secondary market*, examines pricing in the secondary market for private equity fund stakes, using a confidential dataset provided by a London-based intermediary in the market. This market offers investors early liquidation of their otherwise illiquid private equity fund investments. The second paper explores the dynamics of pay-for-performance sensitivity in a GP's compensation that arises due to the carried interest provision. The paper links variation in the pay-for-performance sensitivity to operational improvements at the portfolio companies acquired by the private equity fund. The third paper focuses on the how operational improvements are related to a change at the portfolio company induced by buyouts: a change in a CEO's ownership stake. In the following, I discuss the general implications and limitations of each paper separately, and suggest directions for future work.

As investments of private equity funds are privately held, one of the characterising features of private equity is a lack of market valuations and publicly available data. Consequently, GPs provide regular appraisals of the fund value to LPs in the form of net asset value (NAV) estimations. However, NAVs are not always accurate (e.g. Barber and Yasuda, 2017; Brown et al., 2019). In the first paper of the thesis I document that

cross-sectional variation in discounts is informative of the underlying value of NAVs. Funds that receive high (low) bids report high (low) returns for the quarter in which the bid is placed, and bids predict fund performance in the subsequent years. These findings have several important implications.

First, the secondary market has the potential to alleviate the illiquidity traditionally associated with private equity investments. The secondary market remained marginal for a long time due to restrictions on the transferability of private equity fund stakes (Lerner and Schoar, 2004). The market has however grown rapidly since the beginning of the 2000s. If liquidating stakes become a viable option for LPs facing liquidity shocks, that will lower the returns required to invest in the primary market (Bollen and Sensoy, 2016; Maurin et al., 2020). This could widen the potential investor base and encourage further growth in the market. The paper adds to our understanding of how this market functions.

Second, how much of a liquidity relief the secondary market offers depends on how much of an haircut investors have to accept for transacting in it. A common interpretation of discounts in the market is that they represent compensation to providers of liquidity (e.g. Nadauld et al., 2019). The results of the paper suggest that a more nuanced view is warranted, as discounts at least partly reflects rational expectations about future fund performance. The model of Bollen and Sensoy (2016) directly takes the discount as a measure of how well-functioning the secondary market is. To the extent that reported NAVs are not always fair, reported discounts are not necessarily capturing the true cost of transacting in the market.

Third, an interesting approach for evaluating private equity investments is taken by Boyer et al. (2019) that develop a private equity index based on transactions in the secondary market. Implicit in their approach is that secondary market transactions reflect the market value of a fund stake. The results of my paper complement theirs by providing supportive evidence of this assumption in the cross-section of discounts. Additionally, results in my paper suggest a potential remedy to a problem of relying solely on transactions: the lack of frequent transactions. Conditional on transacting at least once, the average fund in their sample only transacts 2.7 times in the period 2006 to 2018. Results in my paper suggest that bids are informative of underlying NAV values and behave similarly to transaction values. If bids, gathered as a limit order book, can be used to complement transaction prices, the frequency of data observations is greatly increased.

The lack of a large amount of transactions in my database is a limitation of my study. Though I take steps to verify that these bids are serious, there will always be a concern that they do not properly reflect transaction prices. It therefore appears as if is the best way forward is to combine information inherent in bids with realized market valuations from transactions. Constructing an index in this way seems like a fruitful area for future research.

For the second and third papers I assemble a representative dataset of UK portfolio companies acquired in a buyout. The dataset contains information on the private equity exit, company-level financials in the pre- and post-buyout periods, and precise ownership data. The UK offers a unique setting for studying portfolio companies controlled by private equity firms. All companies in the UK are required to submit financials and ownership information annually to Companies House, and these filings are publicly available.

The second paper, *The dynamics of pay-for-performance sensitivity in private equity funds*, explores how the sensitivity of GPs' pay to performance varies over a fund's life. GP compensation is linked to fund performance through the carried interest provision, providing the GP with a fraction of fund profits conditional on beating a hurdle rate. Consequently, a GP's pay-for-performance sensitivity is increasing in fund performance, and increasingly so as the fund matures. I estimate this sensitivity using an extended version of the model framework developed by Metrick and Yasuda (2010).

I examine whether variation in pay-for-performance sensitivity is related to operational improvements in portfolio companies. GPs often claim that they add value to their portfolio companies, and several papers document operational improvements following buyouts (e.g. Bernstein and Sheen, 2016; Boucly et al., 2011). Presumably, adding value to portfolio companies takes effort on behalf of the GP, and agency theory predicts that we should expect higher effort exerted when an agent's pay is more sensitive to performance that can be improved from exerting effort.

Exploiting the staggered nature of investments by private equity funds, I find that within-fund variation in pay-for-performance sensitivity is positively related to growth in portfolio companies acquired in buyouts. The effect is stronger when the importance of the direct component of pay for performance is high relative to the indirect component of pay for performance. To rule out possible confounding factors, public market movements are utilized to generate exogenous variation in the measure. Private equity valuations are positively impacted by public market movements (e.g. Ang et al., 2018), but a common market shock has a heterogeneous impact on the pay-for-performance sensitivity of private equity funds. This is primarily driven by the amount of capital invested at the time of the shock, as well as the non-linear payoff structure of carried interest. The main finding of the paper holds using only exogenous variation in pay-for-performance sensitivity. The findings of the paper are important for several reasons.

First, a large part of compensation in private equity funds is varying with performance (Chung et al., 2012; Metrick and Yasuda, 2010), which is seen by some as drivers of strong returns in private equity funds (e.g. Jensen, 1989; Kaplan and Strömberg, 2009). However, we have only limited evidence on how variation in pay-for-performance sensitivity relates to performance in private equity funds.

Robinson and Sensoy (2013) examine variation in fund terms and how it relates to fund performance, finding little evidence of differential net-of-fees returns. For venture capital funds they find no relationship, and for buyout funds they document a positive relationship between the carried interest level and fund performance. However, only 3% of buyout funds in their sample has a carried interest level different from the typical 20%, implying that their results are driven by a small subset of funds. Hüther et al. (2020) show that, among venture capital funds, performance is higher among funds with "GP-friendly" contract terms, where carry is paid on a deal-by-deal basis. In both of these studies, it is difficult to attribute any results to an effect of contract terms. More able GPs will in expectation perform better, and that performance might allow them to extract better contract terms from investors, as in Berk and Green (2004). By contrast, my paper utilizes the dynamics of pay-for-performance sensitivity to perform within-fund estimations. I also utilize exogenous variation in pay-for-performance sensitivity generated by public market movements to confirm the robustness of my findings.

Second, my findings have implications for the more general question of how variation in pay-for-performance sensitivity in compensation to managers relates to performance. This is a question that has received considerable attention in the CEO literature, though it is difficult to establish any causal relationship (e.g. Edmans et al., 2017). Many problematic features when studying CEO pay relate to the fact that setting compensation is an ongoing process. The manager may influence the process (Bebchuk et al., 2002), engage in ex post renegotiating which makes ex ante incentives unclear (Brenner et al., 2000), time the delivery of news (Aboody and Kasznik, 2000; Yermack, 1997), and compensation may be set in a way which exploits managerial optimism and overconfidence (Humphery-Jenner et al., 2016; Otto, 2014). By contrast, in private equity funds, contract terms are fixed at inception, which implies that many of these issues are not relevant. A similar argument is made by Agarwal et al. (2009) in their study of hedge fund compensation. They provide evidence that cross-sectional variation in pay-for-performance sensitivity among hedge funds is positively related to fund performance. Similarly to Hüther et al. (2020) and Robinson and Sensoy (2013), their results may reflect variation in managerial ability that influences contract terms. Thus, to the extent that my empirical approach is convincing, these results are relevant beyond the private equity field.

Third, by linking the pay-for-performance sensitivity to operational improvements at the portfolio company I add to our understanding of when private equity firms contribute to value creation in portfolio companies. However, this focus is one of the major limitations of the study. GPs' pay for performance is linked to fund returns, and improving operations of portfolio companies is not the only way in which profits can be generated. While deal-level cash flow data was not widely available when this study

was undertaken, Brown et al. (2020) provide a first look at a dataset that Burgiss is assembling, containing deal-level data. This suggest an avenue for improving the study of this paper by using deal-level performance data.

Another limitation of the study is its focus on the direct component of pay for performance. As shown by Chung et al. (2012), the indirect component is at least as large in magnitude. While I exploit variation in the relative importance of the direct versus the indirect component to strengthen the interpretation of my results, I do not measure it directly. As Chung et al. (2012) note, private equity appears ideally suited for such an endeavour, as the repeated fundraising allows a quantification of the indirect component of pay, something that is difficult in other settings. An interesting avenue for future research is to jointly consider the role of direct and indirect pay for performance on performance. It is likely that one can disentangle these effects in private equity, as hurdle rates are fixed numbers while fundraising success is likely about performance relative to peers.

The third paper, *Managerial Ownership and Operational Improvements in Buyouts*, investigates the relevance of CEO ownership stakes for operational improvements of companies acquired in buyouts. I manually collect data on managerial ownership stakes pre- and post-buyout from ownership filings, required to be submitted annually by all companies in the UK. This data is combined with the portfolio company financials assembled for the second paper of the dissertation.

I find that post-buyout CEO equity ownership stakes are positively associated with profitability improvements. The results are stronger when the ownership stake increases, and are driven entirely by the subsample in which the CEO is retained. This paper contributes to our understanding of the impact of private equity ownership on portfolio companies in multiple ways.

First, while many studies document the impact of private equity ownership on various aspects of the operations of portfolio companies (e.g. Antoni et al., 2019; Bernstein and Sheen, 2016; Boucly et al., 2011; Davis et al., 2014), we know relatively little about how these changes come about. There is evidence that private equity can support growth by relaxing credit constraints and injecting capital (e.g. Bernstein et al., 2019; Boucly et al., 2011; Cohn et al., 2020), and two recent papers offer insights into what GPs say they do. Biesinger et al. (2020) examine value creation plans prepared for individual deals. They document a significant heterogeneity in strategies, but find that ex ante selection of strategy is not related to deal returns. Instead they document that, somewhat less surprisingly, returns are high in deals in which the GP claims they successfully executed their strategies. Gompers et al. (2016) survey GPs and ask what they believe generate value in their deals. The top three expected sources of value creation are "increase revenue

or improve demand", "improve incentives", and "follow-on acquisitions". Clearly, these sources are not mutually exclusive as, for example, follow-on acquisitions increase revenue.

My paper contributes to this literature by focusing on a salient change induced by buyouts: the change in CEO ownership stakes. By relating changes in CEO ownership stakes to subsequent operational improvements, I partially open up the black box of value creation. If we interpret changes in a CEO's ownership stake as changing incentives to the CEO, the paper validates the belief of GPs documented in Gompers et al. (2016) that improved incentives matter for value creation. The results are consistent with an effect of incentives, especially as improved profitability is primarily found in companies with a retained CEO that experiences an increase in the ownership stake. However, most of the results are also consistent with an explanation of a CEO with private information that bargain for higher shares. As the paper does not offer any evidence from exogenous variation in ownership stakes, the findings should be cautiously interpreted.

Second, private equity firms have been viewed as strong principals, whose actions can inform us of optimal governance policies (e.g. Cornelli and Karakas, 2015; Cronqvist and Fahlenbrach, 2013; Kaplan and Strömberg, 2003). However, these papers typically do not link variation in the changes made by private equity firms to subsequent improvements in operational performance. Presumably, not all companies acquired in buyouts require the same amount of change to approach optimality, as is the case for perks in Edgerton (2012). My paper contributes to this literature by focusing on a specific action — changes in CEO ownership stakes — and examining how variation in this action relates to subsequent improvements in operational performance. A drawback of this focus is that I do not account for the full range of changes implemented by private equity firms. It cannot be ruled out that changes in CEOs' ownership stakes are related to other, unobserved, changes implemented, which in turn drive the performance. However, an alternative explanation would have to be able to explain why this is only the case in the subsample where the CEO is retained, and not when the CEO is replaced.

Finally, to the extent that buyouts are seen as a shock to the ownership stake held by a CEO, the paper contributes to the wider question of how pay for performance of CEOs relates to company performance. As noted above, it is unlikely that CEOs have no bargaining power, so one should be careful in interpreting these results. Still, the results provide evidence of the impact of a shock to ownership stake, and future research may be able to exploit the private equity setting to generate exogenous variation in the ownership stake awarded.

Three limitations of the study are worth discussing, as they provide an avenue for future research. First, the CEO ownership stake is measured as the fraction of ordinary shares held. However, due to the often significant amount of leverage imposed by private

equity, the position is akin to a barrier option. Higher performance not only leads to higher payoffs, but also lowers the risk that the equity position is wiped out. Consequently, the capital structure matters for the pay-for-performance sensitivity. Second, an additional component of pay for performance is the likelihood of being fired. While Cornelli and Karakas (2015) document that CEO turnover becomes less contingent on performance, it is an important aspect that is omitted from the analysis. The omission is to allow an ex ante measure, whereas a firing decision is an endogenous choice. Still, the analysis could be improved by including an ex ante estimation of the risk of being fired due to low performance. Third, CEOs typically cash out in a buyout, even as their ownership stakes increase (Kaplan and Stein, 1993; Cronqvist and Fahlenbrach, 2013). It clearly matters whether ownership stakes increase because CEOs invest a large fraction of their wealth, or due to an active capital structure choice made by the private equity firm to generate high-powered incentives. Improving on these limitations will further our understanding of the role that managerial incentives play in improving operations of portfolio companies in private equity.

Taken together, these three studies contribute to the growing body of work on private equity investments and the impact of private equity ownership on companies acquired in buyouts. Hopefully, they will open the door to further research on these topics.

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