The Risk Appetite of Private Equity Sponsors

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Abstract

Using a unique proprietary data set of 460 realized buyouts completed between 1990 and 2005, we examine the risk appetite of private equity (PE) sponsors in different states of the PE market and analyse key determinants of deal-level equity risk. We develop a new approach to mathematically model PE investment equity risk based on the Black-Cox default model. We find higher equity volatilities during boom periods. Further, deals conducted by more reputed PE sponsors have lower equity volatilities as they are unwilling to imperil their reputation by taking excessive risks. In addition, we find that PE sponsors' risk appetite is negatively related to the ownership stake in the buyout target company.

Keywords: Risk Appetite, Equity Volatility, Private Equity

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1. Introduction

This study has two major goals. Firstly, we want to introduce a mathematical model that allows for computing transaction-level risk in private equity (PE) buyout investments.[1] Secondly, we want to empirically investigate the patterns of PE sponsors' risk appetite over time and identify key determinants of deal-level risks chosen.

In recent years, empirical research on PE investments has focused to a large extent on returns and its drivers on fund (see, e.g., Kaplan and Schoar, 2005) and investment level (see, e.g., Nikoskelainen and Wright, 2007; Acharya et al., 2010; Achleitner et al., 2010; Guo et al., 2011). Consequently, with regard to understanding PE as an asset class and the drivers of deal returns, considerable progress has been made. Stylized facts include:

1. PE funds do not significantly outperform public benchmarks; some results even indicate that PE is an underperforming asset class (Kaplan and Schoar, 2005; Phalippou and Zollo, 2005).
2. However, funds managed by more experienced PE sponsors persistently generate excess returns and outperform public and private benchmarks, thus explaining why PE is still an attractive asset class for some investors despite the relatively poor performance of the industry overall (Kaplan and Schoar, 2005).
3. Successful PE sponsors mainly use three different instruments to generate high returns (see, e.g., Kaplan and Strömberg, 2009; Guo et al., 2011; Achleitner et al., 2010): (1) Governance improvements through a combination of the disciplining effect of debt in dealing with agency problems (Jensen, 1989), management incentives, and active monitoring through board control. (2) Operational engineering, i.e. provision of operational and

[1] In this paper we use the term private equity as a synonym for (leveraged) buyout investments, excluding venture capital.

industry expertise. (3) Financial engineering, i.e. increased tax shields and use of the leverage effect.

This research shows that the returns yielded by PE investments come along with considerable risks and that only few PE sponsors are able to consistently cope with these risks in order to generate persistent returns. The high levels of leverage in buyouts - one of the main reasons for these high risks - particularly has recently received considerable attention (see, e.g., Nikoskelainen and Wright, 2007; Acharya et al., 2010; Axelson et al., 2010). In this context, Axelson et al. (2009) have proposed the convincing theoretical argument that the typical compensation structure of PE funds gives PE firms an incentive to undertake risky but unprofitable investments, i.e. with a negative net present value, if there is at least one possible state of nature with a positive outcome. The basic idea of this theory is that PE sponsors as general partners (GPs) only provide a small fraction of the funds they invest in companies, but participate in the success of transactions through their compensation scheme. In contrast, their downside risk, in case of failure, is limited and mainly borne by the investors into their fund, the so-called limited partners (LPs). This situation resembles a call option for the PE sponsor as it faces a strong upside potential if the investment turns out to be successful, but the lion's share of downside risk is borne by their investors. This problem of potential over-investment can be mitigated by the use of external leverage in financing buyout transactions as banks will be hesitant to provide debt for unprofitable deals that PE firms might otherwise undertake.

While our approach is not limited to issues of leverage, this theory as general framework provides at least two predictions that are relevant to the central goals of our study. First, Axelson et al. (2009) have argued that during periods in which external debt providers perceive investment opportunities to be favourable, over-investment will be more likely. If they are right with their theory, we should find that the risk appetite of PE sponsors is higher during PE boom periods, i.e. times characterized by a favourable credit market environment. Second, the agency problem in the option-like situation could also be mitigated by alternative mechanisms. Diamond (1989) has theoretically shown that the creditor's reputation is an important factor in debt markets. This theory states that reputation is an asset which reduces the creditor's incentives to engage in risk shifting. If this is correct we should observe in our cross-sectional analyses of deal-level risks that more highly reputed PE sponsors should exhibit a reduced risk appetite as failure would threaten their reputation (Axelson et al., 2009).

Overall, we consider risks associated with PE investments of extraordinary importance toward any understanding of the business. In this regard, we see two major challenges for researchers in the field that we would like to address in this study.

The first major challenge is of a conceptual nature and relates to which is the appropriate model to use to measure the risk of PE transactions on investment level. This problem arises from the illiquidity and opaqueness of the PE business (see, e.g., Ljungqvist and Richardson, 2003). Market valuations of enterprise and equity values can hardly be observed or appropriately calculated over the holding period of the PE sponsor, i.e. the time span between purchasing and selling the target company. However, the (observable) fluctuation in a value is fundamental to the calculation of risk, e.g. the standard deviation, of any asset. Consequently, calculating risk indicators for PE-sponsored companies is considerably more difficult compared to publicly listed, and therefore continuously or at least frequently valued, companies.

So far, we have not found a satisfactory solution for this conceptual challenge. Previous studies often focus on systematic risks excluding unsystematic risk factors (see, e.g., Franzoni et al., 2009; Groh and Gottschalg, 2009). However, both risk components are obviously inherent in single PE investments as it is often impossible to fully diversify PE funds that often embrace no more than 20 investments. For example, Lossen (2006) reports an average number of portfolio companies per buyout fund of 15.5. On the other side, one could argue that only systematic risk matters as investors in PE do not hold only one PE fund, but many such funds. In addition, typical investors in PE funds only commit a small part of their overall wealth into PE. However, in order to fully understand risks and their determinants in individual PE transactions it is essential to include systematic as well as idiosyncratic risks. This is in line with Müller (2010) who provides evidence that idiosyncratic risk matters when explaining equity returns for owners of private companies. Similarly, Jones and Rhodes-Kropf (2003) find that idiosyncratic risk is correlated with net fund returns.

Other studies focus on venture capital (VC) investments (see, e.g., Cochrane, 2005). However, we consider a distinction between VC and buyout investments to be inevitable given the special set-up of leveraged buyouts (LBOs). For example, the relatively high leverage ratios and the related effects on the corporate governance of a buyout target in the sense of Jensen (1989) are only prevalent in buyout transactions. This makes the risk profile of these transactions considerably different compared to VC investments. In this context, banks play a very important role in LBO transactions as they provide a significant part of the required capital to finance a buyout transaction. This is completely different to VC investments where the role of debt financing is mostly negligible.

Methodologically, a common procedure is to match buyout transactions with comparable (i.e. of similar risk) public benchmarks, either on the transaction level (see, e.g., Groh and Gottschalg, 2009; Acharya et al., 2010) or on the fund level (see, e.g., Kaplan and Schoar, 2005). However, given the structural differences between publicly listed and PE-backed companies (e.g. in terms of size, ownership structure, governance mechanisms, management incentive schemes, leverage ratios) this approach seems suboptimal, even if it is possible to account for some of these differences.[2]

[2]For example, Acharya et al. (2010) account for different leverage ratios by calculating unlevered returns.

One of the rare studies explicitly dealing with risk associated with buyout investments including unsystematic risks is Groh et al. (2008). The authors introduce a contingent claims analysis model based on Ho and Singer (1984) that allows them to compute asset and equity value volatility. While that paper represents an important conceptual contribution, we think that the underlying model is overly simplistic and does not incorporate central characteristics of the PE business model. Our main concern is that the model is discrete and only allows for debt redemption and interest payments as well as default at two points in time during the holding period of the PE sponsor.

In this paper, we capitalize on the basic idea of Groh et al. (2008) and present a new model for pricing equity and debt of buyouts on the firm level. We think this model is more adequate in this context as it allows for continuous default and redemption payments during the holding period and because such a continuous model displays real PE transactions to a superior degree. Based on the Black-Cox default model (Black and Cox, 1976), we develop a new approach to calculate deal-specific implied asset and equity risk. These risks represent the ex-ante assumptions, i.e. at investment entry, of the PE sponsor regarding the expected volatility of the company/enterprise value (asset risk) and equity value (equity risk). The latter represents the risk appetite of a PE sponsor since it can be interpreted as the intentionally chosen risk level from the perspective of the PE sponsor, given a certain willingness of banks to provide leverage.

We are aware that one major assumption which underlies our risk measure and which we have had to make to allow for the use of standard deviation, is that returns are normally distributed and that this assumption is questionable in the context of PE returns. However, Eling and Schuhmacher (2005) and Eling and Schuhmacher (2007) show that for hedge funds the use of different risk-adjusted performance measures (with changing assumptions with regard to the underlying return distribution) does not change the ranking between different hedge funds. This even holds true if significant deviations in hedge fund returns from a normal distribution exist. We think that these arguments are also applicable to the PE business as both asset classes share common factors with regard to (the distribution of) returns (e.g. illquidity, opaqueness of asset classes and positive skewness of returns). Consequently, we are confident that the risk measures we introduce are serviceable in assessing risks associated with PE investments.

The second major challenge involved in research on risks in PE investments is to get access to appropriate data sets. The limited availability of reliable data on PE deals has been repeatedly discussed in recent literature (see, e.g., Nikoskelainen and Wright, 2007; Metrick and Yasuda, 2010). For example, in the only study somewhat comparable to ours, the mathematical model of Groh et al. (2008) is empirically applied using a small (40 transactions) and obviously biased sample.[3] In general, empirically reliable evidence on the PE industry, in particular at deal level, is still relatively scarce.

In order to overcome this second major challenge and to shed light on risks associated with PE sponsored buyouts and their relation to returns, we construct a proprietary dataset. We obtain detailed information about the financial structure of buyout transactions and the corresponding cash flows between the buyout companies and their PE sponsors gross of any fees or payments. We end up with a final sample of 460 transactions from North America as well as Western Europe which were acquired between 1990 and 2005. Unlike most previous studies, we do not rely on information about buyouts of public companies but also observe more common private buyout transactions.

In considering our sample of international transactions covering different market cycles of the PE industry as an interesting setting for longer temporal analyses, we provide a description of equity volatilities, asset volatilities and default probabilities within the relevant market cycles of the PE markets introduced by

[3]The authors themselves confine the explanatory power of their empirical analysis with the following statement: „As it is not the purpose of this paper to calculate idiosyncratic risks of historic transactions, but to propose an approach for benchmarking current and future ones (in which appropriate interest rates can be considered), our simplification seems acceptable.“

Strömberg (2008), i.e. the boom periods between 1995-1999 and 2003-2005, as well as the relative bust periods between 1990-1994 and 2000-2002. We find high equity volatilities in the periods from 1995 to 1999 and 2003 to 2005 accompanying higher probabilities of default. In line with the theoretical predictions of Axelson et al. (2009), we argue that this has been induced by increasing availability of debt and decreasing costs of debt resulting in increasing deal activity and higher leverage levels. Looking at it in detail, there are two potential explanations for this observation. First, PE sponsors may simply be using the improved availability of debt (independent from the costs of debt) which is suggested by their asymmetric risk profile, even at the expense of LPs. This would imply a rather negative view on the use of debt in boom periods and indicate a severe agency conflict between GPs and LPs. Second, our findings could also mean that if more debt is available and costs of debt are not priced adequately, PE sponsors use more inadequately priced debt since the costs for higher probabilities of default are not reflected in the interest rates. This could also be beneficial for the LPs and consequently represents a rather positive view of the use of debt during boom periods.

After investigating the temporal patterns of PE sponsors' risk appetite during boom and bust periods, we intend to shed some light on these issues by addressing the determinants of cross-sectional variation in transaction-level equity risks. We also want to identify relevant buyout company and PE sponsor characteristics, and to find out whether PE market environment patterns found before are robust for the inclusion of several control variables. Indeed, our regressions support the findings from our time series analysis. In addition, deals entered during times of high volatility in public equity markets (representing a high uncertainty with regard to future economic development) exhibit lower equity risks. This implies that the risk appetite of investors in both public and private equity markets is at least partially influenced by similar factors. We also find that larger buyout targets are subject to less equity risk. This finding suggests that PE sponsors do not offset the equity risk-reducing effect of larger firms' lower asset risk by excessive leverage. We continue by showing that an increasing risk exposure of PE sponsors, in terms of the share of ownership they acquire, goes along with decreasing risk appetite. This fits into the view of Axelson et al. (2009) as participation in downside risks (irrespective of leverage) generally increases with the ownership stake. Furthermore, we find that more experienced, higher reputed PE sponsors exhibit less risk appetite. Again, this is convincing evidence supporting the prediction of Axelson et al. (2009) that reputational assets of PE sponsors can mitigate the risk shifting problem. Overall, these findings suggest that some PE sponsors use excessive debt, also at the expense of LPs, and that certain mechanisms (e.g. ownership stake and reputation) help to align the interests between GP and LP.

Our findings are related to the PE literature in several regards. We contribute to the discourse on deal-level risks associated with PE investing (see, e.g., Cochrane, 2005; Axelson et al., 2010). While other studies do not focus exclusively on buyout investments or only concentrate on leverage (which is only one part of equity risk), we take a more general stance and calculate total equity risk, determined by both the leverage ratio as well as the asset volatility of the buyout target company. Further, we contribute to the current discussion on agency conflicts between GP and LPs (see, e.g., Axelson et al., 2009) and provide evidence that PE sponsors with a strongly pronounced risk appetite do not act in the interest of the LPs.

The remainder of the paper is organized as follows: In Section 2 we mathematically develop our model and provide an intuitive interpretation. Section 3 describes the data set and reports descriptive statistics of the sample. Section 4 provides empirical results for cross-sectional drivers of equity risk. Section 5 summarizes our findings and concludes.

2. The Model

This section presents a new model for pricing equity and debt of buyouts on transaction (firm) level. With the help of this model, the main idea is to calculate an implied volatility, using deal-specific information concerning time horizon, debt and equity prices, average recovery rates, as well as quoted riskless rates and bond spreads.

Following the seminal papers of Black and Scholes (1973) and Merton (1974), the company's equity is seen as a call option on its total value, with its total debt corresponding to the strike price. This accounts for the intuitive fact that a company is forfeited to the debt holders as soon as its equity falls below its total debt. This option-like valuation for highly leveraged firms is also empirically supported (see, e.g., Arzac, 1996; Green, 1984).

The Merton model, assuming constant debt and allowing for no default during the lifetime of the transaction, is, however, too simplistic a model for buyouts. Buyouts are characterized by substantial debt redemptions after the transaction entry and a continuous default risk (see, e.g., Groh et al., 2008). There are several extensions that allow for more realistic assumptions. First, Black and Scholes (1973), Geske (1979) as well as Brockman and Turtle (2003) see equity as a (path-dependent) option that allows for continuous default. However, these models either assume constant debt or neglect the fact that debt usually does not decrease to zero at the end of the investment horizon.

Second, Ho and Singer (1984) present a two-step extension that allows for two redemption payments during the lifetime of the PE transaction. Groh et al. (2008) apply this model to price LBOs. This underlying assumption of only two payments during the holding period is, however, unrealistic.

The idea of this paper is to combine these two extensions to gain a more realistic model for pricing equity and debt of buyouts. First, we follow Ho and Singer (1984) and use the following assumptions for a firm value model:

1. The firm's capital structure consists of a single equity and a single debt layer.
2. The yield curve is flat and non-stochastic.
3. Until the maturity of the debt, the firm's investment decisions are known.
4. The firm does not pay dividends and does not make any other contributions to shareholders.
5. Amortization payments are fixed in the indentures.
6. Amortization payments are financed with new equity.
7. Default occurs when the firm (enterprise) value $V(t)$ falls below the face value of debt $D(t)$, $0 \leq t \leq T$. In this case, the debt holders have the right to take control of the firm and the shareholders need to forfeit the buyout company's assets to the lenders without cost.

While it is mathematically possible to relax most of the given assumptions, the limited availability and level of detail of PE data makes it practically difficult to calibrate more complicated models with many parameters. For this reason we stay at this level of simplification and present the mathematical framework in the next section.

2.1. Mathematical Description

The firm's assets $V(t)$, $0 \leq t \leq T$ are modeled as a Geometric Brownian motion (GBM) with drift μ_V and volatility σ_V:

$$dV(t) = V(t)(\mu_V dt + \sigma_V dW_t), \; V(0) > 0, \tag{1}$$

where W_t is a standard Brownian motion.

The face value of debt $D(t)$ bears continuous interest at a rate of c. The debt holders receive a continuous rate λ that consists of (part of) the interest payments plus a potential amortization payment. Both c and λ are assumed to be constant over time. Thus, the face value of debt at time t is given by

$$D(t) = D(0)\ e^{(c-\lambda)t}. \tag{2}$$

The company defaults when the firm's assets $V(t)$ fall below the face value of debt $D(t)$ (see Assumption (7)). The time to default is the so-called first-passage time τ defined as

$$\tau := \inf\{t : V(t) \leq D(t)\}. \tag{3}$$

Figure 1 displays the two possible outcomes of a sample PE transaction.[4] While on the left-hand side, the company value (*grey line*) stays above the face value of debt (*black line*) until maturity T, the grey path on the right-hand side hits the face value of debt and the company defaults. The default time is the first-passage time τ defined in Equation (3).

— *Insert Figure 1 about here* —

As already mentioned, the debt holders receive the redemption payments of the continuous rate λ until the company either defaults or matures in T. Apart from those redemption payments, the debt holders demand the remaining debt as soon as the transaction is terminated. If the company defaults, they receive $D(\tau)$ times a recovery rate $0 \leq \delta \leq 1$ at time τ, or else the remaining debt $D(T)$ in T. Figure 2 displays the payments to the debt holders for the two possible cases of no default (*left*) and default (*right*) using the same sample transaction as in Figure 1.

— *Insert Figure 2 about here* —

A well-known result by Black and Scholes (1973) is the continuous barrier-hitting probability in the presented continuous setting. Lemma 1.1 summarizes

[4] We randomly picked one transaction from our data set.

the main findings.

Lemma 1.1 (Barrier hitting probability GBM). *Let $V(t)$ denote a Geometric Brownian motion (GBM) over $[0,T]$ as defined in Equation 1, starting at $V(0) > D(0)$. The barrier level is $D(t) = D(0)\ e^{(c-\lambda)t}$, $d = \ln(D(0)/V(0))$ is the initial leverage ratio and r the riskless interest rate. The survival probability*

$$\mathbb{Q}(\tau > T) = \mathbb{Q}(V(t) > D(t), \forall t \in [0,T]),$$

abbreviated by $\Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T)$, simplifies to

$$\Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T) := \Phi\left(\frac{-d + \mu_{V^*}T}{\sigma_V\sqrt{T}}\right) - e^{\frac{2\mu_{V^*}d}{\sigma_V^2}}\ \Phi\left(\frac{d + \mu_{V^*}T}{\sigma_V\sqrt{T}}\right), \tag{4}$$

where $\mu_{V^*} := r - c + \lambda - \frac{1}{2}\sigma_V^2$ and $\Phi(\cdot)$ denotes the standard normal cumulative distribution function and $\ln(\cdot)$ the natural logarithm.

Proof: If $V(t)$ is a Geometric Brownian motion with drift μ_V and volatility σ_V, then, according to It$\hat{o}$'s lemma, $\ln(V(t)/D(t))$ is a Brownian motion with drift μ_{V^*} and volatility σ_V. The corresponding result for Brownian motion is given in, e.g., Musiela and Rutkowski (2004), p. 61, Lemma 3.2. □

If we continuously test for default, the total value of debt $V_D(0)$ can be priced using the results on structural credit risk models. For an introduction and more details on those models see, e.g., Scherer and Zagst (2010). $V_D(0)$ is seen as a coupon bond with initial face value $D(0)$ and continuous payments $\lambda D(t)dt$.

Then[5],

$$V_D(0) = \left[\int_0^T e^{-rt}\lambda D(t)dt + e^{-rT}D(T)\right] \mathbb{Q}(\tau > T) + \int_0^T \left[\int_0^s e^{-rt}\lambda D(t)dt + \delta e^{-rs}D(s)\right] d\mathbb{Q}(\tau \leq s), \qquad (5)$$

where $d\mathbb{Q}(\tau \leq s)$ is the density of the first-passage time distribution (see Lemma 1.1). Equation (5) implies that default can occur at any time during the holding period $[0,T]$. As soon as the firm's assets $V(t)$ are less than the face value of debt $D(t)$, the equity holders forfeit their company. Equation (5) consists of the survived (*first term*) and defaulted (*second term*) firm value paths. Those terms contain the discounted redemption payments $\int_0^{\min(\tau,T)} e^{-rt}\lambda D(t)dt$ plus the discounted remaining debt value at maturity $(e^{-rT}D(T))$ or at default $(\delta e^{-r\tau}D(\tau))$.

Theorem 1.2 gives an analytic expression for the bond in Equation (5).

Theorem 1.2 (Pricing the face value of debt). *The total value of debt $V_D(0)$ can, under the risk-neutral measure $\mathbb{Q}$ with the riskless interest rate r, be priced as*

$$V_D(0) = -\,D(0)\,\frac{\lambda}{c-r-\lambda} + D(0)\,e^{(c-r-\lambda)T}\,\frac{c-r}{c-r-\lambda}\,\Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T) + D(0)\,e^{-\frac{d(\tilde{\mu}_{V^*}-\mu_{V^*})}{\sigma_V^2}}\left(\delta + \frac{\lambda}{c-r-\lambda}\right)(1-\Phi^{GBM}_{d,\tilde{\mu}_{V^*},\sigma_V}(T)), \qquad (6)$$

where the notation is the same as in Lemma 1.1, $\mu_{V^*} = r - c + \lambda - \frac{1}{2}\sigma_V^2$, $\tilde{\mu}_{V^*} = \sqrt{\mu_{V^*} + 2(c-r-\lambda)\sigma_V^2}$, $d = \ln(D(0)/V(0))$ and $\lambda \neq c - r$.

[5] $V_D(0)$ is the general formula for the market price of defaultable debt. Note that in the case of $\lambda > c$, the face value of debt decreases over time, while it increases for $\lambda < c$. Also note that the spread c is a par spread, i.e. at the closing of the transaction it is set such that $D(0) = V_D(0)$.

Proof: It holds that

$$\int_0^{\min(\tau,T)} e^{-rt}\lambda D(t)dt = D(0)\ \int_0^{\min(\tau,T)} e^{(c-r-\lambda)t}\lambda dt = D(0)\ \frac{\lambda}{c-r-\lambda}(e^{(c-r-\lambda)\min(\tau,T)}-1).$$

Equation (5) can then be rewritten as

$$\begin{aligned} V_D(0) =& \left[D(0)\ \frac{\lambda}{c-r-\lambda}(e^{(c-r-\lambda)T}-1)+e^{-rT}D(T)\right]\ \mathbb{Q}(\tau>T) \\ &+\int_0^T \left[D(0)\ \frac{\lambda}{c-r-\lambda}(e^{(c-r-\lambda)s}-1)+\delta e^{-rs}D(s)\right]\ d\mathbb{Q}(\tau\leq s) \\ =& -D(0)\ \frac{\lambda}{c-r-\lambda}+D(0)\ e^{(c-r-\lambda)T}\ \frac{c-r}{c-r-\lambda}\mathbb{Q}(\tau>T) \\ &+D(0)\left(\delta+\frac{\lambda}{c-r-\lambda}\right)\int_0^T e^{(c-r-\lambda)s}d\mathbb{Q}(\tau\leq s). \end{aligned}$$

The latter integral is solved in Scherer and Zagst (2010), Theorem 3.3.

$$\int_0^T e^{(c-r-\lambda)s}d\mathbb{Q}(\tau\leq s) = e^{-\frac{d(\tilde{\mu}_{V*}-\mu_{V*})}{\sigma_V^2}}\ (1-\Phi^{GBM}_{d,\tilde{\mu}_{V*},\sigma_V}(T)),$$

with the notation of Lemma 1.1, $\mu_{V^*}=r-c+\lambda-\frac{1}{2}\sigma_V^2$, and $\tilde{\mu}_{V^*}=\sqrt{\mu_{V^*}^2+2(c-r-\lambda)\sigma_V^2}$. Then,

$$\begin{aligned} V_D(0) =& -D(0)\ \frac{\lambda}{c-r-\lambda}+D(0)\ e^{(c-r-\lambda)T}\ \frac{c-r}{c-r-\lambda}\ \Phi^{GBM}_{d,\mu_{V*},\sigma_V}(T) \\ &+D(0)\ e^{-\frac{d(\tilde{\mu}_{V*}-\mu_{V*})}{\sigma_V^2}}\ \left(\delta+\frac{\lambda}{c-r-\lambda}\right)(1-\Phi^{GBM}_{d,\tilde{\mu}_{V*},\sigma_V}(T)). \end{aligned} \qquad \square$$

Theorem 1.2 can be applied to obtain an implied asset volatility σ_V using data on d, T, r, λ, and δ. This can for example be achieved using Brent's algorithm (see, e.g., Brent, 1973).

The following results in Theorem 1.3 can then be used to retrieve an equity volatility σ_E from the asset volatility σ_V. The proof is an application of Itô's Lemma and can be found in, e.g., Schönbucher (2003), p. 276.

Theorem 1.3 (Equity volatility). *With the notation of Lemma 1.1, it holds that*

$$\sigma_E = \sigma_V \, \frac{\partial V_E(0)}{\partial V(0)} \, \frac{V(0)}{V_E(0)}, \tag{7}$$

where $V_E(0)$ denotes the initial equity value of the firm.[6]

Using the results of this section, we are able to calculate deal-specific asset and equity volatilities. The application to a large PE data set is shown in Sections 3 and 4.

2.2. Intuitive Explanation

Before empirically applying this model, we first provide an intuitive interpretation in order to outline the rationale behind the mathematical model and its application in the PE context. The basic sequence of actions is as follows:

1. The parties arranging a buyout transaction (incl. the seller of a company, PE sponsor and banks) make assumptions about the future development, especially future cash flows, of the buyout target and conduct different scenario analyses. These forecasts are based on various assumptions and conditions (e.g. expected holding period of the PE sponsor, revenue development of the company, etc.). Since a PE transaction implies a total recapitalization of the company, they do not consider the existing capital structure of the buyout company.
2. As a result, the parties agree on a certain enterprise value [$V(0)$]. This price to be paid is partly financed with debt [$D(0)$] at cost [c]. The remaining sum (delta of enterprise value and debt value) is covered with equity from the PE sponsor's fund [$E(0)$][7]. The parties' assumptions about future developments

[6] The calculation of $\partial V_E(0)/\partial V(0)$ is shown in the Appendix.

[7] Note that we assume that the market value of equity $V_E(0)$ equals the value of the equities $E(0)$ paid by the PE sponsor's fund.

determine the price paid and the transaction structure that is imposed. The final capital structure is supposed to secure the desired return on equity for the PE sponsors on the one hand, but at the same time the company must be capable of servicing the debt providers' requirements regarding redemption and debt covenants. In other words, PE sponsors intend to increase leverage (as it increases expected equity return) as much as possible given that debt providers' requirements can be met.

3. Consequently, the involved parties implicitly assume certain volatilities in the target company's asset (σ_V) and equity (σ_E) values when they agree on debt and equity prices. This implies that a company with relatively low inherent (unlevered) asset volatility, e.g. a company in a stable industry, is less likely to default in terms of debt payments and is therefore more highly levered.

4. The deal-specific equity risk calculated by our model reflects the equity risk borne by a PE sponsor. Since the equity risk is mainly determined by the buyout target's asset volatility and its specific financing structure, i.e. debt to equity ratio, it can also be interpreted as the risk appetite of a PE sponsor. However, it is reasonable to assume that banks might (at least sometimes) restrict the maximum accepted debt level. Consequently, PE sponsors are not always able to use the desired financing structure fully corresponding to their risk appetite.

3. Data description

3.1. Data Sources and Sample Selection

Our initial sample of 1,290 buyout transactions initiated between 1990 and 2005 is drawn from proprietary databases of two international PE funds-of-funds. When considering investing into a PE fund, these investors request detailed information on historical transactions managed by the PE sponsor. This information is a key element of their fund due diligence process. The PE funds-of-funds grant us access to all information they possess (in anonymous form), irrespective of their final investment decision. This means we have information on deals sponsored by a variety of PE firms and the investment pattern exhibited by the PE funds-of-funds is not a source of sample selection. Nevertheless, as these investors are more likely to engage in due diligence processes with previously successful PE sponsors, there is likely to be a bias in our sample towards deals from more successful funds.

While all of the buyouts included in our initial sample have been realized, i.e. the PE sponsor has already sold the company, a substantial share of these transactions does not meet the data requirements as imposed by our mathematical model. We remove all buyouts with missing values for variables which are relevant for our model (581 transactions). Because we do not consider "quick flips", i.e. short-termed investments in which PE sponsors do not aim at realizing the actual value potential of the buyout firms, to be PE (Kaplan and Strömberg, 2009), we also delete all transactions for which the reported holding period, i.e. the time span between acquisition and exit, is six months or shorter (11 transactions). Finally, for some transactions the final debt levels reported in the databases exceed the compounded initial debt. In these cases, the companies were apparently financed with further external capital within the holding period. As our model does not allow for such additional financing rounds (if not anticipated at investment entry) we discard these 168 deals. In addition, we have to remove 70 deals for which certain deal-related data is not available (e.g. industry affiliation of the target company, PE sponsor characteristics etc.), ending up with 460 buyouts.

We identify the 5-Year US Treasury Notes at the date of transaction as proxy for the riskless interest rate [r]. We decide to use this maturity as it is closest to the holding periods said to be characteristic for buyouts (e.g. six years as reported by Strömberg, 2008) and similar to those observed in our sample. The default spread consists of an interbank rate and a deal-specific spread. In order to obtain information on these loan characteristics, we use Reuters' LPC

DealScan database (DealScan).[8] DealScan reports comprehensive information on syndicated loan deals sponsored by PE firms. We were able to match 95 of our total 460 transactions in the final sample. For these deals DealScan provided information on the interbank rate underlying the loans and the size and spread of each debt tranche. The spreads were all based on the London Interbank Offered Rate (LIBOR) or the Euro Interbank Offered Rate (EURIBOR). Historical data is publicly available for both rates and we retrieved them from the European Central Bank.[9] We calculate the corresponding historical offered rate for each of the 95 matched deals in our sample by using the geometric mean of all monthly interbank rates during the holding period of the transaction. Further, we compute the tranche size-weighted average spread for each matched deal. By adding up the interbank base rate and the weighted total spread for each of the matched deals we obtained the total cost of debt [c].

We fill the missing values of the default spread for the other 365 deals we were unable to find in DealScan by imputation. Imputation is a procedure which has been shown to be superior to ad-hoc filling of missing data in finance research (Kofman and Sharpe, 2003) and is common among other researchers in the field (see, e.g., Bernstein et al., 2010). We impute missing default spreads by constructing fitted values from a regression of default spreads on deal size, the ratio of net debt to equity, the ratio of net debt to EBITDA, the yield spread on corporate bonds (Moodys BAA bond index) on the risk-free rate over time, a dummy variable distinguishing European and North American deals, and industry variables.

Further, since our model allows for default during the holding period of the PE sponsor we have to make assumptions about the debt recovery rate [δ] in case of default. In line with Wilson et al. (2010) we assume a recovery rate of 62%

[8] Data from DealScan was retrieved while Reiner Braun was a visiting researcher at Said Business School, Oxford University.

[9] http://sdw.ecb.europa.eu.

throughout the paper.[10] With regard to the calculation of Lambda [λ], i.e. the continuous rate the debt holders receive (including interest and debt redemption payments), we calibrate λ using the equation $D(T) = D(0)\ e^{(c-\lambda)t}$ and $D(0)$, $D(T)$ from our database. In other words, since all transactions used in our analyses are already realized we can resort to the actual value of debt at investment exit in order to make assumptions about [λ].

In addition, in order to calculate variables relating to the PE sponsor experience at the time of each transaction we use Thomson Venture Economics (TVE). First, we count the number of transactions the respective PE firm had historically sponsored before the deal at hand as reported in TVE. Second, we calculate the total assets under management of the PE sponsor accumulated in the five years before each transaction. Finally, in order to account for the volatility in public equity markets we use the MSCI website[11] to obtain data on the MSCI World index.

3.2. Sample Characteristics and Representativeness

Figure 3 provides descriptive statistics of our sample. While most studies dealing with data on buyout-level are either from Western Europe (including the UK) or North America (the US and Canada), our data set covers both regions which represent the lion's share (about 95%) of the global PE market in the years between 1990 and 2005 (Kaplan and Strömberg, 2009). However, our study is overweighting Western European buyouts as 77% of our transactions are from this region, while they accounted for only 42% of the total number of global transactions in the PE universe (Kaplan and Strömberg, 2009). This bias is due to the focus of due diligence activities of the funds-of-funds providing us with data.

— Insert Figure 3 about here —

[10] Wilson et al. (2010) report a recovery rate of 62-63% for secured debt of PE-backed firms which is more than twice the recovery rate of public companies.

[11] http://www.mscibarra.com.

The enterprise values at entry [$V(0)$], i.e. when the buyout company is acquired, in our final sample range from 0.9 to 8,800 million US dollars, with a mean of 239 million US dollars and a median of 78 million US dollars. These numbers are quite similar to those of the entire PE universe with a mean of 318 million US dollars and a median of 61 million US dollars as reported by Stromberg (2008) for the period between 1970 and 2007.

Our sample shows that the repayment of debt imposed at the time of acquisition is a key element of PE sponsors' business model. While the median equity value at entry [$E(0)$] is 30.5 million US dollars, it increases to 99.1 million US dollars at exit [$E(T)$]. Conversely, the median net debt value at entry [$D(0)$] is 48 million US dollars and decreases to 34.5 million US dollars at exit [$D(T)$]. This development becomes apparent in the drop of the net debt to equity ratio over the holding period [T] from 1.6 to 0.4.

The median deal-level equity internal rate of return (IRR) gross of carried interest and any management fees in our final sample is 33.5%. This median return is similar to comparable studies dealing with deal-level returns of buyouts (see, e.g., Lopez-de Silanes et al., 2009; Acharya et al., 2010). Again, the fact that the funds-of-funds granted us access to their entire databases irrespective of the investment decision largely precludes that there would be any positive bias in our sample.

In addition, Figure 3 presents descriptive statistics on the variables used in the regression analyses. The median PE sponsors' ownership stake in a buyout target is 61% at investment entry. It should be mentioned that our data set only includes explicit information on the ownership stake of the PE sponsor for 152 deals. For the residual 308 transactions we calculate the ownership stake by dividing the total capital invested by the PE sponsor by the total equity value at investment entry. Given that equity injections during the holding period (not related to the purchase price) are relatively uncommon in buyout transactions, this simplification seems acceptable (see, e.g., Nikoskelainen and Wright, 2007).

Looking at median values, a PE sponsors has already conducted 34 transactions at the time of investment entry as reported by TVE. In addition, according to TVE the median PE sponsor accumulated 681.8 million US dollars in assets under management in the five years before investment entry.

From Panel B of Figure 4 it can be derived that around 44% (203 out of 460) of our sample transactions occurred between 1995 and 1999, compared to 29% in the same period in the PE universe according to Stromberg (2008). While the relative shares of transactions in our sample are representative for the periods 1990-1994 and 2000-2002 the overweighting in the late 1990s is at the expense of more recent deals between 2003 and 2005. While these buyouts make up 20% in our sample they account for 38% of the deals in the period between 1990 and 2005 in Stromberg (2008).

Altogether, even though our final sample is more representative of the universe of buyouts in comparison to most previous research, our study still has a bias towards European deals and buyouts carried out in the late 1990s. However, as we will show in the cross-sectional analyses our main results are robust in controlling for region, size and time.

4. Equity Risk in Buyout Investments

In this section we analyze the risk appetite of PE sponsors reflected in deal-level equity volatilities. The first part deals with patterns of PE sponsors' risk appetite over time, i.e. in different cycles of the PE market. In the second part we report the results of cross-sectional analyses to assess the role of several drivers explaining equity volatility variation among PE transactions. We put a particular emphasis on factors related to the PE sponsor.

4.1. Time Trends

Figure 4 shows summary statistics on the equity volatilities, i.e. the standard deviations resulting from our model, over time in our dataset grouped by investment year (Panel A) and PE market cycles (Panel B) according to Strömberg (2008). These volatilities represent the annual implied equity volatilities for the individual transactions and are calculated with our mathematical model. The mean and median values in the entire final sample are 80% and 72% respectively. This is considerably higher than the average firm equity volatility of 51.3% p.a. and the median firm equity volatility of 43.6% p.a. reported by Choi and Richardson (2008) who calculate the implied equity volatility for over 150,000 public companies. However, given that in general PE-backed firms have higher leverage ratios (which, ceteris paribus, increases equity risk) this result is intuitive (see, e.g., Guo et al., 2011). This finding confirms the general feeling that PE deals are particularly risky, at least from the perspective of equity investors. In line with this argument, Cochrane (2005) reports an annualized standard deviation of equity returns of 89% for a sample of VC-backed firms. Taking into consideration that Cochrane (2005) analyses VC investments, which are thought to be even more risky than buyout transactions, this finding is intuitive.

Our equity risk numbers reflect the risk appetite of a PE sponsor in the sense that they are mainly determined by the buyout target's asset volatility and its specific financing structure. Both factors can be influenced by the PE sponsor. Even if one argues that the financing structure is mainly determined by the willingness of banks to provide debt, since the PE sponsor always takes as much debt as possible, it is still the choice of a PE sponsor to choose a company with a relatively high or low asset volatility. As Figure 4 shows banks do not always offset investments in companies with high asset volatilites by providing less debt, which would imply a constant equity risk for all deals. Significant rank sum tests indicate considerable fluctuations of equity risk levels over time. Overall, our results imply that it is reasonable to assume that the PE sponsor can significantly influence this process, especially during boom periods when banks have a relatively pronounced risk appetite.

— *Insert Figure 4 about here* —

In this context, Figure 5 shows the mean and median asset volatility and net debt to equity ratio grouped by the same PE market cycles as Figure 4. Interestingly, our mean and median asset volatility of 32% and 27% respectively is considerably lower than the mean and median asset volatility of 40% and 31% reported by Choi and Richardson (2008). This finding supports the assumption that appropriate buyout targets are companies with low inherent asset volatilities. However, given the relatively high equity risks of buyout transactions, PE sponsors obviously offset the low asset volatilities by deploying high leverage ratios. In this context Figure 5 also reveals another interesting observation. The relatively high mean asset risk of 38% for deals conducted in the 2003-2005 period is very close to the result by Choi and Richardson (2008) which indicates that during boom periods, which in general are accompanied by increasing fundraising activity, higher investment pressure might induce PE sponsors to invest in less appropriate companies, i.e. companies with more volatile cash flows and consequently higher asset risk. This could be due to the fact that elevated supply of capital meets a relatively inflexible demand, i.e. a somewhat given pool of appropriate buyout companies. This is an intuitive assumption as there are only a limited number of appropriate buyout companies, i.e. firms that produce stable and predictable cash flows allowing the forecasting of interest payment and debt repayment schemes over any given holding period (Opler and Titman, 1993). This finding is in line with the over-investment problem described by Axelson et al. (2009).

— *Insert Figure 5 about here* —

Another intuitive and interesting observation from Figure 4 are the high average equity volatilities in the periods from 1995 to 1999 and 2003 to 2005. The period after 1994 was a period with increasing deal activity after the burst of the first leverage buyout bubble around 1990 (Guo et al., 2011). Similarly, the period beginning after 2003 is considered to be a boom period in the PE market (see, e.g., Axelson et al., 2010) with increasing deal activity, decreasing costs of debt and, consequently, high leverage levels. This situation emerged out of the bust period between 2000 and 2002 after the bursting of the dot.-com bubble. This can be seen in a sharp decline of deals observed in our sample and the considerably lower equity risk compared to the late 1990s.[12] The patterns of risk appetite of PE sponsors shown in Panel B of Figure 4 are intuitively in line with the market cycles of the PE market.

We argue that these findings result from agency problems inherent in the PE business in combination with loose debt market conditions. PE funds are limited partnerships with the PE sponsor acting as the GP who manages the fund. Institutional or other investors are LPs and provide most of the capital. In turn, PE sponsors only provide a relatively small amount of the capital (typically about 1 percent) (Kaplan and Strömberg, 2009). PE sponsors as fund managers are (at least) compensated through management fees and a share of the profits of the fund (carried interest).

As described by Axelson et al. (2010) PE sponsors have an incentive to use as much leverage as possible for each transaction since they hold a call-option-like stake in the fund. Through the carried interest they disproportionatelly participate in the up-side potential of the fund, while being exposed to a limited downside risk only, which is mainly borne by the LPs as providers of most of the capital invested. In other words, the equity stakes in the PE sponsor's portfolio companies, which can be seen as call options on the firm values, increase in value

[12]The most recent period 2003-2005 contains relatively few deals considering that it is a boom period of the PE market. This is a direct result from our sampling requirement since we can only use realized deals for calculating equity risk. Hence, at the time the fund-of-fund investors obtained information on these deals, fewer deals entered in the most recent period were realized, even though deal activity was relatively high.

if the volatilities of the underlying assets, i.e. the volatility of the PE-backed firms, increase.

However, while this argumentation explains why PE sponsors generally prefer risky deals it does not sufficiently explain the increasing risk appetite from 2003 onwards. A closer look at the debt markets during this period could help to find another pattern of explanation. First, in times of favourable debt market conditions PE sponsors are simply able to use more debt to finance a transaction as banks probably demand a lower minimum equity stake from a PE sponsor. Given their asymmetric payoff profile they use as much debt as possible. Second, as Axelson et al. (2010) and Demiroglu and James (2010) show, the overall debt financing terms for PE sponsors improved considerably after 2003. If costs of debt are not priced adequately due to overheating debt markets it might be rational for any investor to use more inadequately priced debt since the costs for higher probabilities of default are not reflected in the interest rates. This means in the present context that equity volatility in PE market boom periods increases. Furthermore, in addition to the increased use of leverage, PE sponsors also invest in companies with higher asset volatilities as shown in Figure 5. Apparently, both factors explain the significant increase in equity risk.

Figure 6 shows that the increased risk appetite of PE sponsors during PE market boom periods also has a downside as default risk increases as well. The assumed ex-ante median probability that a PE company will default within the first year after the buyout increased from about 2% in 2000-2002 to more than 5% in 2003-2005. The average and median default rates for the whole sample are 4.3% and 3.5% respectively. This supports the notion of an incentive conflict between the PE sponsor on the one side and LPs as well as other stakeholders of the company, e.g. employees and creditors, on the other side, as PE sponsors, at least partially, try to shift risks from themselves to others.

With regard to the explanatory power of our model, a comparison with other studies delivers encouraging results. Given that the probability of default in our model is at a maximum in the first year after the PE sponsor acquired a company (due to high interest and redemption payments) this number is comparable to the average annual default rates of 1.2% and 2.8% per year in Stromberg (2008) and Jason (2010), respectively, neither of whom account for the fact that the probability of default is not equally distributed over the holding period.[13]

— Insert Figure 6 about here —

In Section 4.2 we will extend the explanatory power of our results by conducting multiple regression analyses using equity volatility as dependent variable.

4.2. Regression Analysis

In our analyses of drivers of deal-level risk appetite we focus on buyout company size, PE sponsor experience and equity risk exposure, public market volatility, and, finally, the PE market cycles introduced in Section 4.1.

To begin with, larger buyout companies are assumed to have a higher lending capacity as they are less risky (Nikoskelainen and Wright, 2007; Halpern et al., 2009) and less exposed to asymmetrical information (Chen, 1983; Chan et al., 1985). In addition, larger companies are assumed to be more diversified and consequently less exposed to industry shocks. According to this argument, we would expect larger companies to have lower asset volatilities, which, ceteris paribus, would result in lower equity volatilities. However, the lower asset risk of larger companies might be offset or even outweighed by more leverage deployed by the PE sponsor. If this holds, we would rather expect larger buyout companies to have higher equity volatilities. Since there are arguments in both directions it remains an empirical question. We address this question by including the logarithmized enterprise value of the buyout company at investment entry in our regressions.

[13] For example, our median default rate of 3.5% is not an annualized default rate over the holding period, but the probability that a firm defaults within the first year after the buyout. In year two, three, etc. the probability of default decreases.

Regarding PE sponsor characteristics, more experienced PE sponsors are thought to be more reputable (Gompers and Lerner, 2000; Kaplan and Schoar, 2005). As reputation can be an important competitive advantage, e.g. in terms of lending capacity (Demiroglu and James, 2010; Ivashina and Kovner, 2010), especially in the PE industry, more reputed PE sponsors would not risk their reputation by taking excessive risks (Diamond, 1989). Therefore, we expect a negative relation between PE sponsor reputation and equity risk. In order to assess this relationship we include the logarithmized number of previously completed deals by the respective PE sponsor at investment entry as proxy for PE sponsor reputation (Demiroglu and James, 2010). As the measures of PE sponsor experience are controversially discussed in the literature (e.g. Gompers and Lerner, 1999) we also use the logarithmized total assets under management of the PE sponsor accumulated in the five years before investment entry as proxy for PE sponsor experience (Gompers and Lerner, 1999; Kaplan and Schoar, 2005).

Another PE sponsor-related deal characteristic is its ownership stake in the company which can be interpreted as the equity risk exposure. While in a typical buyout transaction the PE sponsor purchases majority control (Kaplan and Strömberg, 2009), the ownership stake, and accordingly the equity risk exposure, varies. The intuition behind this is that if a PE sponsor owns a large part of the equity value, the willingness to take excessive risks might be reduced. This argument fits into the concept of equity stakes as call options on firm values (Axelson et al., 2009). If the PE sponsor provides a higher share of the enterprise's equity value the downside risk, ceteris paribus (in particular regarding leverage levels), increases. We expect a negative relation between PE sponsor ownership and equity risk. Accordingly, we include the total capital invested by the PE sponsor divided by the total equity value at investment entry in our regressions.

Apart from company- and PE sponsor-related characteristics, it is reasonable to assume that the conditions of public equity markets also have an influence on the chosen deal-level equity risk. Very volatile public equity markets may indicate a relatively high uncertainty with regard to future economic development which could lead to a reduced risk appetite among all participants in both public and private equity markets. In order to test for these more general market effects we assign the average volatility of the MSCI World Index in the last twelve months (LTM) before the entry date of a specific PE transaction to each deal. Considering that we have a regionally diverse sample of European and North American transactions, the MSCI World Index may be the best measure to account for worldwide market volatility and is consequently the best proxy for the level of uncertainty about future economic development. As a result, we expect a negative relationship between LTM public market volatility and deal-level equity risk.

In order to account for the effects of PE market cycles outlined in Section 4.1 we include time dummies to control for systematic time patterns in the buyout market. Again, we resort to the PE market cycle time categories introduced by Strömberg (2008) and described above.

Furthermore, there are some other standard factors we include in our analysis: First, to control for significant systematic differences between European and North American deals a dummy variable is used which adopts a value of 1 if the PE transaction took place in Europe and a value of 0 if the deal took place in North America. Second, we include eight ICB industry dummies to control for industry specific risks.

Figure 7 shows the regression results on our final sample of 460 buyout transactions using the equity volatility resulting from our model as a dependent variable. We use the logarithmized value in our regression analysis since equity volatility can only take non-negative numbers. In our first specification, which only includes the volatility of the MSCI World Stock Market Index before the transaction, our PE market cycles and control variables, we find that deals conducted in a relatively bullish economic environment (i.e. the periods between 1995-1999 and 2003-2005) are riskier than those carried out during the relatively bust period during the years 2000-2002 that we use as reference category. For instance, buyout transactions entered between 2003 and 2005 have a 26% ($e^{0.23} = 1.26$) higher equity risk compared to the deals entered during the period 2000-2002. The coefficients for the boom periods of the PE market are highly significant throughout all specifications and strongly support our findings concerning time patterns reported in Section 4.1.

Throughout all specifications we find a significantly (5% and 1% level) negative relation between the LTM volatility of the MSCI World Index and deal-level equity risk. For example, a 10% increase from the mean MSCI World volatility of 1.52 in specification (1) results in an 1.18% lower equity risk ($1.1^{-0.127} = 0.9880$). Higher volatility in public markets represents a strong uncertainty with regard to the economic outlook. Apparently, this situation also reduces the risk appetite of PE sponsors who craft less risky deal structures in such an environment.

The highly significant (1% level) negative coefficient of buyout company size in specification (2) confirms the argument that larger deals are less risky. A 10% increase in the mean enterprise value at investment entry, a change of about 22 millions of US dollars in our sample, results in an approximately 0.43% lower equity risk ($1.1^{-0.045} = 0.9957$). Apparently, PE sponsors do not use excessive leverage in order to offset the lower asset volatility of larger companies.

— *Insert Figure 7 about here* —

Our findings consistently show that PE sponsor reputation is significantly (1% level) negatively related to deal-level equity risk. Measured by the logarithm of historical deals in specifications (3) and (4), we find that a 10% increase in PE sponsor experience (a change of about 16.5 historical deals) results in a 0.28% drop in equity risk ($1.1^{-0.0295} = 0.9972$). Specification (5) shows a similar result when using the logarithm of assets under management as proxy for PE sponsor reputation.[14] A deal done by a PE sponsor with 10% higher experience (an

[14] We only have data on PE sponsor's assets under management for 416 transactions.

increase of about 176.4 millions US dollars at the mean value in our sample) embraces a 0.48% lower equity risk ($1.1^{-0.05} = 0.9952$). While this estimated coefficient is significant at the 1% level, the relationship decreases in statistical and practical significance when including deal size in specification (6). We think that this finding is intuitive as larger PE funds conduct larger deals. Hence, there is a strong positive correlation between assets under management and deal size which has a moderating effect on the relationship between PE sponsor experience and equity risk. In addition, some very experienced and highly reputed PE sponsors deliberately restrict their maximum fund size in order to avoid putting their fund-level performance at risk. As the assets under management proxy would indicate low PE sponsor experience, we believe that our first reputation proxy is a superior proxy in this context. Thus, we argue that more experienced and higher reputed PE sponsors exhibit less risk appetite because they fear losing their reputation and its corresponding competitive advantage.

Our specifications (4) to (6) consistently show a significantly negative relationship between the ownership stake at investment entry and equity risk. A 10% higher equity ownership stake in the mean buyout company (holding 54.4% of the buyout company's shares) results in an approximately 0.17% lower equity risk ($1.1^{-0.0183} = 0.9983$). Our results are in line with viewing PE investors' equity stakes as call options. As higher equity stakes go along with reduced risk appetite, lower stakes in the total equity values could trigger "gambling for resurrection" behaviour (Axelson et al., 2009, 2010).

5. Conclusion

During the last two decades, PE has become an important source of capital for companies and considerable amounts of money have flown into these funds from investors around the globe. While academic work has made significant progress in recent years, evidence on the risks associated with PE investing is still relatively scarce. The main reasons for this situation are the conceptual problems to compute risks for these illiquid investments as well as the limited availability of appropriate data sets. Using a proprietary data set of 460 realized European and North American buyouts entered between 1990 and 2005, this paper has analysed time patterns and determinants of the risk appetite of PE sponsors. Applying the Black-Cox debt pricing model we were able to calculate deal-specific implied asset and equity volatilities including both systematic and idiosyncratic risks.

We started by developing a mathematical model to calculate deal-level asset and equity risk which is based on the Black-Cox default model. This model allows for continuous interest and redemption payments as well as for continuous default. We think that the implied deal-level asset and equity risks resulting from our model represent good indications of the PE sponsors' assumptions about the development of the asset and equity risk over the holding period at investment entry.

We then calculated the deal-level equity volatilities for our transactions in order to analyze the risk appetite of PE sponsors over time. We have found that the risk appetite of PE sponsors fluctuates remarkably over time indicating that these investors adjust their attitude towards risk according to the economic environment. In this context we have found that PE sponsors take more risk during boom periods which explains (or can be explained by) boom and bust cycles in the buyout market. It is important to note that it is not only banks issuing cheap debt in times of economic upturns which causes overheating buyout markets but also the increasing risk appetite of PE sponsors. PE sponsors could use more equity to finance a transaction and not accept all supplied debt or offset higher leverage ratios by choosing companies with lower asset risk.

In this context we also have found high volatility in public equity markets prior to the investment entry of a PE sponsor, i.e. in the twelve months before the PE sponsor buys a company, has a negative influence on deal-level equity risk. Obviously, high uncertainty with regard to future economic development leads to reduced risk appetite of PE sponsors and/or a reduced willingness by banks to provide debt to finance a transaction.

In a next step, we have taken a detailed look at the determinants of PE sponsors' risk appetite. We find that larger buyouts exhibit lower equity risks. This finding indicates that PE sponsors do not use excessive leverage in order to offset the lower asset volatility of larger companies. If they were to do so, the equity risk increases through heightened leverage would outweigh the effect of low asset risk embraced in the company. Further, regarding PE sponsor characteristics we find that buyouts initiated by more experienced and higher reputed PE sponsors are less risky in terms of equity volatility. We attribute this reduced risk appetite to their fear of damaging their reputation and its corresponding competitive advantage which has been repeatedly shown to exist in the PE context (Achleitner et al., 2011; Demiroglu and James, 2010; Ivashina and Kovner, 2010). Finally, we have found that an increasing ownership stake by the PE sponsor is related to a decreasing risk appetite. This finding is in line with viewing the PE investors' equity stake as a call option. If the price the PE sponsor has to pay for his option rises, the risk appetite decreases. Since we have found that equity volatilities increase during boom periods and that reputation (as well as ownership stake) is negatively related to equity risk, we argue that PE sponsors do not always act in the interest of LPs when they deploy a certain debt to equity ratio on a buyout target, but take excessive risks. This is further support for agency conflicts between GPs and LPs which can (at least partially) be solved through reputation.

We think that this study sketches out some paths for future research on deal-level risk in PE investments and, in a next step, the linkage to returns. For instance, having more information on deal-level risk and return as well as PE sponsor characteristics could reveal more information on the persistence phenomenon, i.e. the fact that some PE sponsors continuously outperform their competitors, (Kaplan and Schoar, 2005). Perhaps, such investors exhibit similar characteristics in terms of deal-level risk-return preference which result in superior performance.

Alternatively, the deal-level investment behaviour of the PE sponsors contingent on the fund's performance situation appears to be an interesting field for future research. Probably, such research reveals that the compensation structure of PE funds incentivizes PE managers of underperforming funds to impose excessive equity risks on their deals in order to "gamble for resurrection", i.e. gamble all in hope of a recovery of the overall fund performance.

APPENDIX

This section derives an expression for $\partial V_E(0)/\partial V(0)$.

A *Down-and-out call option* (DOC) guarantees the holder a payoff of 0 in case of default ($\tau < T$) and a final payoff $\max\{V(T) - D(T)\}$, where $D(T)$ denotes the strike price at maturity and $D(t)$ the time-varying default barrier. The price of such an option, $DOC^{GBM}_{d,\mu_{V^*},\sigma_V}(V(0), D(0), T)$, is presented in the following Lemma 5.1 and can be found in, e.g., Hull (2006), p. 534.

Lemma 5.1 (Down-and-out call option (DOC)). *Let $V(t)$ be the value of the firm's assets at time t (see Equation (1)). The time to maturity is T, r the risk-free interest rate, and $D(0)$ the strike and knock-out barrier.*
Then, the value of a DOC option is given by

$$DOC^{GBM}_{d,\mu_{V^*},\sigma_V}(V(0), D(0), T) = V(0)\Phi^{GBM}_{d,\mu_{V^*}+\sigma_V^2,\sigma_V}(T) - e^{-rT} D(0)\Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T).$$

Theorem 5.2 (Equity value $V_E(0)$). *The equity price $V_E(0)$ in the presented model is given by*

$$\begin{aligned} V_E(0) =& V(0)\ e^{(c-\lambda)T}\ \Phi^{GBM}_{d,\mu_{V^*}+\sigma_V^2,\sigma_V}(T) \\ &+ D(0)\ \frac{\lambda}{c-r-\lambda} - D(0)\ e^{(c-r-\lambda)T}\ \frac{c-r}{c-r-\lambda}\ \Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T) \\ &- D(0)\ e^{-\frac{d(\tilde{\mu}_{V^*}-\mu_{V^*})}{\sigma_V^2}}\ \frac{\lambda}{c-r-\lambda}\ (1 - \Phi^{GBM}_{d,\tilde{\mu}_{V^*},\sigma_V}(T)). \end{aligned} \tag{8}$$

Proof: The equity holders have to pay redemption payments of the continuous rate λ until the company either defaults or matures in T. They receive $V(T) -$

$D(T)$ if the company survives until T, else they receive nothing. Thus

$$\begin{aligned}
V_E(0) =& \mathbb{E}[e^{-rT}\ 1_{\{\tau>T\}} \max\{V(T)-D(T),0\}] \\
&- \left[\int_0^T e^{-rt}\lambda D(t)dt\right]\ \mathbb{Q}(\tau>T) - \int_0^T \left[\int_0^s e^{-rt}\lambda D(t)dt\right] d\mathbb{Q}(\tau\leq s)
\end{aligned}$$

$$\begin{aligned}
=& e^{(c-\lambda)T}\ DOC^{GBM}_{d,\mu_{V^*},\sigma_V}(V(0),D(0),T) \\
&- \left[D(0)\ \frac{\lambda}{c-r-\lambda}(e^{(c-r-\lambda)T}-1)\right]\ \mathbb{Q}(\tau>T) \\
&- \int_0^T \left[D(0)\ \frac{\lambda}{c-r-\lambda}(e^{(c-r-\lambda)s}-1)\right]\ d\mathbb{Q}(\tau\leq s)
\end{aligned}$$

$$\begin{aligned}
=& e^{(c-\lambda)T}\ (V(0)\ \Phi^{GBM}_{d,\mu_{V^*}+\sigma_V^2,\sigma_V}(T) - e^{-rT}D(0)\ \Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T)) \\
&+ D(0)\ \frac{\lambda}{c-r-\lambda} - D(0)\ e^{(c-r-\lambda)T}\ \frac{\lambda}{c-r-\lambda}\ \Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T) \\
&- D(0)\ e^{-\frac{d(\tilde{\mu}_{V^*}-\mu_{V^*})}{\sigma_V^2}}\ \frac{\lambda}{c-r-\lambda}\ (1-\Phi^{GBM}_{d,\tilde{\mu}_{V^*},\sigma_V}(T))
\end{aligned}$$

$$\begin{aligned}
=& V(0)\ e^{(c-\lambda)T}\ \Phi^{GBM}_{d,\mu_{V^*}+\sigma_V^2,\sigma_V}(T) \\
&+ D(0)\ \frac{\lambda}{c-r-\lambda} - D(0)\ e^{(c-r-\lambda)T}\ \frac{c-r}{c-r-\lambda}\ \Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T) \\
&- D(0)\ e^{-\frac{d(\tilde{\mu}_{V^*}-\mu_{V^*})}{\sigma_V^2}}\ \frac{\lambda}{c-r-\lambda}\ (1-\Phi^{GBM}_{d,\tilde{\mu}_{V^*},\sigma_V}(T)),
\end{aligned}$$

using the results from Lemma 5.1. □

Lemma 5.3 (Delta $\Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T)$). *The derivative of the default probability $\Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T)$ (see Lemma 1.1) with respect to $V(0)$ is given by*

$$\begin{aligned}
\triangle^{GBM}_{d,\mu_{V^*},\sigma_V}(T) =& \frac{\partial\Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T)}{\partial V(0)} \\
=& \frac{2}{V(0)\sigma_V\sqrt{T}}\ \phi\left(\frac{-d+\mu_{V^*}T}{\sigma_V\sqrt{T}}\right) + \frac{2\mu_{V^*}}{\sigma_V^2 V(0)}\ e^{\frac{2\mu_{V^*}d}{\sigma_V^2}}\ \Phi\left(\frac{d+\mu_{V^*}T}{\sigma_V\sqrt{T}}\right),
\end{aligned}$$

where $\Phi(\cdot)$, respectively $\phi(\cdot)$, denotes the standard normal cumulative distribution function, respectively the standard normal density function.

Proof:

$$\frac{\partial \Phi^{GBM}_{d,\mu_{V^*},\sigma_V}(T)}{\partial V(0)} = \frac{1}{V(0)\sigma_V\sqrt{T}}\ \phi\left(\frac{-d+\mu_{V^*}T}{\sigma_V\sqrt{T}}\right) + \frac{1}{V(0)\sigma_V\sqrt{T}}\ e^{\frac{2\mu_{V^*}d}{\sigma_V^2}}\ \phi\left(\frac{d+\mu_{V^*}T}{\sigma_V\sqrt{T}}\right)$$
$$+\frac{2\mu_{V^*}}{\sigma_V^2 V(0)}\ e^{\frac{2\mu_{V^*}d}{\sigma_V^2}}\ \Phi\left(\frac{d+\mu_{V^*}T}{\sigma_V\sqrt{T}}\right)$$

$$= \frac{2}{V(0)\sigma_V\sqrt{T}}\ \phi\left(\frac{-d+\mu_{V^*}T}{\sigma_V\sqrt{T}}\right) + \frac{2\mu_{V^*}}{\sigma_V^2 V(0)}\ e^{\frac{2\mu_{V^*}d}{\sigma_V^2}}\ \Phi\left(\frac{d+\mu_{V^*}T}{\sigma_V\sqrt{T}}\right).$$

□

Using the results from Theorem 5.2 and Lemma 5.3, Theorem 5.4 gives the derivative $\partial V_E(0)/\partial V(0)$. The result is a straight forward application of the product rule on Equation (8).

Theorem 5.4 (Deriving $\partial V_E(0)/\partial V(0)$). *The derivative of the equity value $V_E(0)$ with respect to $V(0)$ is*

$$\frac{\partial V_E(0)}{\partial V(0)} = V(0)\ e^{(c-\lambda)T}\ \triangle^{GBM}_{d,\mu_{V^*}+\sigma_V^2,\sigma_V}(T)$$
$$+ e^{(c-\lambda)T}\ \Phi^{GBM}_{d,\mu_{V^*}+\sigma_V^2,\sigma_V}(T)$$
$$- D(0)\ e^{(c-r-\lambda)T}\ \frac{c-r}{c-r-\lambda}\ \triangle^{GBM}_{d,\mu_{V^*},\sigma_V}(T)$$
$$- \frac{D(0)}{V(0)}\ \frac{\tilde{\mu}_{V^*}-\mu_{V^*}}{\sigma_V^2}\ e^{-\frac{d(\tilde{\mu}_{V^*}-\mu_{V^*})}{\sigma_V^2}}\ \frac{\lambda}{c-r-\lambda}\ (1-\Phi^{GBM}_{d,\tilde{\mu}_{V^*},\sigma_V}(T))$$
$$- D(0)\ e^{-\frac{d(\tilde{\mu}_{V^*}-\mu_{V^*})}{\sigma_V^2}}\ \frac{\lambda}{c-r-\lambda}\ \triangle^{GBM}_{d,\tilde{\mu}_{V^*},\sigma_V}(T).$$

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Figure 1: Default barrier.

This figure gives an example of a private equity transaction with parameters: firm's asset value $V(0) = 1.0$, initial face value of debt $D(0) = 0.8$, time to maturity $T = 5.3$, asset drift $\mu = 5.0\%$, asset volatility $\sigma = 18.2\%$, debt yield $c = 8.0\%$, and redemption rate $\lambda = 13.4\%$ (one sample transaction from our database). Two samples of the firm value path (*grey line*) were generated using Monte Carlo simulation. The company defaults whenever its value hits the current face value of debt (*black line*).

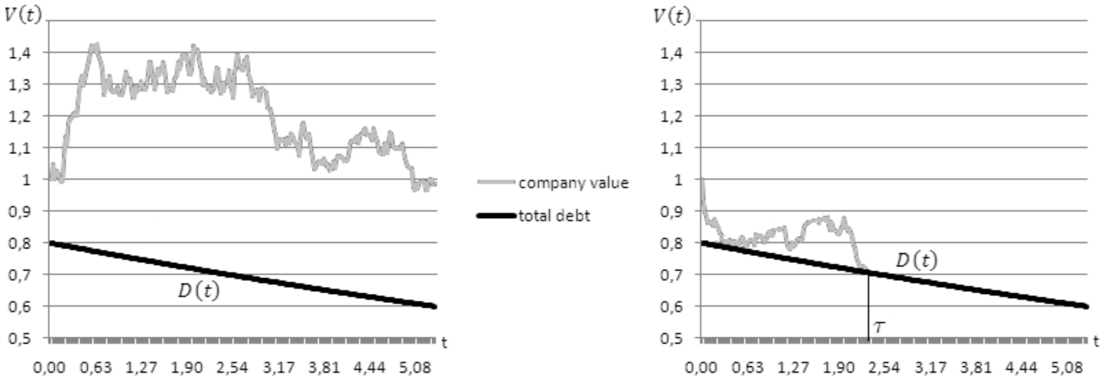

Figure 2: Payments to debt holders.
This figure shows the payments to the debt holders (P) in case of no default (*left*) and default (*right*). The chosen parameters are the same as in Figure 1, the recovery rate δ is 0.62 (Wilson et al., 2010).

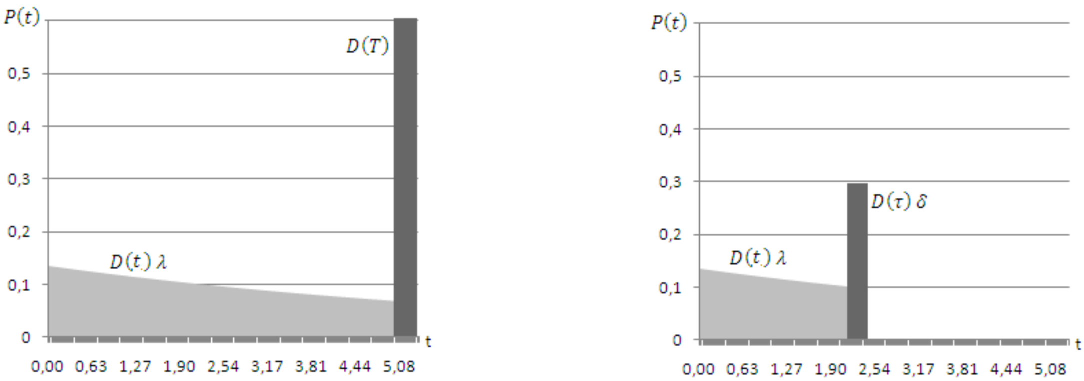

Figure 3: Descriptive Statistics.
This figure presents summary statistics for our final sample of 460 leveraged buyout transactions. Equity IRR is calculated from monthly cash flows between private equity (PE) sponsor and the portfolio company gross of fees and carried interest in percent. It is the discount rate that equates the present value of the cash flows to zero in percent. We winsorized this variable at the 95th percentile in order to account for outliers. Enterprise, equity, and net debt values at entry are the amounts in millions of US dollars at the time when the buyout company was acquired by the private equity sponsor. In turn, the values at exit are the amounts in millions of US dollars when the PE sponsor sold the buyout company to someone else. Holding period is the time span in years between entry and exit. Similarly, we report the net debt to equity ratios at both points in time for each deal. We report the ownership stake of the PE sponsor at investment entry which is the share of equity the PE sponsor buys at entry. For 152 transactions in our final sample the data sets provided by the funds-of-funds included explicit information on the share of equity that was purchased by the PE sponsor. For all remaining transactions, we calculated the PE sponsor's ownership stake by dividing the reported investment sum by the reported total equity value. PE number of deals is the number of historical buyout transactions by the respective PE sponsor at the time of the transaction as reported by Thomson Venture Economics. PE assets under management is the amount of the total assets under management (in millions of US dollars) of the PE sponsor accumulated in the five years before investment entry as reported by Thomson Venture Economics. MSCI World Index Volatility is the average volatility (standard deviation) in the last twelve months (LTM) prior to the investment entry date of the respective PE transaction of the MSCI World Stock Index.

	Variable	Notation	n	Mean	Median	Std. Dev.	Min.	Max
(1)	Equity IRR [% p.a.]		460	45.0	33.5	58.2	-100.0	212.5
(2)	Enterprise Value at Entry [$m]	V(0)	460	238.5	78.0	556.1	0.9	8,800.0
(3)	Enterprise Value at Exit [$m]	V(T)	444	458.6	142.1	1,041.7	0.2	14,086.7
(4)	Equity Value at Entry [$m]	E(0)	460	85.9	30.5	236.8	0.3	4,100.0
(5)	Equity Value at Exit [$m]	E(T)	402	340.3	99.1	925.6	-216.5	13,167.7
(6)	Net Debt Value at Entry [$m]	D(0)	460	152.6	48.0	337.8	0.7	4,700.0
(7)	Net Debt Value at Exit [$m]	D(T)	452	125.3	34.5	275.6	-99.0	2,548.4
(8)	Net Debt/Equity at Entry		460	2.2	1.6	2.5	0.0	25.0
(9)	Net Debt/Equity at Exit		401	0.6	0.4	1.5	-2.7	23.7
(10)	Holding Period [years]	[T]	460	4.7	4.1	2.5	0.6	13.8
(11)	PE Ownership Stake [%]		460	59.2	61.0	34.6	0.1	100.0
(12)	PE Number of Deals		460	187.7	34.0	384.4	0.0	1,599.0
(13)	PE Assets Under Management [$m]		418	1,892.5	681.8	2,247.0	20.8	9,826.0
(14)	MSCI World Index Volatility		458	1.5	1.6	0.5	0.1	2.8

Figure 4: Equity Risk Over Time.
This figure presents summary statistics on the computed equity risk from our model across time. In Panel A we sort the leveraged buyout transactions according to the entry year, i.e. the year when it was acquired by the private equity (PE) sponsor. In Panel B, we classify the transactions into four categories which represent different cycles of the PE market based on Stromberg (2008). Each transaction is assigned to a category based on the entry year. At the bottom of Panel B we report tests on the significance of time trends based on the four time categories with two methods: On the left-hand side we report t-tests to test on the equality of means. On the right-hand side we report Wilcoxon rank-sum (Mann-Whitney) tests (equality test of unmatched data). *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. A (+) indicates that the latter of both comparison groups has a significantly higher mean or median value, a (-) indicates a lower value.

	No. of Deals	Equity Risk			
		Mean	Median	Min	Max
Panel A: Investment year					
1990	1	0.64	0.64	0.64	0.64
1991	11	0.71	0.68	0.36	1.00
1992	8	0.85	0.75	0.47	1.62
1993	13	0.74	0.74	0.28	1.42
1994	15	0.86	0.68	0.41	2.04
1995	19	0.95	0.90	0.34	2.01
1996	34	0.95	0.79	0.44	2.51
1997	48	0.90	0.75	0.29	2.99
1998	39	0.73	0.69	0.21	1.48
1999	63	0.76	0.67	0.29	1.79
2000	47	0.70	0.66	0.34	1.68
2001	33	0.69	0.63	0.34	1.59
2002	38	0.64	0.63	0.31	0.97
2003	35	0.89	0.76	0.38	2.27
2004	33	0.81	0.82	0.46	1.42
2005	23	1.02	0.90	0.65	2.89
Total	*460*	*0.80*	*0.72*	*0.21*	*2.99*
Panel B: Time Categories					
1990-1994	48	0.79	0.68	0.28	2.04
1995-1999	203	0.84	0.73	0.21	2.99
2000-2002	118	0.68	0.64	0.31	1.68
2003-2005	91	0.89	0.82	0.38	2.89
Total	*460*	*0.80*	*0.72*	*0.21*	*2.99*
1990-1994 vs. 1995-1999		(+)		(+)	
1995-1999 vs. 2000-2002		(-)***		(-)***	
2000-2002 vs. 2003-2005		(+)***		(+)***	

Figure 5: Asset Risk and Net Debt to Equity Ratio.
This figure shows the mean and median values of deal-level asset risk and the net debt to equity ratio according to private equity (PE) market cycle periods based on Stromberg (2008). Asset risk for each transaction shown on the left-hand side is calculated based on the model introduced in this paper. The reported net debt to equity ratios of the buyout companies at the right-hand side are those at entry, i.e. when the PE sponsor acquired the company. At the bottom we report tests on the significance of time trends based on the four time categories applying mean comparison tests (t-tests) and Wilcoxon rank-sum (Mann-Whitney) tests. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. A (+) indicates that the latter of both comparison groups has a significantly higher mean or median value, a (-) indicates a lower value.

	No. of	**Asset Risk**				**Debt to Equity**			
	Deals	Mean	Median	Min	Max	Mean	Median	Min	Max
1990-1994	48	0.34	0.27	0.09	1.01	2.61	1.59	0.03	17.50
1995-1999	203	0.31	0.27	0.06	1.01	2.59	1.82	0.06	25.00
2000-2002	118	0.29	0.25	0.07	1.10	1.83	1.56	0.13	7.13
2003-2005	91	0.38	0.32	0.02	1.22	2.56	1.62	0.01	71.65
Total	*460*	*0.32*	*0.27*	*0.02*	*1.22*	*2.39*	*1.64*	*0.01*	*71.65*
1990-1994 vs. 1995-1999		(-)	(-)			(-)	(+)		
1995-1999 vs. 2000-2002		(-)	(-)			(-)***	(-)**		
2000-2002 vs. 2003-2005		(+)***	(+)***			(+)	(+)		

Figure 6: Default Probabilities.
This figure reports yearly summary statistics on the probabilities of default of buyout targets for the first year after the private equity (PE) sponsor acquired a company over the period from 1990 to 2005. The numbers are calculated based on the model introduced in this study. In this model a company defaults when the enterprise value falls below the value of debt. We sort the leveraged buyout transactions according to the entry year, i.e. the year when it was acquired by the PE sponsor. At the bottom we report tests on the significance of time trends based on the four time categories applying mean comparison tests (t-tests) and Wilcoxon rank-sum (Mann-Whitney) tests. *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively. A (+) indicates that the latter of both comparison groups has a significantly higher mean or median value, a (-) indicates a lower value.

	No. of	**Default Probability**			
	Deals	Mean	Median	Min	Max
1990-1994	48	4.35%	3.03%	0.00%	22.41%
1995-1999	203	4.92%	4.52%	0.00%	16.54%
2000-2002	118	2.38%	1.91%	0.00%	10.92%
2003-2005	90	5.59%	5.41%	0.27%	15.44%
Total	*459*	*4.34%*	*3.53%*	*0.00%*	*22.41%*
1990-1994 vs. 1995-1999		(+)	(+)		
1995-1999 vs. 2000-2002		(-)***	(-)***		
2000-2002 vs. 2003-2005		(+)***	(+)***		

Figure 7: Equity Risk as Dependent Variable.

This figure presents the results of ordinary least squares regressions with heteroscedasticity-robust errors on the determinants of equity risk using our final sample of 460 leveraged buyouts acquired between 1990 and 2005. The dependent variable is the logarithmized equity risk volatility as computed in our model. In order to account for temporal effects, a value of one is assigned to all buyouts that, for example, were done between 1990 and 1994 for this variable and zero otherwise. Again, these categories represent different cycles of the PE market based on Stromberg (2008). We have chosen the period between 2000 and 2002 as the base category. In addition, we include eight ICB industry category dummies accounting for industry effects. We also include the logarithmized value of the average volatility in the last twelve months (LTM) prior to the investment entry date of the respective PE transaction of the MSCI World Stock Index to account for public market volatility. Finally, the Region Dummy obtains a value of one if the buyout target company's headquarters is in Europe and zero if it is located in North America. While specification (1) only contains these control variables, we add the natural logarithm of the enterprise value at entry in million of US dollars as proxy for deal size in specification (2). In specification (3) we include the natural logarithm of the number of historical buyout transactions by the respective PE sponsor at the time of the transaction as reported by Thomson Venture Economics. We use this variable as proxy for PE sponsor experience and reputation. In specification (4) we add a PE sponsor ownership variable. For 152 transactions in our final sample the data sets provided by the funds-of-funds include explicit information on the share of equity that was purchased by the PE sponsor. For all remaining transactions, we calculate the PE sponsor's ownership stake by dividing the reported investment sum by the reported total equity value. We also logarithmized this variable. Finally, we test the robustness of our results by the inclusion of an alternative PE sponsor reputation variable in specifications (5) and (6). This proxy is the natural logarithm of the total assets under management (originally in millions of US dollars) of the PE sponsor accumulated in the five years before investment entry as reported by Thomson Venture Economics. For all variables, the numbers in the upper rows represent the regression coefficients. *, ** and *** indicate p-values of 10 percent, 5 percent, and 1 percent significance level, respectively. In the lower rows the detailed t-statistics are reported in parentheses.

VARIABLES	(1) Ln (Equity Volatility)	(2) Ln (Equity Volatility)	(3) Ln (Equity Volatility)	(4) Ln (Equity Volatility)	(5) Ln (Equity Volatility)	(6) Ln (Equity Volatility)
Ln (Enterprise Value)		-0.045***	-0.045***	-0.047***		-0.033**
		(-3.290)	(-3.318)	(-3.423)		(-2.289)
Ln (Number of Deals)			-0.026***	-0.033***		
			(-2.656)	(-3.242)		
Ln (Ownership)				-0.020**	-0.018*	-0.017*
				(-2.080)	(-1.829)	(-1.764)
Ln (Assets under Management)					-0.050***	-0.031**
					(-3.314)	(-2.046)
Ln (MSCI World Volatility)	-0.127***	-0.118**	-0.131***	-0.125**	-0.131***	-0.123**
	(-2.656)	(-2.401)	(-2.593)	(-2.426)	(-2.612)	(-2.368)
1990-1994	0.046	0.010	-0.038	-0.040	-0.041	-0.036
	(0.638)	(0.143)	(-0.479)	(-0.510)	(-0.514)	(-0.449)
1995-1999	0.164***	0.162***	0.138***	0.132***	0.094**	0.106**
	(3.856)	(3.894)	(3.286)	(3.164)	(2.153)	(2.477)
2003-2005	0.233***	0.249***	0.273***	0.260***	0.201***	0.202***
	(4.467)	(4.830)	(5.229)	(4.901)	(3.746)	(3.777)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	458	458	458	458	416	416
R-squared	0.096	0.121	0.133	0.140	0.126	0.137

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1